When Education is Productive but not a Signal. An Experiment[†]

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Abstract

We examine a labor market with agents of different productivity levels. In the first stage, ex ante symmetrical agents become educated and each of them decides whether to invest in high productivity, i.e., study hard in school. After the education phase, all agents get the same degree but only those who worked hard are highly productive. Since an agent's study habits in school are invisible to a potential employer, firms on the labor market are unable to distinguish between the two productivity levels. Therefore, education cannot serve as a signal for high productivity as it does in the famous Spence (1973, 1974) model. E.g., a certain bachelor's degree from a certain university provides no information as to whether the potential employee is of high or low quality.

In the second stage, firms therefore are forced to rely on a screening device (i.e., a menu of contracts) in order to separate between heterogenous labor supply. This comes at the cost of paying a so-called "information rent" to the more productive types in order to elicit their private information. This rent monotonically increases with higher probability p of meeting low productive types on the labor market. Thus, the optimal menu of contracts differs with p.

We investigate experimentally the optimal screening contracts for varying levels of p in the second stage. We also focus on the coordination game among the workers in the first stage: An agent's individual investment in high productivity theoretically pays off only if the frequency of low productive types does not fall short of a certain p-level.

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1 Introduction

Spence (1974) introduced workers signaling their productivity in labor market models. He demonstrated that education, even if it does not change a worker's productivity, can provide a signal thereof. Since becoming educated is more costly to workers of low type than it is for high type workers, educated workers on the labor market have a higher probability of being highly skilled than low skilled. Stiglitz (1975) broadened this analysis to the case of screening workers' education by firms. Again education is the observable variable on which employers can condition wages. Signalling and screening taking place at the same time is modelled by Inderst (2000, 2001). Despite the informational asymmetry, this leads to the first best outcome.

Riley (1976) linked the basic screening model to a classical human capital model. He also analyzed education as a mere signal, and not as an influence on productivity. A screening model where firms invest into their workers' productivity is examined in Kübler (1996).

There is empirical evidence for both productive, and unproductive education (see Taubman/Wales, 1973; Riley, 1979; Wolpin, 1977). The only experiment on labor market screening and signaling (we know of) was conducted by Kübler/Müller/Normann (2003). They compare the outcomes of a signalling treatment versus a screening treatment where at least two firms compete to employ one worker. In both treatments, they observe a separation between high and low skilled types in their decision to invest in education (education has no productivity enhancing effect).

The paper that is the most closely related to our idea of observable education on the one hand but unobservable productivity on the other hand is that of Borghans (2003). In this paper, the author empirically examines learning activities of university students when employers screen with respect to time spent on education. His theoretical model predicts that screening leads to shifting time spent on education from unobservable to observable learning, which then serves as a signal. However, if the signal is overused ("overeducation"), students turn to unobservable learning activities in order to distinguish themselves from their peers. Based on key data on education in the European Union, he shows that in regions with better access to higher education, students spend less hours on unobservable learning and combine education with work and international experience to signal a large amount of observable learning to their future employers. In reaction to this, firms intensify screening with regard to observable learning. In this context, unobservable learning can be interpreted as education that cannot serve as a signal but can lead to higher productivity like in our model.

In what follows, we analyze a situation where firms are able to observe the education level, but not the productivity level of a worker. Thus, education can be productivity enhancing, but is no signal. Workers must invest in unobservable learning in order to come better off than the unproductive types in the screening game on the labor market. However, if everyone invests in becoming productive, it does not pay off. We run an experiment where we investigate the actual investment in education in stage one, and the corresponding optimal menus of contracts with regard to different p-levels in stage two.

2 Investment in Education

We analyze a game with two stages. In the first stage, ex ante symmetrical agents each invest in education. An agent during education can opt for becoming productive by working hard at some fixed cost K. In the second stage, the agents enter the labor market which is heterogenous with respect to productivity if agents behaved differently in the first stage. Firms, when hiring an agent, face the risk of adverse selection since hard work during education is unobservable to the firms. Therefore, as everyone is educated, education per se signals nothing, and the respective type is each employee's private knowledge. By moving first as a Stackelberg leader under asymmetric information, a firm can design an optimal screening device in order to separate between heterogenous labor supply.

In order to perfectly separate between the two types of employees, the firm has to pay an information rent to the more productive (high skilled) employee. It decreases with lower relative frequency of less productive (low skilled) employees in the market, and drops to zero if only high skilled employees are active. It is this information rent that creates an incentive for unproductive agents to become productive in the first stage. However, this is individually profitable only as long as the future information rent is high enough to cover the cost, that is, as long as not too many agents choose to work hard during education in order to become high types. As working hard is a decision made individually, this creates a coordination game among the ex ante identical agents in the first stage.

Theory shows that different groups prefer different p-levels in the second stage: a single agent who in the first stage decided to invest in productivity prefers p to be nearly equal to 1, i.e., prefers to be the only high skilled among otherwise low skilled agents. From a firm's point of view, the optimal p should equal zero such that only high types are active in the market and screening is needless, since the asymmetric information disappeared - together with the costly information rent.

To solve for the sub-game perfect equilibrium, we work backward by starting with the second stage of the game in section 2.1. The analysis of stage one of the game is presented in section 2.2

2.1 The Screening Model in the Second Stage

Consider a labor market[1] in which risk-neutral employees (agents) differ with respect to their marginal production cost $\theta \in \{\underline{\theta}, \overline{\theta}\}$, where $(\overline{\theta} - \underline{\theta}) = \Delta\theta > 0$. The agent's type is unobservable to the risk-neutral firm (principal), but it is common knowledge that an agent can be inefficient ($\overline{\theta}$) with probability p, and efficient ($\underline{\theta}$) with probability $1 - p$. We assume zero fixed cost. The agent's outside option equals zero by assumption. An agent produces $q \geq 0$ units of a good that has value $S(q)$ to the firm, where $S(0) = 0$, $S' > 0$, and $S'' < 0$. He is compensated by the firm through a money transfer $t \in \mathbb{R}$. Furthermore, t and q are both observable and verifiable.

An agent accepts an offer (t, q) if working with the firm yields at least his

[1]See, e.g., Laffont/Martimort (2002), p. 32-46 for the standard screening model with different types of agents.

outside option utility level and thereby satisfies the participation constraint, i.e. if

(1) $\underline{u} = \underline{t} - \underline{\theta}\underline{q} \geq 0$ for the productive type, and

(2) $\overline{u} = \overline{t} - \overline{\theta}\overline{q} \geq 0$ for the unproductive type.

Without knowing the type of agent he is facing, the principal offers a menu of contracts $\{(\underline{t}, \underline{q}); (\overline{t}, \overline{q})\}$. For this menu to be incentive compatible, and therefore self-selecting, each type of agent must be worse off mimicking the other type compared to revealing his true type, i.e.

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

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

Thus, the principal maximizes expected profits by choosing $\{(\underline{t}, \underline{q}); (\overline{t}, \overline{q})\}$ with regard to each 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) to (4).

Using the agents' participation constraints, the incentive compatibility constraints (3), and (4) can be rewritten as follows:

(3.1) $\underline{u} \geq \overline{u} + \Delta\theta\overline{q}$, and

(4.1) $\overline{u} \geq \underline{u} - \Delta\theta\underline{q}$.

It follows from participation constraint (2) that $\overline{u} \geq 0$, and constraint (2) together with (3.1) and $\Delta\theta > 0$ immediately imply that (1) is strictly satisfied for $\overline{q} > 0$. Thus $\underline{u} > 0$. From the principal's yield function we can conclude that the firm as a Stackelberg leader chooses the lowest possible transfer $\underline{t}$ that just satisfies a high productive agent's incentive constraint (3.1) with $\underline{u} = \overline{u} + \Delta\theta\overline{q}$. The transfer, therefore, amounts to $\underline{t} = \overline{t} + \underline{\theta}\underline{q} - \underline{\theta}\overline{q}$.

By showing that the unproductive agent gets negative utility by selecting the "wrong" contract, i.e., $\underline{u} - \Delta\theta\underline{q} < 0$, it can easily be seen that he has no incentive to mimic the productive one. From participation constraints (1), (2) and $\underline{u} > 0$ it follows that $\underline{u} - \Delta\theta \underline{q} \leq \overline{u} < \underline{u} - \Delta\theta\overline{q}$ and $\underline{q} > \overline{q}$. As $\underline{u} = \overline{u} + \Delta\theta\overline{q}$, it holds true that $\underline{u} - \Delta\theta\underline{q} = \overline{u} + \Delta\theta\overline{q} - \Delta\theta\underline{q} < \overline{u} = 0$. Thus (4.1) is irrelevant. Again, the principal will pay the lowest possible feasible transfer, which amounts to $\overline{t} = \overline{\theta}\overline{q}$ according to the unproductive agent's participation constraint.

Plugging the feasible transfers into the firm's yield function and differentiating the latter with respect to q gives the optimal outputs $\underline{q}^*$, and $\overline{q}^*$ where the first order conditions satisfy

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

(6) $S'(\overline{q}^*) \stackrel{!}{=} \frac{1-p}{p}\Delta\theta + \overline{\theta}$.

The corresponding optimal transfers are

(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.

It follows immediately from (1), (2), (7), and (8) that $\overline{u}^* = 0$, and that $\underline{u}^* = \Delta\theta\overline{q}^* > 0$ for $\overline{q}^* > 0$. This inequality indicates that the sub-game perfect equilibrium path of the screening game provides the efficient type with a so-called "information rent" as compensation for revealing his true type. The transfer $\underline{t}^*$ renders the efficient type exactly indifferent between information revelation and mimicking the inefficient type.

In a situation like this, low types ex ante have an incentive to work hard during education time and to become high types in the screening game. But, since $S(.)$ is concave with $S' > 0$, and $S'' < 0$, $\overline{q}^*$ increases with higher frequency p of inefficient types on the labor market. As $\underline{u}^*$ positively depends on $\overline{q}^*$, the information rent is higher, the less employees there are of high type on the market. If becoming productive is individually costly, this suggests that not all low types decide in favor of becoming efficient before entering the market for heterogenous labor, which creates a coordination problem.

In order to be able to exactly analyze the interdependence between the information rent and the frequency p of bad types, we present the parameters we used in the experiment in the next section.

2.2 Experimental Parameters, and Investment in Productivity in the First Stage

We let the employee's marginal cost of production be $\underline{\theta} = 0.5$, and $\overline{\theta} = 1$, and the firm's value of quantity produced be $S(q) = 10 \cdot \sqrt{q}$. The resulting incentive feasible menu of contracts $\{(\underline{t}^*, \underline{q}^*); (\overline{t}^*, \overline{q}^*)\}$ is

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

The prospective information rent for an efficient type of employee amounts to

$$\Delta\theta\overline{q}^* = \frac{50p^2}{(1-p)^2}.$$

We ran the experiment with groups of eight: four subjects in the role of employee were randomly paired with four employer subjects. For that reason, the probability p of low types on the labor market can take five possible values: 0%, 25%, 50%, 75%, or 100%. For example, if in the first stage every (or no) employee subject in one group decided to invest in becoming productive, the p-level amounts to 0% (or 100%) in the screening game in the second stage. In a situation like this, an agent's type is no longer unobservable by the firm and incentive compatibility considerations are no longer prevalent. Under the now attainable first-best contract offered by the firm, each agent reaches his outside option utility level when producing the firm's payoff-maximizing quantity. The optimal contracts predicted by theory, as well as the principal's and the agents' expected payoffs are given in table 1.

We assume that, before entering the screening game, agents of the same type can individually and simultaneously choose between staying an inefficient agent ($\overline{\theta} = 1$), or working hard at cost K and become efficient ($\underline{\theta} = 0.5$). Let the cost of becoming productive in the first stage be $K = 5$. Assuming optimal

Table 1: Optimal Contracts at Different p-levels

p	$\underline{q}^*$	$\underline{t}^*$	$\overline{q}^*$	$\overline{t}^*$	$S(\underline{q}^*) - \underline{t}^*$	$S(\overline{q}^*) - \overline{t}^*$	$\underline{t}^* - 0.5\underline{q}^*$	$\overline{t}^* - 1 \cdot \overline{q}^*$
0	100	50	-	-	50	-	0	-
0.25	100	52	4	4	48	16	2	0
0.5	100	56	11	11	44	22	6	0
0.75	100	59	18	18	40	24	9	0
1	-	-	25	25	-	25	-	0

contract offers in the second stage, an agent's decision to invest in productivity in stage one pays off only if no more than half of the agents of the same group do likewise. In other words, for effort cost of $K = 5$ to be profitable, at least 50% of the employee population has to stay unproductive, which unfolds a coordination problem in the simultaneous game between the ex ante unproductive agents in terms of who should invest in efficiency. Investment in productivity in stage one **b**reaks even in stage two for

$$p_b \geq 0.5.$$

The highest possible information rent for an efficient agent occurs in a situation in which he is the only highly productive worker on the labor market. Therefore, the **i**ndividually optimal p-level for a high skilled type is

$$p_i = 0.75.$$

The maximum of **f**irm's expected profits, $p \cdot (S(\overline{q}) - \overline{t}) + (1 - p) \cdot (S(\underline{q}) - \underline{t}))$, is achieved with only high productive employees on the labor market, that is,

$$p_f = 0.$$

What firms prefer above all is a labor market with only efficient agents where screening is no longer necessary, and highly productive workers can be employed at a cost no greater than that of their outside option utility level (of zero).

The experimental results, as well as the experiment itself are presented in the following section.

3 The Experiment

3.1 Experimental Design

The experiment was conducted at the University of Karlsruhe in June 2005. A group of 64 undergraduate students of mostly Business Engineering participated in four sessions of 16 subjects each. The participants interacted in groups of 8, each consisting of four employee and four employer subjects to whom the roles had been randomly assigned. The experiment consisted of two, five period plays. After the first half of the experiment (five periods), new groups of 8 were randomly formed. Thus, each group of 8 stayed together for five periods. Within each group, employer and employee subjects were again randomly paired at the beginning of each period.

The subjects were seated in separate sections of the rooms, facing the wall, thus making it impossible to gather information from their peers. The participants were not permitted to communicate with each other. The written instructions were distributed and read aloud. Questions were asked and answered only in private. To make sure that everyone understood the experiment, each subject had to answer a computer-based questionnaire consisting of 25 questions prior to the start of the experiment.

Each employer subject received an initial endowment of 200 CU (currency units) in period one and six, thereby assuring that the optimal contracts, given the distribution of skills in the workforce, were affordable. Workers received 50 CU per period.

At the beginning of each period, every worker was low skilled with marginal and average production cost of 1 CU per quantity unit (QU). The experiment started with the employees making their investment decisions. In each period anew, employees decided whether to become high skilled at a cost of $K = 5$. A high skilled worker produced at a cost of 0.5 CU per quantity unit. Following the investment decision, both employees and employers learned about the proportion of low skilled types within their group of eight. After the matching process, the employers were able to offer up to two contracts to their agent. A contract consisted of a lump sum wage, and an amount of quantity units to be produced. The maximum values accepted by the computer program amounted to 500 each, which was told to the subjects. Each agent decided whether or not to accept one of the two offered contracts. If the offer was accepted, the contract was fulfilled. A rejected offer yielded zero profits for both employer and employee in the respective period.

Profits were calculated and reported to the participants before the next period started (if it had not been the 10th). Throughout duration of the experiment, all participants at any time were allowed to use two tools. “History” reported the results of all prior periods, including contracts, skill levels, and resulting profits for employees and employers. The “Pocket Calculator” allowed for computing the profitability of any possible contract for employers and each type of employee. Additionally, an employer’s expected profits from a pair of offered contracts was available and varied depending on the proportion of low skilled within the workforce. A screen shot of the pocket calculator, as well as the full instructions are provided in the appendix of this paper.

At the end of the experiment, the sum of the payoffs from all periods were cashed individually and anonymously. Thereby, 1 CU amounted to 0.03 EUR. The chosen parameters yielded an average payment of about 17.9 EUR (18.8 EUR for employer, and 17 EUR for employee subjects). The experiment lasted approximately 90-120 minutes.

3.2 The Data

3.2.1 Investment in Stage One, Contract Offers in Stage Two

Employee subjects in large part invest in productivity in stage one. Even though in theory this investment breaks even only with at least 50% of all agents being unproductive types per group, we do not once observe a higher frequency than $p = 0.5$ of low types in the experiment. In 8 groups with 4 employees each, investment decisions amount to 320 altogether during 10 periods. Of that, 88.8% are made in favor of becoming productive (85.6% in periods 1-5, and 89.4% in periods 6-10). The resulting p-levels together with the number of offered contracts are presented in Table 2. In each cell, the second figure represents the number of employers who offered a second contract that differed from the first one (amount given by first figure). An entry containing a payment and a quantity of both zero were not counted as a contract.

Table 2: Number of Contracts Offered at Different p-levels

Periods	$p = 0$	$p = 0.25$	$p = 0.5$
1-5	80 + 44	68 + 52	12 + 10
6-10	96 + 42	60 + 51	4 + 3

From Table 2, we learn that a slight majority of interactions between an employer and an employee took place in a homogenous labor market with only high skilled agents (55% of 320 interactions proceeded under condition $p = 0$). In these cases, only 55% of the employers during the first five periods, and only 44% during the second five periods offered two different contracts. This demonstrates that the employer subjects well recognized the homogenous labor market. No more than 5% of all contract offers during 10 periods occurred under the principal's expectations of meeting a low or a high skilled worker with equal probability $p = 0.5$.

The 522 offered contracts summarized in Table 2 are presented in Figure 1. The quantity units are categorized by intervals $[i{+}5;\ i{+}14]$ with $i = 0, 10, 20, ...110$. The very first interval, named "< 5", covers quantity units lower than 5, the last interval "> 124" includes quantities between 125 and the maximum of 500 accepted by the computer program. The percentage of quantities requested by contract are displayed for the observed p-levels, each differentiated between the first and the second five periods of the experiment.

According to Table 1, the theoretically optimal quantities for the high skilled are 100 QU for all possible p-levels. They amount to 4 and 11 QU for the low skilled under $p = 0.25$ and $p = 0.5$, respectively.

In Figure 1, only a few contract quantities are below 15 QU under $p = 0$ as opposed to $p = 0.25$ and $p = 0.5$. The quantity of 100 QU (precisely, a quantity between 95 and 104 units) is the mode value for all p–levels. Table 3 shows the exact percentages for the corresponding intervals. Note, however, that the observations under $p = 0.5$ encompass only 5% of the data.

Contract Offers

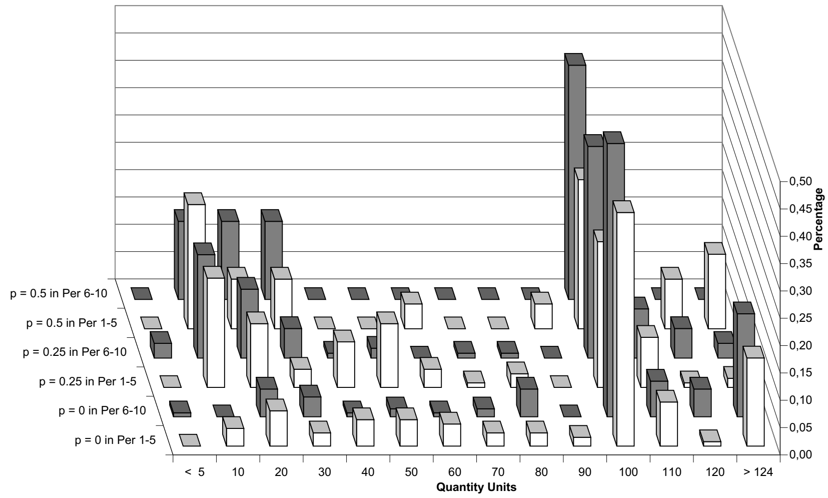


Figure 1: Contracts Offered by Employers

Overall, we conjecture from theory that contract quantities are different when low types are active on the market ($p = 0.25$, and $p = 0.5$) compared to a situation in which they are not ($p = 0$). Moreover, mean quantities under $p = 0.5$ should be slightly higher than under $p = 0.25$. The first null hypothesis with respect to quantities is:

Ha: Contract quantities do not differ

- when comparing $p = 0$ to $p = 0.25$,
- when comparing $p = 0$ to $p = 0.5$,
- when comparing $p = 0.25$ to $p = 0.5$.

The test results are presented in Table 4.[2] Differences that are significant at a 10%–level (*), or highly significant at a 5%–level (**) are indicated. The pair-wise (i.e., row-wise) comparisons demonstrate that there is a highly significant

[2] We used the software package SigmaStat 3.0 for Windows to execute the tests. We use the Mann–Whitney Rank Sum Test which is applicable to samples of different length. It tests the null hypothesis that multiple ordinal responses come from the same population.

Table 3: Percentages of Contract Quantities

	Quantity Units		
Periods 1 – 5	5 to 14	95 to 104	> 124
$p = 0$	3%	43%	25%
$p = 0.25$	21%	28%	13%
$p = 0.5$	23%	27%	0%
Periods 6 – 10	5 to 14	100	> 124
$p = 0$	0%	51%	31%
$p = 0.25$	19%	39%	17%
$p = 0.5$	14%	43%	14%

difference if only high types are active compared to if one out of 4 employees on the market is of low type (P–Value $< 5\%$). The rest of the results should be interpreted cautiously since there are very few observations for $p = 0.5$.

Table 4: Do Requested Quantities Differ?

Periods 1 - 5	Mean Quantities		
$p = 0$	100.6	100.6	-
$p = 0.25$	59.2	-	59.2
$p = 0.5$	-	89.3	89.3
Significance	**		
P–Value	*0.0002*	*0.146*	*0.730*

Periods 6 - 10	Mean Quantities		
$p = 0$	111.4	111.4	-
$p = 0.25$	69.3	-	69.3
$p = 0.5$	-	66.9	66.9
Significance	**		
P–Value	*<0.0001*	*0.115*	*0.489*

Result a: Only the first part of **Ha** can be rejected.

Quantities requested under $p = 0$ are significantly higher than under $p = 0.25$. The quantities under $p = 0$ compared to $p = 0.5$, as well as under $p = 0.25$ in comparison with $p = 0.5$ do not differ significantly. However, this is very likely due to the small sample for $p = 0.5$.

We now turn to the wages offered to the employees in exchange for the requested quantities. For different contracts to be comparable, we refer to the corresponding average wages. Each offered contract can be expressed by the corresponding average wage. In line with Table 1, the average wages $\frac{t^*}{q^*}$ offered to the agents should equal 1 for a low type under any p–level. For a high type, the optimal average wages offered should be 0.5, 0.52, and 0.56 in ascending order of p–levels.

As the employers offer up to two contracts to *their* agent rather than to a *certain type* of agent, average wages cannot be meaningfully analyzed on a stand-alone basis. For that reason, we explore wage offers that are accepted or rejected by a *certain type* of employee in the following.[3] When scrutinizing rejected offers, we choose the best offer from the agent's viewpoint if more than one contract has been offered and rejected. Therefore, the next null hypotheses with respect to average wages accepted or rejected by a certain type are:

Hb: The average wages

- do not differ across different p–levels for low types,
- do not differ across different p–levels for high types.

Table 5 displays the average wages accepted or rejected by either high or low types. The columns show rejected, accepted, and not accepted average wages for each type. The columns "not acc(epted)" refer to contracts that were offered together with an accepted contract.[4] In the columns "rejected", if more than one contract had been offered and rejected, we analyze the contract with the higher payoff for the employee.

For the high types in all conditions, the mean average wages are larger than expected by theory, i.e., they are larger than 0.5. For low types, mean accepted

[3]In 10 rounds of play, the workers made 320 decisions altogether regarding the acceptance of a contract. In 237 cases, a contract was accepted. In 16 cases, only high types took the "wrong contract", i.e., chose the alternative with the lower payoff (twice under $p = 0$, 13 times under $p = 0.25$, and once under $p = 0.5$). 4 out of 16 decisions avoided or reduced negative payoffs for the employer. Only once an employee chose a contract with payoff -97 CU instead of an alternative -19 CU for the employer.

[4]If an employer offered the same contract twice, and one of them was accepted, the second one is excluded from not accepted contracts.

average wages are higher than the theoretically expected value of 1, the rejected and not accepted contracts consist of mean average wages below 1.

Using a Kruskal-Wallis One Way ANOVA, we tested with respect to differences in average wages for high and low types. The results are given in table 5. Average wages accepted by high types increase significantly with higher p-levels. The results for rejected offers are mixed, and the average wages not accepted by high types differ significantly but are not monotonic. Under $p = 0.5$, average wages are lower than expected, however, the data also is very limited. When looking at low types, the average wages differ significantly (at a 10%-level) only with respect to contracts accepted during the first five periods. The entry "no test" indicates where a statistical test is impossible because of too few observations. The underlined numbers represent only one observation and should therefore be interpreted very cautiously.

Table 5: Do Offered Average Wages Differ (means displayed)?

Periods 1 – 5	High Types			Low Types		
	reject	accept	not acc	reject	accept	not acc
$p = 0$	0.60	0.71	0.71	-	-	-
$p = 0.25$	0.68	0.86	0.97	0.83	1.20	0.75
$p = 0.5$	0.6	1.11	0.68	0.98	1.66	0.56
Significance		**	**		*	
P–Value	*0.812*	*<0.001*	*0.006*	*0.241*	*0.073*	*0.142*

Periods 6 – 10	High Types			Low Types		
	reject	accept	not acc	reject	accept	not acc
$p = 0$	0.57	0.66	0.74	-	-	-
$p = 0.25$	0.71	0.77	1.16	0.87	1.40	0.71
$p = 0.5$	-	0.90	0.66	0.93	1.15	0.67
Significance	**	**	**		no test	no test
P–Value	*0.019*	*0.003*	*<0.001*	*0.764*	no test	no test

Result b: The results concerning average wages are mixed.

Average wage offers, $\frac{t}{q}$, dealt with by high types differ across different labor market scenarios and seem to increase with higher p-levels, especially with respect to accepted offers. Thus we reject the second part of hypothesis **Hb**. Average wages that reached a low type seem rather stable across different labor market situations and we do not reject the first part of hypothesis **Hb**. These observations are in keeping with the theoretical predictions drawn from Table 1.

According to this section's test results, there are no significant differences with regard to contract quantities[5] and average wages[6] between the first and the second five periods of play. Thus we will analyze the combined play of 10 periods in the following.

3.2.2 Profitability of Accepted Contracts

Let us now turn to the analysis of the contracts with respect to allocation and distribution effects. A firm's profits from a contract quantity are given via the profit function $S(q)$. Employees bear an effort cost of θq. Net joint profits (the "cake size"), therefore, amount to $S(q) - \theta q$. Thus q determines efficiency, and the wage offered to an agent divides the "cake" between employer and employee.

Efficiency of the contracts, as well as the offered (or even accepted) shares between employers and employees are presented in Figures 2 to 4. Each entry represents a contract. First and second five periods of play are jointly pictured. In each figure, the bold line represents net joint profits, and the dotted line depicts where net joint profits are equally distributed between employer and employee. The higher two curves in figures 3 and 4 refer to the high types, the lower to the low types. Accepted contracts are printed in grey, the rejected ones in black.[7]

In Figure 2[8], with only high types on the labor market ($p = 0$), efficiency is reached at 100 QU, which is very often observed. The bold circles indicate rejected offers. To a large extent, refusals are located far beneath the equal split curve. With regard to the accepted contracts, high skilled employees get 31% of net joint profits on average under $p = 0$. In absolute figures, this amounts to

[5] The quantities displayed in figure 1 suggest that there be no large difference in quantities in the first compared to the second five periods of the experiment. Indeed, the second part quantities over all values of p are not significantly different (P–Value=0.720) from the respective play during the first part.

[6] Test Results:

[7] The accepted and rejected contracts refer to the displays in table 5 under the respective columns.

[8] The following three outliers are not included in figure 2: (500 QU, -230 CU) and two times (500 QU, -250 CU). All three are rejected contracts.

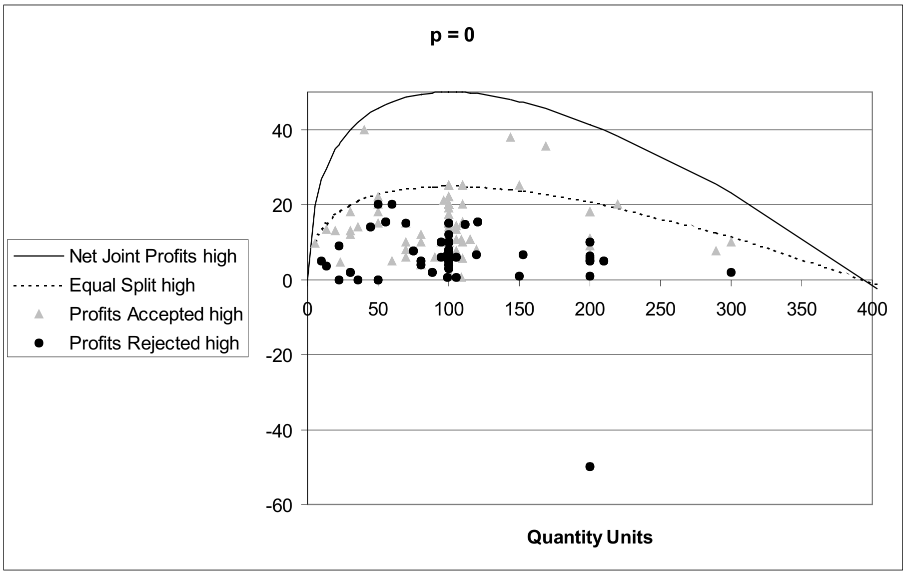


Figure 2: Contracts Offered by Employers under $p = 0$

an average of 14.8 CU for the agents, and 33.1 CU for the employers.

Figure 3 displays the labor market condition with one high and three low types ($p = 0.25$). Efficient agreements with low types occur at 4 QU, those with high types at 100 QU. Again, refusals are worse offers than accepted offers for the agents overall. Clearly, low types receive the lower share of the cake than high types: the former earn 19% of "net joint profits low", the latter get 36% of "net joint profits high". On average, low and high types earn 4.4 CU, and 16.4 CU, respectively. Employers' mean surplus is 18.3 CU with the high types, and 28.6 CU with the low types.

Finally, Figure 4 depicts the few observations under $p = 0.5$. Efficient agreements are reached at 11 QU and 100 QU, respectively. High types get paid an average 38% (17.6 CU), low types an amount of 30% of net profits (6.8 CU). On average, employers get 16.1 CU when contracting with a low type, and 29 CU with a high type.

Only high types make net losses, mainly by rejecting contracts but having invested 5 CU in productivity in stage 1 of the game.[9]

[9]Under $p = 0$, in 42 out of 47 cases of net losses the agents did not accept any contract.

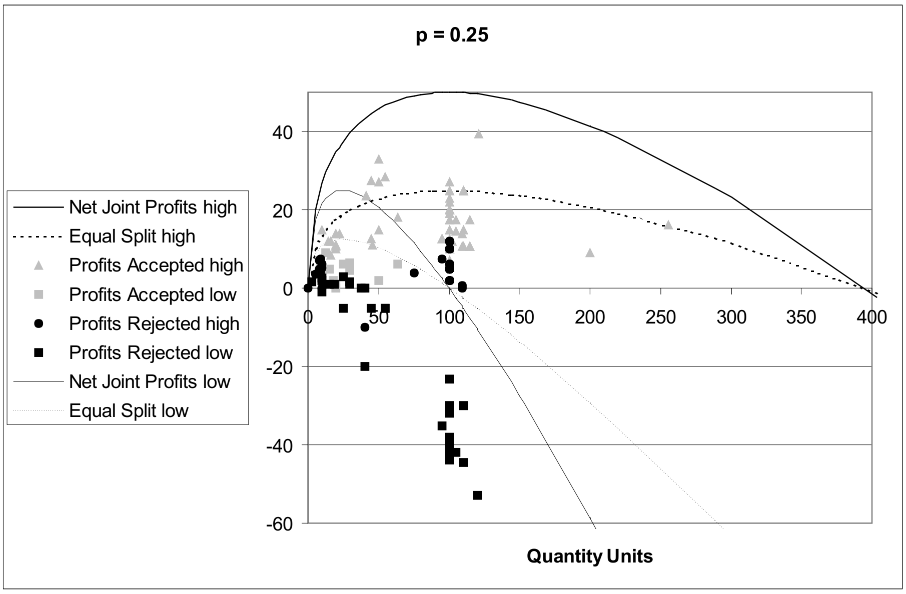


Figure 3: Contracts Offered by Employers under $p = 0.25$

According to theory, employers' profits rise with increasing probability p when contracting with high types, whereas they decrease with p when employing a high type (see Table 1). Hence, the next null hypothesis reads as follows:

Hc: Employers' profits do not differ across different p-level when contracting with

- with high types or

- with low types.

The average earnings for employers with different types are listed in Table 6. A Kruskal-Wallis One Way ANOVA[10] shows that profits with high types are significantly different for different values of p. This is in line with the theoretical prediction: the higher p is, the lower are the employers' profits. However, there are very few observations under $p = 0.5$. With p increasing from 0.25 to 0.5,

The remaining 5 minimized their net loss by accepting contracts that gave them more than zero though less than the invested 5 CU. Under $p = 0,25$ and $p = 0,5$, 18 and 1 high type, respectively, did not accepting a contract (but invested 5 CU at stage 1)

[10]The Kruskal-Wallis One Way ANOVA on Ranks is based on ranks and represents the nonparametric analog of a one-way analysis of variance. When there are only two groups, this procedure reduces to the Mann-Whitney test.

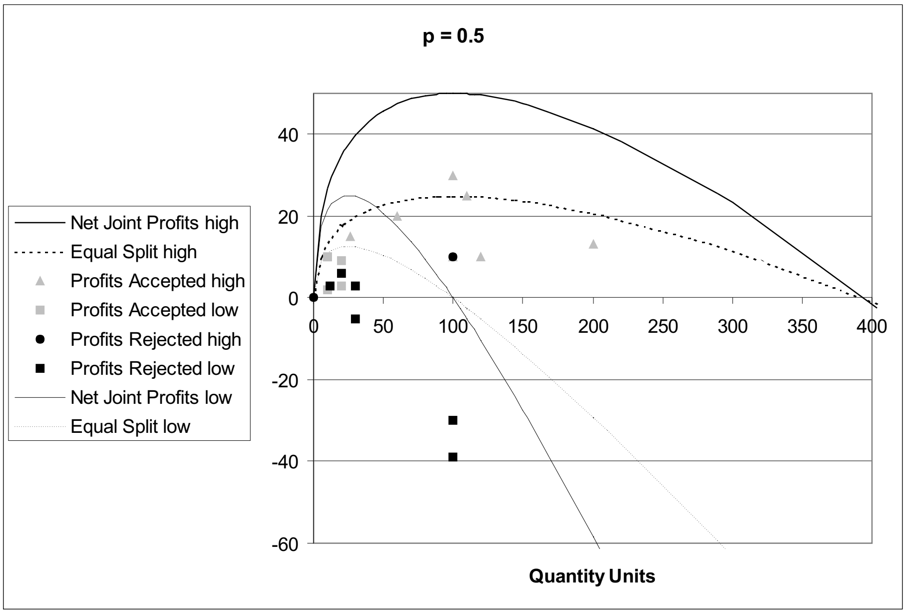


Figure 4: Contracts Offered by Employers under $p = 0.5$

employers' earnings with low types decrease from 18.29 to 16.04 CU on average. However, there is no significant difference.

Result c: We reject only the first part of **Hc**.

Employers profits differ significantly for contracts with high types, whereas they do not for interactions with low types.

Table 6: Do Employers Profits Differ (averages displayed)?

	High Types	Low Types
$p = 0$	33.27	-
$p = 0.25$	28.63	18.29
$p = 0.5$	29.04	16.04
Significance	**	-
P–Value	*<0.001*	*0.326*

In addition, Table 6 shows that mean earnings of employers differ for high and low types over all values of p.

After all, the question arises as to which market situation may be the most profitable for different types of agents. Theory predicts (see Table 1) that the more low skilled employees are in the market (higher p), the higher are the high types' earnings. Low types' wages should remain stable across different p-levels. Thus the next null hypothesis is:

Hd: Low types' as well as high types' wages remain stable across different p-levels.

The descriptive data (average earnings) in Table 7 is in line with theory regarding the high types, but not with respect to the low types. However, a Kruskal-Wallis One Way ANOVA shows that differences are not significant. Unfortunately, due to too small a sample at $p = 0.5$, the test is not powerful on low types' earnings.

Table 7: Do Employees' Earnings Differ (averages displayed)?

	High Types	Low Types
$p = 0$	14.76	-
$p = 0.25$	16.39	4.38
$p = 0.5$	17.57	6.8
Significance		
P–Value	*0.157*	*0.145*

Result d:

Both types' earnings are not significantly different for different values of p. High types earnings increase with p, as they do for low types.

4 Conclusion

In a labor market with two 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. This provides an incentive for being of high type. However, the high types' so-called "information rent" decreases, the higher the amount of high types on the market.

We investigate experimentally a game with two stages. In the first stage, ex ante identical agents independently decide whether to invest in (unobservable) education and become highly productive. From a theoretical viewpoint, such an investment individually pays off only if not too many agents decide likewise. This coordination game among the agents in stage one constitutes the labor market situation in stage two, i.e., it determines the mixture of high and low types on the market. In the second stage, firms can offer up to two contracts to an agent of unknown productivity, one of which the agent can accept.

In the first stage, we observe a very large amount of decisions in favor of becoming a high type. Thus, our observations with regard to different labor market scenarios reduce to situations in which only 0%, 25%, or 50% of low types are active in stage two. [11] At least two reasons may account for the high number of high types in the experiment. On the one hand, high productivity presumably is highly desirable among university students. Thus, a couple of subjects may have been tempted to want to be highly productive at any rate. On the other hand, the cost of investment in education in stage one was rather low compared to the agents' endowment, and also in comparison with the wages actually offered by the firms in stage two. In other words, where theory predicts net losses for the high types because too many agents invested in high productivity in stage one, the experimental data shows average net profits because firms do not fully exploit their bargaining power in the ultimatum game in stage two.[12]

Moreover, the firms clearly profit from the large amount of highly productive agents, as their profits are higher with high types than with low types. Thus, the "over-investment" in education in stage one is highly desirable from the viewpoint of economic efficiency. As long as the firms give off a respectable share to their employees, which they did in our experiment, this also enhances the individual welfare of the employees.

Despite the rather complicated interaction structure in our game, we observe what is well-known from a broad variety of ultimatum game experiments: the

[11] But, the situation in which a firm meets an agent of high or low type with equal probability (50%) is very seldom observed and must therefore be interpreted cautiously.

[12] In October this year, we will be conducting a second experimental design with higher cost of investment in high productivity in stage one.

proposers, i.e., the firms, offer a share of about 20% to 40% to the responders (the agents). A closer look, however, reveals an interesting difference between agents of high and low type. The high types' relative shares of the cake increase with less agents of high type on the market, which qualitatively is in line with theory but by far exceeds the quantitative predictions. The low types' relative shares tend to be lower than those of the high types but also higher than theoretically predicted. The low types' shares range between 19% and 30%, those of the high types run from 31% to 38% of the cake on average. Apparently, if more than one type exists, the outcome of an ultimatum game may depend on the type of responder to whom the proposer makes his offer.

The policy implications derived from our results vary with the specific viewpoint. Even though theory predicts an investment in high productivity in stage one to be individually profitable only if at least 50% of all agents remain low productive, the average data shows the contrary. The failed coordination among the agents in the first stage does not affect their profits adversely. We rather observe that in the ultimatum game in the second stage firms make offers more generous in absolute and also in relative measures to the high than to the low types. The theoretical predictions and experimental observations reveal that the high number of investments in high productivity is highly desirable from a firm's as well as from the society's viewpoint, as it enhances overall efficiency.

Finally, let us discuss the example mentioned at the very beginning of this paper in the light of our results. If degrees from different schools or universities are indistinguishable with respect to the education standards of their graduates, the individual decision of investing in productivity and the subsequent labor market situation matches our experimental design. In contrast to the theoretically predicted net losses for high productive types if too many agents are of high type, the experimental reality does not confirm the apprehension. However, graduates as well as schools or universities itself may be interested in taking efforts to observably distinguish themselves from others, i.e., by sending reliable signals of the graduates' high productivity to potential employers. This would turn the second stage game at least partly in a signaling game, which is left to further research.

Appendix: Instructions

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 during 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 rounds. 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 period anew, you will be randomly matched with one of your group members that has a role different from yours.
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 low skilled. They can invest in education to become high 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. A low skilled employee has higher production cost per QU than a high skilled employee.
As soon as each employee has chosen his qualification for the respective period, employers and employees learn the remaining proportion of low skilled 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 worker he has been matched with. Each employer can now offer up to two contracts to the worker. Any contract i consists of an amount of quantity units M_i to be produced, and of a lump sum wage L_i paid for M_i. Only values up to 500 CU are accepted for both variables.
The employees view the contracts offered by the employer they had 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 low skilled. Every employee decides whether he wants to invest to become high skilled or to remain low skilled. This investment costs 5 CU for the employee. After the investment the employee is high skilled. If he does not invest he remains low skilled. The production cost for a **low skilled employee** are **1 CU** per produced QU of the good. A **high skilled employee** has production cost of **0.5 CU** per produced QU of the good. 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 skilled** employee is:

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

The profit of any **low skilled** 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 skilled employees in their group of eight. The **proportion of low skilled 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 skilled employee, i.e. the proportion p of low skilled employees in their group. The **profit of an employer** is independent of the qualification of the worker he has been matched with. It is:

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

   To help you with your decisions you can always use the “pocket calculator”. This tool will be explained later.

3. At stage 3 of a period, the contracts are offered to the employees and they 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 workers’ 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 this has not yet been the tenth period.

Tools

There are two types of tools during the experiment. The first one is called **History** and gives an overview over 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 of a low skilled employee out of this contract. The used **variables** are explained in the table at the end of the instructions.

History

You can view the history either by clicking on the button **“Geschichte”**[13] at the bottom of the monitor, or with the key **F1**. You get an overview of your own decisions as well as those of the employers/employees you had been matched with in the respective periods. The used **variables** are explained in the table at the end of the instructions.

[13] “Geschichte” is German for “History”.

Pocket Calculator

You can open the pocket calculator either by clicking on the button **"Taschenrechner"**[14] at the bottom of the monitor, or with the key **F2**. At the end of the instructions you can see a screen-shot of the pocket calculator. In stage 1, the percentage p of low skilled 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 skilled employees in your group. You see the profits for employers and employees. As soon as the percentage of low skilled 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 skilled 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 button **"Speichern"** you can save two contracts per proportion p of low skilled employees. Saved contracts can be viewed at the bottom of the pocket calculator.
- With the buttons **"Abrufen"** next to the saved contracts, you can put the saved values back into the input fields.

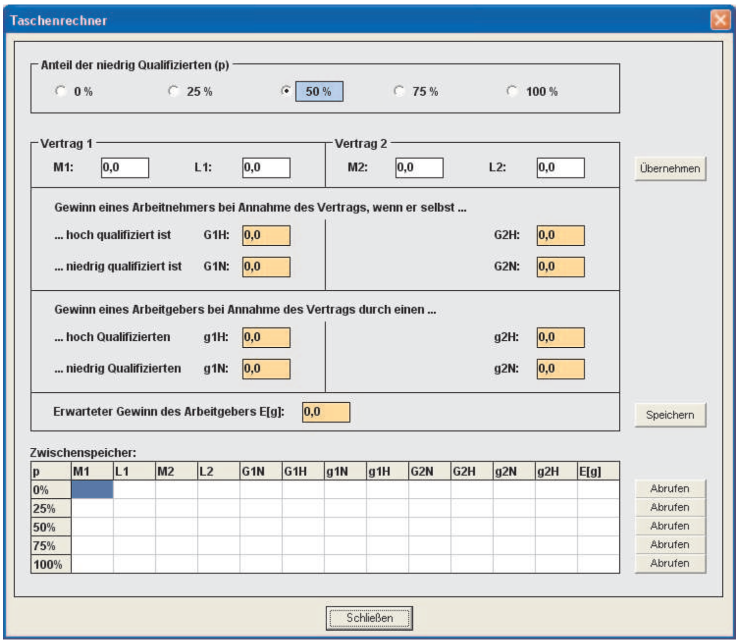
As an employer does not know the skills of the employee he is matched with, there is also the **employers expected profit** $E[g]$. The following procedure is applied to calculate $E[g]$:

- Each **employee** accepts the contract with the **higher profit** regarding his qualification.
- A contract with **negative profits** 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 worker.
- The employer's profit resulting from an accepted contract is weighted by the current percentage of high skilled and of low skilled employee 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.

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



Payment

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

Before the experiment starts you will be asked some questions at your computer terminal. If anything is unclear you can lift your hand and your questions are 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

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