Gathering Information before Signing a Contract: Experimental Evidence

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Abstract

A central insight of agency theory is that when a principal offers a contract to a privately informed agent, the principal trades off ex post efficiency in the bad state of nature against a larger profit in the good state of nature. We report about an experiment with 508 participants designed to test whether this fundamental trade-off is actually relevant. In particular, we investigate settings with both exogenous and endogenous information structures. We find that theory is indeed a useful predictor for the relative magnitudes of the principals' offers, the agents' information gathering decisions, and the occurrence of ex post inefficiencies.

Keywords: Agency theory; adverse selection; information gathering; experiment.

JEL Classification: D82; D86; C72; C91

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1 Introduction

Agency models with precontractual private information (i.e., adverse selection models) are at the center of much recent research in the theory of incentives and mechanism design.[1] A basic lesson of incentive theory is that a principal who offers a contract to a privately informed agent may be willing to accept distortions away from the first best in the bad state of nature, in order to make a larger profit in the good state of nature. In particular, there typically is a downward distortion of trade levels in the bad state, while ex post efficiency is achieved in the good state (i.e., there is "no distortion at the top"). While this trade-off is a crucial driving force behind numerous theoretical contributions in various fields of applications,[2] up to now there is scarce empirical evidence whether decision-makers actually take this trade-off into consideration when faced with real-world agency problems. As a first step, in this paper we report about a large-scale laboratory experiment designed to assess how subjects behave when they are confronted with the simplest version of an adverse selection problem.

We consider a principal who can make a wage offer to an agent for the production of a good. The agent has private information about his disutility of production,[3] which can be either low or high with equal probability. If the agent accepts the offer, the principal obtains a return and the agent has to incur the disutility of production. If the agent rejects the offer, both parties make zero profits. We consider a setting where the principal's return is larger than the disutility of production in both states of nature. Hence, ex post efficiency is achieved if the agent accepts the wage offer regardless of the state of nature. We investigate the subjects' behavior in two different parameter constellations with regard to the possible realizations of the agent's disutility of production. In both treatments, the expected disutility of production is the same. Yet, in the first treatment, the spread between the low and the

[1] See the seminal contributions by Myerson (1981), Baron and Myerson (1982), and Maskin and Riley (1984). For a recent appraisal of mechanism design theory, see also Nobel Prize Committee (2007).

[2] For comprehensive surveys, see Fudenberg and Tirole (1991, ch. 7), Laffont and Martimort (2002), and Bolton and Dewatripont (2005).

[3] There will be two kinds of costs in this paper, information gathering costs and production costs. To avoid confusion, we follow Crémer and Khalil (1992) and refer to production costs as "disutility of production."

high disutility of production is large, so that according to standard theory the principal would give up ex post efficiency in the bad state of nature in favor of a small wage offer that is thus accepted in the good state of nature only. In contrast, in the second treatment, the spread between the low and the high disutility of production is small, so that standard theory predicts a large wage offer that is accepted by both types of agents; i.e., ex post efficiency is achieved. Our experimental results largely confirm the theoretical predictions. Average wage offers are significantly larger in the second treatment, while ex post inefficiencies occur significantly more often in the first treatment. The subjects' behavior thus suggests that the outlined trade-off which forms the basis of adverse selection models actually does play a central role in agency problems given asymmetric information.

While in the vast majority of agency models it is assumed that the information structure is exogenously given, Crémer and Khalil (1992, 1994) and Crémer, Khalil, and Rochet (1998a, 1998b) have pointed out that in practice agents often first have to acquire information to become privately informed. Building on their work, we develop a simple model in which the principal first makes a wage offer and then the agent can decide whether he wants to spend resources to learn his disutility of production before accepting or rejecting the offer. We consider two further treatments where the parameter constellations are as in the first two treatments, except that now instead of being privately informed at the outset, the agent has to decide whether to engage in costly information gathering. In the third treatment, according to our theoretical model, the principal would make a wage offer which induces the agent to gather information and to accept the contract whenever he learns to be of the low type. In the fourth treatment, our model implies that the principal makes a wage offer which will be accepted by the agent without information gathering. Our experimental findings again largely corroborate the theoretical predictions. In particular, in the third treatment the agents gather information significantly more often than in the fourth treatment. Moreover, the relative magnitudes of the principals' wage offers and the relative frequencies of ex post inefficiencies are again in line with the theoretical predictions. Hence, our experiment provides first empirical evidence that agency models with exogenous as well as endogenous information structures seem to capture important aspects that are taken into consideration by decision-makers facing adverse selection problems.

In the light of the enormous attention that has been paid to agency models with precontractual private information in the theoretical literature, there is remarkably little empirical literature on this topic.[4] In particular, as far as laboratory experiments are concerned, Cabrales, Charness, and Villeval (2006) point out that experimental studies on contract theory have typically examined hidden action problems, while there is only little experimental work on adverse selection. Their study shows that in line with theoretical predictions, competition between privately informed agents enhances efficiency. In a related paper, Cabrales and Charness (2008) experimentally examine optimal contracting with teams of privately informed agents. In another experimental study, Charness and Dufwenberg (2008) find that communication can sometimes mitigate problems due to asymmetric information.

In agency theory, it is typically assumed that the principal makes a take-it-or-leave-it offer to the agent. While in the experimental literature papers on the ultimatum game abound, the vast majority of these contributions considers complete information. Papers that do study ultimatum bargaining with asymmetric information typically assume that it is the proposer (and not the responder) who is privately informed about the size of the pie to be divided (see Huck, 1999, and the literature discussed there). Yet, Forsythe, Kennan, and Sopher (1991) have conducted an experiment with one-sided private information where the responder may be privately informed, but they look at more complex bargaining games. In particular, they consider a bargaining game with free exchange of messages and a random dictator game. They find strong predictive power of the so-called strike condition. This condition is similar to the one under which ex post inefficiency in the bad state of nature occurs in our framework, provided that asymmetric information is exogenously given.

To the best of our knowledge, there is not yet any experimental evidence on adverse selection problems in which the agent can gather private information. Following Crémer and Khalil (1992) and Crémer, Khalil, and Rochet (1998a), we consider a scenario in which costly information gathering can occur after the principal has offered the contract, but before the contract is signed.[5] It

[4]For surveys of empirical tests of contract theory, see Prendergast (1999) and Chiappori and Salanié (2003).

[5]See also Lewis and Sappington (1997). In contrast, Crémer and Khalil (1994), Crémer,

turns out that in our model the principal offers a contract with properties that are similar to those derived in Crémer, Khalil, and Rochet (1998a), even though in their model information gathering is a productive activity, while it is a pure rent-seeking activity in our framework, where ex post efficient behavior does not depend on the state of nature.[6]

The remainder of the paper is organized as follows. In the next section, we introduce the theoretical framework which serves as the basis for our experiment. In section 3, the experimental design is presented. In section 4, we derive qualitative hypotheses based on the theory and on previous experimental findings. We explain and analyze our experimental results in section 5. Concluding remarks follow in section 6. All proofs have been relegated to the appendix.

2 The theoretical framework

In this section, to motivate our experimental study, we present the theoretical framework as a starting point. Consider a principal and an agent, both of whom are risk-neutral. At an initial date 0, nature draws the agent's type, i.e. his disutility of production $c \in \{c_l, c_h\}$, where $prob\{c = c_l\} = p$. At date 1, the principal makes a wage offer w to the agent. At date 2, the agent can either accept or reject the offer. If he accepts the offer, he has to incur the disutility of production c in order to create the return R for the principal, so that the agent's profit is $w - c$ and the principal's profit is $R - w$. If the agent rejects the offer, both parties' profits are zero. We assume that $R > c_h > c_l$, so that ex post efficiency is achieved if the return R is generated regardless of the state of nature. All parameters of the model are common knowledge, except for the agent's type c. We consider two different scenarios.

Asymmetric information. In the first scenario, the agent privately learns the

Khalil, and Rochet (1998b), and Kessler (1998) analyze information gathering before the contract is offered.

[6]Note that in Crémer and Khalil (1992, 1994) and Crémer, Khalil, and Rochet (1998b), information gathering is also pure rent-seeking, but for a different reason (they assume that the agent costlessly learns his type after the contract is signed but before production). In the incomplete contracting literature, Aghion and Tirole (1997) and Dewatripont and Tirole (1999) study productive information gathering, while Schmitz (2006) considers a setting where information gathering is rent-seeking only.

realization of his type c before he has to decide whether or not to accept the wage offer.

Proposition 1 *In the asymmetric information scenario, the principal's wage offer is*

$$w = \begin{cases} c_h & \text{if} \quad p(R - c_l) \leq R - c_h, \\ c_l & \text{if} \quad p(R - c_l) > R - c_h. \end{cases}$$

Proof. See the appendix.

According to standard theory, an agent accepts any wage offer that covers at least his disutility of production. Hence, if the principal offers $w = c_h$, then any type of agent will accept the offer, so that the principal's profit is $R - c_h$. In contrast, if the principal offers $w = c_l$, then only the low type accepts, such that the principal's expected profit is $p(R - c_l)$. This means that if the condition $p(R - c_l) > R - c_h$ is satisfied, so that the principal sets $w = c_l$, then ex post efficiency is achieved only in the good state of nature ($c = c_l$). If the condition is not satisfied, then ex post efficiency is always achieved.

Information gathering. In the second scenario, at date 1.5 (i.e., after the principal has made his wage offer, but before the agent's decision to accept or reject the offer), the agent can decide whether he wants to spend information gathering costs γ in order to observe the state of nature.

Proposition 2 *In the information gathering scenario, the principal's wage offer can be characterized as follows.*

(i) If $p(R - c_l) \leq R - c_h$, then the principal induces no information gathering and sets

$$w = \begin{cases} c_h - \frac{\gamma}{1-p} & \text{if} \quad \gamma < p(1-p)(c_h - c_l), \\ E[c] & \text{if} \quad \gamma \geq p(1-p)(c_h - c_l). \end{cases}$$

(ii) If $p(R - c_l) > R - c_h$, then the principal induces information gathering whenever $\gamma < \frac{1-p}{2-p}[p(R - c_l) - (R - c_h)]$. Moreover, he sets

$$w = \begin{cases} c_l + \frac{\gamma}{p} & \text{if} \quad \gamma < \frac{1-p}{2-p}\left[p(R - c_l) - (R - c_h)\right], \\ c_h - \frac{\gamma}{1-p} & \text{if} \quad \frac{1-p}{2-p}\left[p(R - c_l) - (R - c_h)\right] \leq \gamma < p(1-p)(c_h - c_l), \\ E[c] & \text{if} \quad \gamma \geq p(1-p)(c_h - c_l). \end{cases}$$

Proof. See the appendix.

Consider the case $p(R-c_l) \leq R-c_h$. If the agent learned his type costlessly (i.e. when $\gamma = 0$, which corresponds to the asymmetric information scenario), the principal would offer $w = c_h$ and the agent would accept the offer regardless of the state of nature. If the agent has to incur information gathering costs $\gamma > 0$ to learn his type, the principal can make a wage offer that is smaller than c_h and still ensure that the agent accepts the offer regardless of the state of nature (i.e., without information gathering). The larger is γ, the smaller can be the wage offer (as long as it does not fall below $E[c]$, since otherwise an uninformed agent would turn down the offer).

Next, consider the case $p(R-c_l) > R-c_h$. If the agent learned his type costlessly (i.e. when $\gamma = 0$), the principal would offer $w = c_l$ and the agent would accept the offer in the good state of nature. But given $\gamma > 0$, the principal has to make a wage offer that is larger than c_l (and increasing in γ) in order to induce the agent to gather information (without information gathering, the agent would not accept a wage offer smaller than $E[c]$). However, for sufficiently large γ, it becomes more profitable for the principal to make an offer that is accepted by both types of agents, so that the principal again faces the same problem as in case (i).

3 Design

Our experiment consists of four different treatments. Each treatment was run in four sessions. Each session had 32 participants, except for one session with 28 subjects (due to no-shows). No subject was allowed to participate in more than one session. In total, 508 subjects participated in the experiment. All subjects were students of the University of Cologne from a wide variety of fields of study. The computerized experiment was programmed and conducted with zTree (Fischbacher, 2007) and subjects were recruited using ORSEE (Greiner, 2004). A session lasted between 20 and 30 minutes. Subjects were paid on average 15.31€.

In each session, half of the participants were randomly assigned to the role of principals and the others to the role of agents. The disutility of production of half of the agents was low ($c = c_l$), while the other half of the agents had a high disutility of production ($c = c_h$). Each principal was randomly matched with one agent. In order to give subjects a monetary incentive to take their decisions seriously and to ensure a large number of independent observations, each session consisted of only one round; i.e., there were no repetitions and this was known to the subjects. All interactions were anonymous; i.e., no subject knew the identity of its trading partner. At the beginning of each session, written instructions were handed out to each subject. We make use of an experimental currency unit (1 ECU = 0.14 €).[7]

Asymmetric information treatment (AI 20-80). There are two stages. In the first stage, the principal makes a wage offer w to the agent (where w can be any integer between 0 and 100). The principal does not know the agent's disutility of production c; all he knows is that it can be either $c_l = 20$ or $c_h = 80$ with equal probability ($p = 1/2$). In the second stage, the agent learns his disutility of production and then he can decide whether or not to accept the principal's wage offer. If the agent accepts the offer, the principal's profit is $R - w = 100 - w$ and the agent's profit is $w - c$. If the agent rejects the offer, both parties make zero profits.

Asymmetric information treatment (AI 40-60). This treatment is identical to the AI 20-80 treatment, except that now $c_l = 40$ and $c_h = 60$.

Information gathering treatment (IG 20-80). There are two stages. The first stage is identical to the first stage in the AI 20-80 treatment. In the second stage, the agent can accept or reject the principal's wage offer immediately (without knowing his type c) or he can decide to incur information gathering costs $\gamma = 6$ to learn his type before accepting or rejecting the wage offer. The resulting profits are displayed in Table 1.

Information gathering treatment (IG 40-60). This treatment is identical to the IG 20-80 treatment, except that now $c_l = 40$ and $c_h = 60$.

	accept	reject
no information gathering	$100 - w, w - c$	$0, 0$
information gathering	$100 - w, w - c - 6$	$0, -6$

Table 1. The profits (principal, agent) in the IG treatments.

[7] To ensure non-negative payoffs, in addition to the profit made in the experiment, all subjects were paid a participation fee of 90 ECU.

4 Qualitative hypotheses

Asymmetric information (AI 20-80). According to standard theory, the prediction for this scenario is that the principal would offer the wage $w = 20$, since $\frac{1}{2}(100 - 20) > 100 - 80$. Hence, an agent will accept this offer only if he is of the low type, which means that according to standard theory, ex post efficiency will be achieved in the good state of nature only.

Yet, it has been demonstrated in numerous experiments on the ultimatum game that proposers typically offer more than what would be necessary if the responders were interested in their monetary payoffs only.[8] According to Camerer (2003), the mean offers of proposers are usually between 30 and 40 percent of the pie to be divided. We did not expect offers above 80 which would be acceptable by both types, because this would mean that the principals would have to give up more than 60 percent of the expected pie.[9] Given that the principals make offers that are accepted by low-type agents only, we thus expected that the mean of the offers would be between 44 and 52.[10] Hence, we hypothesized that wage offers would be such that generally they are accepted by low-type agents and rejected by high-type agents, so that in line with standard theory ex post inefficiencies tend to occur whenever we are in the bad state of nature.

Asymmetric information (AI 40-60). The standard theoretical prediction for this scenario is that the principal would offer the wage $w = 60$, since $\frac{1}{2}(100 - 40) < 100 - 60$. Hence, an agent will always accept the offer, so that ex post efficiency will always be achieved.

We expected that indeed principals would make offers that are generally accepted by both types of agents. Specifically, we expected that the mean offers would be between 65 and 70, such that the principals give up 30-40 percent of the expected pie. We hypothesized that even high-type agents would typically accept such an offer, because their disutility of production is more than covered and they may have in mind that from the principal's perspective they could

[8] On the ultimatum game, see Güth, Schmittberger, and Schwarze (1982). Camerer (2003) provides an extensive literature survey. For possible explanations of the regularities found in this literature, see also the surveys by Fehr and Schmidt (2003, 2006).

[9] If both types of agents accept, the expected total surplus is $\frac{1}{2}(100-20)+\frac{1}{2}(100-80) = 50$.

[10] These values are obtained if we add 30-40 percent of the total surplus in the good state of nature ($100 - 20 = 80$) to the low-type agent's costs (20).

have been of the low type with equal probability. This implies, again in line with standard theory, that ex post inefficiencies should occur only rarely.

Information gathering (IG 20-80). Given this parameter constellation, the wage offer $w = c_l + \frac{\gamma}{p} = 32$ would be optimal for the principal in the standard theoretical framework as shown in Proposition 2(ii). Then the agent would always gather information and accept the offer whenever he is of the low type.

Given that the principal's offer is such that the agent gathers information and accepts the offer in the good state of nature only, we expect mean offers between 48 and 56, so that the agent gets again 30-40 percent of the total surplus.[11] Note that offers in this range are actually very likely to induce information gathering, because an agent might neither want to simply reject them nor accept them without information gathering (immediate rejection would mean to miss the chance of a sizeable profit, while immediate acceptance would imply the risk of a considerable loss).

Information gathering (IG 40-60). In this parameter constellation, the wage offer $w = E[c]$ would be optimal for the principal according to standard theory as shown in Proposition 2(i). In this case, the agent would accept the offer immediately without gathering information.

Given that both types of agents accept the offer, we expect again that principals on average give up 30-40 percent of the expected pie, so that the same range of offers results as in the AI 40-60 treatment. Since we argued in the AI 40-60 treatment that offers in this range should be accepted even by agents with a high disutility of production, we expected that in the IG 40-60 treatment information gathering should not occur as it would only lower the agents' profits.

The preceding considerations lead us to make the following qualitative hypotheses.

Hypothesis 1. *Wage offers.*
(i) In the AI 20-80 treatment, average wage offers are lower than in the AI 40-60 treatment.
(ii) In the IG 20-80 treatment, average wage offers are lower than in the IG 40-60 treatment.

[11] Specifically, the offers are obtained if we add 30-40 percent of the total surplus in the good state of nature ($100 - 20 - 6 = 74$) to the low-type agent's total costs ($20 + 6 = 26$).

(iii) In the AI 20-80 treatment, average wage offers tend to be lower than in the IG 20-80 treatment.
(iv) In the AI 40-60 treatment and in the IG 40-60 treatment, the average wage offers are about the same.

Hypothesis 2. *Information gathering.*
In the IG 20-80 treatment, information gathering occurs more often than in the IG 40-60 treatment.

Hypothesis 3. *Ex post inefficiency.*
(i) In the AI 20-80 treatment, rejections of the principals' wage offers occur more often than in the AI 40-60 treatment.
(ii) In the IG 20-80 treatment, rejections of the principals' wage offers occur more often than in the IG 40-60 treatment.
(iii) In the AI 20-80 treatment and in the IG 20-80 treatment, the shares of offers that are rejected are about the same.
(iv) In the AI 40-60 treatment and in the IG 40-60 treatment, the shares of offers that are rejected are about the same.

Note that the aim of the present study is not to investigate how social preferences or norms lead to a particular division of the pie, which has been the focus of many previous studies of the ultimatum game under complete information. Instead, we take it as given that average offers are such that a substantial fraction of the surplus is left to the agent. Our interest is to explore whether the considerations that are the basis of adverse selection models with exogenous and endogenous information structures are indeed suggestive to make meaningful predictions about information gathering, ex post inefficiencies, and the size of the total surplus. Observe that in all four treatments, our predictions for the agents' behavior with regard to their decisions whether or not to accept the wage offers and whether or not to gather information are the same as the standard theoretical predictions. Since the total surplus depends only on these two decisions, we might expect that also the average realized surplus levels in the different treatments will be close to the levels that are predicted by standard theory. Specifically, we expected that the realized surplus levels will be somewhat smaller than the theoretically predicted levels, because we know from numerous ultimatum game experiments that typically some rejections occur even when it is known that acceptance would increase both parties' profits.

5 Results

In this section we present and analyze our results. Table 2 summarizes the main findings for the different treatments. Furthermore, Table 3 shows p-values for pairwise comparisons of the principals' wage offers and the agents' decisions with regard to information gathering and contract rejection. Figure 1 depicts for all observed wage offers the realized surplus levels, which are determined by the state of nature, the agent's decision whether to accept the principal's offer, and (in the IG treatments) the agent's decision whether to gather information.

	AI 20-80	AI 40-60	IG 20-80	IG 40-60
number of principal-agent pairs	64	64	64	62
mean offer (ECU)	50.95	65.98	54.98	65.97
information gathering			43 (67.2%)	4 (6.3%)
number of rejections	30 (46.9%)	9 (14.1%)	30 (46.9%)	7 (11.3%)
rejections by (informed) high types	25	9	20	1
rejections by (informed) low types	5	0	0	0
rejections by uninformed agents			10	6
surplus (ECU)	35.94	44.38	30.03	44.13
mean principal profit (ECU)	20.95	27.20	22.28	27.18
mean agent profit (ECU)	14.98	17.17	7.75	16.95

Table 2. Descriptive statistics.

The second row in Table 2 demonstrates that in all four treatments the mean wage offers lie within the predicted intervals. In particular, it turns out that in the asymmetric information treatments as well as in the information gathering treatments, the average wage offers are lower in the 20-80 parameter constellation. In both cases, the difference is highly significant, as shown in the first row of Table 3. Hence we find strong support for Hypotheses 1(i) and (ii). As predicted in Hypothesis 1(iii), the mean wage offer in the IG 20-80 treatment is somewhat larger than the one in the AI 20-80 treatment. Even though the difference is not statistically significant,[12] it is consistent with the

[12] The p-value of a one-tailed Fisher exact test is 0.0887.

idea that the principal wants to induce the agent to gather information and hence reimburses him for part of the information gathering costs. Furthermore, we cannot reject Hypothesis 1(iv), according to which average wage offers in the AI 40-60 and IG 40-60 treatments are nearly the same. Taken together, it turns out that the predictions about the principals' average behavior as derived from standard theory and previous experimental studies are largely confirmed by the wage offers actually observed in the experiment.

In line with Hypothesis 2, information gathering occurs much more often in the IG 20-80 treatment than in the IG 40-60 treatment. The difference is highly significant. Figure 1 reveals that the reason why information gathering actually does not occur in all cases in the IG 20-80 treatment can be seen in both the principals' and the agents' behavior. Obviously, there are some principals who make offers for which information gathering is clearly not a reasonable reaction, and there are also some agents who decide not to acquire information when it appears to be in their interest.

	AI 20-80 vs. AI 40-60	IG 20-80 vs. IG 40-60	AI 20-80 vs. IG 20-80	AI 40-60 vs. IG 40-60
offers	<0.0001	<0.0001	0.1775	0.5929
info. gath.		<0.0001		
rejections	0.0001	<0.0001	1.0000	0.7904

Table 3. Significance levels for pairwise comparisons between the treatments. With regard to the offers, the reported p-values are obtained by two-tailed Mann-Whitney U tests, while with regard to information gathering and rejections, they are obtained by two-tailed Fisher exact tests.

With regard to rejection rates, Table 2 shows that in the asymmetric information treatments as well as in the information gathering treatments, rejections of wage offers occur considerably more often in the 20-80 parameter constellation, which is in support of Hypotheses 3(i) and (ii). As can be seen in Table 3, these differences are highly significant. Moreover, we cannot reject Hypotheses 3(iii) and (iv), which say that there is no difference in rejection rates between the AI and IG treatments in a given parameter constellation.

Moreover, Table 2 and Figure 1 also illustrate how the rejections in the different treatments are split among (informed) high types, (informed) low types, and uninformed agents. In particular, one can see that rejections occur only rarely when the agent knows or learns that he is of the low type, which is in line with the theoretical prediction that there should be "no distortion at the top."

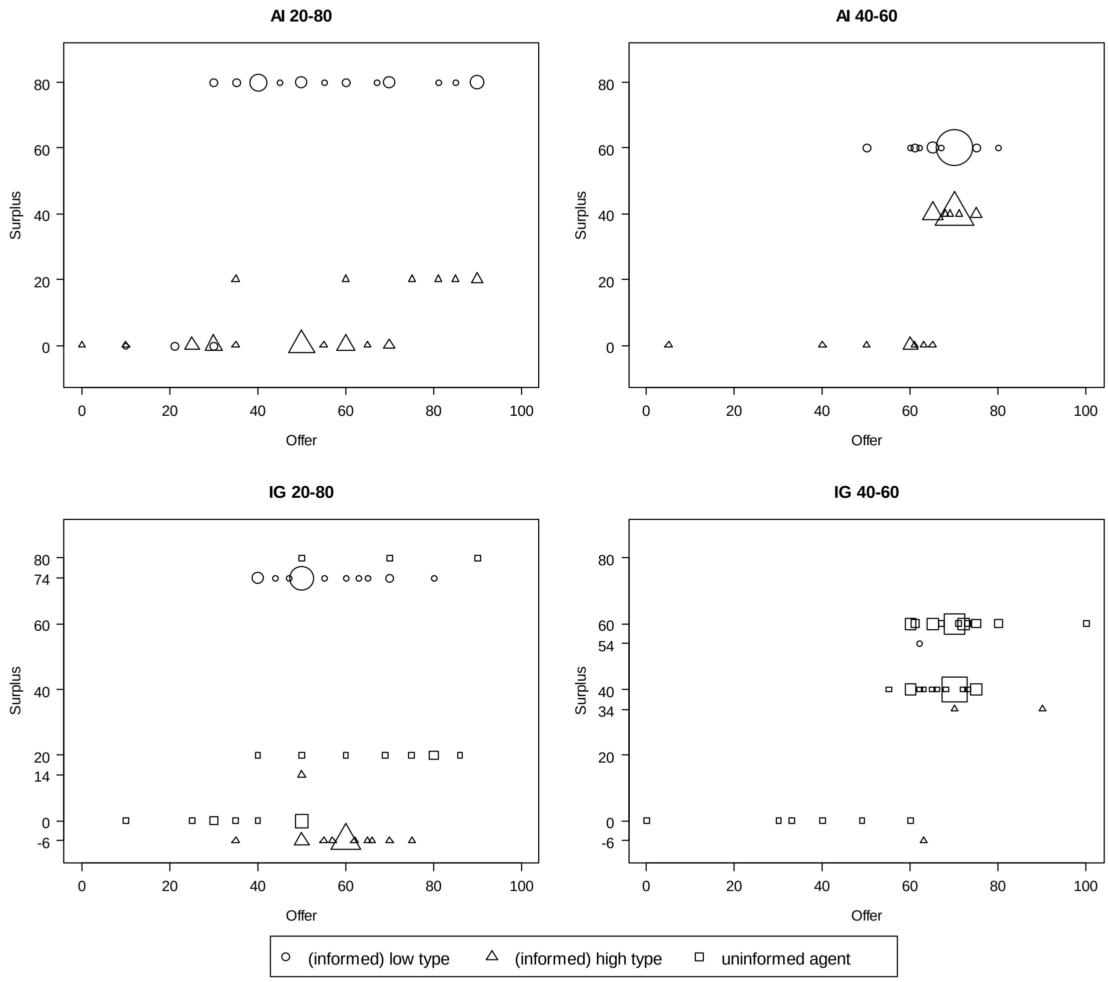

Figure 1. Realized surplus levels for all observed offers. The size of the symbols represents the number of observations.

Taking into consideration the by now huge literature on ultimatum games under complete information, we did not expect that the principals would obtain as much of the total surplus as predicted by standard theory. Instead, our predicted wage offers implied that the principals would leave a considerable share of the surplus to the agents. Indeed, the actually observed splits of the total surplus in the different treatments were as shown in Table 2.

With regard to the total surplus, we expected that the observed surplus levels would be close to (but somewhat smaller than) the theoretically predicted levels. According to standard theory, in the 20-80 treatments ex post efficiency would be achieved in the good state of nature only. Hence, in the AI 20-80 treatment the expected total surplus would be $\frac{1}{2}(100 - 20) = 40$, while in the IG 20-80 treatment it would be only 34 (since we have to subtract the information gathering costs). In contrast, in the 40-60 treatments, standard theory predicts that ex post efficiency would always be achieved and there would be no information gathering, so that the theoretically predicted surplus is $100 - \frac{1}{2}(40 + 60) = 50$.

Table 2 reports the actually observed surplus levels. Note that the ranking of the surplus levels is as predicted by standard theory. In particular, in all four treatments, the realized surplus levels are about 89% of the theoretically predicted levels. Taken together, we find that standard theory is a useful predictor with regard to the agents' information gathering and rejection decisions and, as a consequence, for the total surplus.

6 Conclusion

Agency problems with private information are ubiquitous in the real world. This fact explains why the number of theoretical models on contracting under asymmetric information has grown so rapidly in the past three decades. A central insight of these models is the fact that a principal who offers a contract to a privately informed agent trades off ex post efficiency in the bad state of nature against a larger profit in the good state of nature. However, due to the inherent availability problem regarding data on private information, empirical tests of this fundamental trade-off are scarce. As a first step, we have implemented the simplest possible agency problem with an exogenously given information structure in the laboratory. Subject to the well established fact that in laboratory ultimatum games proposers make relatively generous offers and responders tend to reject relatively small offers, our experimental findings are in very good accord with the standard adverse selection model and thus lend support to the empirical relevance of the postulated trade-off.

As has been pointed out by Laffont and Martimort (2002, p. 395), an often heard criticism of incentive theory is that it takes the information structure as given. Following the theoretical work of Crémer and Khalil (1992) and Crémer, Khalil, and Rochet (1998a), we have thus extended our simple adverse selection model to incorporate an endogenous information structure. Our experimental results again largely confirm the empirical relevance of the theoretical model.

Conducting further experiments on agency problems with adverse selection seems to be a promising path for future research. In particular, we plan to supplement the present study by performing experiments in which the agent can gather information before the principal offers the contract. Moreover, we plan to conduct experiments on adverse selection problems where in the bad state of nature the theoretically predicted trade level is positive but smaller than in the good state. In such a setting it would be interesting to see whether the principals will then offer two different contracts and thereby succeed in separating the agents.

Appendix

A. Proof of Proposition 1

The agent will accept the wage offer whenever $c \leq w$. Note that if $c_l < w < c_h$, then the principal would be better off by setting $w = c_l$. If $w > c_h$, then the principal would be better off by setting $w = c_h$. If $w < c_l$, then the principal would make zero profit which is less than $R - c_h$, the profit that he could make by setting $w = c_h$. Hence, the principal will take into consideration wage offers $w \in \{c_l, c_h\}$ only. If the principal sets $w = c_l$, so that only an agent of type c_l accepts, then his expected profit is $p(R - c_l)$. If he sets $w = c_h$, then the offer is always accepted, so that the principal's profit is $R - c_h$.

B. Proof of Proposition 2

Suppose that the principal has offered the wage w. The agent's expected profit if he accepts the offer without information gathering is $w - E[c]$. The agent's expected profit if he gathers information is $E[\max\{w - c, 0\}] - \gamma$, because when informed, the agent accepts the wage offer whenever $w - c \geq 0$. Finally, the agent makes zero profit if he rejects the offer without gathering information.

Lemma 1 *Consider the case* $E[\max\{E[c] - c, 0\}] - \gamma \leq 0$, *which is equivalent to* $\gamma \geq p(1-p)(c_h - c_l)$. *Then the principal sets* $w = E[c]$ *and the agent does not gather information and accepts.*

Proof. Observe that $E[\max\{E[c] - c, 0\}] = p(1-p)(c_h - c_l)$ because $c_l \leq E[c] \leq c_h$, so that $E[\max\{E[c] - c, 0\}] = p(E[c] - c_l) = p(pc_l + (1-p)c_h - c_l)$. If the principal offers $w = E[c]$, the agent does not gather information (since then $E[\max\{w - c, 0\}] - \gamma \leq 0$) and he accepts the offer, because for this wage offer $w - E[c] = 0$. If the principal set $w > E[c]$, his profit would decrease, because at $w = E[c]$ the principal already gets the expected first-best surplus $R - E[c]$. If the principal set $w < E[c]$, the agent would not gather information (since then $E[\max\{w - c, 0\}] - \gamma < 0$) and he would reject the offer, because in this case $w - E[c] < 0$. ■

Lemma 2 *Consider the case* $E[\max\{E[c] - c, 0\}] - \gamma > 0$, *which is equivalent to* $\gamma < p(1-p)(c_h - c_l)$.

(a) If the principal wants to induce the agent to accept the wage offer without gathering information, then he sets $w = c_h - \frac{\gamma}{1-p}$.

(b) If the principal wants to induce the agent to gather information, then he sets $w = c_l + \frac{\gamma}{p}$.

(c) The principal prefers to induce information gathering if $\gamma < \frac{1-p}{2-p}[p(R - c_l) - (R - c_h)]$.

Proof. (a) The agent accepts the wage offer without gathering information if $w - E[c] \geq 0$ and $E[\max\{w - c, 0\}] - \gamma \leq w - E[c]$. Note that the principal considers only wage offers that satisfy $c_l \leq w \leq c_h$. (If the principal set $w > c_h$, then the agent would accept the offer without information gathering and the principal would be better off by choosing $w = c_h$. If the principal set $w < c_l$, then agent would reject the offer without information gathering, so that the principal would make zero profit, while the principal could make the profit $R - c_h$ by choosing $w = c_h$.) Hence, $E[\max\{w - c, 0\}] - \gamma = p(w - c_l) - \gamma$. This expression is smaller than $w - E[c] = w - (pc_l + (1-p)c_h)$ whenever $w \geq c_h - \frac{\gamma}{1-p}$. Hence, $w = c_h - \frac{\gamma}{1-p}$ is the smallest wage such that the agent accepts the wage offer without gathering information, because then $w - E[c] = c_h - \frac{\gamma}{1-p} - (pc_l + (1-p)c_h) = p(c_h - c_l) - \frac{\gamma}{1-p}$ (which is positive, since $\gamma < p(1-p)(c_h - c_l)$).

(b) The agent's expected profit if he gathers information must be non-negative, $E[\max\{w - c, 0\}] - \gamma \geq 0$, which is equivalent to $w \geq c_l + \frac{\gamma}{p}$ [since $c_l \leq w \leq c_h$, as has been explained in part (a)]. Moreover, the agent must not be better off by accepting the contract without gathering information, $E[\max\{w - c, 0\}] - \gamma > w - E[c]$, which is equivalent to $w < c_h - \frac{\gamma}{1-p}$. Hence, the principal sets $w = c_l + \frac{\gamma}{p}$, because then $w < c_h - \frac{\gamma}{1-p}$ is satisfied since $\gamma < p(1-p)(c_h - c_l)$.

(c) If the principal induces information gathering by setting $w = c_l + \frac{\gamma}{p}$, then the (informed) agent accepts the offer if and only if $c = c_l$, because then $c_l < w < c_h$ (note that $c_l + \frac{\gamma}{p} < c_h$ holds since $\gamma < p(1-p)(c_h - c_l)$). Hence, the principal's expected profit is $p(R - c_l - \frac{\gamma}{p})$. If the principal induces the agent to accept the offer without gathering information by setting $w = c_h - \frac{\gamma}{1-p}$, then his profit is $R - c_h + \frac{\gamma}{1-p}$. ■

Proof of Proposition 2(i). Consider the case $p(R - c_l) \leq R - c_h$. The principal induces the agent to gather information only if $\gamma < p(1-p)(c_h - c_l)$ and $\gamma < \frac{1-p}{2-p}[p(R - c_l) - (R - c_h)]$. However, if $p(R - c_l) \leq R - c_h$, then $\frac{1-p}{2-p}[p(R - c_l) - (R - c_h)] \leq 0$, so that in this case the principal never induces information gathering. Proposition 2(i) then follows immediately from Lemma 1 and Lemma 2(a).

Proof of Proposition 2(ii). Consider the case $p(R - c_l) > R - c_h$. Proposition 2(ii) follows again from Lemma 1 and Lemma 2. Note that now there exist information gathering costs γ such that the principal induces information gathering, because $p(R - c_l) > R - c_h$ is equivalent to $\frac{1-p}{2-p}[p(R - c_l) - (R - c_h)] > 0$. Moreover, there again exist γ such that $w = c_h - \frac{\gamma}{1-p}$, because $\frac{1-p}{2-p}[p(R - c_l) - (R - c_h)] < p(1 - p)(c_h - c_l)$ holds. In order to see this, note that the latter condition is equivalent to $c_h - pc_l - (1 - p)R < p(2 - p)(c_h - c_l)$, which is always satisfied because $R > c_h$.

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Supplementary Material

The following instructions were handed out to the participants in the AI 20-80 treatment:

Experimental Instructions

In this experiment there is always one principal who interacts with one agent. You are randomly assigned either to the role of the principal or to the role of the agent.

The currency in the experiment is called ECU (Experimental Currency Unit).

The experiment consists of only one single period.
The period consists of two stages.

Stage 1:
On the screen you can see whether you have been assigned to the role of the principal or to the role of the agent.

The principal can now make a wage offer w to the agent.
(The wage has to be an integer between 0 ECU and 100 ECU.)

If the agent accepts the wage offer in stage 2, the principal obtains a return of 100 ECU and the agent incurs costs c.

The principal knows only that the agent's costs c are either c = 20 ECU or c = 80 ECU with equal probability.

Stage 2:
The agent learns the principal's wage offer and whether his costs are c = 20 ECU or c = 80 ECU.
Then the agent can decide whether to accept or reject the wage offer.

The profits are as follows:

If the agent accepts the wage offer:
Principal's profit: 100 ECU - w
Agent's profit: w - c

If the agent rejects the wage offer:
Principal's profit: 0 ECU
Agent's profit: 0 ECU

The following instructions were handed out to the participants in the IG 20-80 treatment:

Experimental Instructions

In this experiment there is always one principal who interacts with one agent. You are randomly assigned either to the role of the principal or to the role of the agent.

The currency in the experiment is called ECU (Experimental Currency Unit).

The experiment consists of only one single period.
The period consists of two stages.

Stage 1:
On the screen you can see whether you have been assigned to the role of the principal or to the role of the agent.

The principal can now make a wage offer w to the agent.
(The wage has to be an integer between 0 ECU and 100 ECU.)

If the agent accepts the wage offer in stage 2, the principal obtains a return of 100 ECU and the agent incurs costs c.

At this stage both parties know only that the agent's costs c are either c = 20 ECU or c = 80 ECU with equal probability.

Stage 2:
The agent learns the principal's wage offer.

Before accepting or rejecting the principal's wage offer, the agent can decide if he wants to gather information to learn the exact level of his costs c. Information gathering means that the agent has to incur additional costs of 6 ECU.

- If the agent does not gather information, the profits are as follows:

  If the agent accepts the wage offer:
  Principal's profit: 100 ECU - w
  Agent's profit: w - c

  If the agent rejects the wage offer:
  Principal's profit: 0 ECU
  Agent's profit: 0 ECU

  Observe that in this case the agent does not yet know the exact level of his costs c when he decides whether to accept or reject the wage offer.

- If the agent gathers information, the profits are as follows:

  If the agent accepts the wage offer:
  Principal's profit: 100 ECU - w
  Agent's profit: w - c - 6 ECU

If the agent rejects the wage offer:

Principal's profit: 0 ECU
Agent's profit: -6 ECU

Observe that in this case the agent knows whether his costs are c = 20 ECU or c = 80 ECU when he decides whether to accept or reject the wage offer.

The instructions for the AI 40-60 (IG 40-60) treatment were identical to those of the AI 20-80 (IG 20-80) treatment, except that throughout c = 20 ECU was replaced by c = 40 ECU and c = 80 ECU was replaced by c = 60 ECU.

Furthermore, at the end of each of the four different instructions, the following information was provided:

Your payoff:
In addition to the (possibly negative) profit realized in the experiment you get 90 ECU and the resulting amount is paid out to you at an exchange rate of 0.14 € per ECU.

Please note:
During the whole experiment communication is not allowed. If you have a question, please raise your hand out of the cabin. All decisions are anonymous; i.e., no participant ever learns the identity of a person who has made a particular decision. The payment is conducted anonymously, too; i.e., no participant learns what the payoff of another participant is.