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SECURED LENDING AND DEFAULT RISK: EQUILIBRIUM ANALYSIS, POLICY IMPLICATIONS AND EMPIRICAL RESULTS*

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I. INTRODUCTION

A. *Motivation and Objectives*

Debt contracts often require borrowers to pledge collateral. Merris (1979) reports that a Federal Reserve survey involving 340 banks found that approximately 40% of all short-term, and 60% of all commercial loans were *secured* between 1977 and 1979. Despite this, the research on collateral is limited. Current attention has focused mainly on the pricing of secured debt and the role of collateral under asymmetric information. Many aspects of secured lending remain unexplored, however. Under what conditions is there a positive association between borrower risk and collateral, as documented empirically by Orgler (1970)? What is the economic role of collateral under private information and moral hazard? How does monetary policy affect the cross-sectional dispersion of unsecured and secured lending?

We seek to answer these and other questions theoretically and empirically in this paper. We develop a model in which banks compete for borrowers and deposits are elastically supplied. Initially we consider moral hazard caused by borrowers being able to take *ex post* unobservable actions that affect the project payoffs from which loans are repaid. We show that collateral is a powerful instrument in dealing with moral hazard, even though it imposes a (deadweight) repossession cost on the bank. We obtain sufficient conditions under which riskier borrowers pledge more collateral.

We then add pre-contract private information to the model. The competitive bank is now unaware of some exogenous parameter of the borrower's payoff distribution as well as the borrower's action choice. We find that private information increases collateral usage in loan contracts, although the positive association between collateral and borrower risk under moral hazard may be either strengthened or weakened by private information.

We extract testable predictions from our model, and briefly examine their implications for monetary policy. We also confront a subset of these predictions with the data. Our evidence suggests that collateral is widely used and its use has been rising. Consistent with our predictions, the evidence also suggests that collateral is used less with larger loans and with loans for which the deadweight costs of collateral are lower.

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B. *Overview of Related Literature and Organisation of Paper*

Secured loans are of two types. Some require that a corporate borrower pledge its own business assets as collateral to a particular lender, whereas others require that assets in which the lender would not otherwise have a claim be pledged as collateral (e.g. an entrepreneur who pledges his house as a collateral for his company's loan). With a few exceptions (see Smith-Warner (1979) and Stulz-Johnson (1985)), most of the literature studies the latter case, to which we will limit our attention.

In an early paper on collateral, Barro (1976) focused on pricing issues when collateral value was stochastic. However, it was not a competitive equilibrium analysis and there were no informational problems. Stulz-Johnson (1985) assume symmetric pre-contract information and examine the effect of collateral on moral hazard. Secured debt is shown to increase firm value because it mitigates the underinvestment incentives that exist with equity or unsecured debt. Much of the subsequent literature has emphasised pre-contract information asymmetry between borrower and lender.[1]

In a recent paper, Chan and Thakor (1987) consider moral hazard, private information and collateral. They find that *all* borrowers will use the maximum amount of collateral. This is because they assume that collateral is costless and its availability unlimited. We avoid that result by assuming that the bank incurs a dissipative cost in taking possession of and liquidating collateral.

Stiglitz and Weiss (1981) hypothesise a somewhat different relationship between collateral and borrower risk. They assume that wealthier individuals are better able to put up collateral *and* are likely to be less risk averse than poorer individuals. This result in an adverse selection effect such that increasing collateral makes both the average and the marginal borrower riskier. However, borrowers are assumed observationally identical.

The empirical literature is scant. Orgler (1970) found that greater collateral is posted by riskier borrowers, a finding recently supported for small business loans by Leeth and Scott (1989). We are not aware of any empirical study of the relationship between moral hazard and collateral.

The paper is organised as follows. Section II develops the basic model and the first best equilibrium. Section III develops the second best equilibrium with only moral hazard, along with a comparative statics analysis. Section IV develops the third best equilibrium with private information and moral hazard. Section V summarises the predictions of the model, discusses their

[1] There are at least four recent papers in this group. Besanko and Thakor (1987*a*) examine the role of collateral in diminishing credit rationing when lenders do not know borrowers' default probabilities. In a second paper, Besanko and Thakor (1987*b*) study loan contracting under asymmetric information within a multidimensional pricing scheme which includes loan quantity, interest rate, collateral and the possibility of rationing. In both papers, Besanko and Thakor find a positive relationship between collateral and borrower quality, i.e., low quality (high risk) borrowers put up less collateral than high quality (low risk) borrowers. Two other papers examine costly collateral. Both Chan and Kanatas (1985) and Bester (1985) conclude that collateral can help sort *a priori* indistinguishable borrowers. Our analysis generalises the results of these papers to the case of both moral hazard and private information. Thus, we explain collateral variations within observationally indistinguishable borrower groups as well as across observationally distinct groups, and find that higher quality borrowers do not necessarily post more collateral.

policy implications, and provides some empirical evidence. Section VI concludes. All proofs are in an appendix available from the authors upon request.

II. MODEL, THE FIRST BEST SOLUTION AND DEFINITIONS OF RISK

A. *The Model*

We assume universal risk neutrality and view banks as competing for both loans and deposits in a perfectly competitive credit market. Deposits are elastically supplied at the riskless rate. These assumptions have three implications: (i) depositors receive an expected return equal to the riskless rate, (ii) borrowers' expected utilities are maximised subject to informational and breakeven constraints, and (iii) banks earn zero expected profits. Deposit insurance is (*de facto*) complete. Thus, the bank's deposit funding cost is the riskless rate. Also, banks hold zero capital.

The economy lasts for one period; there are two points in time, an initial point $t = 0$ and a terminal point $t = 1$. At $t = 0$, the borrower can invest one dollar in a point-input, point-output project. The borrower has no initial wealth to finance the project and must therefore seek a bank loan. At $t = 1$, the project pays \$$R$ if successful and zero if unsuccessful. The probability of success, $p(\theta, a)$, for any project depends on its quality, θ, and the borrower's choice of action, $a \in A$, where A is a feasible set of actions for the borrower. θ varies cross-sectionally in (B, G) with $p(B \mid \hat{a}) < p(G \mid \hat{a}) \, \forall \hat{a} \in A$, and every borrower's θ is potentially private information. A borrower with $\theta = B$ will be called 'bad' and one with $\theta = G$ will be called 'good'. The borrower's action choice is *ex post* unobservable to the lender. For simplicity, we assume $A \equiv \{\underline{a}, \bar{a}\}$, with $0 < \underline{a} < \bar{a} < \infty$ and $p(\underline{a} \mid \hat{\theta}) < p(\bar{a} \mid \hat{\theta}) \, \forall \hat{\theta} \in \{B, G\}$. Choosing either $\underline{a}$ or $\bar{a}$ is costly for the borrower. The cost of choosing an action a is $V(a) > 0$, with $V(\underline{a}) < V(\bar{a}) < \infty$. A choice of $a = 0$ yields $p(0 \mid \theta) = 0 \, \forall \theta$. Since this is equivalent to not investing in the project, we will let the borrower's feasible set of actions by A, although it is to be understood that autarky is a possibility. We now define

$$p(\underline{a} \mid \theta = G) = \underline{h}, \quad p(\bar{a} \mid \theta = G) = \bar{h}, \quad V(\underline{a}) = \underline{V}, \quad V(\bar{a}) = \bar{V},$$

and for a bad borrower,

$$p(\underline{a} \mid \theta = B) = \underline{q}, \quad p(\bar{a} \mid \theta = B) = \bar{q}, \quad V(\underline{a}) = \underline{V}, \quad V(\bar{a}) = \bar{V}.$$

Given the assumption made before we have

$$\bar{h} > \underline{h}, \quad \bar{q} > \underline{q}, \quad \bar{h} > \bar{q} \quad \text{and} \quad \underline{h} > \underline{q}. \tag{A 1}$$

The condition (A 1) implies that the good borrower has a higher success probability than the bad borrower for any given action. This implies that the *maximum* possible improvement in the success probability for the good borrower – due to a higher action choice – is *smaller* than that for the bad borrower. We extend this implication by assuming that the marginal impact of action on a borrower's success probability is *decreasing* in borrower quality, i.e.,

$$p(\bar{a} \mid B) - p(\underline{a} \mid B) > p(\bar{a} \mid G) - p(\underline{a} \mid G),$$

or

$$\bar{q} - \underline{q} > \bar{h} - \underline{h}. \tag{A 2}$$

The lower marginal return to action for good borrowers makes them less willing to choose $\bar{a}$. That is, quality and action are *partially* substitutable, and a likely first best (self-financing) solution is one in which the good borrowers choose $\underline{a}$ and the bad borrowers choose $\bar{a}$.[2] We will base our analysis on the conditions that guarantee this first best equilibrium.

The loan contract designed by the bank consists of an interest factor (one plus the loan interest rate), $\alpha \geqslant 1$, and a collateral requirement, $C \geqslant 0$. Each borrower has unconstrained access to collateral.[3] This assumption ensures that endowment constraints on collateral do not in themselves induce distortions. Collateral in our model consists of productively employed assets that the borrower pledges to the bank and that the lender would not otherwise have a claim to. Examples are fixed assets such as real estate and possibly plant and equipment. Hence, liquidating collateral prematurely is costly for the borrower, and we assume these costs are high enough so that liquidating collateral to self-finance the project is never preferred to a bank loan.

The borrower's action is chosen after receiving a contract from the bank. The moral hazard arising from the bank's inability to observe the borrower's action can be eliminated altogether only if the borrower pledges sufficient collateral to make the loan riskless. In reality, however, due to regulatory and operating constraints, banks must expeditiously liquidate collateral acquired upon default and convert it into cash. This imposes transactions costs as well as losses from selling (partially illiquid) assets at prices below their 'intrinsic' worth. Further, many assets are worth more to the borrower as components of a productive whole than they are worth piecemeal to the bank. We capture these costs by assuming that the bank evaluates the collateral at a fraction β of its worth to the borrower, where $\beta \in [0,1)$.

B. *The First Best Solution*

In this subsection we derive the first best (no moral hazard, no private information) equilibrium, and specify the conditions under which the good borrowers choose optimally action $\underline{a}$ and bad borrowers $\bar{a}$ (see the discussion following (A 2)). With self-financing (or when both a and θ are observable to the lender), a borrower solves

$$\text{maximise} \quad \mathrm{p}(a|\theta)R - V(a) - r, \quad a \in \{\underline{a}, \bar{a}\}$$

where r is one plus the riskless interest rate. Here the borrower maximises the value of its project net of the \$1 investment compounded for one period at r. Clearly, $\underline{a}$ is optimal for the good borrower if

$$\underline{h}R - \underline{V} - r > \bar{h}R - \bar{V} - r,$$

which implies

$$\bar{h} - \underline{h} < [\bar{V} - \underline{V}]R^{-1}. \tag{A 3}$$

[2] Alternatively, we could have assumed that action and quality are complementary. In this case, the first best solution would entail the good borrower choosing $\bar{a}$ and the bad borrower choosing $\underline{a}$. While this case is interesting too, we have chosen to focus on the case in which action and quality are substitutes.

[3] This assumption differs from that in Besanko and Thakor (1987 *a*, *b*).

It also follows readily that $\bar{a}$ is optimal for the bad borrower if

$$\underline{q}R-\underline{V}-r < q\bar{R}-\bar{V}-r,$$

which implies

$$\bar{q}-\underline{q} > [\bar{V}-\underline{V}]R^{-1}. \tag{A 4}$$

It is easy to see that (A 3) and (A 4) are compatible with (A 1) and (A 2).

C. *Definitions of Borrower Risk with Moral Hazard and Private Information*

In this subsection we define borrower risk two ways. With both moral hazard and private information, it is difficult to pick one risk measure as the 'best', although we will say something about their relative merits.

Default Risk. Let $a^*(\theta_i)$ and $a^*(\theta_j)$ be the *equilibrium* action choices of borrowers with quality parameters θ_i and θ_j respectively. Then, borrower i is riskier than borrower j if $p[a^*(\theta_i) \mid \theta_i] < p[a^*(\theta_j) \mid \theta_j]$.

This risk measure compares success probabilities, given *equilibrium* action choices, recognising that these action choices will generally differ across borrowers. Since endogenously determined action choices of borrowers affect risk, it would be difficult to compare borrower risk with this measure using only the exogenous data of the model. An alternative risk measure is based on the variability of the *bank's* equilibrium payoff.

Project Variance. Let $a^*(\theta_k)$, $\alpha^*(\theta_k)$, and $C^*(\theta_k)$ be the equilibrium action choice, interest factor and collateral requirement for the type-θ_k borrower, $k = i, j$. Then the type-θ_i borrower is riskier than the type-θ_j borrower if $\text{var}^*(\theta_i) > \text{var}^*(\theta_j)$, where for $k = i, j$,

$$\text{Var}^*(\theta_k) \equiv p[a^*(\theta_k) \mid \theta_k]\,[\alpha^*(\theta_k)-r]^2+\{1-p[a^*(\theta_k) \mid \theta_k]\}[\beta(\theta_k)\,C^*(\theta_k)-r]^2.$$

This risk measure coincides with the Rothschild and Stiglitz (1970) notion of increasing risk. Since the bank's expected payoff is always r in equilibrium, its payoff from borrower θ_i represents a mean-preserving spread of its payoff from borrower θ_j. Clearly, the ranking provided by default risk may conflict with that provided by project variance.

What is the motivation for these two risk measures? The default risk measure is concerned solely with the probability that there will be no default. It is theoretically unappealing as a yardstick for risk measurement. However, in the banking literature on the positive association between collateral and risk, it is claimed that the most reliable and relevant risk measure is the *loan classification* made by *bank examiners* (e.g., Orgler (1970) and Wu (1969)). While many factors may affect an examiner's assessment of loan risk, a key factor is apparently the loan's default probability (Wu, 1969). Apart from this, default risk is also closest in spirit to the notion of borrower risk found in Bester (1985) and Besanko and Thakor (1987*a*, *b*). Project variance is theoretically more appealing. Moreover, it *should* be the risk measure most relevant for the federal deposit insurer (FDIC), since it accounts for the bank's collection from a delinquent borrower; this collection is of interest to the FDIC because of the practice of allowing banks in imminent danger of failure to merge with healthier banks.

This is not an exhaustive listing of risk measures, since we only wish to caution that any statements about observed cross-sectional relationships between borrower risk and collateral are sensitive to the risk measures employed. And it is unclear which risk measure underlies the claim that riskier borrowers pledge more collateral. Moreover, the assessed risk is an outcome of the credit market equilibrium.

III. ANALYSIS WITH MORAL HAZARD: THE SECOND BEST EQUILIBRIUM

Suppose a borrower chooses $\bar{a}$ in the first best case (that is, the borrower is of the bad type). Then moral hazard is present if such a borrower chooses $\underline{a}$ in the second best case when offered an unsecured loan with interest factor $r(\bar{q})^{-1}$ (bank would make zero expected profit if borrower would have chosen $\bar{a}$). The condition that guarantees this is

$$\underline{q}[R-r(\bar{q})^{-1}]-\underline{V} > \bar{q}[R-r(\bar{q})^{-1}]-\bar{V},$$

which implies

$$(\bar{q}-\underline{q})R-(\bar{V}-\underline{V}) < (\bar{q}-\underline{q})(\bar{q})^{-1}r \tag{A 5}$$

A. *The Second Best Equilibrium*

For each observable $\theta \in (B, G)$, the equilibrium credit contract is obtained by solving the following principal-agent problem

$$\underset{\{\alpha(\theta),\, C(\theta)\}}{\text{Maximise}}\, L(\theta) = \mathrm{p}(a^* \mid \theta)[R-\alpha(\theta)]-[1-\mathrm{p}(a^* \mid \theta)]C(\theta)-V(a^*) \tag{1}$$

subject to

$$\mathrm{p}(a^* \mid \theta)\alpha(\theta)+[1-\mathrm{p}(a^* \mid \theta)]\,\beta(\theta)\, C(\theta) \geqslant r \tag{2}$$

$$a^* \in \underset{a \in \{\underline{a}, \bar{a}\}}{\operatorname{argmax}}\, p(a \mid \theta)[R-\alpha(\theta)]-[1-\mathrm{p}(a \mid \theta)]\, C(\theta)-V(a) \tag{3}$$

where α and C are stated as functions of the borrower's observable type. Thus each borrower's expected utility is maximised ((1)) subject to the bank at least breaking even ((2)) and the borrower choosing an incentive compatible action a^* ((3)). We have assumed that $R > r[\min_\theta \mathrm{p}(\underline{a} \mid \theta)]^{-1}$, which implies that the borrower's return in the successful state exceeds the maximum possible interest-related payment even if the loan is unsecured. We now have

PROPOSITION 1. *The second best equilibrium (under moral hazard) is as follows.*

(a) For good borrowers, there is a unique equilibrium in which each borrower is offered an unsecured loan contract

$$\alpha^*(G) = r(\underline{h})^{-1} \tag{4}$$

(b) For bad borrowers, given the existence restriction[4]

$$(\bar{q}-\underline{q})R-(\bar{V}-\underline{V}) \geqslant (1-\beta)(1-\bar{q})\bar{q}[\bar{q}+(1-\bar{q})\beta]^{-1}\phi, \tag{A 6}$$

[4] (A 6) guarantees that bad borrowers will not find their second best secured loan less attractive than action choice of $\underline{a}$ in conjunction with an unsecured loan $\hat{\alpha}^*(B) = r(\underline{q})^{-1}$. The interpretation of (A 6) is that collateral is not too costly.

the equilibrium contract is a secured loan. The contract is

$$\alpha^*(B) = r(\bar{q})^{-1} - (1-\bar{q})\beta C^*(B)(\bar{q})^{-1} \tag{5}$$

$$C^*(B) = \bar{q}[\bar{q} + (1-\bar{q})\beta]^{-1}\phi \tag{6}$$

where

$$\phi \equiv -[R - r(\bar{q})^{-1}] + (\bar{V} - \underline{V})(\bar{q} - \underline{q})^{-1}.$$

This proposition says that the bad borrower can be motivated to choose its first best action $\bar{a}$ by offering it an appropriately designed secured loan. The reason why collateral has this incentive effect is that the borrower loses collateral only upon default, and the probability of default can be reduced by choosing a higher action. The good borrower gets an unsecured loan since it is not efficient to motivate it to work harder; $\underline{a}$ is its first best action choice.

This clarifies the dependence of Proposition 1 on the assumed substitutability between action and borrower quality. While we have chosen to focus on this case, note that if action and borrower quality are complements – so that good borrowers have a higher marginal productivity of effort than bad borrowers – then it would be the good borrowers who post more collateral. Thus, more general than Proposition 1 is the observation that the relationship between the equilibrium collateral level and observable borrower attributes that proxy for quality rests on the link between borrower quality and project technology. This link appears in the differing degrees to which borrowers of different types can influence their project returns.

Even though Proposition 1 provides a sufficient condition under which bad borrowers post more collateral, as yet we have no predicted relationship between borrower risk and collateral. We turn to this next.

PROPOSITION 2. *If $\bar{q} < \underline{h}$, then the bad borrower has higher default risk than the good borrower. If $\bar{q} > \underline{h}$, then the good borrower has higher default risk. Finally, the bad borrower has higher project variance than the good borrower if*

$$r^2(\bar{q})^{-1} + \bar{q}(1-\bar{q})Q^2 - 2(1-\bar{q})Qr > r^2(\underline{h})^{-1} \tag{7}$$

where $Q \equiv \beta[\bar{q} + (1-\bar{q})\beta]^{-1}\phi$. If the inequality in (7) is reversed, the good borrower has higher project variance.

An empirical study by Orgler (1970) found that bank examiners classified secured loans as riskier. This is consistent with the prediction of our model. As Proposition 2 tells us, if $\bar{q} < \underline{h}$ and (7) holds, then the bad borrower (granted a secured loan) is riskier than the good borrower (granted an unsecured loan) using both risk measures.

B. *Comparative Statics*

In the proposition below we provide some comparative statics properties of the second best equilibrium. One property we consider is the effect of a change in project scale. With a \$1 investment, the borrower gets \$$R$ if the project succeeds and nothing if it fails. Suppose that with a \$$S > 1$ investment (for S finite), the borrower gets \$$SR$ if the project succeeds and nothing if it fails. This does *not* mean that we allow the borrower to have a *choice* of project scale. We simply ask what would happen to collateral as S (and hence loan size) increases.

PROPOSITION 3. *Consider the second best equilibrium stated in Proposition 1. (i) An increase in the riskless rate increases the loan interest factor of the good borrower and increases both the interest factor and the collateral requirement for the bad borrower. (ii) A reduction in the dissipative cost of collateral (i.e., an increase in β) reduces the collateral requirement for the bad borrower. It leaves unchanged the good borrower's contract. (iii) An increase in* R, *each borrower's gross project payoff in the success state, reduces the bad borrower's collateral requirement and increases its interest factor. It leaves the good borrower's contract unaffected. (iv) An increase in the marginal nonpecuniary cost of high effort (i.e., an increase in $\bar{V}-\underline{V}$) increases the bad borrower's collateral requirement and reduces its interest factor. It leaves the good borrower's contract unchanged. (v) An increase in the loan size (project scale) decreases the amount of collateral used in loan contracts.*

The intuition behind (i) is that as the bank's marginal cost of funds rises, it must demand higher loan interest factors from both borrowers in order to continue to break even. However, letting the loan interest rates absorb the entire burden of a higher r may not be efficient because borrowers reduce effort levels when faced with higher loan interest rates. Thus, the bank may also increase collateral requirements. Doing this serves the dual purpose of: (*a*) limiting the extent to which loan interest rates must be increased to meet the higher cost of deposits and (*b*) coping with the heightened moral hazard associated with higher loan interest rates (since higher collateral elicits higher effort). (ii) obtains because a lowering of the dissipative cost of collateral implies that collateral is now worth more to the bank and less of it is needed to enable the bank to break even. Of course, sufficient collateral is still needed to ensure that the bad borrower chooses the high action. The intuition underlying (iii) is that an increase in R permits the bank to increase the loan interest factor for the bad borrower at least a little without causing it to prefer the lower effort. The reason for this is that, for a *given* interest factor, an increase in R increases the borrower's net marginal return to effort. Hence $\alpha^*(B)$ can be increased, and by the same token $C^*(B)$ can be reduced. To see why (iv) obtains, note that an increase in $\bar{V}-\underline{V}$ makes it more difficult to elicit high effort from the bad borrower. This calls for higher collateral. To keep the bank's expected profit anchored at zero, the borrower's interest factor declines. As for (v), the intuition is that a larger project scale increases the net payoff accruing to the borrower in the successful state. Since the marginal benefit to effort is now greater, moral hazard is reduced and hence there is a lower collateral requirement.

IV. PRIVATE INFORMATION AND MORAL HAZARD: THE THIRD BEST EQUILIBRIUM

We now further complicate the contract design problem by assuming that the bank does not know any particular borrower's θ, but knows only that $\theta \in \{B,G\}$. Each bank's prior is that there is a probability γ that the borrower is bad and a probability $1-\gamma$ that it is good. Each borrower knows its own type. By the revelation principle (e.g., Myerson (1979)), the bank can do no better than asking each borrower to directly and truthfully reports its type. A borrower reporting itself to be bad is awarded $\{\alpha(B), C(B)\}$ and a borrower reporting itself to be good is awarded $\{\alpha(G), C(G)\}$. Thus, this is a game in which the uninformed agent moves first. We use the Riley (1979) *reactive equilibrium* (RE) to characterise the competitive equilibrium contracts. The RE contracts provide a (constrained) Pareto efficient resolution of moral hazard and private information, i.e., they solve

$$\underset{l}{\text{Maximise}} \quad L = \gamma U(B \mid B) + (1-\gamma)\, U(G \mid G) \tag{8}$$

subject to

$$\mathrm{p}(a \mid \theta)\, \alpha(\theta) + [1-\mathrm{p}(a \mid \theta)]\beta C(\theta) \geqslant r \,\forall\, \theta \in \{B,G\} \tag{9}$$

$$a^* \in \underset{a \in \{\underline{a}, \bar{a}\}}{\operatorname{argmax}} \{p(a \mid \theta)\, [R-\alpha(\theta)] - [1-\mathrm{p}(a \mid \theta)]\, C(\theta) - V(\theta)\} \,\forall\, \theta \in \{B,G\} \tag{10}$$

$$U(\hat{\theta} \mid \hat{\theta}) \geqslant U(\tilde{\theta} \mid \hat{\theta}) \,\forall\, \hat{\theta}, \quad \tilde{\theta} \in \{B,G\}, \quad \hat{\theta} \neq \tilde{\theta} \tag{11}$$

where

$$U(B \mid B) \equiv \mathrm{p}(a \mid B)\, [R-\alpha(B)] - [1-\mathrm{p}(a \mid B)]\, C(B) - V(a)$$
$$U(G \mid G) \equiv \mathrm{p}(a \mid G)\, [R-\alpha(G)] - [1-\mathrm{p}(a \mid G)]\, C(G) - V(a)$$
$$U(\hat{\theta} \mid \hat{\theta}) \equiv \mathrm{p}(a \mid \hat{\theta})\, [R-\alpha(\hat{\theta})] - [1-\mathrm{p}(a \mid \hat{\theta})]\, C(\hat{\theta})$$
$$U(\tilde{\theta} \mid \hat{\theta}) \equiv \mathrm{p}(a \mid \hat{\theta})\, [R-\alpha(\tilde{\theta})] - [1-\mathrm{p}(a \mid \hat{\theta})]\, C(\tilde{\theta}).$$
$$l \equiv [\alpha(B),\, C(B),\, \alpha(G),\, C(G)].$$

The only difference between this programme and (1)–(3) is the addition of the (global) truth-telling constraint (11). The solution to (8)–(11) depends on the constellation of exogenous parameter values. To limit the possible number of solutions, we focus on parameter values for which the moral hazard problem is not severe.[5] That is, we assume

$$(\bar{q}-\underline{q})R - (\bar{V}-\underline{V}) \in [\eta,\, (\bar{q}-\underline{q})\, (\bar{q})^{-1} r) \tag{A 7}$$

where η is a strictly positive scalar. (A 4) and (A 5) imply that η is non-negative, and the moral hazard problem is more severe for smaller values in the set $[\eta, (\bar{q}-\underline{q})\, (\bar{q})^{-1} r)$. Hence for η sufficiently large, moral hazard is moderate. A natural case to analyse is one where good borrowers have a higher success probability than bad borrowers ($\underline{h} \geqslant \bar{q}$) despite their lowest (first best) action choice. Under this condition the second best equilibrium in Proposition 1 gives good borrowers better contracts than bad borrowers. This equilibrium cannot be sustained if private information is added; bad borrowers will envy the (unsecured) good borrower's contract. The proposition below presents the solution for this (third best) case. In the text following the proposition we will discuss a potential alternative case.

[5] The effect of severe moral hazard might predominate that of private information.

PROPOSITION 4. *Suppose*

$$\underline{h} \geqslant \bar{q} \tag{12}$$

$$\eta = (\bar{q}-\underline{q})(\underline{h})^{-1}r, \tag{A 7-1}$$

then the optimal RE credit contracts in the third best case are

$$\hat{\alpha}^*(B) = \alpha^*(B) = r(\bar{q})^{-1} - (1-\bar{q})\,\beta\hat{C}^*(B)\,(\bar{q})^{-1}, \tag{13}$$

$$\hat{C}^*(B) = C^*(B) = \bar{q}[\bar{q} + (1-\bar{q})\,\beta]^{-1}\phi, \tag{14}$$

$$\hat{\alpha}^*(G) = r(\underline{h})^{-1} - (1-\underline{h})\beta\hat{C}^*(G)\,(\underline{h})^{-1}, \tag{15}$$

$$\hat{C}^*(G) = \underline{h}[\underline{h}(1-\bar{q}) - \bar{q}(1-\underline{h})\beta]^{-1}[(\underline{h}-\bar{q})\,r(\underline{h})^{-1} + (1-\beta)\,(1-\bar{q})\,\hat{C}^*(B)]. \tag{16}$$

The case presented in this proposition holds for a situation in which moral hazard is moderate (see A 7-1), and the good borrower has a higher success probability than the bad borrower when both borrowers choose their respective first best actions. If we compare the solution here to the one given in Proposition 1, we observe that only the specification of the contract for the good borrower has changed. The good borrower's contract now involves collateral because otherwise the bad borrower would covet this contract. It follows that the presence of private information leads to a higher use of collateral in the equilibrium contracts, and an introduction of collateral in all equilibrium contracts.

An alternative to Proposition 4 is the case in which the bad borrower has a higher success probability than the good borrower when both choose their respective first best actions. In an appendix available upon request, we show that in this case the equilibrium involves an unsecured loan for the good borrower (identical to the one specified in Proposition 1) and a secured loan for the bad borrower which calls for *more* collateral than stipulated in Proposition 1. Greater collateral is necessary than in the second best contract for the bad borrower because it is the good borrower which now has the lower success probability, leading it to be envious of the bad borrower's contract.

V. PREDICTIONS, POLICY IMPLICATIONS AND THE EVIDENCE

A. *Testable Predictions*

It can be shown that in Proposition 4, $\partial\hat{C}^*(B)/\partial r > 0$ and $\partial\hat{C}^*(G)/\partial r > 0$. Likewise it can also be shown that $\partial\hat{\alpha}^*(B)/\partial r > 0$, and $\partial\hat{\alpha}^*(G)/\partial r > 0$. We can thus summarise the testable predictions of our models as follows.

(1) Despite deadweight costs associated with collateral, we should expect it to be widely used to cope with moral hazard and private information problems.

(2) An increase in the (real) riskless interest rate increases collateral levels in secured loans, in both the second and third best equilibria.

(3) An increase in the (real) riskless rate increases interest rates on all loans, in both the second and third best equilibria.

(4) A reduction in the dissipative cost of collateral reduces the level of collateral used in the second best equilibrium.

Table 1
Summary Statistics

		Sample Means				
		5/77	8/81	5/83	5/88	All
Dummy Variables						
COLLATERAL	One if loan is secured	49·7%	49·7%	55·6%	69·1%	57·5%
DEMAND	One if loan is made under a demand note	17·9%	20·1%	22·3%	49·2%	26·1%
COMMIT	One if loan was made under commitment	39·0%	48·0%	53·3%	73·8%	52·9%
FLOATING	One if loan is on a floating-rate basis	33·7%	59·7%	66·9%	81·4%	61·2%
Continuous Variables						
LNDUR	Logarithm of the duration of the loan	−2·10	−2·26	−1·86	−2·07	−2·02
LNSIZE	Logarithm of the size of the loan in 1987 dollars	9·75	10·46	10·45	10·75	10·57
Number of observations		24,824	24,080	23,658	30,545	1,127,479

Table 2
Multiple Regression

Regression number	Intercept	*LNDUR*	*LNSIZE*	*DEMAND*	*COMMIT*	*BKSIZE*	*FLOAT*	R^2	No. of observations
1	187·071 (1·761)	−0·428** (−3·262)	−0·286** (−5·270)	0·801** (3·058)	0·569** (2·600)	0·169** (3·004)	0·478* (2·148)	0·30	306

* Significant at the 5% level.
** Significant at the 1% level.

(5) An increase in the loan size decreases the amount of collateral used in the second best equilibrium.

B. *Policy Implications*

Since the use of collateral is dissipative, monetary policy has real effects. For instance, a restrictive monetary policy that elevates interest rates will prompt greater collateral use in equilibrium loan contracts, exacerbating the attendant deadweight losses.[6] In our partial equilibrium framework, this makes borrowers worse off without improving the welfare of the bank (which exactly breaks even at every r) or the depositors (for whom deposits always yield an expected return equal to that available on alternative instruments).[7] Monetary policy also affects the (federal) deposit insurer's liability. Since monetary policy affects collateral levels, it affects borrower action choices and hence project risk. This implies an effect of monetary policy on the deposit insurer's contingent liability through its effect on bank portfolio risk.

C. *The Empirical Evidence*

We could test the predictions (1), (4) and (5) listed in Subsection V-A. Testing the other predictions is precluded by data availability constraints.

The Federal Reserve's Survey of Terms of Bank Lending permits testing the three predictions mentioned above. During one or more days of the second month of each quarter, approximately 300–340 respondent banks report the individual characteristics of every commercial and industrial loan made. The survey has been conducted every quarter since 1977 and includes the 48 largest banks in the United States and a stratified random sample of smaller banks. Table 1 presents some summary statistics for selected observation periods and for the entire sample. Of particular interest is the ubiquitous nature of collateral. Over the entire sample period 57·5% of the loans are secured. For the most recent observation period, May 1988, 69·1% were secured. This is evidence supportive of prediction (1). The table also provides casual evidence in favour of prediction (2). Interest rates (both nominal and real) have been generally rising during our sample period. The table points out that collateral use has been moving in the same direction.

Testing prediction (4) directly is not possible since our data do not provide any direct information about β. However, it is reasonable to suppose that the dissipative costs of collateral are lower (β is higher) for longer maturity loans. For a longer maturity loan, the bank has greater timing flexibility in terms of precisely when to force default and take possession of collateral.[8] This allows the bank better control over the nature of borrower assets it designates *ex ante* as collateral and takes possession of *ex post* upon default. It will be the bank's best interest to use its flexibility to minimise collateral costs. Thus, an

[6] These losses may also include the greater expenditure on bank monitoring of collateral that higher collateral may involve.

[7] Since ours is a partial equilibrium analysis, we cannot say anything about the overall welfare implications of monetary policy. Thus, we are *not* suggesting that a restrictive monetary policy is undesirable.

[8] This is because a borrower will typically be in violation of loan covenants some time prior to actual default, and thus the bank has the option of whether to call back the loan then.

implication of prediction (4) is that less collateral should be encountered with longer maturity loans. Our data do permit us to test prediction (5) directly. Although our data do not provide information on the amount or nature of collateral used to secure each loan, they do tell us whether a particular loan was secured or unsecured. The independent variable representing loan maturity is labelled *LNDUR* and the variable representing loan sized if labelled *LNSIZE*.

To test these predictions, a grouped logit model was used to measure the probability that one dollar being lent for one year will be on a secured basis. The most recent survey date available, May 1988, was used. Each loan observation was weighted by its size-duration contribution to the future loan portfolio and then grouped by bank.[9] The dependent variable is of the log-odds ratio form $\ln[Y/(1-Y)]$ where Y is the size-duration weighted proportion of loans which are secured. In order to avoid heteroskedasticity problems, we used weighted least squares.

The regression is shown in Table 2. The dependent variable is the log-odds ratio for secured loans. The exogenous variables include *LNSIZE* and *LNDUR* and various control variables. *DEMAND* is a dummy variable used to account for differences in collateral usage associated with using a demand promissory note. A demand promissory note gives the bank the option to call the loan, usually under conditions specified in the loan agreement. *COMMIT* is a dummy variable used to control for any differences associated with the loan being made under a commitment. Papers by Avery and Berger (1989) and Berger and Udell (1990) report evidence that commitment loans are less risky, suggesting that commitment borrowers may differ from noncommitment borrowers. *BKSIZE* is a control variable for bank size and accounts for any differences in collateral practices associated with the size of the bank. And, finally, *FLOAT* controls for any differences associated with borrowers who borrow under floating rate terms versus borrowers who borrow on a fixed-rate basis.

The regression in Table 2 includes all 306 banks. *LNSIZE* has the expected negative coefficient and its coefficient is statistically significant at the 1 % level. This means that as the size of the loan increases, the likelihood that the loan will be made on a secured basis goes down, consistent with prediction 5. Further, the coefficient of *LNDUR* is also significant at the 1 % and has a negative coefficient, which is consistent with prediction 4.

The control variables merit some discussion. The coefficients on *DEMAND* and *COMMIT*, both of which are significant at the 1 % level, suggest that collateral is positively associated with each. This may reflect the fact that loans secured by accounts receivable and inventory ('asset-based loans') are almost invariably made under a commitment arrangement which specifies a demand note. Asset-based loans are generally considered to be the riskiest in the commercial loan portfolio (Morsman, 1986). The fact that bank size (*BKSIZE*)

[9] The weighting is necessitated by the fact that the Survey of Terms of Bank Lending consists of new loans made on a particular date, *not* the stock of loans on that date. Consequently, a loan of $100,000 with a duration of one year will have the same average effect on the portfolio as a loan for $50,000 with a duration of two years.

has a positive coefficient may also be related to asset-based lending. This type of lending is relatively sophisticated and involves expensive collateral monitoring (Swary and Udell, 1988), and thus often avoided by small banks.

VI. CONCLUSION

We have examined secured lending with both moral hazard and private information. Our analysis explains why secured lending may be widespread despite deadweight costs associated with collateral. Because private information may either accentuate or retard the positive relationship between collateral requirements and borrower risk encountered with just moral hazard, higher collateral may be posted by either safer or riskier borrowers. Moreover, borrower risk is endogenous and an outcome of the equilibrium.

Higher interest rates in the economy lead to both higher equilibrium loan interest rates and higher equilibrium collateral requirements. A decline in the dissipative costs of collateral or an increase in the loan size lead to lower equilibrium collateral utilisation. Our empirical evidence supports those predictions of the model that could be tested. In particular, well over half of all loans in the sample period were secured, with a temporal increase in secured lending. Larger loans have lower collateral requirements. Loans of longer maturity, for which the dissipative repossession costs of collateral are likely to be smaller, also have less collateral.

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