Moral Hazard and Collateral as Screening Device:
Empirical and Experimental Evidence*

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Abstract

This paper tests the separating role of contracts that involve both interest rates and collateral in credit markets with asymmetric information. To test this prediction data from real credit markets and controlled experiments are used. Using a sample of credits to small and medium-sized firms in Valencia, Spain, we relate two different types of contracts with an objective approximation to each ex ante borrower risk, i.e., the real outcome of each loan and other relevant variables. Moreover, two incentive compatible contracts are designed and decisions analyzed under two different experimental treatments, one with moral hazard. Results confirm that borrowers of lower risk choose contracts with higher collateral and a lower interest rate. However, it is ascertained that moral hazard reduces separation.

JEL classification: G21, D82, C92

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1. Introduction

Leading theoretical studies about the role of collateral in credit markets with asymmetric information\(^1\) consider the effect of collateral in an isolated manner showing that adverse selection and moral hazard imply that riskier credit applicants select high collateral requirements (Stiglitz and Weiss, 1981 and Wette, 1983). Later analyses by Bester (1985b) and Chan and Kanatas (1985) demonstrate that, by treating collateral requirements together with variations in interest rates, collateral is negatively related to

\(^1\)The type of collateral on which the greatest part of theoretical work concerning asymmetric information is based, is external collateral, i.e., collateral in form of assets which do not belong to the company; assets which the lender might otherwise not claim. 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 (see Smith and Warner (1979), Stulz and Johnson (1985) and Gorton and Kahn (2000)). Here we concentrate merely on the first type.
the borrower’s risk.² Bester (1985b) shows that lenders are capable of indirectly distinguishing between borrowers of different risk levels by offering pairs of incentive compatible contracts with different interest rate-collateral combinations. In his later work, Bester (1987) considers moral hazard because of ex ante asymmetric information and reinforces previous conclusions. In addition, he suggests that the demanded collateral softens the effects of moral hazard, since higher collateral gives incentives to borrowers to choose projects involving a smaller risk.³ The possibility of separating borrowers by their risk level is of great importance because of its consequences on credit rationing and, hence, on the effectiveness of monetary policies by central banks.⁴ 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 is yet to be verified empirically. Unfortunately, empirical tests of the theories of the static relationship between collateral and credit risk are difficult to conduct because of the scarcity of micro data on the contractual terms of commercial bank loans, which are usually confidential. In spite of this, some evidence has been generated on the effect of collateral in an isolated manner. Hester (1979), Leeth and Scott (1989), Berger and Udell (1990), Boot, Thakor and Udell (1991) and Machauer and Weber (1998) examine the characteristics of loans with collateral to establish a

³ A more detailed discussion of the existing theoretical literature can be found in Coco (2000)
⁴ To classify borrowers, other studies introduce loans of variable sizes (Bester (1985a), Milde and Riley (1988) and Grinblatt and Hwang (1989)). On the other hand, work by Leland and Pyle (1977) and Brennan and Kraus (1987) suggests that the firm’s equity could be used to classify borrowers.
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.
relationship between collateral and risk\textsuperscript{6}. All these papers, except Machauer and Weber, show that collateral is greatly correlated to higher risk. Most of this research uses measures of \textit{ex ante} observable risk to approximate to the real borrower risk of a concrete loan. Hester (1979) and Machauer and Weber (1998) concentrate on the borrower credit \textit{rating}. Leeth and Scott (1989) use the “company age”. Berger and Udell (1990), who developed two tests, use the risk premium of the interest rate in the first one. The loan risk premium (dependent variable) is regressed on measures of collateral and on several control variables in a cross-section analysis. In the second test, introducing a novelty in this kind of research, they try to corroborate their previous results by examining the performance of borrowers and loans on an \textit{ex post} basis. Net charge-offs (charge-offs minus recoveries) as a measure of loan risk and several non-performing characteristics (past due, nonaccrual and renegotiated status) are used as measures of borrower risk. However, as the required data is not individually reported, aggregate data are used. Our analysis differs from previous empirical work because our database allows us to use a more direct approximation to each credit applicant risk level (privately known to him/her and, consequently, \textit{ex ante} unobservable), i.e. his/her real or \textit{ex post} insolvency.

Also, this paper differs from previous work as we analyze the effect of the combination collateral/interest rate in each loan under moral hazard, which allows us to test the empirical implications of theoretical models concerning the role of collateral in incentive compatible contracts. Moreover, as far as we know, we present the first experimental study in this field. According to most of the previous papers, and also limited by our database, our analysis is restricted to small and medium-sized firms.

\textsuperscript{6} Moreover, Orgler (1970) evaluates credit applications including collateral as an explanatory variable so that, indirectly, evidence is provided on the relationship between collateral and credit risk.
We first use data collected from real credit markets considering two types of contracts: one with external collateral and a low interest rate, and the other without collateral and a high interest rate. The hypothesis to be tested is that by offering this menu of contracts credit applicants are “separated” according to their ex ante unobservable risk. Given the limitations we face with the data, we propose to complement our study with experiments. In particular, we design an experiment that would control for some key factors, such as moral hazard.

In the next section, the theoretical model and contrast hypotheses are presented. In section 3, the empirical analysis, the database, the design of the test and its results are described. In section 4, the experimental design, the treatments, and 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 the level of risk of their projects. Each firm has the possibility of starting a project that requires an initial fixed investment $I$. 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 $R > 0$. 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

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7 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.

8 This condition ensures that there is a positive probability of failure as long as the interest payments exceed the collateral.
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 the investment project and its return. Thus, the expected profit of the project for firm \( i \) and a credit contract \( \gamma \) is given by:

\[
\prod_i(\gamma) = E\{\max [R_i - (1+r) B - kC, -(1+k) C]\} \quad [1]
\]

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:

\[
\prod_a(\gamma_\alpha) > \prod_a(\gamma_\beta); \quad \prod_b(\gamma_\beta) > \prod_b(\gamma_\alpha) \quad [2]
\]

Firm \( i \) will invest only if it receives a loan \( \gamma \) such that \( \prod_i(\gamma) > (1+\pi) W \). 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 (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 Figure 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.

\[\text{According to Rostchild and Stiglitz (1970)}\]
This fact makes it possible for the bank to offer different pairs of incentive-compatible contracts.\textsuperscript{10}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{isoprofit_curves.png}
\caption{Borrowers' isoprofit curves}
\label{fig:isoprofit}
\end{figure}

\begin{center}
Source: Own elaboration
\end{center}

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 investment allow repayment.\textsuperscript{11} The investment decision of the firm affects the failure probability and, therefore, the profit 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 \( i = 1,\ldots,n \) 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

\textsuperscript{10} 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.

\textsuperscript{11} 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.
project fails and provides no (0) return on investment with probability \((1 - p_i)\). It is assumed that \(1 > p_1 > p_2 > \ldots > p_n > 0\) and \(B < R_1 < R_2 < \ldots < R_n\). 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, \(U\), 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, the parameter \(\lambda, 0 < \lambda \leq 1\), is the probability of receiving the loan. The banks then offer contracts \(\gamma_i\) under the condition that the applicant invests in project \(i\). However, since there is asymmetric information \textit{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 \(\gamma_i\) (i.e., with loan \(\gamma_i\) she/he should not want to choose a different project). Contract \(\gamma_i\) is incentive-compatible if:

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

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 contracts \(\gamma_i\) and \(\gamma_j\) 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 \(j\) \((p_i < p_j)\). Indeed, if \(p_j\) were less than \(p_i\), the assumption of concavity of the utility function would be violated since \(R_j > R_i\). Bester concludes that an increase in the interest rate results in a negative effect over the repayment probabilities, whereas an increase in collateral requirements results in a positive effect. That is, an increase in collateral makes the riskier project less attractive.

Our objective is to contrast and compare the Bester’s (1985) results about the separating power of incentive compatible contracts defined as a collateral-rate pair and

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12 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 \(p_i R_i = p_j R_j\), has been treated by Stiglitz and Weiss (1981), and Bester (1985).
the incentives that collateral requirements create when there is moral hazard (Bester 1987). Hence, in section 3, we measure the separating role using data from a sample of credits given to small and medium size firms in Spain between 1982 and 1989. More specifically, we test the following hypothesis: \( H_1: \) two contracts, one with high collateral and a low rate and the other without collateral and a higher rate allows credit applicants to separate according to their risk levels. The lower risk borrower chooses the first contract and the higher risk borrower chooses the second contract.

Experimental techniques can be used to overcome inherent obstacles in the data collection of real markets by creating data under controlled environments; thus, in section 4, 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 \textit{ex ante} asymmetric information. The aim is to test the effect of moral hazard following Bester (1987). Given that theoretically \textit{ad hoc} incentive compatible contracts were designed, we reformulate the hypotheses as described below to design two adequate tests.

Hypothesis \( H_{1E}: \) 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 collateral).

Hypothesis \( H_{2E}: \) When there is moral hazard generated by \textit{ex ante} asymmetric information, higher collateral incentive borrowers choose lower risk projects (i.e., there is a positive incentive effect of collateral).

3. Empirical Analysis

3.1 Cross-section data and test description

In the test we established a relationship between the dummy variable that represents the combination collateral/interest rate for each individual borrower and an
objective approximation to the credit applicant *ex ante* risk level, i. e., his/her real or *ex post* insolvency, and some control variables through an analysis of variance with one factor (ANOVA) and through the logit analysis.

Our source of information is the Sociedad de Garantia Reciproca (SGR) of Land of Valencia. The SGRs are financial entities that facilitate the access to credit to small and medium-sized firms by guaranteeing loans these firms obtain from the banking system.\(^\text{13}\) When SGRs guarantee a loan, there is a transfer of the credit risk from the lender to the SGR. This means that, although SGRs do not give the loans, they accept the risk of the loans. Hence, SGRs bear with the effects of asymmetric information and, to mitigate its negative effects, they can decide to increase the collateral required or ration credit.\(^\text{14}\)

Only all SGR operations dealing with loans given to small and medium-sized firms, i.e. firms with less than 250 employees,\(^\text{15}\) were considered\(^\text{16}\). Thus, individualised information of 3,875 loans formalised from January 1\(^\text{st}\), 1982 to May 31\(^\text{st}\), 1998 is obtained. Of these, 2,729 (70%) had security provided by a guarantor, 305 (8%) had real asset external collateral (i.e. assets not belonging to the company), and 841 (22%) had no collateral\(^\text{17}\). All loans correspond to PLCs, limited liability companies,

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\(^\text{13}\) SGR are financial institutions that represent small and medium size firms and channel funds from banks that provide the loans. Their functions are to provide advise, assist and back firms. They are a hybrid between an anonymous society and cooperatives. They are for profit, but work under legal restrictions on how they divide the dividends (dividends must be accumulated as reserves in a guarantee fund). The SGR also receive help from the government. One of their tasks is to evaluate the risk of their clients’ projects before backing them. Although the SGR do not provide financing to firms, the facilitate loans for small and medium size firms. Hence, the information that the SGR of Valencia provides about risk is useful since they are independent from the banks. To obtain further information on this type of societies in Spain and other countries, please refer to Ramirez-Comeig and Ferrando-Bolado (1999).

\(^\text{14}\) More precisely, the SGR can react rationing their guarantee, which can indirectly result in credit rationing, i.e if a small business does not have a SGR guarantee, it will find itself with more difficulties to access credit from the banking system.

\(^\text{15}\) The Law concerning SGRs states that a small and medium-sized firm is one that has less than two hundred and fifty employees.

\(^\text{16}\) The SGR of Valencia has provided us with an anonymous list of the individual characteristics of each of the transactions it backed since January 1982 until May 1998. A total of 24,355 transactions were recorded, 6,473 of which were loans given to firms with less than 250 workers.

\(^\text{17}\) In these contracts, the SGR does not require collateral, although all loans are backed by the SGR.
and sole proprietors. As the aim is to explore whether the borrowers with loans combining high collateral with a low interest rate are less willing to take risks than those with loans with a high interest rate and no collateral, only these two “extreme” groups of loans were selected.\textsuperscript{18} Thus, loans are classified according to the difference between the initial interest rate and the legal interest rate in Spain at the same time and term (differential rate). Then, loans with a negative differential rate and real external collateral and loans with a positive differential rate (2 percentage points) and no collateral are chosen.

In this manner, we obtain individualized information concerning 323 loans granted by 28 different financial institutions. Among these loans, there are 172 combining real asset collateral with a low rate of interest, called Contract C\textsubscript{2}, and 151 loans combining no collateral with a higher interest rate, called Contract C\textsubscript{1}. We expected the insolvency rate of the borrowers with Contract C\textsubscript{2} to be significantly lower than the one for borrowers with Contract C\textsubscript{1}. The variables used in this test are the following:

- **Endogenous variable:**
  CONTRACT: Dummy variable that summarizes the information about collateral and interest rates of a loan being given a value of 0 for Contract C\textsubscript{2} and 1 for Contract C\textsubscript{1}.

- **Exogenous variables:**
  OUTC: Dummy variable that indicates the outcome of the loan being given a value of 0 if the outcome is *insolvency* and 1 otherwise. We define *insolvency* as the incapacity to fulfil loan obligations, including temporary failure.
  SIZE: Measures loan size in local currency, pesetas.
  TERM: Defines the term of the loan in months.

\textsuperscript{18} Loans with an intermediate rate of interest and those with security provided by a guarantor were excluded as the objective was to deal with theoretically incentive-compatible contracts.
DEST: Dummy variable measuring the loan destination being given a value of 0 when the loan is used to start a new business and 1 otherwise.

EMPL: Number of borrower’s employees.

FIRMTYPE: We used this variable in the analysis of variance to characterize the type of the borrower’s firm being given a value of 0 for sole proprietors, 1 for limited companies, and 2 for PLCs. ¹⁹

FIRMTYPE (1): Given a value of 1 for sole proprietors and 0 for limited companies and for PLCs.

FIRMTYPE (2): Given a value of 1 for limited companies and 0 for sole proprietors and for PLCs.

The most relevant exogenous variable is the outcome of the loan, OUTC, since it constitutes the approximation to the \textit{ex ante}, i.e. privately known, borrower risk which is the basis of the separating hypothesis. Given that this risk is not observable, an approximation becomes necessary. Instead of using an indirect approximation, we use the real or \textit{ex post} loan outcome (0= insolvency, 1= otherwise) as it represents an objective measure of the borrower risk concerning this particular loan. Our definition of \textit{ex post} insolvency includes any delaying payment, not only legal insolvency. ²⁰ The rest of the variables play a double role. On the one hand, they specify information about the type of loan or borrower related to each combination collateral/interest rate and, on the other hand, they are also used as control variables since they are indicators of the \textit{ex ante} borrower’s risk. Unfortunately, our data base is not sufficient to consider all the relevant control variables, which was taken into account at the time of the analysis of

¹⁹ In the logit analysis, we characterise the type of firm by the dummy variables FIRMTYPE(1) and FIRMTYPE(2). When both of these are given a value of 0, the firm is a PLC.

²⁰ The real or \textit{ex post} outcome of each loan is usually confidential information known only to the bank and the respective client. Therefore previous empirical research uses more or less indirect measures of the \textit{ex ante} non-observable borrower risk. We had access to the \textit{ex post} loan outcome from an anonymous database. Such database contained the most relevant characteristics of loans guaranteed by the SGR of Valencia from 1982 to 1998, which we used as a proxy.
results. Using qualitative variables to measure collateral and interest rates we hope to soften some of the seasonal and business cycle effects.\textsuperscript{21}

Finally, to test whether the logit function is robust against a change in the sample, the total sample is divided into two sub-samples. The estimation sub-sample is composed of formalized loans from January 1\textsuperscript{st}, 1983 to May 31\textsuperscript{st}, 1998 consisting of 172 loans of Contract C\textsubscript{2}, and 131 loans of Contract C\textsubscript{1}. The validation sub-sample is composed of the 20 loans formalized in 1982, all without collateral and high interest rate.\textsuperscript{22}

\textbf{3.2. Empirical Results}

\textbf{3.2.1 Results of the Analysis of Variance}

Table 1 gives the results of the analysis of variance\textsuperscript{23}. Each of the exogenous variables clearly differentiate the two types of contracts, except FIRMTYPE(1); as shown by the F statistics. Most of the firms with loans that combine real asset collateral and low interest are limited companies and sole proprietors. PLCs have a greater presence in the group of loans without collateral and with higher rates, as shown by the mean values of the variables FIRMTYPE, FIRMTYPE (1) and FIRMTYPE (2). Moreover, Contract C\textsubscript{2} is held by companies with a smaller number of employees, higher mean term and higher import than those opting for Contract C\textsubscript{1}. With respect to the operation's destination, the weight of the loan for the establishment of new businesses is higher in Contract C\textsubscript{2}, representing 13% of the total loans in this group, while they represent only 4% of Contract C\textsubscript{1} loans. Finally, OUTC variable shows that

\textsuperscript{21} We thank an anonymous referee to point us to this sigue.
\textsuperscript{22} The choice of the estimation subsample was made in order to have a homogenous and sufficient number of each type of contracts. However, we ran logit analysis using other selection criteria for subsamples and we obtained similar results.
\textsuperscript{23} Implicit hypotheses of the analysis of variance with one factor were tested, as shown in Table 1. Only FIRMTYPE(1) presents equal variance in the two types of loans. However, the lack of homogeneity of variance affects the F statistics if the ratio of the larger sample size to the smaller one is above 2, and in this case it is 1.13 (see, for instance, Uriel, 1995 and Cabrer et al., 2001). FIRMTYPE, FIRMTYPE(1),
the proportion of Contract C2 loans with insolvency problems is only 2%, whereas loans without collateral and high rate present a much higher index of insolvency, 32%.

[INSERT TABLE 1]

3.2.2 Results of the Logit Analysis

The variable selection method is the forward stepwise process of the likelihood ratio. In Table 2 the results of the logit estimation and the variable selection are shown. It is more likely that a loan formalizes with real asset collateral and low interests, the higher the loan term, the larger the import, and the lower the number of employees in the firm, in particular, if it is a sole proprietor or a company (PLC) and if funds obtained by the loan are destined to the establishment of a new business. The results analyzed so far reinforce the conclusion reached in the analysis of variance. When the loan presents characteristics that make lenders presuppose a higher insolvency risk, they demand real asset collateral. However, this higher ex ante risk is not translated into higher interest rate requirements. The effect of the collateral has a greater weight than the interest rate effect.

[INSERT TABLE 2]

OUTC coefficient implies that the loans with real asset collateral and low rate of interest have no solvency problems, as observed in the ANOVA, despite the strong collateral requirements were originated from higher borrower risk detected a priori by the lender. In contrast, the loans without collateral and high interest rates have a high probability of default.

With respect to the goodness of fit, Table 2 shows that each of the coefficients $\beta_j$ is significantly different from zero. Globally, the model is also significant when determining the probability of providing collateral combined with a low rate of interest.

FIRMTYPE(2), DEST and OUTC are categorical which requires precaution in the interpretation of the F statistics.
The value of the Chi-square test with seven degrees of freedom is 238.69 with a level of significance of 0.000, rejecting all coefficients to be zero. The percentage of loans correctly classified according to the estimated probability is shown in Table 2, 89.11%. The designed model correctly classified 270 of the 303 analyzed loans. Hence, the two analyzed contracts permit the classification of borrowers by their risk level, concentrating those with lower risk in Contract C₂, which combines real asset collateral with low interest rates.

4. Experimental Analysis

An environment was designed in which there are Nᵢ 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 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

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24 Even though it is not shown here, a 100% correct classification in the validation sample was obtained. In addition, there is a low correlation among the variables in the final solution.
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 return for each individual $s$ and $r$ for acquiring the asset is:

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

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

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

$$ER_s (C_2) \geq ER_s (C_1)$$

$$ER_r (C_1) \geq ER_r (C_2)$$

[INSERT TABLE 3]

Table 3 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. Table 3 also shows Treatment A (described above) with which we test whether the pairs of contracts designed, combining prices and security deposits, permit the separation of individuals by their risk level. Chart 1 shows the contracts offered and the isoreturn curves that provide the individuals with an expected return of 660. Any isoreturn curve above these provides individuals with a lower expected return. 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 a different project risk. The contracts, hence, are designed to work as mechanisms to separate different types of buyers.

[INSERT CHART 1]

In this experiment we consider, according to Bester (1985b), 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 C2 and that the subjects with riskier projects prefer Contract C1. However, if the subjects were risk averse, the incentive-compatibility of the contracts should depend on the expected utility, as Bester (1987) notes. Therefore, the pair expected return-standard deviation would determine subjects’ decisions. To prove this, Table 4 shows the standard deviations of each of the contracts in each period. In this case we still expect $r$ subjects to prefer Contract C1.

All of the subjects, after making their decisions in Treatment A, read new instructions for Treatment B. Under this treatment, moral hazard generated by *ex ante* asymmetric information was introduced. This second treatment permits the comparison of the same subjects’ decisions under two different environments (Treatment A and Treatment B) in the same session. Thus, Treatment B allows us to test the effect of moral hazard (generated by *ex ante* asymmetric information) on 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 entailing an increase in the project probability of failure and expected return.

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25 In the first session, we offered an initial "test" contract to make sure the subjects understood the instructions.
Under this treatment, moral hazard originated from the lack of control that sellers have on the buyers’ project choice. Whenever the buyer was successful, he paid the contract price. Consequently, moral hazard derived from the *ex post* asymmetric information between buyers and sellers was excluded. 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. Subjects $r$ modifying the original projects had a success probability of 0.3 and obtained a return of 2,160 monetary units; in case of failure the payoff was zero. Hence, the expected return for each $s$ and $r$ subject for modifying the initial project was:

$$ER_{sm} = 0.6 \left(300 + 1200 - \text{Price}\right) + 0.4 \left(300 + 0 - \text{Deposit}\right)$$

$$ER_{rm} = 0.3 \left(300 + 2160 - \text{Price}\right) + 0.7 \left(300 + 0 - \text{Deposit}\right)$$

Column 4.2 of Table 3 shows expected returns for each contract and each type of subject in case they choose 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. In each period, the type $s$ subjects modifying their original project reached an expected return with Contract $C_1$ very close to that of Contract $C_2$ which could lead them to decide to increase the risk of the project regardless of choosing $C_1$ or $C_2$. On the other hand, 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 also increased the risk of their project and were inclined to choose Contract C1.

This design was chosen for various reasons. First, real credit markets might present this situation. Second, it is the case in which a higher moral hazard can be generated, when both types of subjects may be interested in increasing the risk of their original projects. In this case, sellers (lenders) might experience harm as they are affected by the increase in project failure probability. The greater this probability, the lower is the lender’s expected return. Finally, it makes it possible to observe whether choices are guided by expected returns.

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 verified in the experiments, the individuals that choose to increase the risk of the project must choose Contract C1, with the lower security deposit. More specifically, to verify hypothesis $H_{2E}$, subjects $s$ who choose to increase their project risk should choose Contract C1 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 3. Individuals $r$ obtain higher returns and lower standard deviations with Contract C1 than with Contract C2 either when modifying the initial contract or not. Moreover, modifying the initial project provides higher return and higher standard deviation than non-modification. Hence, if the preferences of the individuals were based on expected utility, subjects $r$ are expected to choose Contract C1, and it would be as rational to keep the original project as to change it. On the other hand, $s$ individuals have very similar expected returns with both contracts C1 and C2,
but a lower risk with Contract C₁. In addition, changing the initial project results in higher return and higher risk. Thus, if preferences are based on expected utility, our expectation is that s individuals choose Contract C₁ when modifying original projects. Nevertheless, it is equally rational to modify the original project or not.

4.1. 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. 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.

4.2. Results

The results of the experiment are summarized in Table 4. 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. Chart 2 shows the distribution of the subjects' responses by treatment in each

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26 The instructions and other documents used in this experiment are available upon request to the corresponding author.
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. In addition, we wanted to test whether this separating effect exceeds the adverse selection and moral hazard effects of high collateral.

[INSERT TABLE 4]

[INSERT CHART 2]

Therefore, first the test of the separating power of contracts was run, similar to the test of the combination collateral/interest rate in the previous section. The one factor analysis of variance and the logit analysis were also used to examine the experimental data.\textsuperscript{27} Contracts (CONTRACT variable) act as exogenous variable because each contract has an incentive compatible combination of price and security deposit. This test analyses whether the contract choice (C\textsubscript{1} or C\textsubscript{2}) can be explained by the project risk level with and without moral hazard. Then, the test of the influence of moral hazard was run completing the analysis of the moral hazard influence on the initial contract and the change of project choices.

4.2.1. Test of the Separating Power of Contracts

The variables used in this test are the following:

- Endogenous variable:

  CONTRACT: Dummy variable that summarizes the information about collateral and interest rates of a loan. Contract C\textsubscript{1} is given value 0 and Contract C\textsubscript{2} is given 1.

- Exogenous variables:

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

\textsuperscript{27} These logit analyses had no validation sample.
TREATMENT: Dummy variable. Treatment A (without moral hazard) is given value 0 and Treatment B (with moral hazard) is given value 1.

Results of the Analysis of Variance

Table 5 shows the ANOVA results. Subjects with safer projects made most of the C2 choices (72%). In contrast, subjects with riskier projects made most of the C1 choices, 71% of the total choices in the two treatments. Therefore, our hypothesis was proven right: by offering pairs of incentive compatible contracts, subjects with safer projects chose Contract C2 and subjects with riskier projects chose Contract C1. On the other hand, TREATMENT shows how choices change from Treatment A to Treatment B. Contract C2 was chosen more frequently under Treatment A, without moral hazard (65% of Contract C2 choices were under Treatment A). In contrast, Contract C1 was chosen more often under Treatment B involving moral hazard (60% of Contract C1 choices were under Treatment B). The last column of Table 5 shows that the inter-group differences are significant in both variables. The ANOVA results suggest that the existence of moral hazard affects initial contract choices thus reducing the separating effect of the incentive compatible contracts.

Results of the Logit Analysis

Risk-free investment decisions were excluded from the total of the observed subject choices in both treatments. Hence, we analyzed 427 choices, 219 of Contract C1 and 208 of Contract C2. The variable selection method was the forward stepwise process of the likelihood ratio. Table 6 gives the results. PROJECT and TREATMENT, were selected.

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28 Normality and homogeneity of variance tests for each of the exogenous variables are also shown in Table 5. 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
PROJECT indicates that the safer the project the greater the probability to choose Contract C₂. This result confirms the significance of the differences between choices of subjects with safer projects and subjects with riskier projects. Hence, it is ascertained that high collateral combined with an adequate low rate of interest attracts principally subjects with safer projects. Moreover, this result suggests that in this context high collateral does not generate adverse selection of borrowers. However, the TREATMENT variable was also selected, i.e. Treatment B lowers the number of C₂ choices compared with Treatment A, confirming the result of the analysis of variance. Moral hazard alters initial contract choices thus reducing the separation effects of incentive compatible contracts. With respect to the goodness of fit, Table 6 shows that each of the coefficients is significantly different from zero. The two variables are jointly significant when determining the probability of selecting Contract C₂. Thus, the chi-square with two degrees of freedom, $-2 \ln \lambda_{g,b}$, reaches 113.912 and a significance level of 0.0000 which indicates that the null hypothesis according to which $\beta_j$ are both zero must be rejected. In addition, a correct classification of 71.66% is obtained using this function.

4.2.2. Test of the influence of moral hazard

The results in the previous test reveal the influence of moral hazard on initial contract choices. This section extends those results by examining the differences in borrowers’ choices according to their project risk. The endogenous variable is now the dummy variable PROJECT. The differences between Group 1 (subjects with safer projects) and Group 2 (subjects with riskier projects) are explained using the ANOVA test based on the following exogenous variables:
CONTRACT(A): Contract choices in Treatment A. No contract choice was given value 0, Contract C₁ choice was given value 1, and Contract C₂ choice was given value 2.

CONTRACT(B): Contract choices in Treatment B. No contract choice was given value 0, Contract C₁ choice was given value 1, and Contract C₂ choice was given value 2.

CONTRACT(A+B): Contract choices in the two treatments globally. No contract choice was given value 0, Contract C₁ choice was given value 1, and Contract C₂ choice was given value 2.

INCREASE IN R: Subject’s second decision in Treatment B: to increase or not to increase the risk level of the original project after choosing a contract. No modification was given value 0, and while modifications were given value 1.

Results of the Analysis of Variance

Table 7 shows the ANOVA results. CONTRACT(A) reveals a significant difference in the contract choices of individuals with safer projects and those with riskier projects. Most of the individuals with safer projects, 83%, chose Contract C₂ in Treatment A, which excludes the possibility of moral hazard. In contrast, most of the individuals with riskier projects, 70%, chose Contract C₁ in the same treatment.

[INSERT TABLE 7]

In Treatment B, 45% of individuals with safer projects chose Contract C₂ and most of the individuals with riskier projects, 81%, chose Contract C₁. CONTRACT(B) changes from a mean of 1.45 in Group 1 to a mean of 1.19 in Group 2, with a level of significance of 0.000. However, though the difference in contract choices is significant, it is lower than the one in Treatment A. It seems that moral hazard introduced in Treatment B reduces the separating power of incentive compatible contracts. The joint

29 Table 7 also shows the results of normality and homogeneity of variance tests. CONTRACT(A+B) has the same variance in the two groups. The rest of exogenous variables do not observe the homogeneity of variance hypothesis required by the ANOVA. On the other hand, the four categorical exogenous variables follow a distribution different from normal.
exam of Treatments A and B shows that, globally, the differences in contract choices between different risk level subjects is significant, as noticed in the test of the separating power of contracts. Group 1 mean value of the CONTRACT(A+B) variable is 1.65 against a mean of 1.24 in Group 2, with a F of Snedecor’s level of significance of 0.000. The results of the analysis of these three variables seem to confirm the effectiveness of this menu of incentive compatible contracts in terms of expected returns to separate borrowers according to their project risk level. Again, we do not find that a high collateral requirement leads to an adverse selection of borrowers. In contrast, high collateral appropriately combined with the interest rate attracts subjects with safer projects. These results are consistent to the ones in section 2, obtained with data of real markets. Moreover, we found that the separating effect of this menu of contracts exists even in the moral hazard environment designed in Treatment B.

However, moral hazard generates an increase in the failure probability of the projects once the loan is granted. Subjects with initially safer projects switch it and increase the risk more often. This is shown by the differences in Group 1 and Group 2 mean values of INCREASE IN R. 79% of the decisions of subjects initially having a safer project are to increase the failure probability, whereas only 47% of the decisions of subjects with an originally riskier project switch. The F of Snedecor’s level of significance indicates the hypothesis of equal means has to be rejected. Thus, moral hazard results in the reduction of borrowers’ separation in two ways. First, the proportion of Contract C2 choices of subjects with originally safer projects is reduced. Second, some subjects with originally safer projects decide to increase the project failure probability once the loan is granted. The Contract C2 choices in Treatment B (a total of 73) change from 71% with safer projects to 22% after taking the decision of increasing the project risk or not.
Results of the Logit Analysis

To verify the effects of moral hazard detected in the previous ANOVA a logit analysis is run. We examine the project type of each subject (PROJECT), riskier or safer, as a function of CONTRACT, representing the contract choice in Treatment B, and INCREASE IN R, representing the decision to increase the probability of failure after obtaining the loan. A logit analysis with the exogenous variable INCREASE IN R requires limitation to Treatment B and exclusion of decisions without any contract choices. In total 204 decisions were analyzed, 100 taken by subjects with safer projects and 104 by subjects with riskier project. The method of variable selection is the forward stepwise process of the likelihood ratio.

Table 8 shows that the two exogenous variables: CONTRACT(B) and INCREASE IN R were selected in the final function. Contract C2 is more likely to be chosen by a subject with a safer project. This variable clearly differentiates the individuals with riskier projects from those with safer projects. Hence, the separating effect of this menu of incentive compatible contracts remains, even in environments where there is moral hazard. The selection of the variable INCREASE IN R indicates that subjects with safer projects are more likely to increase their project risk once the loan is granted, also shown in the previous analysis of variance. These results are fairly robust. Table 8 shows that the coefficients of the two variables are far different from zero. On the whole, these are also significant when differentiating contract choices, since the chi-square with two degrees of freedom, \(-2 \ln \lambda_{LR}\), reaches a value of 58.028 and a level of significance of 0.0000, indicating that the null hypothesis according to which the \(\beta_j\) are all zeros, should be rejected. In addition, the percentage of correct classification of choices is 66.67%.

[INSERT TABLE 8]
5. Conclusions

This paper examines the separating effect of collateral empirically by analyzing data of real markets and of a controlled experiment, taking the role of moral hazard into account. Such an analysis is suggested by the extant theories of the role of collateral in credit markets with asymmetric information which assume that borrower preferences among different combinations of interest and collateral systematically depend on their risk levels. Empirical studies, so far, have been unable to examine the incentive compatibility of this menu of contracts because individualized information on loan contract features is unusual and does not include a direct and objective approximation to the \textit{ex ante} unobservable borrower risk.

First, we investigated the separating role of collateral by analyzing data concerning a sample of credits to small and medium-sized firms guaranteed by the SGR of Valencia, Spain. In contrast to other studies, we explored the combination collateral/interest rate. Moreover, we used the real outcome of each loan as approximation to the \textit{ex ante}, i.e. privately known, borrower risk. Consistent with previous papers, we found evidence that collateral is related to higher \textit{ex ante} borrower risk. Nevertheless, our results suggest that by combining collateral appropriately with the interest rate, borrowers with different risk levels are separated and the borrowers with higher risk tend to ask for loans without collateral and high interest rates. Whereas, the borrowers with lower risk ask for loans with real asset collateral and low interest rate. Hence, we provide first empirical evidence on the effectiveness of collateral as a separating mechanism when it is adequately combined with interest rates. Our results support the theoretical conclusions concerning collateral of Bester (1985b, 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). Our results are also consistent with the assumption that borrowers produce information about the *ex ante* borrower risk and indicate that lenders systematically use this information to ask high-risk borrowers for higher collateral. However, the evidence does not suggest that lenders use this information to ask a higher interest rate from high-risk borrowers. Nevertheless, this empirical result must be examined with caution as our data come from loans guaranteed by SGR’s. The lender designs the terms of the contract given that the loan is secured by the SGR which, in turn, analyzes the risk of the operation and decides whether to provide a guarantee and, if so, what level of collateral is requested.

Experimental data involving relatively simple decisions in a controlled setting also support previous results of our empirical analysis in real credit markets. However, our experimental results show the existence of moral hazard that reduce the efficacy of incentive compatible contracts in separating borrowers according to their risk levels. Moreover, in contrast to Bester (1987), we find no positive incentive effects of contracts with high collateral. Indeed, we find that contracts with high collateral do not make subjects less likely to increase the probability of failure of their projects in an environment with moral hazard.

**References**

Allen (1983)

Benjamin (1978)


Jaffe y Russell (1976)


Rostchild y Stiglitz (1970)


Table 1. - Test of the combination collateral-interest rate.

<table>
<thead>
<tr>
<th>Exogenous variables</th>
<th>Kolmogorov-Smirnov*</th>
<th>Kolmogorov-Smirnov*</th>
<th>Levene's Test</th>
<th>Mean** Contract C₂</th>
<th>Mean** Contract C₁</th>
<th>F***</th>
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<td></td>
<td>Contract C₂</td>
<td>Contract C₁</td>
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<td>FIRMTYPE</td>
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<td>37.681</td>
<td>0.86</td>
<td>1.25</td>
<td>20.181</td>
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<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.67)</td>
<td>(0.86)</td>
<td>(0.000)</td>
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<td>FIRMTYPE(1)</td>
<td>0.439</td>
<td>0.454</td>
<td>1.398</td>
<td>0.31</td>
<td>0.28</td>
<td>0.347</td>
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<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.238)</td>
<td>(0.46)</td>
<td>(0.45)</td>
<td>(0.556)</td>
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<td>FIRMTYPE(2)</td>
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<td>(14,756.79)</td>
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<td>TERM</td>
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<td>80.51</td>
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<td>(0.00)</td>
<td>(18.8)</td>
<td>(22.0)</td>
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<td>DEST</td>
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</table>

- EMPL: number of employees per firm; SIZE: amount granted in thousands of pesetas; TERM: term of the loan in months. The rest are dummy variables.
- *Correction of the significance of Lilliefors. Level of significance is in parenthesis.
- **Standard deviations are in parenthesis.
- ***Level of significance is in parenthesis.
Table 2. Test of the combination collateral - interest rate. Logit Results.

The estimation sample consists of 303 loans to small and medium-sized firms guaranteed by SGR of Land of Valencia from 1983 to 1998. CONTRACT is the endogenous variable (value 1 given to contract C1 (172 observations) and value 0 given to contract C2 (131 observations). Exogenous dummy variables FIRMTYPE(1), FIRMTYPE(2), DEST and OUTC are given value 1 in the case of sole proprietors, PLCs., investments not corresponding to the set-up of a new company and in case of non-repayment, respectively. Variables SIZE and TERM, in pesetas and months, respectively.

<table>
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<th>Variable</th>
<th>Coefficient</th>
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<td>FIRMTYPE(1)</td>
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<td>Correct classification</td>
<td>89.11% of estimation sample</td>
<td>100% of validation sample</td>
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*** Significant at the 1% level.
Wald statistics are in parenthesis.
### Table 3. - Pairs of offered contracts and expected returns

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<th>Contract C₁</th>
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<td>Safer Project</td>
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<td></td>
<td></td>
<td>556 (102)</td>
<td>660.2 (203.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>660 (410)</td>
<td>629 (579)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>814 (460.5)</td>
<td>816.8 (626.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>820 (870.7)</td>
<td>721.4 (1025.6)</td>
</tr>
<tr>
<td>4</td>
<td>285</td>
<td>75</td>
<td>175</td>
<td>225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>576 (117)</td>
<td>660 (195)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>660 (435)</td>
<td>640 (565)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>819 (485)</td>
<td>825 (612.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>810 (893.6)</td>
<td>738 (1012.7)</td>
</tr>
<tr>
<td>5</td>
<td>260</td>
<td>100</td>
<td>177</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>596 (132)</td>
<td>660.7 (186.9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>660 (460)</td>
<td>651.5 (551.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>824 (509.5)</td>
<td>833.8 (599.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>800 (916.5)</td>
<td>754.9 (1000.4)</td>
</tr>
</tbody>
</table>

ERₜ(.) Expected returns for each contract under each treatment
Standard deviations are in parenthesis
Table 4. – Experimental Results

4.1. –Treatment A

<table>
<thead>
<tr>
<th>Contracts</th>
<th>Subjects with safer projects</th>
<th>Subjects with riskier projects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of observations and percentages</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C1</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>85%</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>2%</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>100%</td>
</tr>
</tbody>
</table>

4.2. –Treatment B

<table>
<thead>
<tr>
<th>Contracts</th>
<th>Subjects with safer projects</th>
<th>Subjects with riskier projects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial choice</td>
<td>Change project</td>
</tr>
<tr>
<td></td>
<td>Number of observations and percentages</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C1</td>
<td>46%</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>4%</td>
</tr>
<tr>
<td>Do not change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>105</td>
<td>100%</td>
</tr>
</tbody>
</table>
Table 5. - Test of the separating power of contracts

<table>
<thead>
<tr>
<th>Exogenous variables</th>
<th>5.1. - Normality and homoskedasticity test</th>
<th>5.2. - Analysis of Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kolmogorov-Smirnov* Contract C₁</td>
<td>Kolmogorov-Smirnov* Contract C₂</td>
</tr>
<tr>
<td>PROJECT</td>
<td>0.449 (0.000)</td>
<td>0.454 (0.000)</td>
</tr>
<tr>
<td>TREATMENT</td>
<td>0.391 (0.000)</td>
<td>0.417 (0.000)</td>
</tr>
</tbody>
</table>

- *Correction of the significance of Lilliefors. Level of significance is in parenthesis.
- **Standard deviations are in parenthesis.
- ***Level of significance is in parenthesis
Table 6. - Test of the separating power of contracts. Logit Results.

Results of logit analysis of 427 experimental decisions (two treatments). CONTRACT is the endogenous variable (value 0 given to contract C₁ (219 observations) and value 1 given to contract C₂ (208 observations)). Exogenous dummy variables PROJECT and TREATMENT, are given value 1 if the subject disposes of a safer project and with moral hazard, respectively.

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Const.</td>
<td>-0.4761</td>
<td>(7.1822)</td>
</tr>
<tr>
<td></td>
<td>PROJECT</td>
<td>2.0037***</td>
<td>(75.4433)</td>
</tr>
<tr>
<td></td>
<td>TREATMENT</td>
<td>-1.2396***</td>
<td>(28.7929)</td>
</tr>
<tr>
<td></td>
<td>-2Lnλ_{LR}</td>
<td>113.912***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cox-Snell R²</td>
<td>0.234</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nagelkerke R²</td>
<td>0.312</td>
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</tr>
<tr>
<td></td>
<td>Correct classification</td>
<td>71.66%</td>
<td></td>
</tr>
</tbody>
</table>

*** Significant at the 1% level.
Wald statistics are in parenthesis.
Table 7. – Test of the Influence of Moral Hazard

<table>
<thead>
<tr>
<th>Exogenous variables</th>
<th>7.1. - Normality and homoskedasticity test</th>
<th>7.2. - Analysis of Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kolmogorov-Smirnov* Group 1 Safer projects</td>
<td>Kolmogorov-Smirnov* Group 2 Riskier projects</td>
</tr>
<tr>
<td>CONTRACT(A)</td>
<td>0.506 (0.000)</td>
<td>0.375 (0.000)</td>
</tr>
<tr>
<td>CONTRACT(B)</td>
<td>0.321 (0.000)</td>
<td>0.476 (0.000)</td>
</tr>
<tr>
<td>CONTRACT(A+B)</td>
<td>0.423 (0.000)</td>
<td>0.423 (0.000)</td>
</tr>
<tr>
<td>INCREASE IN R</td>
<td>0.486 (0.000)</td>
<td>0.355 (0.000)</td>
</tr>
</tbody>
</table>

- *Correction of the significance of Lilliefors. Level of significance is in parenthesis.
- **Standard deviations are in parenthesis.
- ***Level of significance is in parenthesis.
Table 8.- Test of the Influence of Moral Hazard. Logit Results.

Results of logit analysis of 204 experimental decisions (Treatment B). PROJECT is the endogenous variable (value 1 given to the subject with safer project (100 observations) and value 0 given to the subject with riskier project (104 observations)). Exogenous dummy variables CONTRACT and INCREASE IN R, are given value 1 if the subject chooses contract C₂ and if the original project is modified, respectively.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Const.</td>
<td>-4.2393***</td>
<td>(33.3143)</td>
</tr>
<tr>
<td>CONTRACT</td>
<td>2.1143***</td>
<td>(27.1317)</td>
</tr>
<tr>
<td>INCREASE IN R</td>
<td>2.0983***</td>
<td>(26.9203)</td>
</tr>
<tr>
<td>-2Ln(\lambda_{LR})</td>
<td>58.028***</td>
<td></td>
</tr>
<tr>
<td>Cox-Snell R²</td>
<td>0.248</td>
<td></td>
</tr>
<tr>
<td>Nagelkerke R²</td>
<td>0.330</td>
<td></td>
</tr>
<tr>
<td>Correct classification</td>
<td>66.67%</td>
<td></td>
</tr>
</tbody>
</table>

*** significant at the 1% level.
Wald statistics are in parenthesis.
Figure 1. - Treatment A. Offered contracts and isoreturn curves.
Figure 2. - Offered contracts and experimental results

**Treatment A**

Periods: 1, 2, 3, 4, 5

- Frequency of C1: 20, 15, 16, 20, 13
- Frequency of C2: 23, 28, 27, 24, 27

**Treatment B**

Periods: 1, 2, 3, 4

- Frequency of C1: 30, 26, 14, 30, 25
- Frequency of C2: 30, 13, 16, 17