Moral Hazard in Credit Markets:
The Incentive Effect of Collateral

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October 25, 2010

JOB MARKET PAPER

Abstract

This paper examines the effect of collateral on moral hazard and credit volume. A standard theoretical argument for the use of collateral is its power in reducing problems of moral hazard. However, collateral may also be used as a screening device and existing empirical studies have not been able to isolate the incentive effect of collateral. This paper uses experimental tools to identify the effect. The results show that, contrary to the theoretical predictions, collateral only decreases moral hazard when interest rates are low. If interest rates are high, an increase in collateral does not decrease moral hazard significantly. The results suggest that borrowers' aversion to losses together with high interest rates offset the incentive effect of collateral. Furthermore, it is shown that collateral increases credit supply. But, if interest rates are high, increases in collateral also lead to a decrease in credit demand. These findings suggest that the effects of collateral depend on the interest rate charged and that these may be weaker than expected when interest rates are high.

Keywords: Collateral, Moral Hazard, Credit Access and Credit Markets.
JEL-Classification: C92, D23, G21, O16.

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I would like to thank Thorsten Beck, Martin Brown, Miguel Carvalho, Eric van Damme, Hans Degryse, Peter Hoffmann, Wieland Mueller, Steven Ongena, Jan Potters, Abraham Ravid and Nathanael Vellekoop for helpful comments and suggestions, and the audiences at the GSS seminar and Economics Workshop in Tilburg University, Brown Bag seminar at DICE (Duesseldorf University) and the doctoral tutorial of the 2010 EFA Meeting, at Goethe University Frankfurt.

1 Introduction

This paper provides the first systematic and direct evidence on the effect of collateral on moral hazard and credit volume. Collateral is widely used in practice for financial contracting. More than 80% of loans issued in the U.S (Berger et al, 2010) and more than 75% of loans issued in over 100 countries, mainly developing economies (Chavis et al, 2010), are collateralized. This widespread use of collateral has spurred a large, mainly theoretical literature which aims at understanding loan collateralization.

A main theoretical motivation for the use of collateral is that it reduces moral hazard. Models of lending under moral hazard predict that pledging collateral induces borrowers to increase effort. Fear to lose the pledged asset increases the incentives to take costly actions that increase the likelihood of repayment (e.g. Innes, 1990, Boot et al, 1991, Besley and Ghatak, 2009a). Since collateral increases effort and thus profits from lending, it may be a key determinant of a borrower's access to credit.

Despite the important role of collateral in reducing problems of moral hazard, the empirical evidence available is scarce. A problem faced by field data is that collateral may also be used as a screening device. Investment projects of borrowers vary in quality, which is often unknown to lenders. Since the quality of projects and actions of borrowers are unobservable, the effect of collateral on moral hazard cannot be easily isolated. Recent studies have used variations in the information on the quality of the loan at the moment of extending a loan to identify the role of private information (Berger et al, 2010, Berger et al, forthcoming). However, the effect of collateral on moral hazard, for a given project quality, remains unknown.

Empirical evidence on the effect of collateral on credit access is also scarce and unexpectedly weak. Recent studies examine exogenous changes to property titles to evaluate the impact of a title, which makes an asset pledgeable as collateral, on credit access. Galiani and Schargrodsky (2010) do not find any increase in credit access after titles have been extended in their Argentinian sample, while Field and Torero (2006) find that credit access increases for public sector banks, but not for private sector banks in Peru. It is unclear why credit access does not always increase. It may be that other enforcement problems remain and that lenders fear not being able to seize assets upon default. But it may also be that interest rates are too high. Surveys conducted by the World Bank, described below, show that in many developing economies high interest rates are the main reason for firms' lack of credit demand. Since interest rates are an important determinant of credit demand, they may affect credit volume and interact with the effect of collateral.

This study contributes to the existing literature by answering three questions using experimental tools: does collateral decrease problems of moral hazard? Does collateral

affect credit supply, demand and ultimately credit volume? Do these effects depend on an important loan characteristic, the interest rate?

The standard model of lending under moral hazard is simplified and implemented experimentally. Each lender is matched with a borrower and decides whether or not he offers a loan. If he offers a loan, he can request collateral. If the borrower accepts the loan offer, she decides on her effort. Effort refers to all costly actions that increase the probability of project success. It is not contractible and not observable to the lender and thus the source of moral hazard. In line with the theoretical models cited above, strategic default, an additional source of moral hazard, and other enforcement problems are ruled out by design.

To identify the effect of collateral, the level of collateral is varied across treatments. Two levels of collateral are considered: collateral that covers fifty percent of the loan amount and collateral that fully covers the loan amount. Fully secured loans are very common in loan contracts. The fifty percent case allows us to examine the effect of a collateral increase towards a fully secured loan. At each level of collateral, the interest rate is varied: a low and a high interest rate are considered. These values correspond to the ex-ante optimal interest rates for the lender at each level of collateral. Varying the level of collateral and the interest rate separately allows the identification of the effect of each variable separately, while they are often observed jointly in the field. Further, a benchmark treatment is added, in which borrowers do not have any collateral, to examine the effect of collateral availability.

An increase in collateral is expected to increase the effort provided by borrowers. Since collateral increases by the same amount at low and high interest rates, the same increase in effort is expected. An increase in collateral is also expected to increase credit supply. In particular, lenders are expected to supply credit when collateral can be pledged. However, the effect of collateral on credit demand is ambiguous. If borrowers are risk neutral, they are expected to always demand credit. However, if borrowers are risk averse, an increase in collateral when interest rates are high may lead to a decrease in credit demand.

The first and most important experimental result is that the effect of collateral on effort depends on the interest rate. At low interest rates, an increase in collateral increases effort significantly. At high interest rates, it does not. Unexpectedly, the incentive effects of collateral are weak when interest rates are high.

To further investigate this result, an additional treatment is added to the design. The weak effect of collateral may be driven by borrowers' aversion to losses or by fairness concerns. When collateral is large, a failure to repay the loan implies that the borrower loses the asset pledged as collateral and faces the effort costs for the effort provided. If interest rates are high, loss averse borrowers may not increase effort with collateral

increases since their profits in case of repayment are small. Alternatively, borrowers may consider the loan offer unfair. A loan gives a large profit to the lender, while leaving the borrower with little profit. By providing a low effort, borrowers decrease the lender's payoff advantage.

In the additional treatment, a tax on the lender's profits is introduced to decrease fairness considerations. The results reveal that the borrower's effort remains low. This suggests that borrowers' loss aversion together with high interest rates offsets the incentive effect of collateral.

The second main finding is that credit supply increases with collateral. But, increases in collateral lead to a decrease in credit demand, if interest rates are high. This decrease in demand is related to borrowers' risk aversion, as hypothesized. Borrowers who are risk averse are less likely to demand credit, if the interest rate is high and collateral increases.

These findings have two main implications. First, the incentive effect of collateral is likely to be weak when interest rates are high. Borrowers' concerns about losses may imply that collateral does not lead to a substantial decrease in moral hazard in some environments. Second, the effect of collateral on credit volume is also likely to be weak in credit markets where interest rates are high. Although institutions are reformed to improve property rights or to increase the use of collateral, if interest rates are high, borrowers may be unwilling to demand credit.

The rest of the paper is organized as follows. In the next section, a brief overview of the related literature and survey evidence is given. Then, the experimental design is described. In Section 4, the experimental results are presented. Section 5 presents additional results, which complement those of Section 4, and and Section 6 concludes.

2 Related literature and survey evidence

Why collateral is used and its effect on loan performance has been widely studied theoretically in the banking literature. Several studies focus on the ex-ante effect of collateral. In the presence of asymmetric information about the borrower quality, collateral has an ex-ante effect on the pool of borrowers (e.g. Stiglitz and Weiss, 1981, Bester, 1985 and 1987). Other studies focus on the ex-post effect of collateral. Collateral provides incentives for borrowers to act as desired by lenders, providing a high effort, as pointed out, among others, by Innes (1990), Aghion and Bolton (1997), Holmstrom and Tirole (1997), Mookherjee and Ray (2002) and Besley and Ghatak (2009a). These effects may vary when the lending relationship is repeated as reputation concerns serve as an incentive to provide effort (Boot and Thakor, 1994). In this paper the focus is on the direct effect of collateral and thus no reputation concerns are considered. Additionally,

collateral may also affect behavior of borrowers after receiving a loan in environments where strategic default is possible (e.g. Banerjee and Newman, 1993) and under costly state verification (e.g. Townsend, 1979). Some studies allow for both roles of collateral, ex-ante and ex-post (Chan and Thakor, 1987, Boot et al, 1991).

Guided by existing theories, several studies examine the determinants of collateral empirically, with the objective of distinguishing between these theories (Berger and Udell, 1990; Jimenez et al, 2006; Berger et al, 2010, Berger et al, forthcoming).[1] A problem is that the ex-ante and ex-post effects are difficult to tear apart because the borrower's quality and actions are both unobserved to the lender. Since they both affect the probability of default, one cannot directly identify the effect of collateral on moral hazard for two projects of the same quality. In this paper, I concentrate on the problem of moral hazard and provide, to the best of my knowledge, the first direct evidence on the effect of collateral on moral hazard. [2] The experimental tools used in this paper contribute to a small but increasing number of papers which use experimental methodologies to increase our understanding of the microeconomics of banking (e.g. Brown and Zehnder, 2007 and 2010, and Fehr and Zehnder, 2009).

The incentive effect of collateral implies that collateral may be key for credit access. Credit access in turn has important consequences for growth and development (Levine, 2005). De Soto (2001)[3] therefore argues that the right institutions, in particular, property rights sytems should be in place. Property titles allow individuals to pledge collateral, among others (Besley and Ghatak, 2009b), and thus should be easy to access. Besley and Ghatak (2009a) have studied the implications of this argument theoretically, while Galiani and Schargrodsky (2010) and Field and Torero (2006) use natural experiments to test it. Earlier papers have surveyed titled and untitled farmers (Carter and Olinto, 2003 and Feder et al, 1988). This paper complements the existing papers providing experimental evidence on the effect of collateral on credit access.

While credit access is often determined by credit supply, lender's willingness to lend, the demand side is important too. As pointed out by Brown et al (forthcoming) in Eastern European countries many firms who need credit choose not to demand it. Taking a broader sample, from the Enterprise Surveys conducated by the World Bank (www.enterprisesurveys.org), a similar result is obtained. This survey, conducted in 96

[1] Other studies consider the more general link between institutions, finance and development, by examining how differences in creditor rights across countries affect the use of collateral (Liberti and Mian, 2009).

[2] The only closely related study is Andreoni (2005). He studies experimentally the effect of implementing a 'satisfaction guaranteed' policy, by which principals can recover their payment if the agent fails to perform as they wish. This differs from the setup here, in that borrowers provide effort, which determines the probability of project success. The lender can therefore only receive the requested collateral if the project fails and receives the interest if the project succeeds.

[3] See Woodruff (2001) for a review of de Soto's (2001) book *The Mystery of Capital*.

countries, mainly developing economies, contains data about firms' access to credit and credit needs. Of over 42,000 firms surveyed from 2006 to 2010, 62.8% report the need for credit, but only 35.7% actually demand it. The reason for not demanding credit which is mentioned most frequently is that interest rates were not favorable. Also, firms mention complex application procedures and high collateral requirements as reasons for not demanding credit. Further, firms, which demanded credit in the past and obtained it, report that in more than 74% of the cases loans or lines of credit were collateralized. The most frequent percentage of collateral relative to the loan amount was 100%.

This paper contributes to the literature and survey evidence by providing a systematic study of the impact of collateral on moral hazard and credit volume using experimental evidence.

3 Experimental design

3.1 Contracting under moral hazard

The standard model of moral hazard, in which collateral can be requested (see Innes, 1990), describes the following situation: a lender has funds available to lend to a borrower, who needs a loan for an investment project. The borrower has some capital, which cannot be used directly for investment but can be pledged as collateral. If the borrower receives a loan, she starts an investment project, which requires her effort. Effort, which is costly for the borrower, refers to all actions by the borrower which make the investment project more likely to succeed. It is neither contractible nor observable by the lender. Thus, a problem of moral hazard arises. The lender wishes a high effort from the borrower, since it increases the likelihood of success and in turn repayment of the loan. By requesting collateral, the lender incentivizes the borrower to provide a high effort, as she loses her property if the project fails.

The standard model of moral hazard is implemented experimentally using a lending game. The parameter values used in the experiment are used to describe the game, except for the variables which vary across treatments: collateral, C, and repayment, R.

The lender (player L) has an initial amount of funds, his endowment, of 150. The borrower, indexed as B, has an initial endowment of 100. The borrower's initial endowment cannot be used for investment. However, a part of it may be pledged as collateral, $0 \leq C \leq 100$. By varying C the impact of institutional changes, which increase the amount of pledgeable collateral, can be studied. These institutional changes may be changes in the property rights system, which extend property titles on the borrower's endowment, or could also be changes in regulation, which increase the type of assets that are pledgeable. Throughout, the value of collateral, C, is assumed to be the same for the

borrower and the lender, and no transaction costs or loss in collateral value ensue from default.

The borrower's investment project requires a loan of 100. If the project is successful, it yields a return of 300. If it fails, it yields a return of zero. The sequence of moves in the game is as follows. The lender and borrower are matched exogenously for one period only. First, the lender decides whether or not to offer a loan, { *offer*, *no offer*}. If he chooses to *offer* and collateral is available, the lender can choose to request *collateral* or *no collateral*. To simplify notation, if the lender chooses *no collateral*, C is set to 0. Instead, when *collateral* is chosen, C is equal to the amount of collateral available. By design, the lender does not decide on repayment, which is varied exogenously across treatments. This allows evaluating the impact of the decision to request collateral on effort, while keeping repayment constant. Repayment is set at the level which maximizes the lender's profits, as detailed below.

If the lender offers a loan, the borrower decides whether to *accept* or *reject* it. If she accepts, the borrower decides on effort, $e = \{1, 2, 3, 4, 5\}$. Effort is costly, in monetary terms, to the borrower: $4e^2$. The cost of effort is paid from a surplus of 100 that the borrower receives when accepting a loan.[4] Thus, the borrower's net surplus from effort is: $S(e) = 100 - 4e^2$. At the same time, effort increases the probability of success of the project, by a factor of $\frac{1}{6}$, as shown in Table 1. None of the effort choices leads to a certain project outcome.

Table 1: Effort, probability of success and surplus

Effort (e)	1	2	3	4	5
Probability of success	1/6	2/6	3/6	4/6	5/6
Surplus $S(e)$	96	84	64	36	0

If the lender decides not to offer a loan or the borrower rejects an offer, no loan is extended. Then, the lender and borrower keep their initial endowments. If a loan is offered and accepted, two outcomes are possible. First, if the project succeeds, the lender is paid back repayment R, which includes the loan principal of 100 and an interest payment. Thus, no strategic default is allowed. Second, the project may fail, in which case the lender receives no repayment, but the requested collateral, C. This leads to the following payoffs for the lender:

[4] Note that this surplus does not affect the borrower's incentives, but only avoids net losses at the end of the game.

$$\pi_L = \begin{cases} 150 & \text{if no loan} \\ 50 + R & \text{if project succeeds} \\ 50 + C & \text{if project fails} \end{cases}$$

The payoffs of the borrower are:

$$\pi_B = \begin{cases} 100 & \text{if no loan} \\ 100 + 300 - R + S(e) & \text{if project succeeds} \\ 100 - C + S(e) & \text{if project fails} \end{cases}$$

The expected payoff of a borrower who accepts a loan offer is

$$E(\pi_B) = 100 + \frac{e}{6}(300 - R) - (1 - \frac{e}{6})C + 100 - 4e^2$$

If the borrower is risk neutral, self-interested and rational, her optimal effort and incentive compatibility constraint (ICC) is

$$e^* = \frac{1}{48}(300 - R + C) \tag{ICC}$$

The ICC reveals two comparative statics regarding the borrower's effort. First, an increase in collateral increases effort, $\frac{\partial e}{\partial C} > 0$, and this increase is independent of the repayment, $\frac{\partial^2 e}{\partial C \partial R} = 0$. Second, an increase in repayment decreases effort, $\frac{\partial e}{\partial R} < 0$. Furthermore, the borrower is willing to accept a loan offer, as long as

$$\frac{e}{6}(300 - R) - (1 - \frac{e}{6})C + 100 - 4e^2 \geq 0 \tag{PC}$$

For a risk neutral, self-interested and rational lender, the maximization problem is

$$\max_{collateral, R} \ \frac{e}{6}R + (1 - \frac{e}{6})C - 100$$

subject to the borrower's incentive compatibility constraint (ICC), the borrower's participation constraint (PC) and his own participation constraint. Requesting collateral is always optimal for the lender as the first derivative with respect to C is always positive. The optimal interest rate is $R = 150 + C$. This interior solution is optimal for values of collateral between 0 and 100. The intuition behind it is as follows. When the amount of collateral is low, the incentive effect of collateral is also low. The borrower must pay a low interest to have an incentive to provide a high effort. As the amount of collateral comes closer to 100, a low interest becomes unnecessary. The larger amount of collateral

already provides the borrower with an incentive to exert effort. Thus, the lender can charge a higher interest rate and still elicit a high effort.[5]

Given $R^* = 150 + C$, the lender's participation constraint is satisfied if $C \geq 100 - 25 \cdot \frac{25}{8} = 21\frac{7}{8}$. Thus, for any $C \geq 21\frac{7}{8}$, it is optimal for the lender to *offer*. For the borrower, it is optimal to *accept* in all cases, as her PC has been taken into account. These results yield Proposition 1. The proof is presented in Appendix A.

Proposition 1 *If the lender and the borrower are risk neutral, an increase in collateral from 0 to 100% of the loan amount, has two main effects: (1) it reduces the problem of moral hazard: effort supply increases; (2) it increases credit supply, while it does not affect credit demand, and therefore it increases credit volume. Both effects do not vary across different interest rate levels.*

Proposition 1 highlights two main effects of collateral. First, pledging more collateral reduces the problem of moral hazard. Second, pledging more collateral makes lending profitable. This increases credit supply and since credit demand remains profitable, it leads to an increase in credit volume. The second effect, however, hinges on the assumption of risk neutral borrowers. Borrower risk aversion can lead to decreases in credit demand as collateral increases. In particular, borrowers, who may lose their initial endowment if the project fails, may be unwilling to take up a loan with a high interest and high collateral. In contrast, for lenders, who have a larger endowment and always keep part of it when lending, risk aversion is likely to play a minor role. Thus, the following subsection examines the effect of borrower risk aversion.

3.2 The role of risk aversion

For a risk averse borrower, the expected utility from accepting a loan may be formulated as follows $E(u_B) = \frac{e}{6} \cdot u(100 + 300 - R) + (1 - \frac{e}{6}) \cdot u(100 - C) + u(S(e))$, where u$(\cdot)$ is increasing, continuous and concave, and the surplus from effort is assumed to be separable.

Risk aversion may decrease the borrower's optimal effort. However, it is important to note that, even if the borrower is risk averse, the effect of collateral on effort is still independent of repayment. Collateral affects the borrower's utility in the case of project failure, while repayment affects utility in the case of project success. Thus, the effect of collateral remains independent of the interest rate.

[5] This result, that the interest rate may increase with the amount of collateral pledged, is the same as in Besley and Ghatak (2009a), for the case of credit markets with monopolistic lenders.

In contrast, risk aversion leads to an interaction between the effect of collateral on credit demand and repayment. If the interest rate on a loan is high and a large amount of collateral must be pledged, a risk averse borrower may prefer to reject a loan offer and have the certainty that she will keep her endowment of 100.

The effects of risk aversion are summarized in Proposition 2. The proof is presented in Appendix A.

Proposition 2 *If the borrower is risk averse, the effect of collateral on moral hazard remains independent of the interest rate. However, the effect of collateral on credit demand may interact with the interest rate: credit demand is more likely to fall with collateral increases at high interest rates.*

Having clarified the role of risk aversion, we now turn to the specific treatments of the experiment and derive hypotheses to be tested.

3.3 Treatments and Hypotheses

The experiment consists of four main treatments and one benchmark treatment. The four main treatments allow for a 2x2 design, where the amount of collateral and the level of interest are varied separately. Two levels of collateral are considered, 50% and 100% of the loan amount. Also, two levels of interest payment are considered, low and high. A low interest corresponds to the case where repayment is 200, while a high interest corresponds to a repayment of 250. These are the optimal repayments for the lender when collateral is 50 and 100, respectively.[6]

Table 2 displays the four treatments and the predicted effort level for risk neutral borrowers. Risk aversion may change the exact effort predicted. However, the increase in effort with an increase in collateral is still expected to be the same in Low and High interest treatments. Since collateral is at least 50, offering and accepting a loan is optimal in all treatments. Thus, all treatments are expected to feature a large credit volume.

Table 2: Experimental Treatments and Predictions

		Interest	
		Low (R=200)	High (R=250)
Collateral	C=50	$e^* = 3$	$e^* = 2$
	C=100	$e^* = 4$	$e^* = 3$

[6] Since repayment is the sum of loan principal and interest payment and the loan principal does not vary across treatments, an increase in repayment is equivalent to an increase in the interest. Therefore, these treatments are labelled as high interest and low interest.

A benchmark treatment is added to evaluate the impact of collateral availability. In this treatment, labelled No Collateral, the amount of collateral is 0. Offering a loan is not profitable and thus credit supply is expected to be zero. The repayment level is set to R=200. The exact level of repayment does not affect predictions, as it is not profitable to offer loans.

Two main hypotheses are tested. First, the effect of collateral on moral hazard is expected to be as follows:

Hypothesis 1: *If collateral increases, effort increases. The same increase is observed in Low and High Interest treatments.*

Note that also if borrowers are risk averse such hypothesis is expected to hold.

The second hypothesis concerns credit volume. When collateral becomes available, credit supply is expected to increase, since offering credit and requesting collateral is optimal at collateral levels of 50 and 100, for both high and low interest. At the same time, credit demand, which is always positive, does not vary.

Hypothesis 2: *When collateral increases from C=0 to C=50 and C=100, credit volume increases. Credit supply increases, while credit demand does not vary, both in Low and High Interest treatments.*

However, as we have seen, Hypothesis 2 may not be satisfied if borrowers are risk averse. In that case, the effect of collateral availability on credit volume is expected to depend on the interest rate. At high interest rates, an increase in collateral may decrease credit demand. Thus, credit volume may fall with increases in collateral.

3.4 Procedures

The experiment was conducted in CentERlab at Tilburg University. In total 156 students participated in the experiment. 28 in the treatment with C=100 and high interest, and 32 in all other treatments. Subjects only participated in one treatment. They were invited via e-mail to participate in the experiment. The experiment was conducted using z-Tree (Fischbacher, 2007).

Subjects started the lending game by reading a printed copy of the instructions (to be found in Appendix B). After all subjects had read the instructions, they were asked to fill in a quiz that was then checked by the experimenter. The labeling of the game was neutral. Each subject was assigned the role of player 1 or player 2, lender or borrower respectively, from the start. Player 1 could offer 100 points to player 2 and, in the treatments with available collateral, player 1 could request collateral. To simplify the

borrower's task in the experiment and make sure the effect of effort on the probability of success was clear, the borrower's task in the investment project consisted in buying red balls. At the start, there were 6 black balls in the project. Player 2 could choose how many red balls to buy (1, 2, 3, 4 or 5) and each red ball substituted a black ball. Black and red balls represented project failure and success, respectively. Therefore, subjects could easily understand that by buying more balls, they were increasing the chances of project success. Buying red balls was costly for the borrower. The borrower was clearly informed about these costs (in the instructions and computer screens).

The game was played once. This prevented wealth effects, which may influence borrowers' perception of collateral pledging over time and thus incentives. It also prevented group reputation effects from influencing lenders' and borrowers' decisions. To elicit borrowers' decisions the strategy method was used. That is, each borrower decided to accept or reject a loan offer and her effort, before knowing the lender's offer. This method provides a within-subject measure of the effect of collateral requests, i.e. borrower decisions are observed for both the case that the lender requests collateral and the case that he does not. After the effort decision, the decisions of the lender and borrower were combined (within each pair) and the computer made a random draw from the distribution, determined by the effort choice of the borrower.

Each session started with three pre-experimental games: a risk preference elicitation task (which is a variation of Holt and Laury, 2002), a p-beauty contest game with $p=\frac{2}{3}$ (Nagel, 1995) and a trust game (Berg et al, 1995). These games, which were played without any feedback, yield measures related to risk preferences, rationality and social concerns. These can then be used as controls on behavior in the lending game.[7] After the lending game, subjects' beliefs about others' behavior were elicited. Subjects were rewarded monetarily, depending on the distance between their belief and the actual average behavior of others.

At the end of the experiment, they were informed about the outcome of each pre-experimental game, the lending game and the accuracy of their beliefs.[8] Subjects were then paid their earnings in private and in cash. Average total earnings were 10.5 EUR. Of these, the largest portion was earned in the lending game, 6.6 EUR. The experiment lasted 45 to 60 minutes.

[7] Appendix C.1 presents a detailed description of these games and summary statistics.

[8] Beliefs were close to actual behavior of other players. A detailed summary of beliefs compared to actual behavior is provided in Appendix C.2.

4 Results

In this section, the effect of collateral on effort is analyzed first. Then, the results on credit supply, demand and volume are presented. The profits obtained across treatments are reported thereafter.

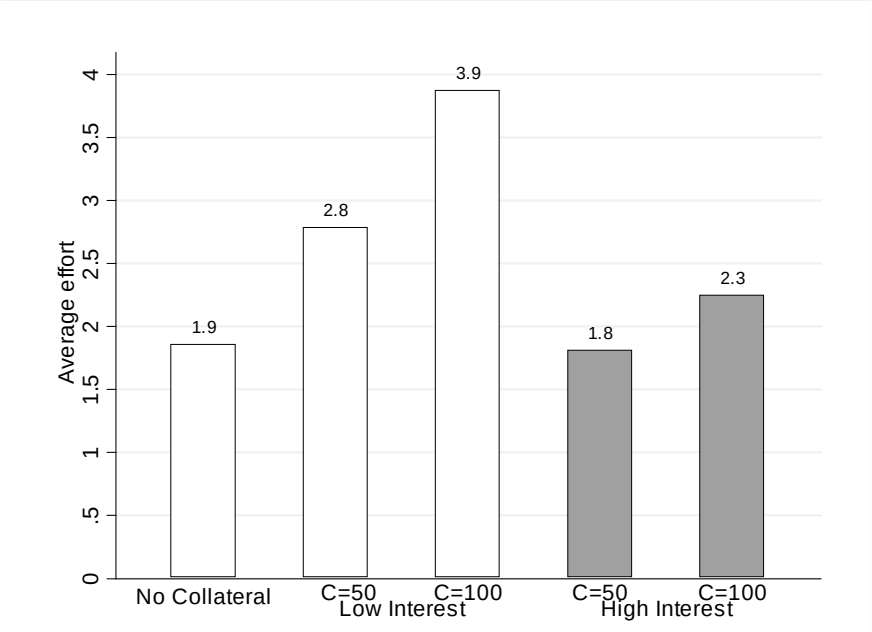
4.1 Effort

An increase in the amount of collateral is expected to lead to the same increase in effort, in low and high interest treatments. The experimental results show, however, that this is not the case. If the interest is low, effort increases significantly with collateral. But, if the interest is high, it does not.

Figure 1 displays average effort by treatment. In the benchmark treatment, No Collateral, effort is 1.9. In treatments with low interest, an increase in collateral yields a significant increase in effort (MW-test, p-value=<.01). If collateral is 50, effort is 2.8 and it increases to 3.9 when collateral is 100. However, if the interest is high, an increase in collateral does not yield a significant increase in effort. The change in effort, from 1.8 to 2.3, is not significantly different from zero (Mann-Whitney test, p-value=0.1878). This evidence leads to the rejection of Hypothesis 1 and yields the first result.

Result 1: *The incentive effect of collateral depends on the interest rate charged. If the interest is low, an increase in collateral leads to a significant increase in effort. However, if the interest is high, an increase in collateral does not increase effort significantly.*

Figure 1: Effect of Collateral on Effort



When the interest is high and C=100, effort is unexpectedly low. The average effort is 2.3, while we would expect it to be 3. As will be shown below, in this treatment lenders always request collateral. Thus, the low effort cannot stem from the lack of collateral requests. It is rather borrowers who are not strongly responding to the incentives of collateral. Comparing effort for the case that the lender requests collateral and the case that he does not, confirms the weak response to incentives. Table 3 presents average effort in each case, for all treatments in which collateral is available.

Table 3: Effort response to a request to pledge collateral

Collateral		Low Interest	High Interest
C=50	Effort if no collateral requested	2.2	1.2
	Effort if collateral requested	2.9	1.8
	WSR-test (p-value)	*<.01*	*<.01*
C=100	Effort if no collateral requested	2.6	1.3
	Effort if collateral requested	3.9	2.3
	WSR-test (p-value)	*0.01*	*0.07*

Note: WSR-test is the non-parametric Wilcoxon signed ranks test.

If C=50, effort when collateral is requested is significantly higher than when it is not, both with low and high interest. This is revealed by the p-value of the WSR-test, which is lower than .01 in both cases. The same result is obtained when C=100 and the interest is low. In contrast, the effect of a collateral request is weaker when the interest and collateral are high. In that case, effort displays a small increase, from 1.29 to 2.25, which is marginally significant, p=0.07.

A regression analysis of effort decisions is shown in Table 4, which reports OLS estimation results for the determinants of effort. These results are presented for the case that the interest is low (columns 1 and 2), if it is high (columns 3 and 4) and pooling both cases (columns 5 and 6). Treatment dummies and a dummy for the case the collateral is requested are considered first. Individual characteristics are added subsequently. Also the interaction term between high interest and risk aversion is included. This term allows us to examine whether the effect of risk aversion is independent of the interest rate.

When the interest payment is low, requesting a larger amount of collateral, 100 compared to 50, increases the effort level significantly. This can be seen from the positive and significant coefficient of the variable *Collateral=100* in columns 1 and 2. However, if the interest payment is high, this effect is no longer observed (columns 3 and 4). Increasing the amount of collateral does not increase effort as already revealed by Figure 2.

Table 4: Determinants of effort

	(1)	(2)	(3)	(4)	(5)	(6)
	Low Interest		High Interest		All	
Collateral=100	0.688**	0.511*	0.240	0.282	0.688**	0.582**
	[0.262]	[0.277]	[0.203]	[0.194]	[0.260]	[0.265]
High Interest					-1.063***	-1.088***
					[0.235]	[0.260]
C=100;High Interest					-0.430	-0.215
					[0.326]	[0.325]
Collateral Requested	1.000***	1.000***	0.757***	0.752***	0.891***	0.885***
	[0.262]	[0.271]	[0.174]	[0.172]	[0.164]	[0.167]
Risk aversion		-0.333		-0.234		-0.288
		[0.289]		[0.172]		[0.300]
Risk aversion*High Int.						-0.013
						[0.360]
Strategic Reasoning		-0.004		0.007		0.005
		[0.010]		[0.005]		[0.006]
Trust		-0.049		0.005		-0.023
		[0.040]		[0.024]		[0.025]
Trustworthiness		0.027		-0.006		0.010
		[0.045]		[0.027]		[0.028]
Constant	2.063***	2.623***	1.122***	0.674	2.117***	1.918***
	[0.249]	[0.722]	[0.140]	[0.402]	[0.223]	[0.445]
Observations	64	64	54	54	118	118
Number of subjects	32	32	30	30	62	62
R-squared	0.263	0.289	0.264	0.309	0.490	0.502

Note: this table reports OLS regression estimates for effort, the dependent variable. The variable *Collateral=100* is a dummy variables that takes value 1 if C=100; *High Interest* takes value 1 if R=250; *C=100;High Interest* is the interaction term between $C=100$ and $High\ Interest$. *Collateral Requested* takes value 1 if the lender choose to request collateral. *Risk aversion, Strategic Reasoning,Trust and Trustworthiness* are measures from the pre-experimental games. *Risk aversion*High Int.* is the interaction term between risk aversion and High Interest.*** p<0.01, ** p<0.05, * p<0.1; Clustered standard errors at the subject level in brackets.

When both levels of the interest payment are combined (columns 5 and 6), we observe that the coefficient *Collateral=100* is significantly positive, but the sum of this coefficient and that of *C=100*R=250* is not significantly different than 0 (F-test, p-value=0.1643).

This confirms that collateral increases lead to an increase in effort when the interest is low, but not when it is high. Individual characteristics, including risk aversion and its interaction with the interest level, do not affect effort decisions significantly.

These results confirm that the incentive effect of collateral depends on the interest rate. Nevertheless, they do not clarify why this is the case. Two potential explanations can be given. First, borrowers may not be willing to take up a loan when project failure may leave them with a lower payoff than their initial endowment. If the project fails, they not only lose their collateral but also face the effort cost. Borrowers who are averse to this loss may choose a low effort to save on effort costs, when the interest is high. In contrast, when the interest is low, payoffs from success compensate the loses in case of project failure and incentivize borrowers to exert a high effort.

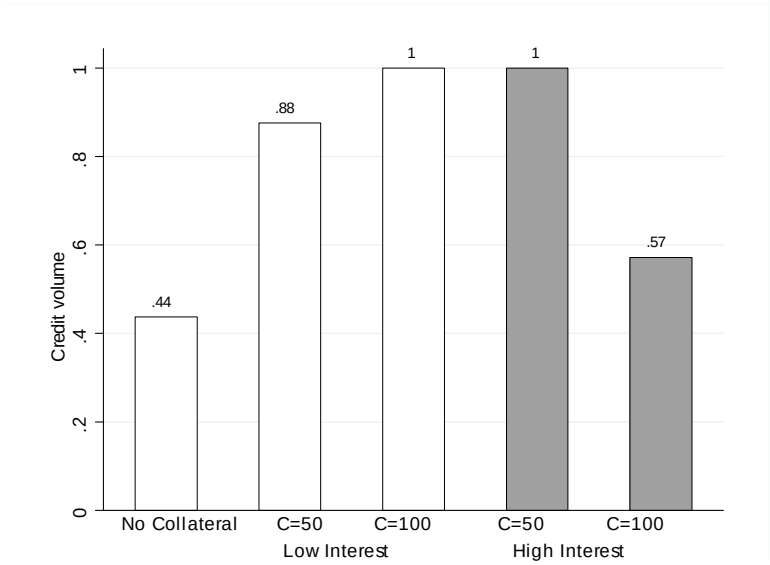
Second, borrowers may perceive a high payoff obtained by the lender as unfair. When the interest is high, the lender's payoff advantage is largest. Borrowers may decrease it by decreasing their effort. These two explanations are detailed in the next section, which presents results from an additional treatment aimed at distinguishing between them.

4.2 Credit volume

Figure 2 displays credit volume per treatment. In the absence of collateral, 44% of all possible loans are offered and accepted. This volume of credit increases up to 100% when collateral becomes available. However, the increase in credit volume is not independent of the interest rate. When the interest rate is high, credit volume drops from 100% to 57% when collateral increases from C=50 to C=100. Therefore, the flow of credit not only depends on collateral availability, but is also sensitive to the particular loan conditions.

The differences in credit volume across treatments can be better understood by considering credit demand and supply separately. The increase in credit volume, when the interest is low, is driven by credit supply. In contrast, the decrease, when interest is high, is driven by credit demand. Table 5 displays credit demand and supply in each treatments.

Figure 2: Credit volume



In the benchmark treatment, No Collateral, 44% of lenders offer credit. Credit supply increases to 88% if C=50 and the interest is low, and to 100% in all other treatments. Collateral is requested by a majority of lenders. If the interest is low, 93% of lenders request collateral in C=50 and 94% in C=100. If the interest is high, all lenders request collateral.

Table 5: Credit supply and demand by treatment

Collateral		Low Interest	High Interest
No Collateral	Supply	44%	-
	Demand	100%	
C=50	Supply	88%	100%
	Demand	100%	100%
C=100	Supply	100%	100%
	Demand	100%	57%

Credit demand is not constant across treatments. Increases in collateral do not affect demand when the interest is low. However, when the interest is high, increases in collateral lead to a decrease in demand. The demand for credit drops from 100% to 57% when collateral increases from C=50 to C=100. This implies that Hypothesis 2 is rejected and leads to Result 2.

Result 2: *If collateral increases, credit supply increases both with high and low interest rates. However, at high interest rates, an increase in collateral decreases credit demand.*

Therefore, we observed the predicted increase in credit supply with increases in collateral. However, there is one surprising result. In the treatment without collateral, offering a loan is not profitable. Nevertheless, a substantial portion of lenders offer loans. This may be driven by lender's trust towards borrowers. Trusting borrowers would be consistent with the presence of trust in many investment environments, in particular in microfinance and venture capital markets (Bottazzi et al, 2010). Such relationship between trust and offers in the absence of collateral is also found among the experimental subjects. The Spearman rank correlation coefficient between trust and offers in No Collateral is positive and significant, 0.4789 (p-value=0.0605). Also, trust is the only individual characteristic which is signficantly correlated to credit offers.

Further, we observe that at high interest rates demand decreases with collateral. As studied above, this may be caused by risk aversion. The data reveal that risk averse borrowers are slightly more likely to reject credit offers, though the relationship is not significant (Fisher's exact test, p-value=0.238). A caveat is that in this treatment the share of risk averse borrowers is higher than in others. 57% of the borrowers are risk averse while in other treatments the share of risk averse borrowers is at most 31%. Due to the limited variation of credit demand in other treatments, it is not possible to directly address this difference in the rate of risk averse borrowers with the existing data and conduct an econometric analysis of demand. However, results from an additional treatment, presented in the next section, will provide the additional data to perform this analysis.

4.3 Payoffs

The incentive effects of collateral have consequences on lender, borrower and total payoffs. More collateral increases the lender's payoff, though it does not always increase the borrower's payoff. Table 6 below displays expected payoffs, using the decisions of players and calculating the expected payoff based on the probability of success. Realized payoffs are basically the same for most of the treatments, where the average of all draws corresponds to the expectation, except for the treatment with low interest and C=50, where draws were unexpectedly lucky.

Starting with the lender, his payoff is lowest when no collateral is available. In this treatment 44% of lenders offer a loan. Doing so is unprofitable, since borrowers exert a low effort. The lender's payoff increases with collateral, both in treatments with high

and low interest. Interestingly, the lender's payoff is largest in treatment where C=100 and the interest is low, and not when it is high (the difference in profits is significant, MW-test p-value=0.0114), despite the fact that when C=100, the high interest is ex-ante optimal.

Table 6: Lender, borrower and total payoffs by treatment

Collateral		Low Interest	High interest
No Collateral	Lender	133.3	
	Borrower	150.0	-
	Total	*283.4*	
C=50	Lender	165.1	157.8
	Borrower	177.0	168.1
	Total	*342.1*	*325.9*
C=100	Lender	214.6	182.1
	Borrower	164.2	119.0
	Total	*378.8*	*301.1*

The borrower's payoff is largest when C=50 and interest is low. This is due to the fact that in this treatment the borrower gains access to credit, without having to pledge a large collateral or pay a high interest. For the opposite reason, the borrower's payoff is lowest when C=100 and interest is high.

The sum of both player's payoffs, labelled as *Total* in Table 6, is highest in when collateral is 100 but the interest is low. In this treatment effort is highest, leading to the highest payoffs. These are significantly higher than in other treatments. A regression analysis yields the same results. The estimation results are available from the author.

Result 3: *The lender's payoff increases with increases in collateral. The borrower's payoff, however, increases when collateral increases from 0 to 50, but decreases when it increases from 50 to 100.*

5 Additional results

The experimental results have left us with one surprising result. The effect of collateral increases on moral hazard depends on the interest rate. This section discusses two potential explanations and examines the results from an additional treatment to clarify which one is dominant.

As mentioned before, borrowers' loss aversion or fairness concerns could affect the impact of collateral on moral hazard. Suppose borrowers are loss averse. A simple utility function that captures loss aversion is proposed by Kahneman and Tversky (1979). Utility is experienced by borrowers in terms of changes with respect to a reference point x. Thus, the borrower's utility depends on the difference between her final payoff π_B and this reference point,

$$U(x) = \begin{cases} \pi_B - x & \text{if } \pi_B - x \geq 0 \\ \lambda(\pi_B - x) & \text{if } \pi_B - x < 0 \end{cases}$$

where $\lambda > 1$. In the lending game a natural reference point is the borrower's initial endowment, 100 points. In treatment No Collateral and treatments with C=50, at most 50 points are pledged and effort supply is at most 3. Thus, the loss domain (where $u_B - x < 0$) is not entered. In contrast, in treatments where C=100, borrowers may enter in the loss domain. If the project fails, borrowers transfer their complete initial endowment of 100 points to the lender. Since they must provide effort of at least one, effort costs are perceived as losses. Importantly, the effect of loss aversion differs across the treatments with low and high interest. This is illustrated in Table 7, which displays the borrower's utility, assuming $\lambda = 2$.[9] Table 7 displays first utility in case of success, which yields gains and thus is valued as $\pi_B - x$. Second, utility is displayed for the case of project failure, which leads to losses valued by $\lambda(\pi_B - x)$. The last row shows the expectation.

Table 7: Loss aversion

	C=100, Low interest					C=100, High interest				
	Effort					Effort				
	1	2	3	4	5	1	2	3	4	5
$\pi_B - x$	196	184	164	136	100	146	134	114	86	50
$\lambda(\pi_B - x)$	-8	-32	-72	-128	-200	-8	-32	-72	-128	-200
Expectation	26	40	46	48	**50**	18	**23**	21	15	8

As shown in bold in Table 7, the optimal effort of a loss averse borrower is 5 if the interest is low, while it is 2 if the interest is high. When the interest is low, the rents

[9] See Booij and van der Kuilen (2009) for population estimates of the value of λ. Also, I abstract from probability biases, for simplicity. Alternatively, one could potentially allow for overweighing of small probabilities and underweighting of large probabilities as suggested by Kahneman and Tversky (1979) and Prelec (1998). Overweighing would decrease optimal effort in all treatments.

from success are large, and therefore the borrower has an incentive to exert a high effort to obtain those payoffs and avoid losing her capital. In contrast, with high interest, the rents from success are small and the borrower is no longer as strongly motivated to make the project succeed but to reduce the losses from failure. This diminishes effort supply to 2.

Alternatively, suppose the borrower has fairness concerns. A simple way to model these is using the inequity aversion model by Fehr and Schmidt (1999). In this model, the utility of the borrower over each pair of final payoffs is $U(\pi_B, \pi_L) = \pi_B - \alpha_B \max\{0, \pi_L - \pi_B\} - \beta_B \max\{0, \pi_B - \pi_L\}$, where $\alpha_B \geq \beta_B$, and $0 \leq \beta_B < 1$.[10] It is easy to show that lower levels of α_B are needed for the borrower to be willing to lower her effort supply when collateral is 100 and the interest is high, compared to when the interest is low. Thus, fairness concerns could explain the low effort in under high interest and collateral.

A potential concern in comparing low and high interest rate treatments, when C=100, is that acceptance varies across treatments, as fewer borrowers demand credit when C=100 and the interest is high. This could lead to differences in the risk aversion of borrowers who accept a loan. Nevertheless, selection works against lower effort. Suppose risk averse borrowers reject offers when C=100 and the interest are high, while they accept offers when C=100 but the interest low. Then the pool of borrowers who demand credit is likely to be less risk averse when the interest rate is high. Thus, when C=100 and interest rates are high, we would not expect a lower effort .

A Tax treatment allows us to disentangle between loss aversion and fairness concerns. This treatment is identical to that with C=100 and high interest, but for a tax on the lender's profits of 75 points if the project succeeds. This tax decreases the difference between the lender and borrower's payoffs and therefore strongly reduces the role of fairness. In fact, it makes payoff differences very close to those in the treatment with C=100 and low interest, where effort is very close to the prediction. Alternatively, one could also consider a treatment which reduces loss concerns. But doing so is difficult. For example, changing the borrower's endowment not only changes the reference point but also the borrower's participation constraint.

Effort in the additional Tax treatment is presented in Table 8. Effort with and without the tax is similar in both treatments. Importantly, when collateral is requested, effort is

[10] Note that inequity aversion is a model that generates spiteful behavior when a player is at a payoff disadvantage. Such spiteful behavior may also be generated by different models, such as Levine (1998). In his model there are altruistic, selfish and spiteful types, which are unidentifiable ex-ante. A player's utility depends on other's types in the following way: $U_i = u_i + \frac{a_i + \lambda a_j}{1+\lambda} u_j$, where u_i is the player's i payoff, -1 $< a_i \leq$ 1 is the coefficient of altruism of player i and λ the weight player i assigns to player j's type. Note that in our experiment most lenders offer loans and request collateral and thus their behavior is consistent with that of a pooling equilibrium (all types choosing the same action). As a consequence, the borrower's perception of a_j is most likely equal to the population average, $\bar{a}$. Therefore, we are left with a parameter which is very similar to that of inequity aversion, and can be simplified to $\alpha_i(a_i, \lambda, \bar{a})$.

low in both treatments: it is 2.3 without a tax and 2.1 with a tax. The Mann-Whitney test has a p-value of 0.6148. Therefore, the impact of collateral on effort is not affected by the presence of a tax. Further, effort does not increase significantly if collateral is requested, compared to when it is not, in the Tax treatment (WSR test, p-value=0.15).

Table 8: High collateral and interest, with and without tax

	C=100, High Interest	
	No tax	Tax
Effort if no collateral requested	1.3	1.7
Effort if collateral requested	2.3	2.1
WSR-test (p-value)	*0.07*	*0.15*

Note: WSR-test is the non-parametric Wilcoxon signed ranks test.

This indicates that effort when C=100 and the interest is high is not likely to be driven by fairness concerns. Instead, it suggests that loss aversion drives effort decisions. Borrowers' explanations for their effort choices in post-experimental questionnaires also point to the role of loss aversion. As one of the subjects mentioned, *'[I chose effort] 2,you can gain a lot if u win and the possibility to win is higer than 1,and if you lose ,you cannot lose that much'*. This leads to Result 4.

Result 4: *The interaction between the effect of collateral on moral hazard and the interest rate seems to be driven by loss aversion. When C=100 and the interest is high, borrowers choose a lower effort than predicted, since they fear losses in case of project failure.*

Additionally, the data in the Tax treatment allow us to examine whether risk aversion affects credit demand. As we have seen above, if the interest is high, an increase in collateral decreases credit demand. A concern is that in the treatment without a tax but with C=100 and high interest, the proportion of risk averse borrowers is higher than in other treatments. In the Tax treatment, the 25% of the borrowers are risk averse, which is similar to that in treatments with C=50 (31% and 22% with low and high interest, respectively) and treatment C=100 and low interest (16%). Thus, in the Tax treatment there are less risk averse borrowers than in the No Tax treatment. This leads to a marginally significant increase in credit demand from 57% to 87% (MW-test, p-value=0.0651).

Table 9 presents probit estimation results for the determinants of demand. It reports the marginal effects of each variable on demand. The first regression, in column 1, only has the Tax treatment dummy as an independent variable. It seems to indicate that the

treatment variation increases demand. However, column 2 reveals that once individual characteristics are entered as controls, this effect disappears. Risk aversion reduces credit demand. A higher degree of strategic reasoning also reduces the probability of credit demand. This effect is weaker than that of risk aversion. This leads to Result 5.

Table 9: Determinants of credit demand

	Credit demand	
	(1)	(2)
Tax	0.304*	0.063
	[0.159]	[0.105]
Risk aversion		-0.378**
		[0.170]
Strategic Reasoning		-0.017**
		[0.008]
Trust		-0.012
		[0.018]
Trustworthiness		0.019
		[0.018]
Observations	30	30
Pseudo-R2	0.104	0.411
Log-likelihood	-15.59	-10.26
Treatments	C=100, Interest High, Tax and No tax	

Note: this table reports marginal effects from a probit regression of credit demand. Tax is a dummy variable that takes value 1 if the treatment includes a lender tax. *Risk aversion, Strategic Reasoning, Trust and Trustworthiness* are measures from the pre-experimental games *** p<0.01, ** p<0.05, * p<0.1; Robust standard errors in brackets.

Result 5: *When the interest rate is high and collateral is 100, borrowers who are risk averse are significantly less likely to demand credit.*

6 Conclusion

Understanding the role of collateral in credit markets is very relevant. Collateral is widely used in financial contracting and can have important consequences for growth and the persistence of income inequality. Several theoretical models have studied the role of collateral. Many have pointed out the effect of collateral in reducing moral hazard and the implications this has for credit supply. However, the empirical evidence of the effect of collateral on moral hazard is scarce. This paper contributes to the literature by providing the first experimental evidence regarding the effect of collateral on moral hazard and credit volume.

A main contribution of the paper is to identify the direct effect of collateral on borrower effort. The main finding is that, contrary to the theoretical predictions, the effect of collateral on effort depends on the interest rate. In markets with low interest rates, increases in collateral have a strong effect on effort. In contrast, in markets with high interest rates, the effect of collateral increases is weak. When the amount of collateral and the interest rate are high, borrowers provide an unexpectedly low effort. Results from an additional treatment suggest that this effect is caused by borrowers' loss aversion. In taking up a loan with high collateral, borrowers face the risk of losing their initial wealth and paying effort costs as well. When the interest rate is high, loss averse borrowers prefer providing a low effort to save on effort costs.

A second important contribution of the paper is to identify the effect of collateral on credit supply and demand. As many theoretical studies have pointed out: increases in collateral, make lending more profitable as they reduce the problem of moral hazard. Thus, credit supply should increase with collateral availability. The experimental results confirm such prediction. The results also point out that credit demand may depend on collateral requirements. As pointed out theoretically in the paper, if borrowers are risk averse, increases in collateral availability may decrease credit demand, especially if the interest rate is high. The experimental results reveal that risk aversion has such effects on credit demand.

The results indicate that the effects of collateral, on moral hazard and credit volume, are likely to be strongest in markets with low interest rates. In these markets, the incentive effect of collateral is likely to reduce loan defaults significantly. Additionally, the availability of collateral is likely to increase credit volume strongly, as it increases credit supply and does not decrease credit demand. Thus, institutional changes which allow more assets to be pledged as collateral, such as reforms which make property registration easier or directly extend property titling, are likely to be most effective in markets where interest rates are low.

Finally, the results also indicate that borrower behavior may be driven by concerns

about risk and losses. Risk concerns decrease credit demand, especially when interest rates are high. This provides an explanation for the low credit demand in developing economies, despite the need of credit. Managers of small and medium enterprises, who indicate that high interest rates are the main reason for their lack of demand, may be averse to the risks of borrowing. Further, the experimental results reveal that borrower behavior, after a loan has been extended, may also be affected by concerns about losses. If loans feature high interest rates and are fully secured, borrowers may choose to save on effort costs rather than provide a high effort. This may substantially weaken the incentive effect of collateral on moral hazard.

Appendix A: Proofs

Proposition 1 *If the lender and the borrower are risk neutral, an increase in collateral from 0 to 100% of the loan amount, has two main effects: (1) it reduces the problem of moral hazard: effort supply increases; (2) it increases credit supply, while it does not affect credit demand, and therefore it increases credit volume. Both effects do not vary across different interest rate levels.*

Proof. If the borrower is risk averse, increases in collateral decrease the problem of moral hazard, independently of the interest rate. However, at high interest rates, increases in collateral may decrease credit demand.$e^* = \frac{1}{48}(300 - R + C)$, $\frac{\partial e}{\partial C} > 0$ and $\frac{\partial^2 e}{\partial C \partial R} = 0$. The second effect of collateral follows from the fact that, given $R^* = 150 + C$, the lender's participation constraint is satisfied if $C \geq 21\frac{7}{8}$, and the borrower's participation is satisfied for all $0 \leq C \leq 100$. ■

Proposition 2 *If the borrower is risk averse, the effect of collateral on moral hazard remains independent of the interest rate. However, the effect of collateral on credit demand may interact with the interest rate: credit demand is more likely to fall with collateral increases at high interest rates.*

Proof. The partial derivative of utility with respect to effort is

$$\frac{\partial U}{\partial e} = g[u(100 + 300 - R) - u(100 - C)] - 8eu'(100 - 4e^2) \tag{1}$$

We have that the optimal effort is determined by $8eu'(100-4e^2) = g[u(100+300-R) - u(100-C)]$. It follows that an increase in collateral (C) increases the optimal effort level. Furthermore, this effect is independent of R. [11]

Additionally, borrower's participation constraint is

$$\frac{e}{6} \cdot u(100 + 300 - R) + (1 - \frac{e}{6}) \cdot u(100 - C) + u(S(e)) \geq u(100)$$

Suppose a risk neutral borrower's participation is satisfied with equality for a given R and C=100. Then, it follows that the participation constraint of a risk averse borrower, for the same R and C is violated. ■

[11] Note that, in general, risk aversion decreases the optimal effort provided by the borrower. This can be seen from the fact that the right-hand side of $8eu'(100 - 4e^2) = g[u(100 + 300 - R) - u(100 - C)]$ decreases due to risk aversion. Therefore, the left hand side must decrease as well. This is achieved only if effort decreases. We have that $\frac{\partial}{\partial e} 8eu'(100 - 4e^2) = 8[u'(100 - 4e^2) - 8e^2 u''(100 - 4e^2)] > 0$, since $u''(100 - 4e^2) < 0$ by concavity. Thus risk aversion decreases effort.

Appendix B: Instructions

Instructions are presented for the treatment where collateral is 100 and repayment is 200. The instructions for the other treatments are similar, and mainly require a change in the numbers presented.

Instructions

This experiment will consist of 1 period only. In this experiment you will be randomly paired with another participant. Each participant is randomly assigned to be player 1 or player 2. You have been randomly assigned to be:

Player 1 or 2

You will keep this role throughout the experiment. You will not know the identity of the other player nor will the other player know your identity at any point. You will be paid your total earnings in cash and in private at the end of experiment 5. The exchange rate from points to EUR is the following:

25 Points = 1 EUR

Overview of decisions

At the beginning of the experiment, player 1 is endowed with 150 points. Player 2 is endowed with 100 points. Player 1 can offer 100 points to player 2 to start a project. Player 2 cannot use his or her endowment for that purpose. If player 1 offers 100 points to player 2, he/she can request a guarantee of 100 points from player 2. Player 2 can accept an offer from player 1.

If player 2 accepts an offer, player 2 makes a decision with regard to a project. In this project, player 2 can use the 100 points he/she gets from player 1 to buy red balls. Player 2 can buy 1, 2, 3, 4 or 5 red balls. At the start, there are 6 black balls in the project. Each red ball bought by player 2 replaces one black ball. Buying red balls is costly. The exact costs will be shown in the next section.

After player 2 has decided how many red balls to buy, a ball is randomly drawn out of the project by the computer. If the ball is red, the project yields 300 points. Player 1 receives 200 points and player 2 receives 100 points. If the ball is black, the project yields 0 points. If player 1 requested a guarantee of 100 points and the ball is black, he/she receives 100 points from player 2.

Instructions for player 1

Offering points

At the beginning of the experiment, you are endowed with 150 points. Player 2 is endowed with 100 points. You can offer 100 points to player 2 to start a project. Player 2 cannot use his or her endowment for that purpose. If you offer 100 points to player 2, you can request a guarantee of 100 points from player 2.

In the screenshots attached at the end of the instructions you find an image of the decision screens you will see during the experiment.These screens are titled 'Offer screen'.

Accepting offers and buying red balls

Player 2 decides whether to accept an offer from you. If player 2 accepts, he/she can use the 100 points received from you to buy red balls for a project. The more red balls are bought, the less black balls there are in the project, as displayed in Table 1. Therefore, the more red balls are bought, the higher is the probability that a red ball is randomly drawn out of the project.

Number of red balls bought	**1**	**2**	**3**	**4**	**5**
The project contains:					
Number of red balls	1	2	3	4	5
Number of black balls	5	4	3	2	1
Probability that red ball is drawn	1/6	2/6	3/6	4/6	5/6
	or 16.7%	or 33.3%	or 50%	or 66.7%	or 83.3%

Table 1: The project's red and black balls

Buying red balls is costly for player 2. The exact costs are detailed in Table 2.

Number of red balls bought	**1**	**2**	**3**	**4**	**5**
Cost	4	16	36	64	100

Table 2: Cost of buying red balls

Player 2 will be asked to decide whether he/she accepts your offer and how many red balls to buy for two cases: if you request no guarantee and if you request a guarantee of 100 points.

At the end of experiment 5, player 2 will be informed about your offer and whether you requested a guarantee of 100 points. You will be informed about whether player 2 accepted this offer and the color of the ball drawn from the project. You will not be informed about the number of balls bought by player 2.

In the screenshots attached at the end of the instructions you find an image of the decision screens player 2 will see during the experiment. These screens are titled 'Accept screen' and 'Project screen'.

Payoffs

Your payoff depends on whether you offer 100 points, whether you request a guarantee of 100 points, whether player 2 accepts the offer, the number of red balls bought by player 2 and the color of the ball that is thereafter drawn from the project.

If you do not offer 100 points or player 2 does not accept the offer, payoffs are equal to the initial endowments:

Your payoff = 150
Player 2's payoff = 100

If you offer 100 points and player 2 accepts this offer, the payoffs depend on whether the ball drawn from the project is red or black. If the ball drawn is red, your payoff is equal your endowment, 150 points, minus 100 points offered to player 2, plus the return you receive from the project, 200 points. Player 2's payoff is his/her endowment, 100 points, plus 100 points received from you, plus the return he/she receives from the project, 100 points, and minus the costs of buying red balls.

Your payoff = 150 – 100 +200 = 250
Player 2's payoff = 100 + 100 + 100 – Costs

If the ball drawn is black, your payoff is equal to your endowment, 150 points, minus 100 points offered to player 2, plus the guarantee requested by you. If you did not request a guarantee, the guarantee requested is 0. If you requested a guarantee, the guarantee requested is 100 points. Player 2's payoff is his/her endowment, 100 points, plus 100 points received from you, minus the costs of buying red balls minus the guarantee requested by you.

Your payoff = 150 – 100 + Guarantee requested
Player 2's payoff = 100 + 100 – Costs – Guarantee requested

Below we display your payoffs and player 2's payoffs if you offer 100 points and player 2 accepts this offer. In each table, first you find the probability that a red ball is drawn. In the first table you find your payoffs and that of player 2 if no guarantee is requested by you. In the second table you find your payoffs and that of player 2 if a guarantee of 100 points is requested by you.

If no guarantee is requested by you:

Number of red balls bought					
Probability that a red ball is drawn	1/6 or 16.7%	2/6 or 33.3%	3/6 or 50%	4/6 or 66.7%	5/6 or 83.3%
			Your payoff		
If a red ball is drawn:	250	250	250	250	250
If a black ball is drawn:	50	50	50	50	50
Expected payoff	83.3	116.7	150.0	183.3	216.7
			Player 2's payoff		
If a red ball is drawn:	296	284	264	236	200
If a black ball is drawn:	196	184	164	136	100
Expected payoff	212.7	217.3	214.0	202.7	183.3

If a guarantee of 100 points is requested by you:

Number of red balls bought					
Probability that a red ball is drawn	1/6 or 16.7%	2/6 or 33.3%	3/6 or 50%	4/6 or 66.7%	5/6 or 83.3%
			Your payoff		
If a red ball is drawn:	250	250	250	250	250
If a black ball is drawn:	150	150	150	150	150
Expected payoff	166.7	183.3	200.0	216.7	233.3
			Player 2's payoff		
If a red ball is drawn:	296	284	264	236	200
If a black ball is drawn:	96	84	64	36	0
Expected payoff	129.3	150.7	164.0	169.3	166.7

Beside each computer terminal, you can find a calculator. You may use it to do any further calculations.

Before the experiment starts, we would like to ask you some questions about the experiment. Please fill in your answer. If you have finished filling in the questions, please raise your hand and an experimenter will come to where you are seated. If you have any questions, please raise your hand.

Questions

Question 1

You do not offer 100 points. What is your payoff and that of player 2?

Your payoff =_ _ _ _ _ _ _ _ _ _

Payoff of player 2 =_ _ _ _ _ _ _ _ _ _

Question 2

You offer 100 points and request a guarantee of 100 points. Player 2 does not accept this offer. What is your payoff and that of player 2?

Your payoff =_ _ _ _ _ _ _ _ _ _

Payoff of player 2 =_ _ _ _ _ _ _ _ _ _

Question 3

You make an offer of 100 points. Player 2 accepts this offer. Please fill in the table below.

If you do not request a guarantee of 100 points:

		Your payoff	Player 2's payoff	Probability that red ball is drawn
If number of red balls bought is:				
1	If red ball is drawn			
	If black ball is drawn			
3	If red ball is drawn			
	If black ball is drawn			
5	If red ball is drawn			
	If black ball is drawn			

If you request a guarantee of 100 points:

		Your payoff	Player 2's payoff	Probability that red ball is drawn
If number of red balls bought is:				
1	If red ball is drawn			
	If black ball is drawn			
3	If red ball is drawn			
	If black ball is drawn			
5	If red ball is drawn			
	If black ball is drawn			

Summary

Before we start, let us briefly summarize the experiment.

1. Player 1 decides whether to offer 100 points to player 2 for a project. If he/she offers 100 points, he/she can request a guarantee of 100 points.
2. Player 2 decides whether to accept this offer.
3. Player 2 decides how many red balls to buy.
4. A ball is randomly drawn from the project.
5. Payoffs are calculated and shown on the screens after Experiment 5.

Instructions for player 2

Offering points

At the beginning of the experiment, player 1 is endowed with 150 points. You are endowed with 100 points. Player 1 can offer 100 points to you to start a project. You cannot use your endowment for that purpose. If player 1 offers 100 points to you, player 1 can request a guarantee of 100 points from you.

In the screenshots attached at the end of the instructions you find an image of the decision screens player 1 will see during the experiment. These screens are titled 'Offer screen'.

Accepting offers and buying red balls

You decide whether to accept an offer from player 1. If you accept, you can use the 100 points received from player 1 to buy red balls for a project. The more red balls are bought, the less black balls there are in the project, as displayed in Table 1. Therefore, the more red balls are bought, the higher is the probability that a red ball is randomly drawn out of the project.

Number of red balls bought	**1**	**2**	**3**	**4**	**5**
The project contains:					
Number of red balls	1	2	3	4	5
Number of black balls	5	4	3	2	1
Probability that red ball is drawn	1/6	2/6	3/6	4/6	5/6
	or 16.7%	or 33.3%	or 50%	or 66.7%	or 83.3%

Table 1: The project's red and black balls

Buying red balls is costly for player 2. The exact costs are detailed in Table 2.

Number of red balls bought	**1**	**2**	**3**	**4**	**5**
Cost	4	16	36	64	100

Table 2: Cost of buying red balls

You will be asked to decide whether you accept player 1's offer and how many red balls to buy for two cases: if player 1 requests no guarantee and if player 1 requests a guarantee of 100 points.

At the end of experiment 5, you will be informed about player 1's offer and whether player 1 requested a guarantee of 100 points. Player 1 will be informed about whether you accepted this offer and the color of the ball drawn from the project. Player 1 will not be informed about the number of balls bought by you.

In the screenshots attached at the end of the instructions you find an image of the decision screens you will see during the experiment. These screens are titled 'Accept screen' and 'Project screen'.

Payoffs

Your payoff depends on whether player 1 offers 100 points, whether player 1 requests a guarantee of 100 points, whether you accept the offer, the number of red balls bought by you and the color of the ball that is thereafter drawn from the project.

If player 1 does not offer 100 points or you do not accept the offer, payoffs are equal to the initial endowments:

Your payoff = 100
Player 1's payoff = 150

If player 1 offers 100 points and you accept this offer, the payoffs depend on whether the ball drawn from the project is red or black. If the ball drawn is red, your payoff is your endowment, 100 points, plus 100 points received from player 1, plus the return you receive from the project, 100 points, and minus the costs of buying red balls. Player 1's payoff is equal his/her endowment, 150 points, minus 100 points offered to you, plus the return player 1 receives from the project, 200 points.

Your payoff = 100 + 100 + 100 – Costs
Player 1's payoff = 150 – 100 + 200 = 250

If the ball drawn is black, your payoff is your endowment, 100 points, plus the 100 points received from player 1, minus the costs of buying red balls minus the guarantee requested by player 1. Player 1's payoff is equal to player 1's endowment, 150 points, minus 100 points offered to you, plus the guarantee requested by player 1. If player 1 did

not request a guarantee, the guarantee requested is 0. If player 1 requested a guarantee, the guarantee requested is 100 points.

Your payoff = 100 + 100 – Costs – Guarantee requested
Player 1's payoff = 150 – 100 + Guarantee requested

Below we display your payoffs and player 1's payoffs if player 1 offers 100 points and you accept this offer. In each table, first you find the probability that a red ball is drawn. In the first table you find your payoffs and that of player 1 if no guarantee is requested by player 1. In the second table you find your payoffs and that of player 2 if a guarantee of 100 points is requested by player 1.

If no guarantee is requested by player 1:

Number of red balls bought					
Probability that a red ball is drawn	1/6	2/6	3/6	4/6	5/6
	or 16.7%	or 33.3%	or 50%	or 66.7%	or 83.3%
			Your payoff		
If a red ball is drawn:	296	284	264	236	200
If a black ball is drawn:	196	184	164	136	100
Expected payoff	212.7	217.3	214.0	202.7	183.3
			Player 1's payoff		
If a red ball is drawn:	250	250	250	250	250
If a black ball is drawn:	50	50	50	50	50
Expected payoff	83.3	116.7	150.0	183.3	216.7

If a guarantee of 100 points is requested by player 1:

Number of red balls bought					
Probability that a red ball is drawn	1/6	2/6	3/6	4/6	5/6
	or 16.7%	or 33.3%	or 50%	or 66.7%	or 83.3%
			Your payoff		
If a red ball is drawn:	296	284	264	236	200
If a black ball is drawn:	96	84	64	36	0
Expected payoff	129.3	150.7	164.0	169.3	166.7
			Player 1's payoff		
If a red ball is drawn:	250	250	250	250	250
If a black ball is drawn:	150	150	150	150	150
Expected payoff	166.7	183.3	200.0	216.7	233.3

Beside each computer terminal, you can find a calculator. You may use it to do any further calculations.

Before the experiment starts, we would like to ask you some questions about the experiment. Please fill in your answer. If you have finished filling in the questions, please raise your hand and an experimenter will come to where you are seated. If you have any questions, please raise your hand.

Questions

Question 1

Player 1 does not offer 100 points. What is your payoff and that of player 1?

Your payoff =_ _ _ _ _ _ _ _ _ _

Payoff of player 1 =_ _ _ _ _ _ _ _ _ _

Question 2

Player 1 offers 100 points and requests a guarantee of 100 points. You do not accept this offer. What is your payoff and that of player 1?

Your payoff =_ _ _ _ _ _ _ _ _ _

Payoff of player 1 =_ _ _ _ _ _ _ _ _ _

Question 3

Player 1 makes an offer of 100 points. You accept this offer. Please fill in the table below.

If player 1 does not request a guarantee of 100 points:

		Your payoff	Player 1's payoff	Probability that red ball is drawn
If number of red balls bought is:				
1	If red ball is drawn			
	If black ball is drawn			
3	If red ball is drawn			
	If black ball is drawn			
5	If red ball is drawn			
	If black ball is drawn			

If player 1 requests a guarantee of 100 points:

		Your payoff	Player 1's payoff	Probability that red ball is drawn
If number of red balls bought is:				
1	If red ball is drawn			
	If black ball is drawn			
3	If red ball is drawn			
	If black ball is drawn			
5	If red ball is drawn			
	If black ball is drawn			

Summary

Before we start, let us briefly summarize the experiment.

1. Player 1 decides whether to offer 100 points to player 2 for a project. If he/she offers 100 points, he/she can request a guarantee of 100 points.
2. Player 2 decides whether to accept this offer.
3. Player 2 decides how many red balls to buy.
4. A ball is randomly drawn from the project.
5. Payoffs are calculated and shown on the screens after Experiment 5.

Appendix C: Additional Experimental Data

C.1. Pre-experimental games

The first pre-experimental game was a risk preference elicitation task. Risk preferences were elicited to have a measure of each subject's risk aversion, as choosing effort is a risky choice. The elicitation is similar to that in Heinemann et al (2009) and Dohmen et al (2010). Each subject is asked to make eleven choices, between a secure payment and a lottery. While the lottery payout remains constant, 25 points in expectation, the secure payment increases from 0 to 50 in steps of 5. As the secure payment increases, subjects are expected to switch from the lottery to the secure payment. If a subject switches to the secure payment when it is 20 or less, he is classified as risk averse. If he switches when it is 25, he is classified as risk neutral and risk seeking for the remaining cases. The variable *Risk aversion* is thus a dummy variable that takes value one if the subject is risk averse.[12]

After the risk elicitation task, subjects played the $p-$beauty contest game with $p = \frac{2}{3}$ in groups of four. In this game each player chooses a number between 0 and 100. The winner is the subject whose guess is closest to 2/3 of the average guess (Nagel, 1995). I measure *Strategic reasoning* as the difference between 100 and the subject's guess. Since the winner is that who is closest to 2/3 of the average, there is a constant unraveling to lower guesses (until the Nash Equilibrium guess of 0). Thus, a larger difference between 100 and the guess proxies higher levels of strategic reasoning.

Then subjects played a trust game (Berg et al, 1995). In the trust game two players, A and B, start with 10 points each. Player A can decide how many points (in integers) to send to player B. The points sent are multiplied by 3 by the experimenter and player B can freely choose how many to send back to A. For this game, the strategy-method was used and thus each player played the role of A, deciding how many points to send, and that of B, deciding for each possible amount sent by A, how many points he or she would send back. As player B has an incentive to send back 0 points to player A, the average amount of points sent back by B is used as a proxy for *Trustworthiness.* The number of points sent by player A are a measure of *trust.*[13]

Table C.1. below presents summary statistics for the variables measured in the pre-experimental games. While *trust* and *trustworthiness* are not significantly different across treatments, *risk aversion* and *strategic reasoning* vary across treatments. For this reason, these variables are included as controls in the analysis of results.

[12] Multiple switches are rare: Only 7.8% of the subjects switch multiple times. These subjects are included in the data analysis below. Results remain the same if they are excluded.

[13] In Appendix C.1 the descriptive statistics for these variables are displayed.

Table C.1. Individual Characteristics by Treatment

		Low Interest		High Interest			Kruskal-Wallis
	No Collateral	C=50	C=100	C=50	C=100 +No Tax	C=100 +Tax	Test (p-value)
Risk aversion	0.28	0.31	0.16	0.22	0.57	0.25	0.1084
	(0.46)	(0.47)	(0.37)	(0.42)	(0.50)	(0.43)	
Strategic Reasoning	65.03	74.28	77.72	66.72	74.61	62.84	0.0002
	(20.55)	(13.11)	(7.95)	(19.16)	(9.60)	(19.01)	
Trust	3.84	4.50	3.75	4.81	3.57	4.56	0.6643
	(3.62)	(3.76)	(3.69)	(3.88)	(3.58)	(3.86)	
Trustworthiness	0.70	0.78	0.94	0.71	0.43	0.76	0.3548
	(0.70)	(0.83)	(0.86)	(0.71)	(0.49)	(0.77)	

Note: Standard deviations in parentheses

C.2. Beliefs

During the belief elicitation task, lenders reported their belief on the probability of acceptance of borrowers (on average across the borrowers in the session) and on their effort choice (conditional on acceptance). Borrowers on the other hand reported their belief on the probability of receiving an offer and being requested collateral.

In Table C.2 beliefs reported by players by treatment and also actual behavior (as we have seen in previous subsections) is displayed. Panel A shows the beliefs of borrowers about the probability that lenders make offers and request collateral. If No Collateral is requested, borrowers believe that 53% of the lenders offer a loan, which is close to 44% the actual offer ratio. In the other treatments, borrowers tend to underestimate the proportion of lenders who offer a loan, though their guesses are above 72% in all cases. With respect to collateral requests, borrowers are even closer in their beliefs to actual behavior.

Table C.2: Beliefs about other player's behavior

			Low Interest		High Interest		
		No Collateral	C=50	C=100	C=50	C=100 +No Tax	C=100 +Tax
	Panel A: Borrower beliefs						
Belief	Offer	0.53	0.73	0.91	0.72	0.86	0.85
	Collateral Request	-	0.92	0.91	0.93	0.89	0.90
Actual	*Offer*	*0.44*	*0.88*	*1.00*	*1.00*	*1.00*	*1.00*
	Collateral Request	-	*0.93*	*1.00*	*0.94*	*1.00*	*1.00*
	Panel B: Lender beliefs						
	Acceptance						
Belief	If no collateral requested	0.94	0.90	0.99	0.92	0.88	0.98
	If collateral requested		0.91	0.76	0.84	0.59	0.47
Actual	*If no collateral requested*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
	If collateral requested	-	*1.00*	*1.00*	*1.00*	*0.57*	*0.87*
	Effort						
Belief	If no collateral requested	2.88	2.53	2.63	1.94	2.22	2.22
	If collateral requested	-	2.81	3.25	2.61	2.51	2.62
Actual	*If no collateral requested*	*2.25*	*2.19*	*2.63*	*1.19*	*1.29*	*1.69*
	If collateral requested	-	*2.94*	*3.88*	*1.81*	*2.25*	*2.07*

Note: this table reports beliefs and actual behavior by treatment. Panel A displays borrower beliefs and lender actual behavior. Panel B displays lender beliefs and borrower actual behavior. Actual behavior is displayed in italics.

In Panel B lenders' beliefs about acceptance decisions, if collateral is requested and if it is not, are displayed first. Again beliefs of lenders are close to borrower's actual behavior. Noticeably, lenders anticipate that a lower portion of borrowers accept their offers if collateral is high and no tax is levied on lenders. They guess that 59% of borrowers accept their offers, while actually 57% do. When a tax is levied, lenders actually expect less borrowers to accept their offer than they actually do.

The lower part of Panel B lender beliefs about effort are detailed. Beliefs about effort when no collateral is requested are slightly higher than actual effort. However, the case where no collateral is requested is rarely observed. In contrast, beliefs about effort when collateral is requested are closer to actual effort and follow the observed treatment effects.

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