An Experiment on Screening When Employees Choose Their Productivity[†]

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Abstract

In the first stage, ex ante symmetrical agents can simultaneously invest in becoming highly productive. In the second stage, since an agent's productivity is his private information, profit–maximization requires a principal to offer a menu of contracts to separate the two types of agents. This comes at the cost of paying an information rent to the highly productive types. However, the information rent decreases as more high type agents become active, and thus investment cost may not be covered. Therefore, the first stage constitutes a coordination game of who should invest in productivity.

We observe much more investment in productivity than expected. Nevertheless, the investments pay off for two reasons. First, efficiency is achieved as principal subjects frequently request optimal quantities. Second, the principal subjects share profits with their employees rather than exploiting them. In addition, the higher the productivity, and the higher the (sunk) investment cost, the more generous the principal subjects are. Moreover, we often observe separation of the two types.

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1 Introduction

Only a few papers deal with empirical aspects of how, and if, screening is successful. We try to fill a part of this gap in economic literature by experimentally analyzing screening when the choice of the productivity type is endogenous.

We analyze a repeated one–shot interaction in which a firm delegates the production of a homogeneous good to an agent. This agent can be of high or of low productivity. The principal cannot observe an agent's productivity, but she knows the proportions of high and low types in the market. In order to separate the two productivity types, a standard screening model is applied (Laffont/Martimort (2002), 32-46). Principals and agents have random one–to–one encounters, and the principal presents a menu of contracts as an ultimatum offer to "her" agent in order to elicit the high type's productivity. For the principal, the information revelation comes at the cost of paying an information rent to the more productive agent. This information rent decreases with a growing presence of high type agents in the market.

We expand the standard model by adding a first stage in which the otherwise symmetrical and low–productivity agents can simultaneously and independently invest in becoming highly productive before entering the labor market in the second stage. Since a high type's returns in stage two decrease as the proportion of that type rises, his earnings may not cover the (sunk) investment cost. Thus, our first stage forms a coordination game of who should invest in productivity.

To the best of our knowledge, the only prior experiment on labor market screening was conducted by Kübler et al. (2008) who compare the outcomes of a signaling treatment versus a screening treatment in the sense of Spence (1973) and Rothschild/Stiglitz (1976).[1] The screening treatment of Kübler et

[1]Spence (1973, 1974) showed that education, even if it does not change an agent's productivity, can provide a signal thereof. Rothschild/Stiglitz (1976) demonstrated that education can be used by the principals to screen and separate the agents into categories that reflect their productivity. There is evidence that both screening and signaling occur in reality (see, e.g., Riley (1979), Shah (1985) on screening, and Bedard (2001) on signaling). Groot/Oosterbeek (1994) use a data set from the Netherlands and find that the human capital theory explains employees' earnings better than a screening model. Shapira/Venezia (1999), and Posey/Yavas (2007) experimentally examine screening in an insurance market. Shapira/Venezia find a lack of empirical evidence for successful screening on the part of the insurers, but Posey/Yavas observe an early convergence to the separating equilibrium. The latter used computerized insurance clients, though.

al. differs from ours in three main respects: First, skill levels are randomly assigned and do not develop endogenously. Second, employers are restricted to offering wages (quantities are fixed by the experimenter). Third, firms offer a specific contract to a particular type of agent.

Under the latter two assumptions, Kübler et al. (2008) often observe efficient screening. These restrictions are very helpful for preventing excessive noise in the data. However, we tried a different way of overcoming noisy contract offers and the difficulty of building mutually consistent expectations between employers and employees. We neither pointed out to the subjects that employers should screen by explicitly asking for one contract for each type, nor did we fix the quantities to the efficient level. Our subjects, at all times during the experiment, had access to a software tool that enabled them to compute their own, as well as their interaction partner's expected profits from arbitrary contracts under all possible configurations of high and low types in the labor market. We also frequently observe separation of our two types of agents.

We pursue four research questions. First, we explore the agent subjects' investments in productivity. Second, we analyze the efficiency and the incentive compatibility of the firm subjects' contract offers. Third, we examine to which extent the high types receive an information rent. Fourth, we survey all subjects' payoffs.

First, we observe that many more subjects than theoretically predicted invest in productivity. Second, we find that the two types are frequently offered efficient contracts, and that, overall, screening is successful in our labor market. Third, our data shows that, on average, our high types obtain their information rent. Fourth, in the majority of cases, the high types' average shares exceed the information rent by far, and their earnings also exceed those of the low types. Thus, the first–stage over–investment in productivity is rewarded by the firms, which can be interpreted as an expression of trust and reciprocity.

The remainder of this paper is organized into three sections. We present our theoretical model in Section 2. Section 3 contains the design and the results of our experiment. In Section 4, we briefly summarize and discuss our results.

2 Our Model

We analyze a game with two stages. Ex ante, all agents are symmetrical, risk–neutral and of low marginal productivity (i.e., of high marginal production cost, $\overline{\theta}$). In the following, we describe the timing of moves from T= 1 till T= 4.

In stage one and **T=1**, the agents individually and simultaneously choose between staying a low–productivity type, or investing K to become a high–productivity type with marginal production cost of $\underline{\theta}$, where $(\overline{\theta} - \underline{\theta}) = \Delta\theta > 0$.[2]

In **T=2**, at the beginning of the second stage, the resulting relative frequencies of low types, p, and of high types, $1 - p$, where $p \in [0, 1]$, are made common knowledge.[3] That is, the agents differ in marginal production cost $\theta \in \{\underline{\theta}, \overline{\theta}\}$, if they have behaved asymmetrically in stage one. The risk–neutral principals cannot observe θ and face the risk of adverse selection when hiring an agent.

Principals and agents meet randomly one–to–one in **T=3**, and the principal moves first by making an ultimatum offer to an agent of unknown type. For producing a quantity $q \in \mathbb{R}_{0+}$ of a homogeneous good at cost θq, an agent is compensated by the principal through a lump sum money transfer $t \in \mathbb{R}$; t and q are both observable and verifiable. Since we assume zero fixed cost, production costs are solely determined by θ, and are borne by the agent. An amount of $q \geq 0$ units of the homogeneous good has value $S(q)$ to a principal, where $S(0) = 0$, $S' > 0$, and $S'' < 0$. All players' outside options equal zero by assumption.

In **T=4**, each agent accepts or rejects the offer. An accepted contract is executed. In case of a rejection, both parties stick to their outside options.

To solve for the sub–game perfect equilibrium, we work backward from the second stage (Section 2.1) to the first stage (Section 2.2) of the game. In stage two, we apply a standard screening model with two types of agents.[4]

[2] Thus, with the labels "low type" and "high type", we refer to an agent's productivity and not to his marginal production cost.

[3] This assumption is crucial for our second–stage screening model. When applying the model to real–world situations, this assumption can be justified through experience and market observation on the part of the firms.

[4] See, e.g., Laffont/Martimort (2002), p. 32-46.

2.1 Screening in the Second Stage

Figure 1 illustrates the second stage of the game, after the probabilities p of low types, and $1-p$ of high types have been determined in stage one. The first stage is discussed in the next section and thus is symbolized by the box containing a question mark. The uninformed principal, P, randomly meets an agent one–to–one. The dashed line indicates that the principal cannot tell a high from a low type, thus both of P's nodes are located in the same information set. In order to maximize expected profits, he has a stake in revealing the agent's type. This is done by offering a menu of contracts, $\{(\underline{t}, \underline{q}); (\bar{t}, \bar{q})\}$, that should be incentive compatible in that the two types choose different contracts and thereby separate themselves. Agent A accepts a contract out of the menu (indicated by $\mathrm{Y}_{(t,q)}$) only if working with the principal yields at least his outside option's utility level (of zero). If he rejects both contracts (N), the principal and agent both receive nothing. The resulting payoffs are indicated.

- Insert Figure 1 about here -

A menu of contracts is incentive compatible, and therefore self selecting, only if each type of agent is worse off mimicking the other type compared to revealing his true type. Using $\underline{\theta} = \frac{1}{2}$, $\bar{\theta} = 1$, and $S(q) = 10 \cdot \sqrt{q}$, which are the parameter values chosen for our experiment, the optimal incentive compatible menu[5] of contracts, $\{(\underline{t}^*, \underline{q}^*); (\bar{t}^*, \bar{q}^*)\}$, where $p \in (0, 1)$, is

$$\{(\underline{t}^* = 50 + \frac{50p^2}{(1+p)^2}, \underline{q}^* = 100); (\bar{t}^* = \frac{100p^2}{(1+p)^2}, \bar{q}^* = \frac{100p^2}{(1+p)^2})\}.$$

The prospective information rent, R, for an agent of high type amounts to

$$R^* = \underline{t}^* - 0.5\underline{q}^* = \frac{50p^2}{(1+p)^2}.$$

R is positively related to p, and drops to zero if only high types are active ($p = 0$). The intuition behind this relation is the following: Raising $\bar{q}$ increases $\underline{t}$ (see equation (7) in Appendix A) and thereby R. Thus, the principal faces a tradeoff with regard to expected profits. A higher quantity $\bar{q}$ increases the revenues generated by the low type, but increases the cost for paying the high

[5]See Appendix A for the derivation.

type. Therefore, in order to maximize expected profits, a principal should choose low amounts of $\overline{q}$ and $\underline{t}$ when the low type's presence in the market is low but the high type is frequently encountered. If p is high, the requested quantity $\overline{q}$, and the high type's payment $\underline{t}$ should be higher.

The information rent R provides an incentive for the agents to invest in productivity. However, if too many agents invest in the first–stage coordination game, and R does not cover the cost, a high type will face net losses.

We ran the experiment with groups of eight containing four agent and four principal subjects. Thus the probability p of meeting a low type could take five possible values: 0, 0.25, 0.5, 0.75, or 1. In the case of $p = 0$ or $p = 1$, the labor market is homogeneous and the principal is fully informed. In these instances, incentive compatibility considerations are no longer relevant and no agent reaches more than the utility level of his outside option.[6]

Table 1: Optimal Contracts and Payoffs at Different p–levels in Stage Two

	Results	Only High Types $p = 0$	$p = 0.25$	$p = 0.5$	$p = 0.75$	Only Low Types $p = 1$
1.	$\underline{q}^*$	100	100	100	100	–
2.	$\underline{t}^*$	50	52	56	59	–
3.[a]	$\underline{t}^* - 0.5\underline{q}^* = R^*$	0	2	6	9	–
4.	$\frac{\underline{t}^*}{\underline{q}^*}$	0.50	0.52	0.56	0.59	–
5.	$S(\underline{q}^*) - \underline{t}^*$	50	48	44	41	–
6.	$\overline{q}^*$	–	4	11	18	25
7.	$\overline{t}^*$	–	4	11	18	25
8.	$\overline{t}^* - \overline{q}^* = r^*$	–	0	0	0	0
9.	$\frac{\overline{t}^*}{\overline{q}^*}$	–	1	1	1	1
10.	$S(\overline{q}^*) - \overline{t}^*$	–	16	22	24	25

[a] *When accounting for stage one, investment K has to be subtracted.*

Table 1 displays the optimal contracts, the players' respective payoffs, and each type's pay per quantity unit, $\frac{t^*}{q^*}$, at each p–level. A high type's maximum information rent (see third row), arises when $p = 0.75$ and he is the only highly

[6] P optimizes $S(q) - t$ over t and q, such that $t - \theta q \geq 0$. In this ultimatum game, $t = \theta q$, and $S'(q^*) = \theta$ applies regarding the optimal quantity.

productive agent in the labor market. A principal's maximum profit (compare rows five and ten) is achieved in a purely high–type labor market ($p = 0$) in which screening is no longer necessary, and highly productive types can be pushed to their outside utility level (of zero).

2.2 Investment in Productivity in the First Stage

The rates of low– and high–productivity types in the market develop endogenously from stage one of our game. In this coordination game between four agents (the size of the group in our experiment), the agents decide individually and simultaneously whether to invest K or 0. Assuming optimal screening contracts in stage two, a high type faces total net earnings of $R^* - K = \underline{t}^* - 0.5\underline{q}^* - K$ at the end of the game. Since R^* decreases with an increasing number of high types, an agent's decision to invest in productivity pays off only if not too many of his peers do likewise, and if investment costs are low enough.

We explore this game by imposing an investment cost of $K = 5$ in our first treatment, and of $K = 15$ in the second one. Under $K = 15$, it is a dominant strategy to never invest, as $R^* \leq 9$ for $p \in [0, 1]$ (see third row in Table 1). Under $K = 5$, it forms an equilibrium in pure strategies when exactly half of the agents invest whereas the remaining half does not, which leads to $p = 0.5$.[7]

2.3 Our Hypotheses

We summarize the predictions from the theory presented in Table 1 by stating the alternative hypotheses H_{11} to H_{17} to be examined in the course of this paper.

H_{11}: $p = 0.5$ under $K = 5$, and $p = 1$ under $K = 15$.

H_{12}: Firm subjects offer incentive compatible contracts with efficient quantities.

[7]Consider the pure strategies "K" and "0". If one agent chooses "K" and three agents choose "0" we have $p = 0.75$ and $R^* = 9$. It is no equilibrium if the remaining three agents stick to "0" since the information rent under $p = 0.5$ amounts to $6 > K$ which provides an incentive for deviation. If three agents invest, $R^* = 2 < K$ generates an incentive for one of them to deviate. Only if two agents have invested, no incentive to deviate exists. We thus have six Nash equilibria in pure strategies in which exactly two out of four agents invest. All of them result in a labor market with $p = 0.5$. We do not analyze equilibria in mixed strategies.

H_{13}: a) At each p–level, firms offer the predicted $\frac{t}{q}$ (see rows 4., 9. of Table 1),
b) with varying p–level, the offered $\frac{t}{q}$ changes as predicted.

H_{14}: a) At each p–level, firms offer the predicted rents (see rows 3., 8.),
b) with varying p–level, the offered rents change as predicted.

H_{15}: The high types earn exactly the information rent, R^*, predicted for each p–level, the low types always earn a zero rent.

H_{16}: The high types' total net earnings increase with p, those for the low types do not differ as p changes (see Table 1, rows 3., 8. net of K).

H_{17}: a) At each p–level, the principals make profits as predicted,
b) with varying p, profits change as predicted in rows 5., 10. of Table 1.

When examining the hypotheses above, we will also test for differences between the low–cost treatment $K5$, and the high–cost treatment $K15$, for which the theoretical predictions are identical, except for the high types' lower total net earnings under $K15$. Whether the principal and agent subjects show some amount of learning during the experiment is analyzed in an explorative way by comparing the first to the second part of play. In the second part, we expect that average behavior will be closer to the theoretically predicted outcome.

3 The Experiment

3.1 The Design of the Experiment

At the University of Karlsruhe, a total of 144 undergraduates, mostly students of Business Engineering, participated in 9 sessions with 16 subjects in each. In the first 4 sessions, the cost of investment in productivity was set at $K = 5$ (Treatment $K5$), in the following 5 sessions, subjects faced an investment cost of $K = 15$ (Treatment $K15$). One session consisted of two 5–period plays. The participants interacted in groups of 8, each consisting of 4 employee and 4 employer subjects to whom roles had been randomly assigned. Subjects maintained their role during the experiment. After the first 5 periods, new groups of 8 were randomly formed. Subjects knew they would be reassigned after 5 periods, but were never told which 7 of the remaining 15 subjects were in their group at any time. Further, employer and employee subjects were randomly rematched within their matching group at the beginning of each period. Written instructions were distributed and read aloud. No communication was permitted, and questions were asked and answered only in private. To ensure that everyone understood the experiment, every subject had to answer 25 computer–based questions prior to the start of the experiment.

Each employer subject was endowed with 200 CU (currency units) in periods one and six, thereby ensuring that the optimal contracts were affordable. Employee subjects received an endowment of 50 CU per period which guaranteed a minimum level of earnings even if no contract was offered or accepted.

At the beginning of each period, every employee subject was of low productivity with production cost of $\overline{\theta} = 1$ CU per QU (quantity unit). The experiment started with the employee subjects making their investment decisions simultaneously and independently. In each new period, employee subjects had to decide whether to invest in productivity. A highly productive employee subject produced at a cost of $\underline{\theta} = 0.5$ CU per QU in both treatments. Following the investment decision, both employee and employer subjects learned about the proportion p of low–productivity types within their group. Firms and employees then met randomly one–to–one, and the employer subjects were able to make an ultimatum offer to their agent by proposing zero, one, or two contracts simultaneously. A contract consisted of a lump sum wage, and a quantity to be produced.[8] If a contract was accepted, it was fulfilled. A rejection yielded zero profits for both parties in the respective period.

At the end of each period, profits were calculated and reported to the participants. All of the participants had access to two software tools throughout the duration of the experiment. "History" reported the personal results of all prior periods, including contracts, productivity levels, resulting own profits and those of the interaction partners. For both employer and employee subjects, a tool called "Pocket Calculator" was available. It allowed the subjects to compute the profitability of any contract for an employer and for each type of employee.

[8]The subjects were informed that the computer program would not accept wage or quantity values above 500. No other limitations existed.

Additionally, an employer's expected profits from a pair of offered contracts was indicated, depending on the probability of meeting a low or a high type.[9]

At the end of the experiment, the sum of the payoffs from all periods was cashed individually and anonymously. The rate of conversion was 0.03 EUR for 1 CU. These parameters yielded an average payment of 18.8 EUR (17.5 EUR) for employer subjects and 17 EUR (16 EUR) for employee subjects in Treatment $K5$ ($K15$). Each session lasted 90–120 minutes.

3.2 The Results

Since our subjects have been randomly rematched in each period we can treat each period as an independent observation when testing for statistical significance.[10] Unless otherwise noted, we used the software package SigmaStat 3.1 to execute the tests which are performed at a 5%–level of significance.

3.2.1 Investment in Productivity in Stage One

We observe that the employee subjects' rate of investment in productivity in stage one is much higher than expected. In Treatment $K5$, 87.5% of the total 320 investment decisions are made in favor of becoming highly productive (86% in periods 1-5, and 89% in periods 6-10). This is far greater than the 50% predicted by the pure strategy equilibrium. Of these 280 investments, 75% are profitable in that the subjects receive strictly positive "total net earnings" which are earnings net of K, and exclusive of endowments (69% in periods 1-5, and 80% in periods 6-10). Although investing in productivity theoretically never pays off under Treatment $K15$, it is widely observed. Of 400 decisions, 53.5% are made in favor of high productivity (59% in the first, and 49% in the second five periods). A share of 75% of the number of 214 investments is profitable (68% in the first and 85% in the second part). How both the number and the profitability of investments develop along the time is displayed in Table 2.

We now turn to examining hypothesis H_{11}. In Table 3, we present the

[9] A translation of the pocket calculator and the instructions are provided in Appendix B.

[10] Treating several repetitions of the same game as independent observations when subjects are randomly rematched in each period such that single subjects only meet by chance, is not without controversy. However, it is fairly common practice (see, e.g., Andreoni (1988, 294ff), Banks et al. (1994, 13ff.), or Falk et al. (2006)).

Table 2: Investments, and Profitable Investments in all Periods (Percentages)

Treatment		Period 1	2	3	4	5	6	7	8	9	10
$K5$	Investments	84	91	78	88	88	81	97	91	84	94
	Thereof Profitable	59	69	72	68	79	85	71	83	81	83
$K15$	Investments	85	58	53	48	50	48	50	48	48	50
	Thereof Profitable	47	70	76	89	75	89	85	79	95	100

Table 3: Observed p–levels (Percentages)

Treatment		$p = 0$	$p = .25$	$p = .5$	$p = .75$	$p = 1$
$K5$	1-5	50	42.5	7.5	0	0
	6-10	60	37.5	2.5	0	0
$K15$	1-5	16	34	26	16	8
	6-10	4	26	36	28	6

percentages of p–levels resulting from the investments during the two parts of play. In $K5$, no more than 7.5% (2.5%) of menu offers take place under the theoretical prediction of $p = 0.5$ in the first (second) part of play. The vast majority of interactions take place in a homogeneous labor market with only highly productive agents. We never observe $p > 0.5$. In the high–cost Treatment $K15$, the theoretically predicted labor market with only low types occurs at a surprisingly low rate of 8% (6%) in periods 1-5 (6-10). Thus we state

Result 1:

Both parts of H_{11} are not supported, since both $p = 0.5$ under $K5$, and $p = 1$ under $K15$ occur less frequently than expected. However, in keeping with theory, investment rates are higher under $K5$ than $K15$.

Further, the comparison of the two parts of play disallows any conclusions with regard to learning. Along the ten periods of play under $K5$, investments grow slightly in number but the profitability of those investments rises strongly, whereas in $K15$, investments abate but profitability also strongly increases.

3.2.2 Screening Attempts in Stage Two: The Principals' Offers

We first focus on the contract quantities, since the quantity determines efficiency whereas the payment solely divides the "pie" between firms and employees. The quantity units contained in all contracts offered during ten periods are presented in Figures 2 and 3 for Treatments $K5$ and $K15$, respectively. The quantity units are grouped into intervals $[i+5;\ i+14]$ with $i = 0, 10, 20, ...110$. The first interval, named "< 5", covers quantity units lower than five. The last interval, "> 124", includes quantities between 125 and the maximum of 500. The relative frequencies of the quantity intervals are displayed for the observed p–levels.

- Insert Figure 2 about here -

- Insert Figure 3 about here -

In the following, we examine hypothesis H_{12}. Table 1 reports 100 QU to be the efficient quantity for high types under all possible p–levels. The predicted quantities for the low types amount to 4, 11, 18, and 25 QU under $p = 0.25$ through $p = 1$, respectively. Figures 2 and 3 show 100 QU (precisely, a quantity between 95 and 104 units) to be the modal value under $0 \leq p \leq 0.5$. In $K15$ and $p \geq 0.75$, an increasing number of contracts are offered to the low types, and the majority of requested quantities are located in the categories of 20 and 30 QU. Quantities in between are rarely observed. Furthermore, a certain type's optimal quantity is requested more often, the more frequently this type occurs.

In order to examine individual screening attempts, we sorted our principal subjects into groups which classify the contracts within a menu by the requested quantities. A contract with less than 35 QU (located in the first four intervals of Figures 2 and 3) is denoted by l and obviously targets the low type. Similarly, a contract offer that contains at least 95 QU addresses the high type and is labeled h. We call this "targeting" the low or the high type, respectively. Quantities labeled n lie in between and, seemingly, target neither low nor high types.

Tables 4, and 5 give the numbers of principals in each group. Menus with two different contracts are symbolized by two letters (e.g., lh means that this menu contains two different contracts, one of which targets the low type (l) and the high type (h), respectively). Furthermore, we treated two identical

Table 4: Numbers of Offered Menus in the Homogeneous Markets

		one contract			two contracts							
		l	h	n	ll	hh	nn	ln	hn	lh	Σ	%targ
$p = 0$												
$K5$	1-5	1	31 *(22)*	6	3	19 *(11)*	5	2	7 *(5)*	6 *(5)*	80	79% *(54%)*
	6-10	3	45 *(33)*	6	1	28 *(17)*	3	–	2 –	8 *(6)*	96	87% *(58%)*
$K15$	1-5	2	14 *(11)*	1	3	3 *(3)*	–	2	2 *(1)*	5 *(4)*	32	75% *(59%)*
	6-10	–	4 *(4)*	2	–	– –	–	–	– –	2 *(2)*	8	75% *(75%)*
$p = 1$												
$K15$	1-5	4 *(4)*	–	–	2 *(1)*	1	1	4 –	–	4 *(1)*	16	88% *(38%)*
	6-10	2 *(1)*	–	–	5 *(2)*	–	–	2 *(2)*	–	3 *(3)*	12	100% *(67%)*

contracts within the same menu as one contract. Menus composed of only one contract are symbolized by one letter. We never observed a firm subject offering no contract, and we did not consider a proposal with zero payment an offer.

We separate between periods 1-5, and 6-10. The column that shows the row totals is labeled "Σ". The italic figures in brackets indicate how many firm subjects pinpoint the efficient quantity for the relevant type(s) by at least one contract. In the column labeled "%targ", we give the percentages of principal subjects who target the relevant type(s), and, in brackets, those who hit a type's efficient quantity exactly. For instance, under $p = 0$, only high types are active. The menus h, hh, hn, and lh address the high type with at least one contract. In $K5$, these four groups contain 79%, and 87% of firm subjects in the first and the second five periods, respectively. Those who hit the efficient quantity exactly, amount to 54%, and 58% of all principal subjects, respectively. The absolute numbers of firm subjects under this condition add up to 80, and 96, respectively, which are 50%, and 60%, respectively of the 160 decisions in each five periods (see column "Σ" in Table 4, and first column in Table 3).

Table 5: Numbers of Offered Menus in the Heterogeneous Markets

		one contract			two contracts							
		l	h	n	ll	hh	nn	ln	hn	lh	Σ	%targ
$p = .25$												
$K5$	1-5	1	12	3	1	3	6	14	3	25	68	37%
		–	*(7)*		–	*(2)*		–	*(1)*	*(–/16/–)*		*(24%)*
	6-10	–	9	–	–	7	–	5	–	39	60	65%
		–	*(6)*		–	*(5)*		–	–	*(2/26/–)*		*(47%)*
$K15$	1-5	4	3	1	3	–	3	14	3	37	68	54%
		–	*(2)*		–	–		–	*(3)*	*(–/26/–)*		*(38%)*
	6-10	–	–	1	1	4	1	10	–	35	52	67%
		–	–		–	–		–	–	*(–/27/–)*		*(52%)*
$p = .5$												
$K5$	1-5	–	2	–	1	2	–	2	–	5	12	42%
		–	*(2)*		–	*(1)*		–	–	*(–/3/–)*		*(25%)*
	6-10	–	1	–	–	–	–	–	–	3	4	75%
		–	–		–	–		–	–	*(–/3/–)*		*(75%)*
$K15$	1-5	–	–	–	5	2	2	10	6	27	52	52%
		–	–		*(1)*	*(2)*		–	*(5)*	*(–/23/–)*		*(44%)*
	6-10	5	–	3	1	2	1	13	1	46	72	64%
		–	–		–	*(1)*		–	*(1)*	*(–/41/–)*		*(57%)*
$p = .75$												
$K15$	1-5	1	–	1	6	1	2	7	–	14	32	44%
		–	–		–	–		–	–	*(–/14/–)*		*(44%)*
	6-10	2	–	–	6	–	–	15	1	32	56	57%
		–	–		–	–		–	–	*(1/23/–)*		*(43%)*

For the menu lh in the heterogeneous markets (see Table 5), we present three figures in brackets to differentiate between requesting the efficient quantity only for the low type, only for the high type, and for both types simultaneously. For instance, in periods 6-10 under $p = 0.25$ of $K5$, 39 firm subjects target both types. Thereof, two firm subjects request a low type's efficient quantity of 4 QU, 26 request a high type's optimal quantity of 100 QU, but no firm subject requests the efficient quantities from both types simultaneously.

The tables display that many firm subjects offer no second contract in the homogeneous labor markets of $p = 0$, or $p = 1$, whereas under $0.25 \leq p \leq 0.75$, almost every firm does. This suggests that a large number of firm subjects might have understood when screening was necessary. Under $p = 0$ and $p = 1$, the majority of firm subjects target the right type(s) and they often request the efficient quantity (see columns "%targ").

In the heterogeneous markets, in which only menu lh targets both types, our findings are similar though less pronounced. The efficient quantity for the high type is frequently requested, and it is requested much more often than that for the low type. This finding may occur due to the fact that, from $p = 0.25$ to $p = 0.75$ the low type's efficient quantity varies as p changes, whereas that of the high type does not. However, in the (rarely observed) $p = 1$ markets, efficiency regarding the low type is frequently sought by the firm subjects.

Table 6: Incentive Compatibility of Menus lh (Average Percentages)

		$K5$		$K15$	
		IC_{low}	IC_{high}	IC_{low}	IC_{high}
$p = .25$	1-5	100	100	100	97
	6-10	100	100	100	100
$p = .5$	1-5	100	80	100	85
	6-10	100	100	100	100
$p = .75$	1-5	*no data*		100	100
	6-10	*no data*		100	97

From the fact that lh targets both types by the appropriate quantity we cannot conclude that the menu is incentive compatible. Thus we have to account for the corresponding payment. Of all menus lh in Table 5, Table 6 contains those that are incentive compatible in that each type weakly prefers "his" contract. We indicate by the label IC_{low} if the low type weakly prefers contract l over h, and by IC_{high} if the reverse is true for the high type. For instance, in periods 6-10 under $p = 0.25$ of $K5$, 39 menus target both types (see column lh in Table 5). Thereof, 28 menus contain the efficient quantity for either type (see numbers in brackets), but all 39 menus are incentive compatible (see Table 6). Overall, we find that almost all menus lh are incentive compatible. We state

Result 2:

Hypothesis H_{12} is supported for both treatments. In the homogeneous (heterogeneous) markets, about 75% to 100% (37% to 67%) of our principal subjects target *the right type(s), and 38% to 75% (24% to 75%) of all firm subjects request the efficient quantities from at least one type. Of those menus in the heterogeneous markets that target both types, nearly 100% are incentive compatible.*

Further, in all markets except $p = 0$ in $K15$, targeting the right type and requesting efficient quantities is much more often observed in the second than in the first part of play. Thus we observe a sound amount of learning. Moreover, we find no systematic differences between $K5$, and $K15$.

Next, we will examine hypotheses H_{13} and H_{14} by analyzing the payment offered to the agent subjects. In Table 7, for a comparison of single contracts rather than menus, we refer to the pay per QU, $\frac{t}{q}$, that corresponds to a certain contract offer. As in Tables 4 and 5, we distinguish between contracts that target the low type or the high type. Thus we present the average pay per QU from the h–contracts contained in the menus h, hh, hn, or lh, and the average $\frac{t}{q}$ offered to low types by menus l, ll, ln, or lh. Of the menus ll and hh, only the more profitable contract for the agent is considered. If two offers are equally profitable, the one preferred by the principal is counted. The menus lh can be found on both sides of Table 7, since both types are targeted. All n–contracts are excluded from this analysis since neither the low nor the high type seem to be targeted. We also present the standard deviations in brackets, and, in italics below, the average rent, $t - \theta q$, that is implicitly offered. This rent reflects an agent's offered earnings from the second stage of the game. We present the two parts of play separately. The pay per QU predicted for the targeted type, $\frac{t^*}{q^*}$, and the corresponding rent, $t^* - \theta q^*$, are given in the columns labeled "pred". According to H_{13}, we expect that they both rise as p rises for the high types, whereas they remain stable for the low types.

We find that, for high and for low types under almost all conditions, both the offered pay per QU and the thereby implicitly offered rents are significantly larger than predicted.[11] We tested the rents, although the test results regarding

[11] Our data meets neither the requirements for the one–sample t–test (normal distribution), nor those for the Wilcoxon one–sample signed rank test (symmetrical distribution). Therefore, we applied the one–sample sign test which is less strong but applicable here. The sign tests were computed manually (see Siegel/Castellan 1988). We assume that one half of the data points, respectively, are located below and above the theoretically predicted mean, i.e., the sign test actually is a binomial test. Where no prediction exists (e.g., for low types in $p = 0$), no tests are executed.

the rents should be no different from those for the pay per QU, since the firm subjects often request the efficient quantities (see Tables 4 and 5) such that the large offered pay per QU implies high rents.

Table 7: The Offered Pay per QU: Averages, (*Std. Dev.*), and $t - \theta q$

		"h" in menus h, hh, hn, lh			"l" in menus l, ll, ln, lh		
p		pred	$K5$	$K15$	pred	$K5$	$K15$
0	1-5	.50	$.62^{*}$ (*.08*)	$.64^{*a}$ (*.08*)	–	1.17 (*.46*)	1.08 (*.25*)
		0	*12.3**	*15.1*^{*a}	–	*1.2*	*0.9*
	6-10		$.63^{*ad}$ (*.06*)	$.70^{*}$ (*.06*)		1.11 (*.95*)	1.28 (*.00*)
			13.8^{*ad}	*20.2**		*-3.3*	*7.0*
.25	1-5	.52	$.62^{*cd}$ (*.07*)	$.69^{*}$ (*.06*)	1.0	1.19^{*bc} (*.27*)	1.33^{*} (*.57*)
		2	*12.6*^{*cd}	*20.2**	*0*	*2.3*^{*bcd}	*4.1**
	6-10		$.66^{*d}$ (*.06*)	$.70^{*}$ (*.04*)		1.34^{*d} (*.26*)	1.23^{*} (*.16*)
			16.3^{*d}	*20.8**		*4.0**	*4.3**
.5	1-5	.56	$.61^{*}$ (*.19*)	$.66^{*c}$ (*.08*)	1.0	1.59^{*d} (*.40*)	1.20^{*} (*.18*)
		6	*11.8**	*16.7*^{*c}	*0*	*6.6*^{*d}	*4.0**
	6-10		$.67^{d}$ (*.05*)	$.71^{*}$ (*.04*)		1.16 (*.09*)	1.23^{*} (*.14*)
			17.3	*21.7**		*2.7*^{d}	*4.4**
.75	1-5	.59	*no data*	$.72^{*c}$ (*.04*)	1.0	*no data*	1.25^{*} (*.14*)
		9		*22.4**	*0*		*5.5*^{*c}
	6-10		*no data*	$.69^{*}$ (*.07*)		*no data*	1.22^{*} (*.17*)
				19.0*			*4.4**
1	1-5	–	*no data*	.62 (*.21*)	1.0	*no data*	1.19^{*} (*.24*)
		–		*11.2*	*0*		*3.9**
	6-10		*no data*	.72 (*.05*)		*no data*	1.30^{*} (*.30*)
				22.0			*6.8**

* *significantly larger than predicted (one–sample sign test, two–sided).*
^{a} *rises significantly with rising p–level (Jonckheere–Terpstra test, one–sided).*
^{b} *differs significantly with varying p–level (Mann–Whitney U, two–sided).*
^{c} *signif. different from corresponding periods 6-10 (Mann–Whitney U, two–sided).*
^{d} *signif. different from corresponding play in* $K15$ *(Mann–Whitney U, two–sided).*

In what follows, we tested each part of play for differences across distinct market conditions of the same treatment.[12] As theory predicts for the low types, both the offered pay per QU and the corresponding rents do not differ

[12] We performed a Jonckheere–Terpstra test (J–T) for the directional hypotheses, a Kruskal–Wallis One Way ANOVA on Ranks (K–W) for the undirectional hypotheses or when the J–T was insignificant, and a Mann–Whitney U–test (M–W) if only two groups were involved. The J–T tests were computed manually (see Siegel/Castellan 1988).

significantly across different p–levels, except for periods 1-5 in $K5$. However, this result has to be treated carefully, since $p = 0.5$ comprises only very few observations. For the high types, the pay per QU primarily rises with an increasing p–level, in some cases even significantly. This leads to

Results 3 and 4:

We reject hypotheses H_{13a} and H_{14a} for both types, since the offered pay per QU and rents are larger than predicted. For the high types, the differences across p–levels point in the right direction and are often significant, whereas for the low types they are undirected and mostly insignificant. This can be seen as evidence to support hypotheses H_{13b}, and H_{14b}.

When comparing the two treatments, we observe that the pay per QU and the rents offered to high types are (often significantly) larger under $K15$ than $K5$, and that the differences concerning low types are nondirectional, yet also mostly significant. A comparison between periods 1-5 and 6-10 with regard to learning shows that, more often than not offers are higher in the second part of play, which is frequently significant. Where the agent subjects are offered less in periods 6-10, there often exist only a few observations. That is, overall the firm subjects are more generous in the second than in the first five periods.

3.2.3 Completed Screening in Stage Two: The Agents' Decisions

In the following, rather than categorizing offers into targeting the low or the high type, we explore the pay per QU accepted or rejected by the low or the high type. We present the averages in Tables 8 and 9. The columns labeled "rej" comprise rejected contracts, those labeled "not acc(epted)" refer to contracts that were offered together with an accepted contract (labeled "acc").[13] Since the differences in accepted pay per QU between periods 1-5, and 6-10 are insignificant for both types under all conditions (Mann–Whitney U–test), and the accepted pay per QU is the variable under scrutiny, we merged the two

[13]If an employer offered the same contract twice within one menu, and one of them was accepted, the second one is excluded from "not accepted" contracts. If two contracts were rejected, we consider the more advantageous offer for the employee to be rejected. If an agents rejects two equally profitable contracts, the one preferred by the principal is counted.

parts of play in Tables 8 and 9.[14] The standard deviations and numbers of cases are listed in the second and third rows, respectively.[15] The fourth rows display the agents' rents, $t - \theta q$, that correspond to the respective pays per QU. The columns labeled "pred" list the predictions based on theory.

Table 8: $K5$, Accepted Pay per QU: Averages, *(Std. Dev.)*, *Cases*, and $t - \theta q$

	High Types				Low Types			
	pred	rej	acc	not acc	pred	rej	acc	not acc
$p = 0$	.50	.59	.69[a]	.72	–	–	–	–
		(.10)	*(.21)*	*(.47)*		–	–	–
		42	*134*	*68*		–	–	–
	0	6.7	14.8[a]	4.8	–	–	–	–
$p = .25$	.52	.57	.81	1.07	1.00	1.00	1.28	.73
		(.04)	*(.25)*	*(.41)*		*(.29)*	*(.25)*	*(.12)*
		18	*78*	*66*		*19*	*13*	*12*
	2	6.6	16.4[a]	11.9	0	-9.1	4.4	-20.4
$p = .5$	.56	.60	.74	1.02	1.00	1.22	1.56	.58
		(–)	*(.18)*	*(.78)*		*(.10)*	*(.42)*	*(.24)*
		1	*7*	*5*		*3*	*5*	*5*
	6	10.0	17.6	-19.5	0	4.0	6.8	-44.4

[a] *signif. diff. from corresponding play in* $K15$ *(Mann–W. U, two–sided).*

Under all p–levels, each type's average accepted pay per QU exceeds the average offered pay per QU categorized as designed to target that respective type in Table 7.[16] Further, the offered pay per QU not accepted by one type was apparently intended to target the other type. For the low types, the not accepted pay per QU falls short of 1 on average when high types are in the market, and would yield huge losses if accepted (see fourth rows). The average pay per QU not accepted by high types oscillates around the low type's optimum

[14] Where the numbers of observations allowed for it, we also tested the two parts of play with regard to the rejected and the not accepted pay per QU. The differences are insignificant in the majority of cases. Exceptions are (M–W): $K5$, high types, rejected, $p = 0.25$; $K15$, high types, not accepted, $p = 0.5$; $K15$, low types, not accepted, $p = 0.75$.

[15] We give an example of how to read the numbers of cases given in the third rows of Tables 8 and 9. In the two parts of play under $K5$ and $p = 0$, 176 firm subjects (see Table 4, column "Σ") offered a total of 260 contracts to 176 agent subjects (see Table 4). Of these 260 contracts, 42 contracts were rejected, 134 were accepted, and 68 were not accepted, which adds up to 244 contracts. The remaining $260 - 244 = 16$ contracts are not listed in Table 8 because of two rejected contracts only the more profitable one for the agent is counted.

[16] The ten–round averages for Table 7 are easily computable by using the absolute numbers of offers in Tables 4, and 5, and the two five–round averages displayed in Table 7.

Table 9: $K15$, Accepted Pay per QU: Averages, *(Std. Dev.)*, *Cases*, and $t - \theta q$

	High Types				Low Types			
	pred	rej	acc	not acc	pred	rej	acc	not acc
$p = 0$	.50	.73	.78[a]	.98	–	–	–	–
		(.25)	*(.17)*	*(.33)*	–	–	–	–
		12	*28*	*12*	–	–	–	–
		9.3	18.9[a]	15.8	–	–	–	–
$p = .25$	.52	.75	.83	1.19	1.00	1.04	1.29	.83
		(.17)	*(.50)*	*(.29)*		*(.21)*	*(.27)*	*(.25)*
		6	*84*	*79*		*16*	*14*	*14*
		14.8	19.5[a]	15.0		-3.3	3.9	-20.2
$p = .5$	.56	1.04	.83	1.11	1.00	1.05	1.26	.73
		(–)	*(.19)*	*(.26)*		*(.21)*	*(.18)*	*(.20)*
		1	*61*	*60*		*28*	*34*	*30*
		13.5	20.8	15.4		-2.0	5.2	-25.7
$p = .75$	.59	–	.89	1.12	1.00	1.11	1.27	.78
		(–)	*(.27)*	*(.27)*		*(.12)*	*(.18)*	*(.15)*
		0	*22*	*22*		*23*	*43*	*40*
		–	18.7	15.3		2.1	5.6	-21.0
$p = 1$	–	–	–	–	1.00	1.01	1.36	1.01
		(–)	*(–)*	*(–)*		*(.28)*	*(.26)*	*(.29)*
		–	–	–		*13*	*15*	*11*
		–	–	–		-5.0	7.7	-7.6

[a] *signif. diff. from corresponding play in* $K15$ *(Mann–W. U, two–sided).*

of 1. Both types' rejected contracts are inferior to the accepted ones.

In all heterogeneous labor markets, the share of rejections is higher for the low types than for the high ones (see third rows in Tables 8, and 9). The high types' rejection rates are largest in the pure high–type markets. Under all conditions, the offers rejected by high types still imply positive average rents (see fourth rows), and would totally or at least partially cover the (sunk) investment cost of 5 CU or 15 CU. That is, many high types reject rather than accept advantageous (ultimatum) offers.

Tables 8, and 9 show that, in contrast to the prediction, the average rent accepted by high types is always higher under $K15$ than $K5$ for all p–levels. These differences are sometimes even significant. For the low types, the differences are undirected and insignificant. Further, the differences in accepted pay per QU and rents between periods 1-5 and 6-10 are always insignificant for both types (which is why the two parts of play have been analyzed together).

3.2.4 The Information Rent

In our experiment, only high types make net losses, predominantly by rejecting contracts after having invested in productivity in stage one. In Table 10, we display the averages of subjects' total net earnings, $t - \theta q - K$, in which the high types' investment costs K are included. In the columns labeled "pred", we also account for the investments by subtracting K from the predicted rent (see third row in Table 1). For instance, theory predicts an information rent of 2 CU under $p = 0.25$. When accounting for K in $K5$ ($K15$), this amounts to the theoretically predicted total net earnings of -3 CU (-13 CU). Note that all test results are no different when testing earnings exclusive or inclusive of K.

Table 10: Employee Subjects' Total Net Earnings, $t - \theta q - K$, in CU (Averages)

		High Types				Low Types		
		$K5$		$K15$			$K5$	$K15$
		pred		pred		pred		
$p = 0$	1-5	-5.0	6.0^{*c}	-15.0	$-3.8^{*a,b}$	–	–	–
	6-10		6.4^{*a}		6.4^{*}		–	–
$p = .25$	1-5	-3.0	6.8^{*}	-13.0	2.6^{*}	0.0	1.8^{*}	1.5^{*}
	6-10		10.0^{*c}		3.9^{*}		1.8	2.2
$p = .5$	1-5	1.0	8.8	-9.0	3.3^{*b}	0.0	5.2	2.8^{*}
	6-10		15.0		7.0^{*}		1.5	2.9^{*}
$p = .75$	1-5	4.0	*no*	-6.0	5.8^{*}	0.0	*no*	4.3^{*}
	6-10		*data*		2.6^{*}		*data*	3.2^{*}
$p = 1$	1-5	–	–	–	–	0.0	*no*	2.9^{*}
	6-10		–		–		*data*	5.8^{*}

* *significantly larger than predicted (one–sample sign test, two–sided).*
[a] *rises significantly with rising p (Jonckheere–Terpstra, one–sided).*
[b] *signif. diff. from corresponding periods 6-10 (Mann–W. U, two–sided).*
[c] *signif. diff. from corresponding play in $K15$ (Mann–W. U, two–sided).*

We analyze hypothesis H_{15} in the following. Table 10 shows that both the low and the high types' net earnings are larger than predicted, which is significant in the majority of cases (in $p = 0.5$ of $K5$, the low number of observations does not allow for significant results). The low types, on average, net roughly 2 to

3 CU above their outside option level of zero. The high types receive average net earnings that exceed the information rent by about 8 to 14 CU in $K5$, and by actually about 9 to 21 CU in $K15$. That is, in all conditions under $K5$ and almost always in $K15$, the high types fully recoup their cost of investment in addition to receiving the information rent. We summarize

Result 5:

We reject hypothesis H_{15} for both types, since, on average, the high types gain significantly more than their information rent, and the low types receive earnings significantly above the level of their outside option.

For the high types under all p–levels, the differences in net earnings between $K5$ and $K15$ amount to less than 10 CU, thus payment is larger for higher advance investment (which is significant in two instances). Nevertheless, high types net more under $K5$ than $K15$. Further, high types earn more than low types in both treatments. The differences between the two parts of play are largely insignificant for both types in both treatments, thus we cannot draw any conclusion with regard to learning.

In line with the theory (see hypothesis H_{16}), we find that in the majority of cases the high types' average net earnings increase with higher p which is significant in the second part of play under $K5$ and the first five periods under $K15$. For the low types, the differences across varying p–levels are insignificant.

Result 6:

The data support H_{16}. The high types' total net earnings (often significantly) increase as p rises. Those of the low types do not differ significantly.

In Table 11, we finally turn to the firm subjects' profits, $S(q) - t$. We observe that they always fall short of the prediction which is mostly significant. According to hypothesis H_{17}, we expect that the profits rise with increasing p when employing a low type, whereas they decrease when contracting with high types. However, except for the high types in periods 1-5 under $K5$, we observe no ordered differences across varying p–levels of the same part of play. Table 11 also shows that the employer subjects earn about three times as much on average when employing a high instead of a low type.

Table 11: Firm Subjects' Total Profits, $S(q) - t$, in CU (Averages)

		High Types			Low Types		
		pred	$K5$	$K15$	pred	$K5$	$K15$
$p = 0$	1-5	50	24.8^{*ac}	18.3^{*}	–	–	–
	6-10		25.5^{*}	27.1^{*}		–	–
$p = .25$	1-5	48	20.6^{*b}	25.7^{*}	16	8.6	11.2
	6-10		26.3^{*}	26.0^{*}		6.1^{*}	5.2
$p = .5$	1-5	44	25.9^{*}	24.5^{*}	22	9.8^{*}	10.0^{*}
	6-10		24.0	26.7^{*}		10.9	10.6^{*}
$p = .75$	1-5	41	*no*	24.8^{*}	24	*no*	12.0^{*}
	6-10		*data*	26.2^{*}		*data*	12.4^{*}
$p = 1$	1-5	–	–	–	25	*no*	9.5^{*}
	6-10		–	–		*data*	8.7^{*}

* *significantly lower than predicted (one–sample sign test, two–sided).*
^{a} *decreases significantly with rising p (Jonckheere–Terpstra, one–sided).*
^{b} *signif. diff. from corresponding periods 6-10 (Mann–W. U, two–sided).*
^{c} *signif. diff. from corresponding play in $K15$ (Mann–W. U, two–sided).*

Result 7:

Overall, both parts of H_{17} are not supported. The firm subject profits with either type are significantly lower than predicted. Further, with one exception, profits do not differ across different p–levels.

The differences in firm subjects' earnings between the first and the second parts of play as well as between the two treatments are negligible.

4 Conclusion and Discussion

In a labor market with two exogenously given, unobservable types of agents, contract theory predicts that optimal screening contracts compensate high–productivity types above their outside option utility level and low–productivity types in accordance with that level. In our model with endogenous choice of type, this information rent for the high types provides an incentive for the initially homogeneous agents to invest in becoming highly productive. However, the higher the proportion of high types in the market, the lower the high types' information rent. Thus, from the viewpoint of our theory, an investment in productivity pays off only if not too many agents decide likewise. This coordination problem among the agents in stage one determines the mixture of high and low types that are subject to screening by the firms in stage two. We conducted a high–cost treatment ($K15$), and a low–cost treatment ($K5$) which differ in their level of investment cost.

In both treatments, we observe an unexpectedly high number of decisions in favor of becoming highly productive in stage one. In stage two, in the homogeneous markets with only low or only high types, 75% to 100% of firm subjects target the right type, i.e., they request a quantity close to the optimal one. In the heterogeneous markets, an average of almost 60% of firm subjects explicitly target both types. Of those, about two thirds request the efficient quantity exactly, and nearly 100% offer menus that are incentive compatible.

The payment offered to our agents by the firm subjects is larger than predicted for both types. Contrary to what theory predicts, our high types are offered more under $K15$ than $K5$. Since these favorable offers are frequently accepted, the firm subjects' earnings fall short of the theoretically predicted values. When turning from offers to the agent subjects' actual earnings, we observe that both types of agent subjects obtain significantly more than predicted. Furthermore, the firm subjects reward the high types' investment in productivity in excess of the information rent. Without consideration of investment cost, the high types earn more in $K15$ than $K5$. Apparently, an investment in productivity is rewarded twice: first, the high types obtain their information rent; second, they earn an "investment rent," since higher investment leads to higher payment. When accounting for the first–stage investment cost, which are three times higher under $K15$ than $K5$, high types net less in $K15$ than $K5$, although the difference is smaller than expected. Even in the high–cost treatment $K15$, the high types, on average, fully recoup their investment cost in all cases but one. Moreover, we observe that many high types reject rather than accept advantageous (ultimatum) offers. This behavior is irrational in that those agents do not minimize losses. However, this result is in line with the high rejection rates of low but advantageous offers usually observed in standard ultimatum game experiments (see Kagel/Roth 1995).

With regard to learning we find that both targeting the right type and requesting efficient quantities is more frequent in the second than in the first five periods. Moreover, the offered payment tends to increase from the first to the second part of play.

An explanation for our high investment rates could be seen in a framing effect, since the choice between staying low skilled and becoming high skilled is literally described in our instructions. Especially university students may be considered eager to invest in productivity. However, especially university students can be expected to master profitability considerations by weighing the expected gains against the cost. From our viewpoint, the fact that the rents are overall cost–covering may better explain why agent subjects frequently invest in productivity during stage one. Many experimental studies report such kind of prior investments that violate the predictions of standard game theory but are still profitable, usually referred to as "trust" and "reciprocity" (see, e.g., Berg et al., 1995, Fehr et al. 1998, and Camerer, 2003, 83-89, for an overview).

Although our model reflects a rather stylized "labor market," it could nevertheless shed some light on real–world situations in which education can enhance productivity but does not serve as a signal thereof. For instance, if a certain degree and also the grades from some (unknown) school or university provide no information about the quality of the graduate, everyone will graduate with an identical degree, but the individual productivity will be unobservable. In the course of their education, agents can invest effort (K) in unobservable learning to enhance their productivity, and would then be of unobservable high type when entering the labor market.

Appendix A: The Screening Game

In stage two, the principal maximizes expected profits by choosing $\{(\underline{t},\underline{q});(\overline{t},\overline{q})\}$ subject to the agents' participation and incentive compatibility constraints:

$$\max_{\{(\underline{t},\underline{q});(\overline{t},\overline{q})\}} p \cdot (S(\overline{q}) - \overline{t}) + (1-p) \cdot (S(\underline{q}) - \underline{t})$$

subject to

(1) $\underline{t} - \underline{\theta}\underline{q} \geq 0$ for the high–productivity type, and

(2) $\overline{t} - \overline{\theta}\overline{q} \geq 0$ for the low–productivity type.

(3) $\underline{t} - \underline{\theta}\underline{q} \geq \overline{t} - \underline{\theta}\overline{q}$ for the high–productivity type, and

(4) $\overline{t} - \overline{\theta}\overline{q} \geq \underline{t} - \overline{\theta}\underline{q}$ for the low–productivity type.

We will prove that at the optimum:

a. inequality (2) is binding, thus $\overline{t} = \overline{\theta}\overline{q}$ for $\overline{q} > 0$

b. inequality (3) is binding, thus $\underline{t} = \overline{t} + \underline{\theta}\underline{q} - \underline{\theta}\overline{q}$

c. $\underline{q} \geq \overline{q}$

d. inequalities (2) and (4) can be neglected

e. the high type produces the efficient quantity, thus $\underline{q} = \underline{q}^*$

Inequalities (2), (3), and $\Delta\theta > 0$ imply that (1) is strictly satisfied for $\overline{q} > 0$. Since the firm's yield function is linear in $\overline{t}$, she chooses the lowest possible transfer $\overline{t}$ that satisfies a low type's participation constraint (2). Thus $\overline{t} = \overline{\theta}\overline{q}$.

Property b. is proved by assuming that (3) is non–binding. Then it holds true that $\underline{t} - \underline{\theta}\underline{q} > \overline{t} - \underline{\theta}\overline{q} > \overline{t} - \overline{\theta}\overline{q} = 0$. Since the principal can lower $\underline{t}$ without breaking (1) or (3), this mechanism cannot be optimal. Thus $\underline{t} = \overline{t} + \underline{\theta}\underline{q} - \underline{\theta}\overline{q}$.

When adding inequalities (3) and (4) it can be shown that $\underline{q} \geq \overline{q}$.

Substitution of $\overline{t} = \overline{\theta}\overline{q}$ and $\underline{t} = \overline{t} + \underline{\theta}\underline{q} - \underline{\theta}\overline{q}$ into (4) shows that (4) is always satisfied. The proof of assertion a. shows that (2) can be neglected.

Inserting $\overline{t}$ and $\underline{t}$ into the firm's yield function and differentiating it with respect to q gives $\underline{q}^*$ and $\overline{q}^*$, where the first order conditions satisfy

(5) $S'(\underline{q}^*) = \underline{\theta}$, and

(6) $S'(\overline{q}^*) = \frac{1-p}{p}\Delta\theta + \overline{\theta}$. The corresponding optimal transfers amount to

(7) $\underline{t}^* = \underline{\theta}\underline{q}^* + \Delta\theta\overline{q}^*$, and

(8) $\overline{t}^* = \overline{\theta}\overline{q}^*$.

Under asymmetric information, $\{(\underline{t}^*,\underline{q}^*);(\overline{t}^*,\overline{q}^*)\}$ represents the optimal incentive compatible menu of contracts offered by the firm. This solution can also be found by applying the Lagrangian techniques.

Appendix B: Instructions Treatment $K5$

You are taking part in an economic decision–making experiment. There are 16 participants in your session. The monetary payoff you will receive at the end of the experiment depends on your decisions as well as on the decisions of the other participants. Each participant makes his decisions independently and enters them into the computer. Communication between participants is not allowed.

At the beginning you get assigned your role for the experiment. It can either be the role of an employee or of an employer. Your role does not change during the experiment.

Four employers and four employees form a **group of eight**. You will stay in the same group during the first 5 periods. You do not know the other members of your group. The experiment consists of two five–period plays. Before the start of the second 5 periods, new groups of eight are randomly formed. The role you were assigned at the beginning does not change. In each new period, you will be randomly matched with one of your group members that has the other role.

At the **beginning** of the experiment and in **period 6**, **employers** receive an endowment of **200** currency units (CU). **Employees** get **50** CU **per period**. No interest will be paid.

Procedure

At the beginning of each period all employees are of low skill. They can invest in education to become highly skilled. Investment in education costs amount K. Employees can produce quantity units (QU) of a certain good. The production cost per QU is paid by the employees. An employee of low skill has a higher production cost per QU than one of high skill.

As soon as each employee has chosen his qualification for the respective period, employers and employees learn the remaining proportion of low–skill employees in that period. Then, employees and employers are matched pairwise within their group of eight. An employer does not know the qualification of the employee he has been matched with. Each employer can now offer up to two contracts to the employee. Any contract i consists of an amount of quantity units M_i to be produced, and a lump sum wage L_i paid for M_i. Only values up to 500 are accepted for both variables.

The employees view the contracts offered by the employer they have been matched with and decide whether to accept either one or none of them. An accepted contract is binding for both sides.

Sequence during one Period

1. Every period consists of 3 stages. At the beginning of stage 1 all employees are of low skill. Every employee decides whether he wants to invest to become highly skilled or to remain as he is. This investment costs 5 CU for the employee. After the investment the employee is highly skilled. If he does not invest he is still of low skill. The production cost for a **low–skill employee** is **1 CU** per produced QU of the good. A **high–skill employee** has a production cost of **0.5 CU** per QU of the good produced. In order to help you with your decisions you always have access to the "pocket calculator". This tool will be explained later. The profit of any **high–skill** employee is:

$$G_iH = L_i - 0.5 \cdot M_i$$

The profit of any **low–skill** employee is:

$$G_iN = L_i - 1 \cdot M_i.$$

This is the end of stage 1.

2. At the beginning of stage 2, employees and employers get to know the proportion of low–skill employees in their group of eight. The **proportion of low–skill employees** is called p. Now, the employers decide which contracts to offer. An employer can offer zero, one, or two contracts. The qualification of "their" employee is unknown to the employers. They only know the probability of being matched with a low–skill employee, i.e. the proportion p of low–skill employees in their group. The **profit of an employer** is independent of the qualification of the employee he has been matched with. It is:

$$g_iH = g_iN = 10 \cdot \sqrt{M_i} - L_i$$

You can always use the "pocket calculator" to help you with your decisions. This tool will be explained later.

3. At stage 3 of a period, the contracts are offered to the employees who then decide whether to accept either one or none of them. An accepted contract is binding for both sides. The third stage is completed with the employees' decisions.

The individual payoff in this period, as well as the overall profit so far, is calculated and made known to everyone. Then, the next period begins if the tenth period has not been reached.

Tools

There are two types of tools that you may use during the experiment. The first one is called **History** and gives an overview of the decisions and results of the past periods. The other one, named **Pocket Calculator**, computes the profit of an employer from a specific contract, as well as the profits of a high– and a low–skill employee from this contract. The **variables** used are explained in the table at the end of the instructions.

History

You can view the history either by clicking on the **"Geschichte"**[17] button at the bottom of the monitor, or with the **F1** key. You get an overview of your own decisions as well as those of the employers/employees you have been matched with in the respective periods. The **variables** used are explained in the table at the end of the instructions.

[17] "Geschichte" is German for "History".

Pocket Calculator

You can open the pocket calculator either by clicking on the **"Taschenrechner"**[18] button at the bottom of the monitor, or with the **F2** key. At the end of the instructions you can see a screen–shot of the pocket calculator. In stage 1, the percentage p of low–skill employees in your group is unknown but the pocket calculator is already applicable. At that time you are able to calculate the profits of a certain contract for different proportions of low–skill employees in your group. You see the profits for employers and employees. As soon as the percentage of low–skill employees is known (i.e., in stage 2) it cannot be changed anymore in the pocket calculator.

- At the top of the pocket calculator you see the proportions of low–skill employees that are possible in your group of eight. With four employees per group, 0%, 25%, 50%, 75%, and 100% are possible.
- You also see four input fields, two for contract 1 and two for contract 2. You can insert combinations of quantity units and wages $(M_1, L_1), (M_2, L_2)$, and receive the resulting profits for the employer and for both types of employees. Only values up to 500 CU and 500 QU are accepted.
- When clicking on the **"Speichern"** button you can save two contracts per proportion p of low–skill employees. Saved contracts can be viewed at the bottom of the pocket calculator.
- With the **"Abrufen"** buttons next to the saved contracts, you can put the saved values back into the input fields.

As an employer does not know the skill level of the employee he is matched with, there is also the **employer's expected profit** $E[g]$. The following procedure is applied to calculate $E[g]$:

- Each **employee** accepts the contract that yields the **higher profit**, taking into account his skill level.
- A contract with **negative profit** for an employee is **not accepted**.
- If both contracts have the **same profit for the employee**, the contract with the **higher profit for the employer** is accepted.
- This procedure unambiguously decides which contract is accepted by which type of employee.
- The employer's profit resulting from an accepted contract is weighted by the current percentage of high– and low–skill employees and then totaled. The equation reads as follows:

$$E[g] = p \cdot g_i N + (1 - p) \cdot g_i H$$

Please keep in mind that this is only how *this function* of the pocket calculator works. The employees in the experiment are able to decide differently.

[18] "Taschenrechner" is German for "Pocket Calculator"

Payment

The profits from all periods are added up for each participant. This amount in CU is converted into Euros with **1 CU = 0.03 EUR**. You will be payed in cash at the end of the experiment. Payment is individual and anonymous.

- Insert Figure 4 about here -

Before the experiment starts you will be asked some questions at your computer terminal. If anything is unclear you can raise your hand and your questions will be answered in private.

Variables

contract 1	
M_1	quantity unit in contract 1
L_1	wage in contract 1
g_1N	profit for the employer if contract 1 is accepted by a *low* skilled
g_1H	profit for the employer if contract 1 is accepted by a *high* skilled
G_1N	profit for a *low* skilled from contract 1
G_1H	profit for a *high* skilled from contract 1
contract 2	
M_2	quantity unit in contract 2
L_2	wage in contract 2
g_2N	profit for the employer if contract 2 is accepted by a *low* skilled
g_2H	profit for the employer if contract 2 is accepted by a *high* skilled
G_2N	profit for a *low* skilled from contract 2
G_2H	profit for a *high* skilled from contract 2
$E[g]$	*expected* profits for an employer from contract offers 1 and 2
p	percentage of *low* skilled in your group of eight
AN	employee
AG	employer
Qualifik.	qualification

References

Andreoni, J. (1988): Why free ride? Strategies and Learning in Public Goods Experiments, in: *Journal of Public Economics* 37, 291-304.

Banks, J.; Camerer, C.; Porter, D. (1994): An Experimental Analysis of Nash Refinements in Signaling Games, in: *Games and Economic Behavior* 6, 1-31.

Bedard, K. (2001): Human Capital versus Signaling Models: University Access and High School Dropouts, in: *Journal of Political Economy* 109, 749-775.

Berg, J.; Dickhaut, J.; McKabe, K. (1995): Trust, reciprocity, and social history, in: *Games and Economic Behavior* 10, 122-42.

Camerer, C. (2003): Behavioral Game Theory, Princeton University Press.

Falk, A.; Fehr, E.; Zehnder, Ch. (2006): Fairness Perceptions and Reservation Wages - The Behavioral Effects of Minimum Wage Laws, in: *Quarterly Journal of Economics* 121, 1347-1381.

Fehr, E.; Kirchler, E.; Weichbold, A.; Gächter, S. (1998): When social norms overpower competition: Gift exchange in an experimental labor market, in: *Journal of Labor Economics* 16, 324-351.

Groot, W.; Oosterbeek, H. (1994): Earnings Effects of Different Components of Schooling: Human Capital versus Screening, in: *The Review of Economics and Statistics* 76, 317-321.

Kagel, J.H.; Roth, A.E. (1995): The Handbook of Experimental Economics, Princeton University Press.

Kübler, D.; Müller, W.; Normann, H.T. (2008): Job Market Signaling and Screening: An Experimental Comparison, in: *Games and Economic Behavior* 64, 219-236.

Laffont, J.-J.; Martimort, D. (2002): The Theory of Incentives. The Principal-Agent Model, Princeton University Press.

Posey, L.L.; Yavas, A. (2007): Screening Equilibria in Experimental Markets, in: *The Geneva Papers on Risk and Insurance Theory* 32, 147-167.

Riley, J.G. (1979): Testing the Educational Screening Hypothesis, in: *Journal of Political Economy* 87, 227-252.

Rothschild, M.; Stiglitz, J. (1976): Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information, in: *The Quarterly Journal of Economics* 80, 629-649.

Shah, A. (1985): Does Education Act as a Screening Device for Certain British Occupations?, in: *Oxford Economic Papers, New Series* 37, 118-124.

Shapira, Z.; Venezia, I. (1999): Experimental Tests of Self-Selection and Screening in Insurance Markets, in: *The Geneva Papers on Risk and Insurance Theory* 24, 139-158.

Siegel, S.; Castellan, N.J. (1988): Nonparametric statistics for the Behavioural Sciences, 2nd Edition, McGraw-Hill.

Spence, M. (1973): Job Market Signaling, in: *The Quarterly Journal of Economics* 87, 355-374.

Spence, M. (1974): Competitive and Optimal Responses to Signals: An Analysis of Efficiency and Distribution, in: *Journal of Economic Theory* 7, 296-332.

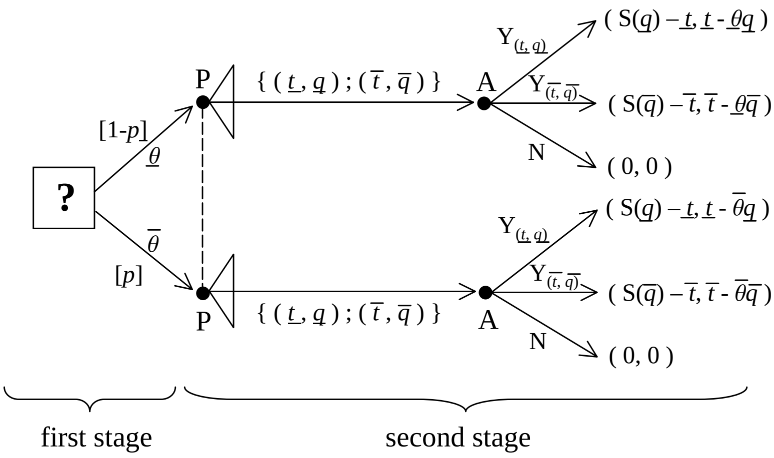

Figure 1: The Game Tree

Figure 1: The Game Tree

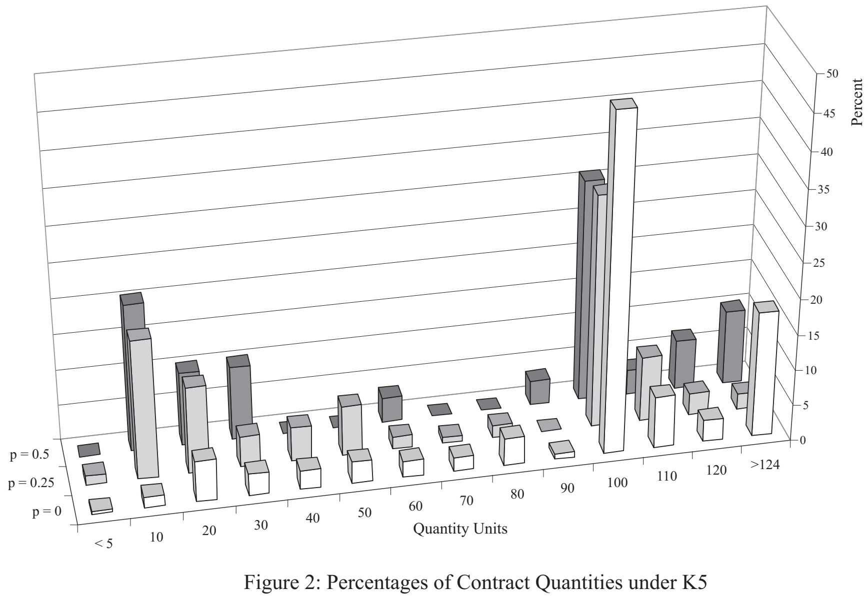

Figure 2: Percentages of Contract Quantities under K5

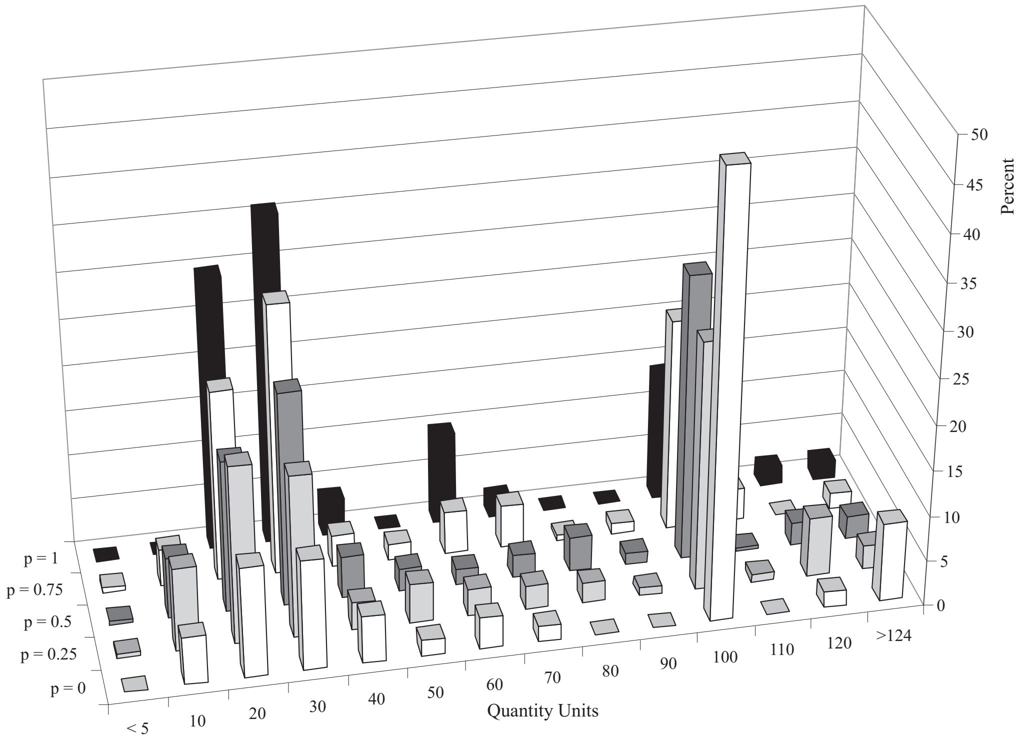

Figure 3: Percentages of Contract Quantities under K15

Figure 3: Percentages of Contract Quantities under K15

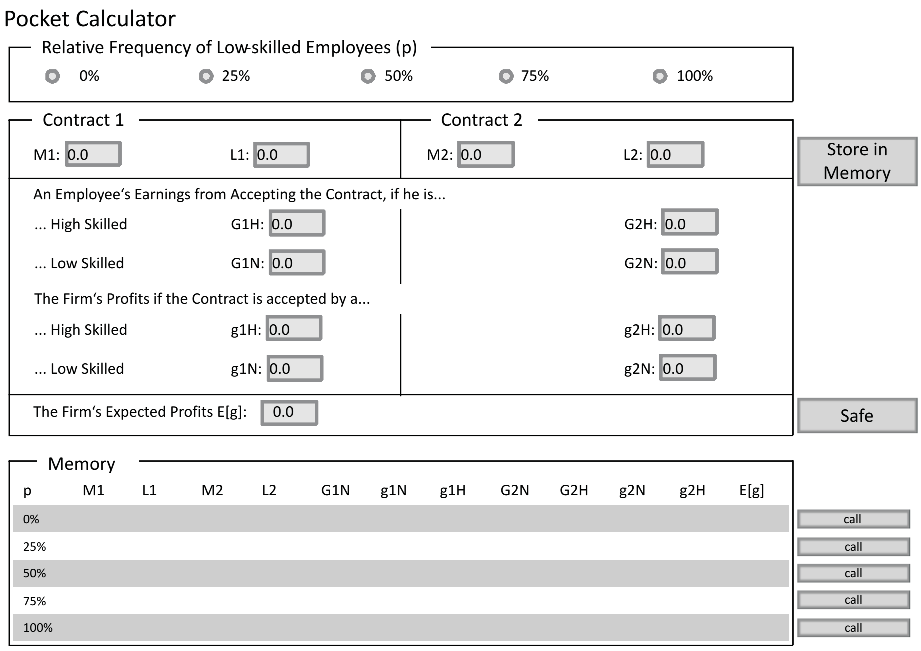

Figure 4: The Pocket Calculator