Moral Hazard and Screening in an Experimental Market

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Abstract

In contracting under asymmetric information, the possibility of screening borrowers by their risk level is of great importance, as shown in recent turbulence in financial markets. In addition, it has consequences on credit rationing and, hence, on the effectiveness of monetary policies by Central Banks. We analyze the screening models by Bester (1985, 1987) in experimental markets. We formulate sets of incentive compatible contracts that consider collateral and interest rates simultaneously, and test them as a mechanism to reveal the borrower's ex ante risk level. We analyze the effect of moral hazard due to ex ante asymmetric information. Our experimental results confirm that borrowers with different risk levels are separated, even in moral hazard settings. Consistent with Bester (1987), we find positive incentive effects in contracts with high collateral.

Keywords: Contracts, Experiments, Incentives, Moral Hazard, Screening

JEL classification: G21, D82, C91

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1. Introduction

Akerlof (1970) showed in his classic 'lemons' paper that asymmetric information led to economic inefficiency. Vickrey (1961) and Mirrlees (1971) initiated a research on mechanism design to minimize or eliminate this inefficiency. In contracting under asymmetric information, without being able to observe the agent's true type, it becomes necessary to devise 'second-best' contracts that lead to separation of types.[1]

In credit markets with asymmetric information, early theoretical studies considered collateral[2] and interest rates in an isolated manner. These studies showed that adverse selection resulted in riskier credit applicants selecting high interest rates, or high collateral (see Stiglitz and Weiss, 1981 and Wette, 1983). Later analyses by Bester (1985) and Chan and Kanatas (1985); however, considered contracts that lead to separation of types by offering rates of interest and collateral simultaneously.[3] Bester (1985) showed that by offering pairs of incentive compatible contracts with different interest rate-collateral combinations, lenders are capable of indirectly distinguishing between borrowers of different risk levels. In his later work, Bester (1987) also considered the possibility of moral hazard due to ex ante asymmetric information. Bester found that the demanded collateral softens the effects of moral hazard, since

[1] See Chiappori and Salanié (2003) for a survey on the vigorous field of the econometrics of contracts.
[2] The type of collateral on which the greatest part of the theoretical work is based on is external collateral (i.e., collateral in form of assets which do not belong to the company). Only a very small number of papers deals with the role of internal collateral (i.e., collateral in form of assets of the business itself. For examples, please refer to Smith and Warner (1979), Stulz and Johnson (1985) and Gorton and Kahn (2000)). Here we concentrate on the first type (external collateral).
[3] See, also, Stiglitz and Weiss (1986, 1992), Besanko and Thakor (1987), Bester (1987), Deshons and Freixas (1987), Igawa and Kanatas (1990), Boot, Thakor and Udell (1991) and Coco (1999).

higher collateral gives incentives to borrowers to choose projects involving a smaller risk.[4]

The possibility of screening borrowers by their risk level is of great importance, as shown in recent turbulence in financial markets (triggered by the fallout from the U.S. sub prime mortgage market). Also, it is of great importance because of its consequences on credit rationing and, hence, on the effectiveness of monetary policies by Central Banks. When creditors offer a menu of contracts inducing the selection of firms, there is a separating equilibrium that reveals information and can resolve rationing.[5] Notwithstanding the relevance of these results, the hypothesis that contracts combining pairs of collateral and interest rates are incentive compatible for borrowers with different risk levels, with or without moral hazard, is yet to be falsified empirically. Empirical tests are difficult to conduct because of the scarcity of micro data on the contractual terms of commercial bank loans, which are usually confidential.[6] Because of these restrictions, most of the existing empirical literature relies on data from surveys, and implicitly assumes that borrowers can correctly and honestly assess their ex ante (project) risk.[7] Given the difficulties inherent with field data, laboratory experiments offer an attractive "complementary" approach, because they make it possible to control, isolate, and vary the factors of interest while keeping all others constant.

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[4] A more detailed discussion of the existing theoretical literature can be found in Coco (2000) and Cressy (2003).

[5] Not all studies that consider collateral as a mechanism to learn about the risk level of borrowers reach these conclusions. Work by Leland and Pyle (1977) and Stiglitz and Weiss (1986, 1992) also use collateral requirements and show that these might not be enough to eliminate credit rationing.

[6] Some evidence has been generated on the effect of collateral in an isolated manner (i.e., not in combination with interest rates). Hester (1979), Leeth and Scott (1989), Berger and Udell (1990), Boot, Thakor and Udell (1991), Machauer and Weber (1998), Jimenez and Saurina (2004), and Burke and Hanley (2006) examine the characteristics of loans with collateral to establish a relationship between collateral and credit risk. All of these papers, except Machauer and Weber, show that collateral is greatly correlated to higher risk.

[7] This assumption is inconsistent with the evidence on overconfidence (see Camerer and Lovallo (1999) and De Meza and Southey (1996)).

In this paper, we perform an experiment designed to test the hypothesis that contracts that combine collateral and interest rates are incentive compatible. In addition, we explore whether moral hazard affect the screening power of incentive compatible contracts as described by Bester (1985, 1987). In the experimental literature, screening has not been studied extensively. Only Shapira and Venezia (1999), Posey and Yavas (2004), and Kubler et al. (2006) study screening experimentally in other contexts. Experimental studies that have examined agents' behaviour in static moral hazard situations include Berg et al. (1992), Epstein (1992), Keser and Willingwer (2000), Anderhub, Gächter, and Königstein (2002), Charness and Dufwenberg (2006).[8] However, no study has considered behavioural elements that affect credit screening in moral hazard settings. Thus, we present the first experimental study on credit screening and, also, the first one that examines credit screening when moral hazard is present.

In the next section, the theoretical model and contrast hypotheses are presented. In section 3, the experimental design and procedures are described. In section 4, the results from the experiment are presented. The final section summarizes the main conclusions and results.

2. Theoretical model and contrast hypothesis

Our analysis follows Bester's (1985 and 1987) models. Bester (1985) considers a credit market with N_i risk neutral firms, which can either be type $i = a$ *or* b, according to their project risk level. Each firm has the possibility of starting a project that requires

[8] Other papers on agents' behaviour in static moral hazard situations concentrate on contract design (Bull, Schotter, and Weigelt (1987), Nalbantian and Schootter (1997); Hackett (1993)) or competition (Plott and Wilde (1982), and Cabrales, Charness and Villeval (2006)).

an initial fixed investment I.[9] The return on the project for firm i is given by the random variable $\tilde{R}_i$, with $0 \leq \tilde{R}_i \leq \bar{R}_i$ and a distribution function $F_i(R) > 0$ for all $R > 0$[10]. As in Stiglitz and Weiss (1981), $\tilde{R}_b$ has a greater risk than $\tilde{R}_a$ according to the second order stochastic dominance criterion. The firms have an initial wealth $W<I$, which together with a loan $B = I-W$ finance the project. Given the size of the loan, B, a credit contract $\gamma = (r, C)$ is specified by the interest rate r and the collateral C. Entrepreneurs may face collateralization costs assumed to be proportional the amount of collateral. When $C > (1+r)B$, the firm would not admit project failure. Therefore, only contracts with $C \leq (1+r)B$ are considered. It is assumed that firm i's project fails if $C+R_i < (1+r)B$, and this becomes observable only after a firm declares project failure. If this happens, the bank becomes the owner of both the investment project and its return. Thus, the expected profit of the project for firm i and a credit contract γ is given by:

$$\Pi_i(\gamma) = E\{max\ [\tilde{R}_i - (1+r)\ B - kC,\ -(1+k)\ C]\} \qquad [1]$$

Banks cannot distinguish loan solicitors by risk; however, they can separate them by offering a pair of contracts $(\gamma_\alpha, \gamma_\beta)$ that are incentive compatible and act as self-selecting mechanisms. The pair $(\gamma_\alpha, \gamma_\beta)$ is incentive compatible if:

$$\Pi_a(\gamma_\alpha) \geq \Pi_a(\gamma_\beta); \qquad \Pi_b(\gamma_\beta) \geq \Pi_b(\gamma_\alpha) \qquad [2]$$

Firm i will invest only if it receives a loan γ such that $\Pi i(\gamma) > (1+\pi)\ W$. As long as a pair of contracts $(\gamma_\alpha, \gamma_\beta)$ is offered, the firm prefers a contract that maximizes its expected profits. Thus, if preferences of investors depend systematically on their types, banks can utilize a menu of contracts with different collateral requirements as self-selection mechanisms. In order to solve the problem of adverse selection, Bester

[9] Given that the required investment is fixed, it is not used as a way to signal information about the risk of the loan applicant. See Milde and Riley (1988) for models in which the investment is used as a signal.

[10] This condition ensures that there is a positive probability of failure as long as the interest payments exceed the collateral.

(1985) concludes that the low risk loan applicants try to differentiate themselves from high risk applicants by accepting higher collateral, as collateral is costly.

The isoprofit curves for the two types of loan applicants are depicted in Fig. 1. Applicant *b's* isoprofit curve has a steeper slope than applicant *a's*, because the first's project is riskier and, by stochastic dominance of second degree, profits are a convex function of the realized returns (*R*). This means that type *a* firms are inclined to accept a higher increment in collateral for a given reduction in interest rates than type *b* firms. This fact makes it possible for the bank to offer different pairs of incentive-compatible contracts.[11]

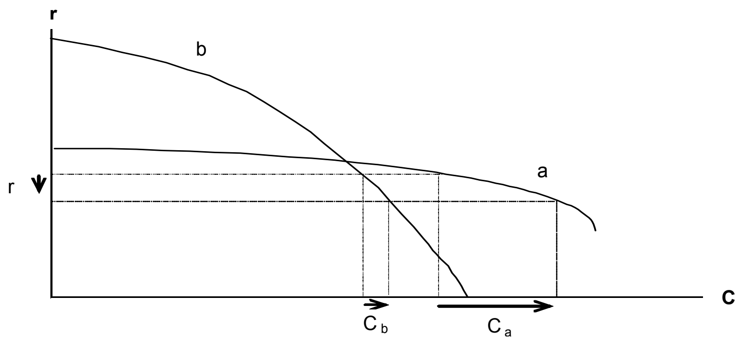


Fig. 1. Borrower's isoprofit curves

In addition to adverse selection, credit contracts also face incentive effects. Perverse incentives arise when the firm has the possibility of choosing projects with different risk levels. Bester (1987) studies this possibility. Moral hazard results from the inability of lenders to control borrowers' choices once the loan has been granted. It is assumed that borrowers do not stop loan payments as long as the returns on the

[11] In Bester (1985), self-selection resulted from stronger assumptions than in Stiglitz and Weiss (1981). To produce a separating equilibrium the additional assumption that $F_i(R) > 0$ for all $R > 0$ is needed. With this assumption, it is possible to have a monotonous relationship between risk and applicants' preferences.

investment allow repayment.[12] However, the investment decision of the firm affects the failure probability and, therefore, the expected profits of the lending firms. A few changes in the model presented previously allow us to study these effects. Bester (1987) considers n investment projects. Each project, i, with $i = 1,...,n$ requires a fixed amount of investment which is financed by a bank loan B. Project i provides a positive return on investment R_i in case the project is successful, which happens with probability p_i. The project fails and provides no return on investment with probability $(1- p_i)$. It is assumed that $1> p_1> p_2>... > p_n> 0$ and $B< R_1< R_2<... < R_n$.[13]. There are N identical firms in the market with the same initial endowment $0< W< B$. Preferences over final wealth are described by a von Neumann-Morgenstern utility function, where $U'>0$, $U''<0$. The expected utility of a firm that applies for a loan $\gamma = (r, C, \lambda)$ is given by $V_i(\gamma)$ if project i is chosen; where λ is the probability of receiving the loan, and $0\leq \lambda \leq 1$. The banks then offer contracts γ_i under the condition that the applicant invests in project i. However, since there is asymmetric information ex ante, these conditions have to be self-imposed by the borrower. That is, credit contracts must be designed so that project i is chosen when the borrower receives a loan γ_i (i.e., with loan γ_i she/he should not want to choose a different project). Contract γ_i is incentive-compatible if:

$$V_i(\gamma_i) \geq V_j(\gamma_i) \text{ for all } j \qquad [3]$$

Bester designs a loan contract as a problem of incentives because the interest payments and collateral requirements affect the choice of the borrower. Thus, if the

[12] This hypothesis excludes another type of moral hazard present in Allen (1983) and Jaffee and Russell (1976). These authors assume that a borrower has an incentive to be opportunistic whenever the size of the loan is superior to the value of the collateral. In this paper, Bester assumes that the legal constraints exclude this possibility. In fact, the wealth of the borrowers is assumed to be lower than the loan. Collateral, then, can merely work as a signaling mechanism and an incentive mechanism. See Benjamin (1978) for an alternative role of collateral requirements.

[13] As a special case of this assumption, projects can be differentiated by the second order stochastic dominance criterion as in Rostchild and Stiglitz (1970). The case, where $p_iR_i= p_jR_j$, has been treated by Stiglitz and Weiss (1981), and Bester (1985).

contracts γ_i and γ_j are incentive-compatible and $r_i \geq r_j$, $C_i \leq C_j$ and $(r_i, C_i) \neq (r_j, C_j)$, Bester shows that project i will be riskier than project j ; $(p_i \leq p_j)$. A safer i project; $(p_j < p_i)$, would violate the assumption of concavity of the utility function would since $Rj>Ri$. Bester concludes that an increase in the interest rate results in a negative effect over the repayment probabilities, whereas an increase in collateral requirements has a positive effect. That is, an increase in collateral makes the riskier project less attractive.

We use experimental methods to analyze incentive compatibility in loan contracts that combine collateral and interest rate requirements under two different environments: first without moral hazard, and then with moral hazard due to ex ante asymmetric information. The aim is to test the effect of moral hazard following Bester (1987). As in theory, we design ad hoc incentive compatible contracts to test the following hypotheses.

Hypothesis 1. By offering two incentive compatible contracts, borrowers can be separated by their risk levels. Lower risk borrowers choose contracts with higher collateral (Separating effect of contracts).

Hypothesis 2. When there is moral hazard generated by ex ante asymmetric information, higher collateral incentive borrowers choose lower risk projects (Positive incentive effect of collateral).

3. Experimental Design and Procedures

An environment was designed in which there are N_i subjects that can have one of the two types i = s (safer) *or* r (riskier), according to the risk level of their project. It is assumed that individuals are risk neutral. Subjects in the experiment can acquire an asset in order to develop their projects with some expected future return. The project of a type s borrower has a return of 600 monetary units in case of success with a probability of 0.9 and a return of zero in case of failure. Type *r* can develop a project that provides a return of 1080 monetary units in case of success and zero in case of failure, each with equal probability.

We offered two contracts for the purchase of the asset. Each contract includes two features: the price to be paid and a security deposit, representing the collateral. In this experimental market, the buyers do not pay for the asset at the time the contract is signed, but at the end of the period when the buyer learns about the return the asset yields. If the project succeeds, they earn the asset's return and pay the contract price. However, if the project fails, they pay the security deposit. Each individual starts each market period with an initial wealth of 300 units; any amount equal to 300 or less can be used as a security deposit. There are five periods in the market and each subject makes five independent decisions (one for each period) in which only the contracts (price and security deposit) change. Each subject must choose one or none of the two offered contracts in each period, whichever he/she prefers. The subjects who do not choose any contract in the period receive a return of 30 monetary units at the end of the period from a risk free investment.

The expected returns for each individual *s* and *r* for acquiring the asset are:

$$ER_s = 0.9\ (300 + 600 - \text{Price}) + 0.1\ (300 + 0 - \text{Deposit}) \quad (1)$$

$$ER_r = 0.5\ (300 + 1080 - \text{Price}) + 0.5\ (300 + 0 - \text{Deposit})$$

In each of the periods, we offered a pair of theoretically incentive compatible contracts (C_1, C_2):

$$ER_s\ (C2) \geq ER_s\ (C1)$$

$$ER_r\ (C1) \geq ER_r\ (C2) \quad (2)$$

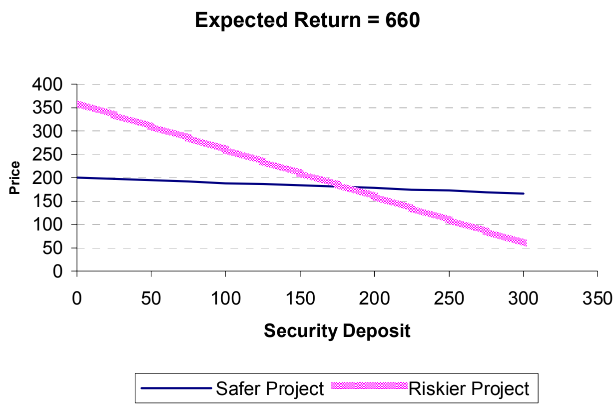


Fig. 2. - Treatment A. Offered contracts and iso-return curves

Table 1 shows the pairs of contracts offered to the subjects in each period. The pairs of contracts vary through periods, progressively decreasing the separation between expected returns to test the sensitivity of different choices.[14] Table 1 also shows Treatment A (described above) with which we test whether the pairs of contracts designed, which combine prices and security deposits, permit the separation of individuals by their risk level. Figure 2 shows the contracts offered and the iso-return curves. The difference in the slopes reflects our hypothesis that individuals with lower failure probability are inclined to accept a higher increment in their security deposit for a given reduction in the asset price compared with individuals with higher failure probability. If this hypothesis is accepted, the security deposit (and asset price) can be used to separate individuals with different project risk. The contracts, hence, are designed to work as mechanisms to separate different types of buyers.

In this experiment we consider the pairs of contracts offered to be incentive compatible because of their differences in the expected returns for the individuals. Hence, we expect that the subjects with safer projects choose Contract C_2 and that the

[14] In the first session, we offered an initial "test" contract to make sure the subjects understood the instructions.

subjects with riskier projects prefer Contract C_1. However, if the subjects were risk averse, the incentive-compatibility of the contracts would depend on their expected utility; and the pair expected return-standard deviation would determine subjects' decisions. Table 1 shows the standard deviations of each of the contracts in each period. In this case, we still expect the riskier, *r* subjects, to prefer Contract C_1.

Table 1
Pairs of offered contracts and expected returns

					Treatment A				Treatment B			
	C_1		C_2		Safer Project		Riskier Project		Safer Project		Riskier Project	
Period	Price	Dep.	Price	Dep.	$ER_s(C_1)$	$ER_s(C_2)$	$ER_r(C_1)$	$ER_r(C_2)$	$ER_s(C_1)$	$ER_s(C_2)$	$ER_r(C_1)$	$ER_r(C_2)$
1	360	0	166	300	516	660.6	660	607	804	800.4	840	688.2
					(72)	(220.2)	(360)	(607)	(411.5)	(653.5)	(824.9)	(1 051.2)
2	335	25	169	275	536	660.4	660	618	809	808.6	830	704.8
					(87)	(211.8)	(385)	(593)	(436)	(639.8)	(847.8)	(1 038.4)
3	310	50	172	250	556	660.2	660	629	814	816.8	820	721.4
					(102)	(203.4)	(410)	(579)	(460.5)	(626.1)	(870.7)	(1 025.6)
4	285	75	175	225	576	660	660	640	819	825	810	738
					(117)	(195)	(435)	(565)	(485)	(612.4)	(893.6)	(1 012.7)
5	260	100	177	200	596	660.7	660	651.5	824	833,8	800	754.9
					(132)	(186.9)	(460)	(551.5)	(509.5)	(599.1)	(916.5)	(1 000.4)

ER(.) Expected returns for each contract under each treatment
Standard deviations are in parenthesis

After making their decisions in Treatment A, all subjects read the instructions for Treatment B. This design permits a within subject comparison. In treatment B, we introduced moral hazard due to ex ante asymmetric information to test the effectiveness of these contracts as a mechanism to separate borrowers with different risk levels. We started within the same, previously described context, the only change being that subjects had the opportunity to make a second decision before learning about the project's success or failure. The second decision was whether to modify the original project. This modification entailed an increase in the projects' expected return and probability of failure. Thus, moral hazard originated from the lack of control that sellers had on the buyers' project choice. Note that in our design, if the buyer was successful, he paid the contract price; thus, we excluded moral hazard derived from the ex post asymmetric information between buyers and sellers.

The second treatment also contained several periods in which each subject $i = s, r$ was offered a pair of incentive compatible contracts. Subjects chose one of these contracts or a risk-free investment, as in Treatment A. The pairs of contracts were identical to those in Treatment A and consequently the expected results, too, in case individuals did not modify original projects. However, when individuals modified original projects, they also modified their expected returns. The modified project of *s* individuals provided a return of 1,200 monetary units in case of success, with a probability of 0.6, and zero in case of failure. For subjects *r,* modifying the original projects had a success probability of 0.3 and resulted in a return of 2 160 monetary units; failure resulted in a payoff equal to zero. Hence, the expected returns for each *s* and *r* subjects for modifying the initial project were:

$$ER_{sm} = 0.6\ (300 + 1\ 200 - \text{Price}) + 0.4\ (300 + 0 - \text{Deposit}) \qquad (3)$$

$$ER_{rm} = 0.3\ (300 + 2\ 160 - \text{Price}) + 0.7\ (300 + 0 - \text{Deposit})$$

Column 3.2 of Table 1 shows expected returns for each contract and each type of subject in case they chose to change the original project. A situation was created in which both types of individuals experienced an increase in their expected return, if they changed the original project.

If the project was modified, subjects *s'* expected return with Contract C_1 was very close to that of Contract C_2, which meant that could lead them to decide to increase the risk of the project regardless of choosing C_1 or C_2. On the other hand, for subjects *r,* modifying their original project had a greater expected return with Contract C_1 than with Contract C_2. Hence, it was expected that the subjects with riskier projects further increased the risk of their project, and were inclined to choose Contract C_1.

We are interested in testing Bester's (1987) hypothesis that contracts with higher collateral have a positive incentive effect on the probability of repayment, making projects with higher failure probability less attractive for borrowers. If this hypothesis is not rejected in the experiments, the individuals that choose to increase the risk of the project must choose Contract C_1, with the lower security deposit in Treatment B.

To control the possible incidence of the subjects' risk aversion, we also calculate the standard deviations in each of the contracts in each period when the original project is modified, see Table 1. Individuals *r* obtain higher returns and lower standard deviations with Contract C_1 than with Contract C_2 either by modifying the initial contract or not. On the other hand, *s* individuals have very similar expected returns with both contracts C_1 and C_2, but a lower risk with Contract C_1. In addition, by changing the initial project, borrowers *s* face higher return, and higher risk. Thus, if preferences are based on expected utility, our expectation is that *s* individuals choose Contract C_1 when modifying original projects.

Experimental Procedures

We organized four experimental sessions with students of Universidad de Valencia (Spain) and Washington and Lee University (USA) as subjects recruited from various courses with flyers. There were 10 participants in each experimental session except the second, which had 14 participants; no single subject participated in more than one session. Each session lasted for one hour and 30 minutes and consisted of 10 periods. After privately assigning their types, riskier or safer, we read the instructions and answered questions. The subjects, in each period, had an initial wealth of 300 monetary units and made their choices privately. During the experiment they were not allowed to communicate with the rest of the participants and each subject only knew their own project success and failure probabilities as well as their returns. After ending the five periods of Treatment A, the subjects read instructions for the five periods of Treatment B.[15] At the end of the session we paid in cash each subject's amount made during five randomly chosen periods from Treatments A and B. Subjects made on average $45.

4. Results

The results of the experiment are summarized in Table 2. There is a total of 440 observations; 230 correspond to Treatment A and 210 correspond to Treatment B. Half of the subjects in the experiment had a riskier project and the other half had a safer project. Figure 3 shows the distribution of the subjects' responses by treatment in each period. The purpose of this experiment is to analyze whether offering a pair of incentive compatible contracts combining collateral and interest rate requirements allows lenders to separate borrowers according to their project risk, both without and with moral hazard. We have two main hypotheses to falsify; the separating power of contracts and the positive incentive effect of collateral.

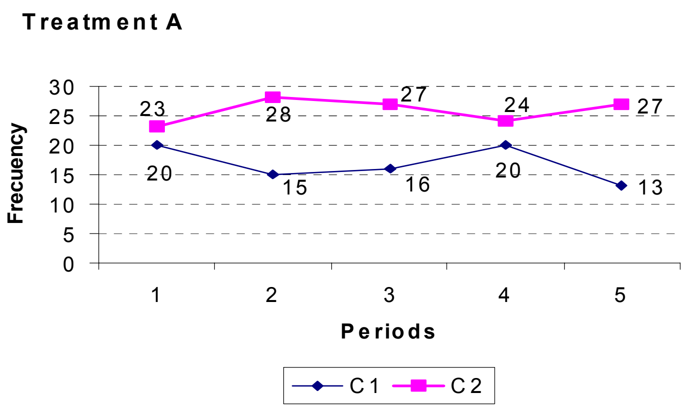
[15] The instructions and other documents used in this experiment are available upon request.

Table 2

Experimental Results

Treatment A				
	Subjects with safer projects		Subjects with riskier projects	
Contracts	Numbers and percentages			
C_1	14	12,7%	70	**63,6%**
C_2	94	**85,5%**	35	31,8%
None	2	1,8%	5	4,5%
Total	110	100%	110	100%

Treatment B			
	Subjects with initial safer projects		
Contracts	Choice	Change project	
C_1	49	49	100%
C_2	56	38	68%
None	5		
Total	110	110	100%



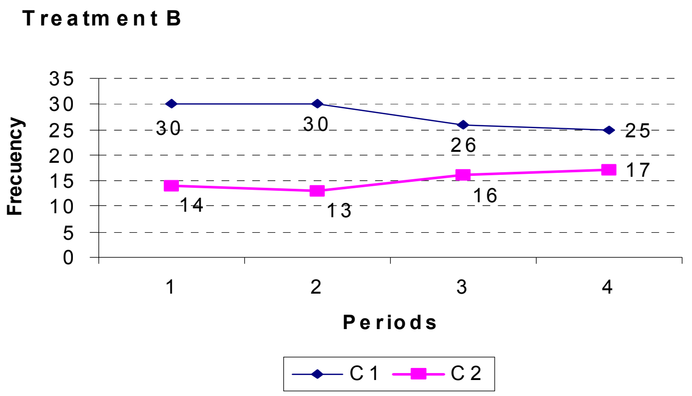


Figure 3. - Offered contracts and experimental results

To test for significance of differences based on chosen contract, we run logit regressions and Analysis of Variance (ANOVA). The variables used for the tests are the following:

CONTRACT: Dummy variable that summarizes the information about collateral and interest rates of a loan. Contract C_1 is given value 0 and Contract C_2 is given 1.

PROJECT: Dummy variable. Riskier projects *r* are given value 0 and safer ones *s* are given value 1.

TREATMENT: Dummy variable. Treatment A (without moral hazard) is given value 0 and Treatment B (with moral hazard) is given value 1.

Table 3 shows the ANOVA results, and normality and homoskedasticity tests.[16] The last column of Table 3 shows that the inter-group differences are significant in both variables (PROJECT and TREATMENT). On average, in our experiments, subjects with safer projects made most of the C_2 choices. In contrast, subjects with riskier projects made most of the C_1 choices. As expected, by offering pairs of incentive compatible contracts, subjects with safer projects chose Contract C_2, and subjects with riskier projects chose Contract C_1.

On the other hand, the variable TREATMENT shows how contract choices compare in Treatment A and Treatment B. On average, Contract C_2 was chosen more frequently under Treatment A (without moral hazard), and Contract C_1 was chosen more often under Treatment B (with moral hazard). The mean differences are statistically significant. On average, subjects with initial safer projects willing to change to a riskier one (after the loan is granted) choose contract C_1 (see Treatment B in

[16] Normality and homogeneity of variance tests for each of the exogenous variables are also shown in Table 3. The two variables PROJECT and TREATMENT followed a distribution clearly different from normal, as expected. With respect to the homogeneity of variance, the null hypothesis of equal variances in the two groups cannot be rejected. However, the lack of normality requires caution in the interpretation of the F of Snedecor.

Table 2). Thus, the contracts successfully screen the borrowers by their project risk level, even in this moral hazard environment. Again, we do not find that a high collateral requirement leads to an adverse selection of borrowers. We find support to the positive incentive effect of collateral.

Table 3

Test of differences based on contract choice.

	Normality and homoskedasticity test			Analysis of Variance		
variables	**Kolmogorov-Smirnov* Contract C_1**	**Kolmogorov-Smirnov* Contract C_2**	**Levene's Test**	**Mean** Contract C_1**	**Mean** Contract C_2**	**F**
PROJECT	0.449	0.454	0.163	0.29	0.72	98.260
(safe =1)	(0.000)	(0.000)	(0.687)	(0.45)	(0.45)	(0.000)
TREATMENT	0.391	0.417	4.596	0.60	0.35	11.544
(moral hazard =1)	(0.000)	(0.000)	(0.033)	(0.49)	(0.48)	(0.001)

*Correction of the significance of Lilliefors.

**Standard deviations are in parenthesis.

Levels of significance are in parenthesis

In the logit regression, the dependent variable is CONTRACT; and the independent variables are PROJECT and TREATMENT. For this analysis, we excluded from the total of the observed subject choices risk-free investment decisions. Hence, we analyzed 427 choices only, 219 of Contract C_1 and 208 of Contract C_2. The variable selection method was the forward stepwise process of the likelihood ratio. Table 4 summarizes the results.

The positive coefficient for the variable PROJECT indicates that the safer the project, the greater the probability of choosing Contract C_2. This result confirms the significance of the differences between subjects with safer projects and subjects with riskier projects mentioned above. Hence, high collateral combined with an adequate low rate of interest (i.e., Contract C_2) principally attracts subjects with safer projects.

Moreover, this result suggests that high collateral does not generate adverse selection of borrowers. The negative coefficient for the TREATMENT variable shows that in Treatment B (with moral hazard), the likelihood of choosing C_2 is lower than in Treatment A, confirming the result of the analysis of variance. With respect to the goodness of fit, Table 4 shows that each of the coefficients is significantly different from zero. The two variables are jointly significant when determining the probability of selecting Contract C_2. The chi-square with two degrees of freedom, $-2\ Ln\ \lambda_{LR}$, reaches 113.912 and a significance level of 0.000, which indicates that the null hypothesis according to which βj are both zero must be rejected. In addition, a correct classification of 71.66% is obtained using this function.

Table 4
Logit Results

Treatments A and B.

CONTRACT is the endogenous variable (value 0 given to contract C_1 (219 observations) and value 1 given to contract C_2 (208 observations)). Dummy PROJECT (safe=1). Dummy TREATMENT (B or moral hazard=1)

Const.	-0.4761 (7.1822)
PROJECT	2.0037*** (75.4433)
TREATMENT	-1.2396*** (28.7929)
$-2Ln\lambda_{LR}$	113.912***
Cox-Snell R^2	0.234
Nagelkerke R^2	0.312
Correct classification	71.66%

*** Significant at the 1% level.
Wald statistics are in parenthesis.

5. Conclusions

We conducted an experiment based on models of contracting under asymmetric information that closely follows Bester (1985, 1987). The main predictions of these models is that by offering a menu of contracts that combine different levels of interest rates and collateral, borrowers can be separated by their risk level. In addition, these contracts are able to soften the effects of moral hazard. Despite of the important implications of these theories on economic policy, empirical studies, so far, have been limited in their ability to examine the incentive compatibility of this menu of contracts. Individualized information on loan contract features is unusual and does not include a direct and objective approximation to the ex ante unobservable borrower risk. In contrast, in the lab, the experimenter is able to control the variables that are unobserved in the field. This control provides a unique advantage for empirically testing predictions of the above mentioned models.

Consistent with theory, we found evidence that by appropriately combining collateral with the interest rate, borrowers with different risk levels are separated; borrowers with higher risk tend to ask for loans without collateral and with higher interest rates. Hence, we provide support for the predictions of screening models of Bester (1985, 1987), Chan and Kanatas (1985), Besanko and Thakor (1987), Deshons and Freixas (1987), Igawa and Kanatas (1990), Stiglitz and Weiss (1986, 1992), Boot, Thakor and Udell (1991) and Coco (1999).

Moreover, our experimental results also showed that the separating effect of this menu of contracts remains even in moral hazard settings. Consistent with Bester (1987), we found positive incentive effects of contracts with high collateral. More specifically, contracts with higher collateral make subjects less likely to increase the probability of failure of their projects in an environment with moral hazard.

References

Akerlof, G. (1970). "The market for 'Lemons': Quality Uncertainty and the Market Mechanism. *Quarterly Journal of Economics*, 84, 488-500.

Allen, F. (1983). Credit rationing and payment incentives. *Review of Economics Studies*, 50, 639-646.

Anderhub, V., Gächter, S., & Königstein, M. (2002). Efficient Contracting and Fair Play in a Simple Principal-Agent Experiment. *Experimental Economics*, 5, 5-27.

Benjamin, D. (1978). The use of collateral to enforce debt contracts. *Economic Inquiry*, 16, 333-359.

Berg, J., Daley, L., Dickhaut, J., & O'Brien, J. (1992). Moral Hazard and Risk Sharing: Experimental Evidence. In Mark Isaac (Ed.), *Research in Experimental Economics* (Vol. 5, pp. 1-34). Greewich: JAI Press Inc.

Berger, A. N., & Udell, G. F. (1990). Collateral, loan quality and bank risk. *Journal of Monetary Economics*, 25, 21-42.

Besanko, D., & Thakor, A. (1987). Collateral and rationing: sorting equilibria in monopolistic and competitive credit markets. *International Economic Review*, 28, 3, 671-689.

Bester, H. (1985). Screening vs. rationing in credit markets with imperfect information. *American Economic Review*, 75, 4, 850-855.

Bester, H. (1987). The role of collateral in credit markets with imperfect information. *European Economic Review*, 31, 887-899.

Boot, A. W. A., Thakor, A. V., & Udell, G. F. (1991). Secured lending and default risk: Equilibrium analysis and policy implications and empirical results. *Economic Journal*, 101, 458-472.

Bull, C., Schotter, A., & Weigelt, K. (1987). Tournaments and Piece Rates: An Experimental Study. *Journal of Political Economy*, 95, 1-33.

Burke, A., & Hanley, A. (2006). Bank interest margins and business start-up collateral: testing for convexity. *Scottish Journal of Political Economy*, 53, 3, 319-334.

Cabrales, A., Charness, G., & Villeval, M. C. (2006). Competition, Hidden Information and Efficiency: An Experiment. *IZA Bonn Discussion Paper* nº 2296.

Camerer, C., & Lovallo, D. (1999). Overconfidence and Excess Entry: An Experimental Approach. *American Economic Review*, 89, 1, 306-318.

Chan, Y. S., & Kanatas, G. (1985). Asymmetric valuations and the role of collateral in loan agreements. *Journal of Money, Credit and Banking*, 17, 84-95.

Charness, G., & Dufwenberg, M. (2006). Promises and Pertnership. *Econometrica*, 74, 6, 1579-1601.

Chiappori, P. A., & Salanié, B. (2003). Testing Contract Theory: A Survey of Some Recent Work. In Dewatripont, M., Hansen, L., and Turnovsky, S. (Ed.), *Advances in Economics and Econometrics* (vol. 1). Cambridge: Cambridge University Press.

Coco, G. (1999). Collateral, heterogeneity in risk attitude and the credit market equilibrium. *European Economic Review*, 43, 559-574.

Coco, G. (2000). On the use of collateral. *Journal of Economic Surveys*, 14, 2, 191-214.

Cressy, R. (2003). Credit constraints on small businesses: theory versus evidence. *International Journal of Entrepreneurship Education*, 1, 4, 515-538.

De Meza , D., & Southey, C. (1996). The borrower's curse: optimism, finance and entrepreneurship. *Economic Journal*, 106, 435, 375-386.

Deshons, M., & Freixas, X. (1987). Le rôle de la garantie dans les contrats de prêt bancaire. *Finance*, 8, 1, 7-32.

Epstein, S. (1992). Testing Principal-Agent Theory. In Mark Isaac (Ed.), *Research in Experimental Economics* (vol. 5, pp. 35-60). Greenwich: JAI Press Inc.

Gorton G., & Kahn, J. (2000). The design of bank loan contracts. *Review of Financial Studies*, 13 (2), 331-64.

Hackett, S. (1993). Incomplete contracting: A laboratory experimental analysis. *Economic Inquiry*, 21, 274-297.

Hester, D. (1979). Customer relationships and terms of loans: Evidence from a pilot survey. *Journal of Money, Credit and Banking*, 11, 349-357.

Igawa, K., & Kanatas, G. (1990). Asymmetric information, collateral, and moral hazard. *Journal of Financial and Quantitative Analysis*, 25, 4, 469-490.

Jaffee, D. M., & Russell, T. (1976). Imperfect information, Uncertainty, and Credit Rationing. *Quarterly Journal of Economics*, 90, 651-666.

Jiménez, G., & Saurina, J. (2004). Collateral, Type of Lender and Relationship Banking as Determinants of Credit Risk. *Journal of Banking & Finance*. 28 (9). 2191-2212.

Keser, C., & Willinger, M. (2000). Principal-Agent Relations with hidden actions: An experimental Investigation. *International Journal of Industrial Organization*, 18, 163-185.

Kübler, D, Müller, W, & Normann, H.T (2006). *Job market signaling and screening: An experimental comparison*. Working paper. Tilburg University.

Leeth, J. D., & Scott, J. A. (1989). The incidence of secured debt: evidence from the small business community. *Journal of Financial and Quantitative Analysis*, 24 (3), 379-394.

Leland, H. E., & Pyle, D. H. (1977). Informational Asymmetries, financial structure and financial intermediation. *Journal of Finance*, 32, 371-387.

Machauer, A., & Weber, M. (1998). Bank behavior based on internal credit ratings of borrowers. *Journal of Banking and Finance*, 22, 1355-1383.

Milde, H., & Riley, J. (1988). Signaling in credit markets. *Quarterly Journal of Economics* 103, 101-129.

Mirrlees, J. A. (1971). An exploration in the theory of optimum income taxation. *Review of Economic Studies*, 38(114), 175-208.

Nalbantian, H. R., & Schotter, A. (1997). Productivity under group incentives: An experimental study. *American Economic Review*, 87, 314-341.

Plott, C., & Wilde, L.L. (1982). Professional diagnosis vs. self-diagnosis: An experimental Investigation of some special features of markets with Uncertainty. In *Research in Experimental Economics* (vol. 2, pp. 63-112). JAI Press.

Posey, L.L., & Yavas, A. (2004). *Screening equilibria in experimental markets*. Working paper. Penn State University.

Rostchild, M., & Stiglitz, J. (1970). Equilibrium in competitive insurance markets: an essay on the economics of imperfect information. *Quarterly Journal of Economics*, 90, 630-649.

Shapira Z., & Venezia, I. (1999). Experimental test of self-selection and screening in insurance decisions. *The Geneva Papers on Risk and Insurance Theory*, 24, 139-158.

Smith, C. W., Warner, J. B. (1979). Bankruptcy, Secured Debt, and Optimal Capital Structure: Comment. *Journal of Finance*, 34 (1), 247-51.

Stiglitz, J. E., & Weiss, A. (1981). Credit rationing in markets with imperfect information. *American Economic Review*, 71, 3, 393-410.

Stiglitz, J. E., & Weiss, A. (1986). Credit rationing and collateral. In Edwards, J., Franks, J., Mayer, C., Schaefer, S. (Eds.), *Recent developments in Corporate Finance* (pp. 101-135). New York: Cambridge University Press

Stiglitz, J. E., & Weiss, A. (1992). Asymmetric information in credit markets and its implications for macro-economics. *Oxford Economic Papers,* 44, 694-724.

Stulz R.M., Johnson, H. (1985). An Analysis of Secured Debt. *Journal of Financial Economics*. 14 (4). 501-21.

Vickrey, W. (1961). Counterspeculation, Auctions, and Competitive Sealed Tenders. *Journal of Finance*, 16, 8-37.

Wette, H., 1983. Collateral in credit rationing in markets with imperfect information. *American Economic Review*, 73, 3, 442-445.