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Do Riskier Borrowers Borrow More?

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Conventional wisdom in the mortgage industry holds that loan-to-value (LTV) ratios are positively correlated with mortgage default rates. However, not all empirical studies of mortgage loan performance support this view. This paper offers a theoretical signaling model of why the correlation between LTV ratios and default risk is contingent upon the default costs of the borrower. Specifically, the model proposes that when default costs are high there exists a separating equilibrium in which risky borrowers will self-select into lower LTV loans to reduce the probability of facing a costly default, while safe borrowers will self-select into higher LTV loans as a signal of their enhanced creditworthiness. This adverse selection process gives rise to the possibility of higher default probabilities for lower LTV loans. Conversely, when default costs are low the conventional result, in which risky borrowers select higher LTV loans than safe borrowers, is obtained. Empirical results, based on a sample of 859 single-family residential mortgage loans drawn from the portfolio of a national mortgage lender, are consistent with the separating equilibria predicted by the model.

Do risky borrowers borrow more? Specifically, does the loan-to-value (LTV) ratio choice of a borrower serve as a signal of that borrower's risk type?[1] The answer to this question is crucial to the mortgage lending industry as it would better enable lenders to screen risky borrowers from safe borrowers and price the default risk of each loan contract correctly.

Mortgage underwriters and academicians have conventionally subscribed to the view that loan-to-value ratios positively influence default rates. The argument usually made is the following: The greater the financial leverage (*i.e.*, the higher the LTV ratio), the greater the debt service requirement, and hence the higher the

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[1] As outlined below, our model takes the purchase price of the asset underlying the mortgage as given, thus the selection of the loan amount is equivalent to the selection of a borrower's LTV ratio.

probability the borrower will ultimately encounter financial distress. Theoretical signaling models, such as those presented by Rothschild and Stiglitz (1976) or Brueckner (2000), lend credibility to this paradigm, while a number of empirical studies, such as Von Furstenberg (1969) or Deng, Quigley and Van Order (2000), provide evidence consistent with the proposition.

Interestingly, however, not all empirical evidence supports this view of the world. Nearly 20 years ago, Campbell and Dietrich (1983) first reported the apparently counterintuitive finding that mortgage loans characterized by high LTV ratios at origination actually exhibit lower default rates over time compared to their low LTV counterparts. They conclude that the pattern of coefficients on the original loan-to-value dummy variables in their model is consistent with the presence of adverse selection in the underwriting process, particularly with respect to mortgages with original LTV ratios below 85%. Recent studies from multifamily and commercial mortgage markets also fail to document any positive relationship between LTV and borrower risk. For example, Archer *et al.* (1999, 2002) investigate pools of mortgage loans securitized by the Resolution Trust Corporation (RTC) for the Federal Deposit Insurance Corporation (FDIC) during the early to mid-1990s and find no significant relationship between LTV ratios at origination and ultimate loan performance (*i.e.*, the probability of default). Similarly, Ambrose and Sanders (2001) find a lack of significance for LTV in their commercial mortgage performance investigation, and they argue this is entirely consistent with lenders using a compensatory model of credit evaluation, where risky borrowers upon any given dimension are held to more stringent standards along alternative dimensions.

The purpose of the current investigation is to bridge the gap between conventional wisdom and the seemingly counterintuitive empirical results which fail to consistently document a relationship between financial leverage and mortgage loan performance. Specifically, this paper offers both a theoretical explanation and empirical evidence to reconcile the apparently conflicting results with respect to the correlation between LTV ratios and default risk. The theoretical signaling model offered in this paper examines default under asymmetric information and demonstrates that the correlation between LTV ratios and default risk depends on the default costs of the borrower. Specifically, when default costs are high there exists a separating equilibrium in which safe borrowers self-select higher loan-to-value ratios than risky borrowers. This adverse selection problem gives rise to the possibility of a higher default probability for loans with lower LTV ratios. When default costs are low the conventional result, in which safe borrowers self-select lower LTV ratios than risky borrowers, is obtained. This theoretical conclusion is supported by an empirical analysis that distinguishes between borrowers with high default costs and those with low default costs. Our results should be particularly relevant to commercial mortgage market participants, as these lenders do not have access to systematically consistent and reliable default risk indicators such as credit (FICO) scores.[2]

The remainder of this paper is organized as follows. We first provide a brief overview of the existing literature on signaling models and determinants of mortgage default. Then, we present a simple screening model of LTV choice and default. Next, we outline the data used in our analysis and present the empirical results of our investigation. Finally, we summarize the results and offer insight into future research avenues in this area.

Previous Literature

Given the importance of discerning default risk in the multitrillion dollar mortgage industry, it is not surprising that a rich theoretical and empirical literature has emerged on pricing this risk and determining the factors that contribute to a borrower's decision to default. The most relevant theoretical study for the current paper is Brueckner (2000), which addresses the signaling role of a borrower's loan-to-value ratio choice with respect to that borrower's default risk. In Brueckner's model, default occurs when the value of the asset plus the borrower's default cost falls below the loan balance. Risky borrowers are defined as those who have lower default costs, and thus are more likely to exercise the default option. Similar to the result of Rothschild and Stiglitz (1976), the unique equilibrium in Brueckner is a separating equilibrium in which risky borrowers obtain a larger loan than safe borrowers. This is in contrast to the equilibrium results of the current paper where risky borrowers may obtain a larger or smaller loan depending on the default costs. The difference is due to the fact that the current investigation analyzes an alternative source of default, one in which default is triggered by a sufficient decline in the borrower's future income and risky borrowers are defined as those with a higher probability of a decline in future income.

The work of Leland and Pyle (1977), which examines the problem of a firm investing in a project and the market portfolio, is also relevant to the current

[2] The past decade has seen a proliferation in the use of credit scoring as an underwriting tool in residential mortgage markets. To the extent that these measures fully capture the default riskiness of individual mortgage applicants, the applicability of our results to the residential market may be limited. However, residential borrowers may still possess private information regarding the potential for future declines in their credit score, and thus retain private information about their ultimate credit risk. In contrast, the commercial mortgage market has no default risk metric that is completely analogous to the residential borrower's FICO score. Thus, our model may be particularly applicable in this context.

investigation. Under their framework, the objective of the firm is to maximize the value of the project and market portfolio. In their model, there are no default costs and the risk level of the project is known to the firm but not to lenders and investors in the market. The authors show that the firm's willingness to invest in its own project serves as a signal of the project quality. In equilibrium, firms with safer projects will invest more in their own project, and they will be able to borrow more. The current model differs from that proposed by Leland and Pyle in a number of ways. First, Leland and Pyle present a signaling model in which the informed party (firm) moves first and makes an equity investment in the project. The current model is a screening model in which the uninformed party (the lender) moves first and offers a menu of mortgage contracts. Second, the total amount the borrower needs to raise in the current model is fixed by the purchase price of the asset. Thus, a higher down payment means a smaller loan, not a larger one. As mentioned earlier, the current model also shows that default costs are critical in that different default costs lead to different equilibrium outcomes. Therefore, the equilibrium offered by Leland and Pyle is only one of the three equilibrium outcomes of the current model.

In addition to the loan-to-value ratio, the existing literature identifies an array of other risk factors that lenders might utilize to screen risky borrowers from safe borrowers. For example, in Titman (1992) firms have private information about their production efficiency. He shows that, under certain parameter conditions, "good risk" firms choose short-term financing while "bad risk" firms choose long-term financing. Similarly, Guedes and Thompson (1995) offer empirical evidence for a signaling model where firms issue either fixed- or adjustable-rate debt to finance a project and obtain support for a separating equilibrium where high-quality firms issue high-default-risk debt and low-quality firms issue low-default-risk debt.[3] Milde and Riley (1988) use a production economy to show that a firm with a less risky investment project may choose larger or smaller debt financing depending upon the firm's production function.

Another line of research studies the prepayment risk of the borrower (*e.g.*, Dunn and Spatt 1988) and analyzes such instruments as ARMs (Brueckner 1992, Rosenthal and Zorn 1993, Posey and Yavas 1999), coupon rates and points on FRMs (Yang 1992, Brueckner 1994a, LeRoy 1996, Stanton and Wallace 1998), and prepayment penalties and due-on-sale clauses (Dunn and Spatt 1985, Chari and Jagannathan 1989) to separate high-prepayment-risk and low-prepayment-risk borrowers.

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[3] In Guedes and Thompson (1995), either the fixed- or the adjustable-rate contract can be the riskier option, and hence either contract may serve as the more favorable signal about the firm, depending on the relative levels of real interest rates and inflation volatility.

Although the setup and focus are different, it is also worth mentioning that there is a considerable literature on both the relationship between the borrower's risk type and his/her choice of a collateral requirement under asymmetric information (*e.g.*, Barro 1976, Wette 1983, Bester 1985, Chan and Kanatas 1985, Besanko and Thakor 1987, Mester 1994), as well as the determinants of mortgage demand (*e.g.*, Brueckner 1994b, Follain and Dunsky 1996, Ling and McGill 1998).[4]

With the exception of the studies discussed earlier (Campbell and Dietrich 1983, Archer *et al.* 1999, 2002, Deng, Quigley and Van Order 2000, Ambrose and Sanders 2001), the primary focus of the empirical literature has been on the pricing of the default option and the timing of the exercise of this option. For example, Vandell (1978) uses a simulation approach to examine default risk across alternative mortgage instruments, including constant payment mortgages, variable rate mortgages, graduated payment mortgages and price-level-adjusted mortgages. He concludes that the primary determinant of default risk is equity accumulation, and he specifically argues that default risk increases for those instruments in which decreased initial payment levels lead to delayed amortization of the outstanding principal balance. Dunn and McConnell (1981) model the pricing of GNMA mortgage-backed pass-through securities and find that amortization, prepayment and callability features each mitigate interest rate risk, and consequently lead to lower expected returns for these securities. Foster and Van Order (1984) formalize the competing risks nature of prepayment and default and offer models designed to explicitly capture the value of the put and call options embedded within the mortgage security contract. Childs, Ott and Riddiough (1996) examine commercial mortgage default to evaluate the risk management benefits of recourse financing and cross-default clauses and employ a contingent claims analysis to value such provisions. Similarly, Titman and Torous (1989) use a contingent claims model to examine the valuation of commercial mortgages, while Schwartz and Torous (1992) examine the pricing of residential mortgage pass-through securities by focusing on the interaction between prepayment and default decisions. Kau *et al.* (1992) model prepayment and default as competing risks and find that in situations where the LTV ratio and housing price volatility are relatively low, the marginal contribution of default risk to residential mortgage valuation is relatively small, while Kau, Keenan and Kim (1994) examine mortgage termination decisions from a real options perspective and offer an analytical approach to estimating default probabilities under such a framework.

[4] Asymmetric information models have also been utilized to study the firm's dividend decisions and identify signaling equilibrium where the firm's payout policy serves as a signal of its unobserved earnings (*e.g.*, John and Williams 1985 and Miller and Rock 1985). Thakor (1991) offers an overview of the asymmetric information models as they apply to finance.

How Do Borrowers Choose LTV Ratios?

A basic premise of our investigation is that mortgage loan applicants with specific default costs[5] and risk profiles will self-select into loan-to-value ratios that maximize their personal utility. If this is correct, a borrower's choice of leverage may then be used as a signal of his/her unobservable risk type (*i.e.*, whether he/she is a safe or risky borrower) and thereby may be used by lenders to enhance the efficiency of lending decisions.

Consider a competitive lending market with risk-neutral lenders and borrowers. Lenders offer a menu of fixed-rate mortgages with different combinations of loan amounts and interest rates, and each borrower selects a mortgage from this menu. Let L be the loan amount and i be the interest rate. In the first period, the borrower obtains L to purchase an asset of value P_0, $P_0 \geq L$ (unsecured debt is ruled out). Given P_0, the choice of L is equivalent to the choice of a loan-to-value ratio. In the second period, the borrower sells the asset and pays the lender the loan balance, the principal plus interest, $B = (1 + i)L$. Mortgage contracts differ with respect to the loan amount and the interest rate. We will utilize the relationship $B = (1 + i)L$ and characterize a mortgage contract in the (L, B) space instead of the (L, i) space.

Each borrower wants to take out a single loan and each borrower has a current income of Y at which he/she qualifies for any of the mortgages offered. The borrowers, however, differ with respect to their second-period income. There are two types of borrowers: type r and type s. Type r (risky) borrowers have a higher probability than type s (safe) borrowers of facing a reduction in their income to y, $y < Y$, in the second period.[6] The second-period income y is a random variable with marginal density $f(y)$ and cumulative density $F(y)$ on the interval $[0, Y]$. The probability that a type j borrower experiences a decline in income in the second period is given by q_j, $j = r, s$, $q_r > q_s$. A borrower's risk type, q_j, is private information to that borrower and not known by the lender.

The value of the asset in the second period, P, is assumed to be small enough such that $P < B$.[7] Thus, the borrower needs to supplement the sale price of the

[5] One can identify various measures of default costs. As described more thoroughly below, our default cost indicator focuses on the damage to a borrower's credit rating.

[6] It should be noted that under this model formulation, riskier borrowers are first-order stochastically dominated by safer borrowers. Thus if lenders could distinguish between these (unobservable) risk types, different menus of contract choices would, in all likelihood, be offered to the two groups.

[7] Although B is chosen endogenously by the borrower, it is constrained by exogenous variables Y and P_0 because the borrower needs to borrow $L > P_0 - Y$ to be able to

asset with a part of the income in order to be able to pay the balance and avoid default. The value of the asset in the second period plus the default cost (C) is assumed to be large enough to exceed the loan balance, $P + C > B$, so that it is in the interest of the borrower to avoid default whenever he/she can.[8] Thus, default occurs only when the second-period income plus the value of the asset is below the loan balance, $y + P < B$, that is, if $y < B - P$. It is assumed that $Y + P > B$ so that there will be no default if the income remains at its current level (clearly, when $Y + P < B$, default becomes imminent and the lending market collapses).

Mortgage defaults occur either due to a significant drop in the asset value or a significant drop in the income level. The purpose of the above properties of the model is to be able to focus on income fluctuations as the source of default. Recent studies by Archer *et al.* (1999, 2002) report that the borrower's ability to make the mortgage payments, as measured by the debt coverage ratio, is more important in explaining default than the loan-to-value ratio. Furthermore, Brueckner (2000) studies a similar model where default occurs due to fluctuations in the asset value. Thus, the current model will also serve to compare the implications of the two sources of default for the lender's ability to separate risky and safe borrowers.

Zero-Profit Contract

In addition to the interest rate, the lender's expected profits from a mortgage contract will also depend on whether the contract is chosen by the risky, safe or both types of borrowers. The lender's zero-profit condition to a type j borrower, $j = r, s$, is characterized by

$$\Pi(L_j, B_j; q_j) = -L + \eta q_j \int_0^{B-P} P f(y)\, dy + \eta q_j \int_{B-P}^{Y} B f(y)\, dy + \eta(1 - q_j)B = 0 \qquad (1)$$

purchase the asset. Thus, a sufficient condition for $P < B$ is that $P < (P_0 - Y)(1 + i)$. Note also that $P < B$ is a necessary condition for default to occur (otherwise, the borrower could sell the property and pay off the mortgage completely).

[8] If $P + C < B$, then the borrower would default regardless of his/her ability to make the mortgage payments. The assumption of a large enough C to satisfy $P + C > B$ dismisses the "ruthless default" argument that the borrower's default decision depends solely on the value of the asset relative to the mortgage balance. Various empirical studies provide support for the role of default costs and reject the "ruthless default" hypothesis (*e.g.*, Riddiough and Thompson 1993 and Quigley and Van Order 1995).

where $\eta < 1$ is the lender's discount factor. In the current period, the lender disperses L to the borrower. In the second period, the borrower experiences a decrease in his/her income with probability q_j, in which case (i) if the income falls below $B - P$, then the borrower defaults and the lender forecloses the asset and receives the asset value P[9] and (ii) if the income is above $B - P$, then the borrower chooses not to default and the lender receives the full payment B. With probability $1 - q_j$, the income stays at its current level and the lender again receives the full payment B.

Borrower's Problem

Each borrower chooses the (L, B) combination from the mortgage offerings that maximizes his/her expected utility. Borrowers differ only with respect to the risk of experiencing a decrease in their future income. If the borrower's income in the second period falls to a level such that $y < B - P$, then the borrower defaults and suffers the default cost of $C > 0$. Default disutility captures social and psychic effects of default, damage to the borrower's credit rating and the transaction costs of default. For simplicity, C will be independent of the amount due at the time of default.

The expected utility of a borrower type j, $j = r, s$, from a mortgage contract (L, B) is given by

$$\begin{aligned} U(L, B; q_j) = Y + L - P_0 + \delta q_j \int_0^{B-P} (y - C) f(y)\, dy \\ + \delta q_j \int_{B-P}^{Y} (y + P - B) f(y)\, dy \\ + \delta(1 - q_j)(Y + P - B) \end{aligned} \tag{2}$$

where $\delta < 1$ is the borrower's discount factor.[10] In the first period, the borrower earns Y and borrows L to make the payment P_0 to purchase the asset. In the second period, with probability q_j the borrower's income falls to y, in which case either (i) $y < B - P$ and the borrower defaults, loses the asset to the lender and suffers the default loss C[11] or (ii) $y > B - P$ and the borrower sells the asset

[9] The assumption here that the lender incurs zero costs from the foreclosure process does not affect the results of the analysis.

[10] For the purposes of the analysis, the borrower's discount can be the same as the lender's discount factor.

[11] It is assumed that in the case of a default the borrower will consume y, instead of giving it to the lender. This assumption is inconsequential for the analysis.

for P, pays the lender B and enjoys the surplus $y + P - B$. With probability $(1 - q_j)$ the income in the second period remains at Y, the borrower pays B to the lender and the borrower enjoys the surplus $Y + P - B$.[12] The ownership of the asset generates a certain level of utility for the borrower that makes it worthwhile to obtain the loan to purchase the asset. The level of this utility is constant and does not affect the borrower's preferences over the available mortgage contracts.

Zero-Profit Curves, Indifference Curves and the Equilibrium

The slope of the zero-profit curves for the lender can be derived by differentiating (1) with respect to L and B:

$$\begin{aligned} MRS_\Pi &= \frac{\Pi_L}{-\Pi_B} \\ &= \frac{1}{\eta[q_j Pf(B-P) - q_j Bf(B-P) + q_j(1 - F(B-P)) + (1-q_j)]}. \end{aligned} \tag{3}$$

Similarly, the slope of the indifference curves for the borrower can be derived by differentiating (2) with respect to L and B:

$$\begin{aligned} MRS_U &= \frac{U_L}{-U_B} \\ &= \frac{1}{\delta[q_j(C + P - B)f(B-P) + q_j(1 - F(B-P)) + 1 - q_j]}. \end{aligned} \tag{4}$$

We will simplify the analysis by assuming that F is a uniform distribution and $Y = 1$ so that $f(x) = 1$ and $F(x) = x\ \forall\ x$. Note that $U_B < 0$, hence $MRS_U > 0$ so that indifference curves are upward sloping. For the zero-profit curves to be upward sloping, $MRS_\Pi > 0$, we need $B - P < 1/(2q_j)$. Note also that MRS_Π and MRS_U are independent of L; thus the zero-profit and indifference curves are horizontal parallel and have the same slope at any given B. Furthermore, it can be checked that $\partial MRS_\Pi/\partial B > 0$ and $\partial MRS_U/\partial B > 0$ so that the zero-profit and indifference curves are convex. Lower indifference curves correspond to higher utility levels (because $U_B < 0$) and the zero-profit curve for the risky

[12] It is assumed that the rate of return on the borrower's surplus from the first period, $Y + L - P_0$, is not greater than the rate he/she has to pay to the lender. Thus, the borrower is better off using the surplus for either consumption or for down payment. This is the reason why there is no transfer of the surplus from the first period to the second.

borrower lies above that of the safe borrower (because $\partial B^0/\partial q_j < 0$ for any given L and $\partial L^0/\partial q_j < 0$ for any given B where B^0 and L^0 are the zero-profit loan and balance amounts). Finally, the existence of an equilibrium (tangency of the zero-profit and indifference curves) requires that the zero-profit curves are more convex than the indifference curves. This can be verified to hold for the current model by checking that the zero-profit curves are flatter than the indifference curves for $B < B^T$ and steeper for $B > B^T$ where B^T is the B value at the tangency point of the zero-profit and indifference curves for a given q_j (*i.e.*, B^T is where $MRS_\Pi = MRS_U$ for a given q_j).

A critical element for the characterization of the equilibrium is the relative slope of the indifference curves of the two borrower types. Differentiating the slope of the indifference curve with respect to the default risk of the borrower for any given (L, B) yields

$$\frac{\partial MRS_U}{\partial q_j} = \frac{-(C+P-B)f(B-P)+F(B-P)}{\delta[q_j(C+P-B)f(B-P)+q_j(1-F(B-P))+1-q_j]^2}. \quad (5)$$

Under the uniform distribution, the numerator simplifies to $-C - 2P + 2B$. Thus, if $C < 2(B - P)$,[13] then $\partial MRS_U/\partial q_j > 0$, in which case the safe borrower's indifference curve at any given (L, B) point is flatter than the risky borrower's indifference curve. This yields the following separating equilibrium.

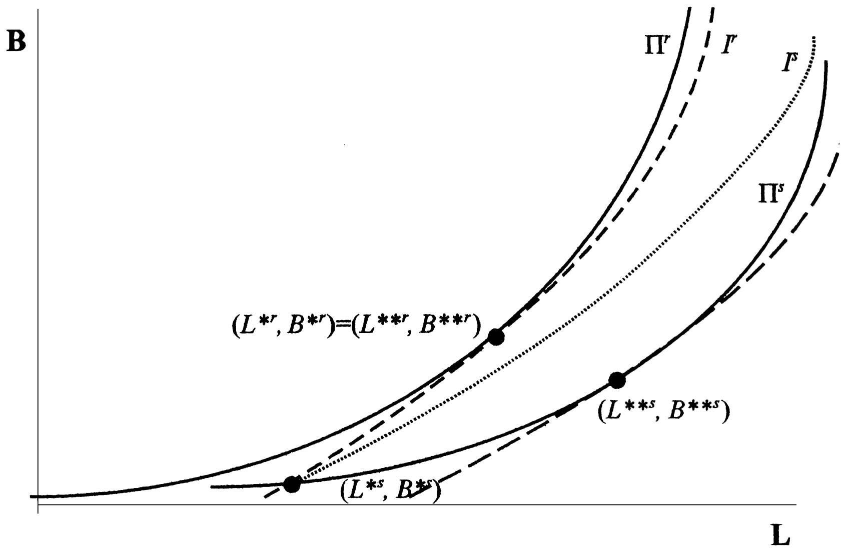
Proposition 1: If $C < 2(B - P)$, then $L^{*r} > L^{*s}$ and $B^{*r} > B^{*s}$. Risky borrowers obtain larger loans and pay bigger balances than safe borrowers.

The equilibrium is illustrated in Figure 1 where L^{**j} and B^{**j} represent the full information equilibrium loan and balance amounts for borrower type j, $j = r, s$. In this equilibrium, risky borrowers obtain the same contract as they would under full information ($L^{*r} = L^{**r}$ and $B^{*r} = B^{**r}$) while safe borrowers end up with a smaller loan and balance than they would under full information ($L^{*s} < L^{**s}$ and $B^{*s} < B^{**s}$). Therefore, the equilibrium involves credit rationing in the sense that safe borrowers obtain a loan size smaller than that of the first–best amount. The equilibrium of Proposition 1 is the unique equilibrium in Brueckner's (2000) model and it resembles the separating equilibrium of Rothschild and Stiglitz (1976) where safe drivers buy smaller insurance coverage than risky drivers, and the coverage of safe drivers is smaller than their full information coverage.

However, for $C > 2(B - P)$, we have $\partial MRS_U/\partial q_j < 0$ in which case the safe borrower's indifference curve at any given (L, B) point is steeper than the

[13] Recall that C is constrained from below by the condition $C > B - P$.

Figure 1 ■ Equilibrium for $C < 2(B - P)$. Π^r and I^r are the zero-profit curve and the indifference curve for risky borrowers, Π^s and I^s are the zero-profit curve and the indifference curve for safe borrowers, (L^{*r}, B^{*r}) and (L^{*s}, B^{*s}) are the asymmetric information equilibrium contracts and (L^{**r}, B^{**r}) and (L^{**s}, B^{**s}) are the full information equilibrium contracts.



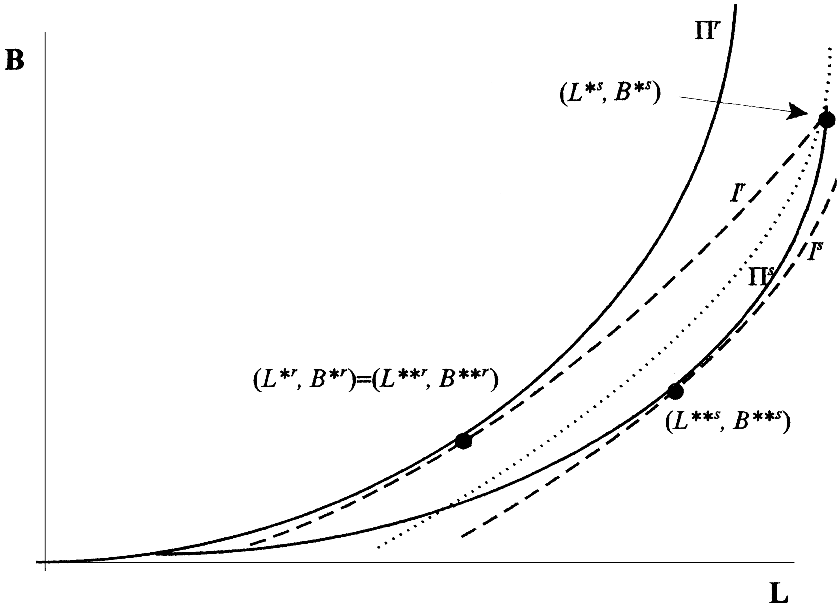
risky borrower's indifference curve. This completely reverses the outcome of Proposition 1. The separating equilibrium is now characterized as follows.

Proposition 2: If $C > 2(B - P)$, then $L^{*r} < L^{*s}$ and $B^{*r} < B^{*s}$. Risky borrowers obtain smaller loans and balances than safe borrowers.

The equilibrium of Proposition 2 is illustrated in Figure 2. Another distinction from the equilibrium of Proposition 1 is that while risky borrowers again obtain the same contract as they would under full information, safe borrowers now end up with a larger loan and balance than they would under full information ($L^{*r} = L^{**r}$, $B^{*r} = B^{**r}$, $L^{*s} > L^{**s}$ and $B^{*s} > B^{**s}$). Therefore, there is no credit rationing in this equilibrium.[14]

[14] Note, it is also possible for the indifference curve of the safe borrower in Figure 2 to be steep enough so that the safe borrower's full information contract is above the point where the risky borrower's indifference curve cuts the safe borrower's zero-profit curve (the authors thank Jan Brueckner for pointing this possibility out). In this case, each borrower type would receive his/her full information contract. Similarly, in Figure 1 the indifference curve of the risky borrower could be steep enough so that the

Figure 2 ■ Equilibrium for $C > 2(B - P)$. Π^r and I^r are the zero-profit curve and the indifference curve for risky borrowers, Π^s and I^s are the zero-profit curve and the indifference curve for safe borrowers, (L^{*r}, B^{*r}) and (L^{*s}, B^{*s}) are the asymmetric information equilibrium contracts and (L^{**r}, B^{**r}) and (L^{**s}, B^{**s}) are the full information equilibrium contracts.



In the special case of $C = 2(B - P)$, the indifference curves of the two borrower types have the same slope at any given (L, B) point. Thus, the indifference curves never intersect. In this case, if the lenders offer different contracts aimed at different borrower types, then the risky borrowers would always imitate the safe borrowers because the zero-profit contract for safe borrowers lies below that of the risky borrowers and lower indifference curves correspond to higher utility levels. As a result, a separating equilibrium cannot exist. As depicted in Figure 3, the unique equilibrium now is a pooling equilibrium.

Proposition 3: If $C = 2(B - P)$, then the equilibrium is a pooling equilibrium where both borrower types obtain the same contract, $L^{*r} = L^{*s}$ and $B^{*r} = B^{*s}$.

The distinction between the three equilibria above is critical. When default costs are small, a larger loan choice by a borrower is a signal to the lender

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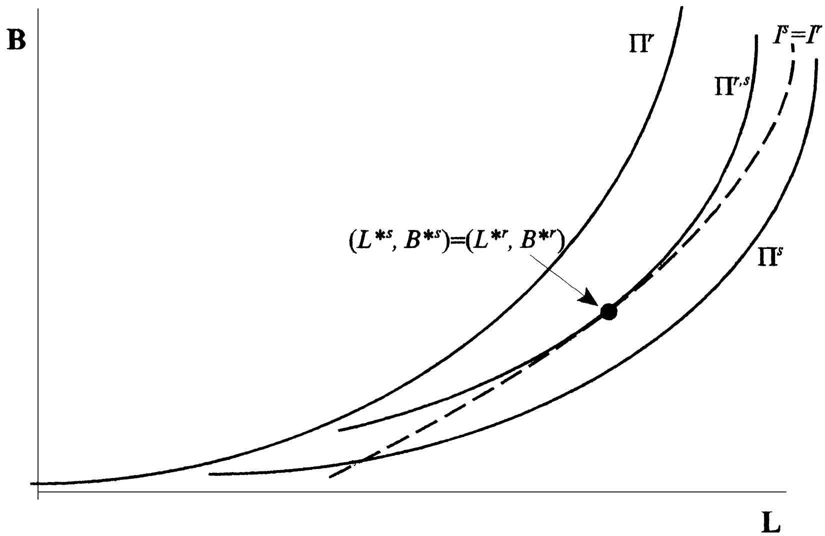
separating equilibrium outcome becomes the same as the full information outcome. Since asymmetric information has no effect in these cases, the analysis will focus on the cases shown in Figures 1 and 2 where the asymmetric information causes distortions.

Figure 3 ■ Equilibrium for $C = 2(B - P)$. Π^r and I^r are the zero-profit curve and the indifference curve for risky borrowers, Π^s and I^s are the zero-profit curve and the indifference curve for safe borrowers, $\Pi^{r,s}$ is the zero-profit curve when the contract is chosen by both borrower types and $(L^{*r}, B^{*r}) = (L^{*s}, B^{*s})$ is the asymmetric information equilibrium contract.



that the borrower is high risk, whereas when default costs are high, a larger loan choice is a signal that the borrower is a low-risk borrower. For the special case where default costs equal $2(B - P)$, a borrower's loan selection cannot serve as a signal of the borrower's risk type. To see the intuition for these results, note that for the borrower a larger loan has the advantage of greater consumption in the first period and the disadvantage of smaller consumption and greater default probability in the second period. However, note also that the borrower's loss from a default is limited to the value of the asset plus the default cost; beyond the default point, the marginal loss due to an additional amount borrowed becomes zero. This limited liability feature of default makes larger loans more attractive for both borrower types as default costs get smaller.[15] According to Proposition 1, when default costs are small, risky borrowers value a large loan more than safe borrowers do because they are more likely to face a drop in their future income and benefit from the limited liability feature of default. On the other hand, when default costs are high, the cost of a larger loan becomes a bigger concern for the borrowers. According to Proposition 2, a

[15] In the extreme case of $C = 0$, for instance, both borrower types would prefer to obtain as large a loan as possible and both types would default in the second period regardless of their second-period income.

large loan now becomes less attractive to risky borrowers than to safe borrowers because risky borrowers are more likely to incur the default cost.

It is worth noting here that the existence of a pooling equilibrium in the current model is in contrast to Rothschild and Stiglitz (1976) and other similar screening models where it is impossible to obtain a pooling equilibrium. The reason behind their result is that a lender always has an incentive and ability to break a pooling equilibrium by offering a contract that attracts low-risk customers only. This is not the case under the parameter conditions of Proposition 3 in our model, either because the lender cannot attract low-risk borrowers without offering below zero-profit rates or because if a lender can lower its rate to attract low-risk borrowers, it ends up attracting high risks as well as low risks and earns negative expected profits. This departure from the results of Rothschild and Stiglitz (1976) and other screening models is due to the fact that the mix of high-risk and low-risk borrower types in our model is fixed. This differs from Rothschild and Stiglitz (1976), where the move from one equilibrium to another is driven by a change in the proportion of high-risk and low-risk consumer types in the market. In our model, the type of the equilibrium that emerges is driven by the magnitude of the borrower's default costs.

How do the interest rates paid by the two borrower types compare to each other? Note from the zero-profit curves that for any given loan amount, the zero-profit loan balance, and hence the zero-profit interest rate, is smaller for safe borrowers than for risky borrowers. However, the convexity of the zero-profit curves indicates that the interest rate of any given borrower type increases with the loan amount (a bigger loan amount carries a higher default risk for any given borrower type). In Figure 1, safe borrowers select a smaller loan size than risky borrowers and thus pay a smaller interest rate. In Figure 2, however, safe borrowers obtain a bigger loan size; thus they may be paying a higher or lower interest rate, depending on the relative size of their loan to that of risky borrowers.

As in previous models of asymmetric information, risky borrowers in the two separating equilibria above pay no signaling cost because they obtain the same contract that they would under full information.[16] It is the safe borrowers who must incur a cost to signal their type. However, the two separating equilibria above differ from each other with respect to the signaling costs paid by the safe borrowers. When default costs are small, $C < 2(B - P)$, we obtain the standard result of Rothschild and Stiglitz (1976) that safe customers (borrowers)

[16] The signaling cost for a borrower is that borrower's utility differential from his/her full information contract and the contract that he/she obtains under asymmetric information.

differentiate themselves from risky ones by obtaining a smaller insurance coverage (loan amount) than they would under full information. For high default costs, $C > 2(B - P)$, however, the cost of signaling for safe borrowers is in the form of obtaining a larger loan amount and at a higher interest rate than what they would under full information.

To summarize, the critical testable proposition that emerges from the above framework is that the effect of a given change in borrower default risk on LTV is contingent upon borrower default cost. When default costs are high, risky borrowers will self-select into lower LTV loans to reduce the probability of encountering a costly default, while safe borrowers will self-select into higher LTV loans as a signal of their enhanced creditworthiness. Conversely, when default costs are low, risky borrowers will select higher LTV loans, as they are more likely to encounter financial distress, and thus find the limited liability feature of debt more beneficial.

Data

To empirically investigate the predictions of the theory, we obtained data on 859 single-family, home-purchase, residential mortgage loans held in portfolio by a nationwide mortgage lender. The loans represent a probability sample[17] of all loans within the lender's portfolio that encountered a severe delinquency ("bad" loans), and a random sample of the nondelinquent accounts ("good" loans).[18] This sampling methodology resulted in a total of 497 bad loans and 362 good loans. All loans within the data set were originated between December 1, 1989, and June 30, 1991 (*i.e.*, a 19-month origination window). The default status of the loans was documented monthly, from origination though mid-1997. This implies that the loans within our data set are characterized by seasoning of between 5.5 and 7 years.

A summary of all the variables and their operationalizations is contained in Table 1. Descriptive statistics for the main variables employed in the analysis are provided in Table 2. Among the highlights, the average loan-to-value ratio (*LTV*) is approximately 76%, with close to one-third (31%) of the borrowers being self-employed (*SELFEMP*). Over half of the loans (60%) do not include

[17] Wolter (1985) provides an excellent overview of the problems encountered in variance estimation for complex samples. Given the stratified random sampling design employed in the current study, the program SUDAAN was used to obtain robust variance estimates based upon the Taylor series linearization method.

[18] Severe delinquency, for the purposes of this study, was defined as any account which had ever experienced a delinquency of 90 days or more.

Table 1 ■ Variable operationalizations.

LTV	Loan-to-value ratio (entered in percentage format) at origination, based on the lesser of sales price or appraised value.
DFCOST	Entered as 1 if the borrower's FICO score is between 620 and 660 (inclusive of the end scores); 0 for all FICO scores above or below this range.
NOADDINC	Entered as 0 if there are two or more formally designated borrowers (*i.e.*, a principal borrower plus one or more coborrowers) and the gross income of the first coborrower is positive; 1 otherwise.
TOTDEBT	Monthly principal, interest, taxes and insurance ("piti") payments plus all other monthly payment obligations, divided by total (including coborrower) gross monthly income (entered in percentage format).
LIQUID	Savings, stocks, bonds, and so forth held by the borrower, relative to total (borrower and coborrower) gross annual income (entered in percentage format).
SELFEMP	Entered as 1 if the borrower is self-employed; 0 otherwise.
AMORT	Entered as 0 if the loan's amortization is 15 years; 1 otherwise.
JUMBO	Entered as 1 if the loan is a jumbo loan; 0 otherwise.
INTEREST	Interest rate at time of loan origination, utilizing a 10-year constant maturity Treasury-rate series.
UNEMP	Unemployment rate in the state at time of loan origination.
ENTRY90Q1 to ENTRY91Q2	Six indicator variables used to flag the quarter in which a loan was originated. The baseline (omitted dummy variable) consists of loans originated in the fourth quarter of 1989.

coborrowers with positive gross incomes (*NOADDINC*). The average total debt ratio (*TOTDEBT*) is quite low, at slightly under 30%, and the typical borrower has liquid assets equal to a little over one year's income (105%). The overwhelming majority (93%) of the loans have amortization periods (*AMORT*) greater than 15 years, and 36% of the loans are characterized as jumbo (*JUMBO*) rather than conventional. Finally, and consistent with the previous literature, when segmented by default status, we observe significant differences in the origination characteristics of our sample loans.

To test the proposed hypotheses, we must distinguish between borrowers with high default costs and those with low default costs.[19] Default costs can take many forms. Specifically, as outlined above, default disutility captures social

[19] Consistent with the theoretical model, our empirical investigation assumes that a borrower's risk type is private information, not known by the lender *a priori*. However, borrowers (partially) reveal this private information when they select contract terms from the menu of available options. Thus, on an *ex post* basis, we may utilize the data contained in the underwriting lender's database to infer information about the borrower's risk type and the potential existence of a separating equilibrium.

Table 2 ■ Variable means and standard deviations, including contrast between good and bad loans.

	All Loans ($n = 859$)		Good Loans ($n = 362$)		Bad Loans ($n = 497$)		Contrast: Good vs. Bad Loans		
Variable	Mean	Dev.	Mean	Dev.	Mean	Dev.	Difference	Std. Error	*T*-statistic[a]
LTV	75.6%	8.6%	72.7%	11.2%	77.6%	5.1%	4.9%	0.6%	8.36***
DFCOST	0.13	0.33	0.06	0.23	0.18	0.39	0.13	0.01	9.22***
NOADDINC	0.60	0.49	0.51	0.50	0.67	0.47	0.15	0.03	5.68***
TOTDEBT	29.6%	9.3%	29.1%	8.7%	29.9%	9.8%	0.8%	0.5%	1.69*
LIQUID	105.4%	167.2%	120.9%	161.5%	94.1%	170.5%	−26.8%	8.9%	−3.02***
SELFEMP	0.31	0.46	0.24	0.43	0.35	0.48	0.11	0.02	4.59***
AMORT	0.93	0.25	0.90	0.30	0.96	0.20	0.05	0.02	3.47***
JUMBO	0.36	0.48	0.43	0.50	0.30	0.46	−0.13	0.03	−4.98***
INTEREST	8.40%	0.32%	8.38%	0.33%	8.41%	0.32%	0.03%	0.02%	1.78*
UNEMP	5.59%	0.86%	5.78%	0.91%	5.45%	0.79%	−0.33%	0.05%	−6.69***

[a]Since the study employs a stratified random sampling design, the program SUDAAN was used to obtain robust variance estimates based upon the Taylor series linearization method.
***Statistically significant at the .01 level; *statistically significant at the .10 level.

and psychic effects of default, damage to the borrower's credit rating, as well as the transaction costs of default. This paper focuses exclusively on damage to the borrower's credit rating as our indicator of default costs. Recent years have seen an increasing reliance by mortgage lenders upon credit scores to summarize credit bureau information. The most common credit score used throughout the residential mortgage underwriting industry today is the FICO score, developed by Fair, Isaac and Company. This numeric indicator of a borrower's aggregate credit history may range from the low-300s for borrowers with very poor credit reputations to the mid-800s for borrowers with superior credit histories. Fannie Mae and Freddie Mac have both endorsed the use of such scores to evaluate mortgage loan applications (see Freddie Mac 1999). Freddie Mac currently considers applications with FICO scores below 620 to be characterized by high credit risk, while applications with FICO scores in excess of 660 are generally acceptable from a credit risk perspective and require only limited underwriting review.[20] Mortgage loan applications with FICO scores between 620 and 660 are considered questionable and require the greatest underwriting review. Borrowers characterized by FICO scores in this range are thus likely to suffer the most from any additional or incremental damage to their credit reputation. Therefore, we define borrowers with high default costs as those borrowers with marginal FICO scores in the range of 620 to 660.[21] The indicator variable *DFCOST* is used to flag such loans (13% of all loans in the data set).

After defining borrower default costs, we next need to construct borrower risk profiles. The approach we take is to define risky borrowers as those borrowers with a higher probability of future income (or asset) decline. The richness of our data set allows us to explore a broad range of borrower risk proxies not traditionally available to academic researchers.[22] For example, our data

[20] The nation's largest private mortgage insurer, MGIC, using similar cutoffs of 620 and 700, finds that borrowers with low scores (<620) are approximately 20 times more likely to become delinquent than applications characterized by high FICO scores (≥ 700) in the first year (Barkley 1996).

[21] As previously noted, our results may have particular relevance to commercial mortgage market lending. However, given the lack of a commercial market analog to credit (FICO) scores to assist in identifying marginal credit risks, we test our theoretical model using residential mortgage data. To the extent that our empirical results confirm the theoretical predictions, we feel they also support the applicability of our model to the analysis of commercial loans.

[22] To ensure our data are free of the potential underwriting issues highlighted in Ambrose and Sanders (2001) and Archer *et al.* (2002), we first regressed the contract rate on the mortgage against borrower risk factors and found no consistent, systematic relationships between the contract interest rate on the loan and traditional measures of individual borrower riskiness. Second, we then sorted the data by origination date and found no evidence of significant differentials in contract interest rates within concise origination

set allows us to control not only for the applicant's FICO score, but also for the presence of a coborrower with positive income (*NOADDINC*) available to satisfy the loan, the borrower's total debt, or back-end, ratio (*TOTDEBT*), the amount of liquid assets available to the borrower at the time of loan origination (*LIQUID*) and the borrower's employment status (*SELFEMP*). C*eteris paribus*, we expect self-employed borrowers and those with higher total debt ratios to exhibit higher default probabilities, but borrowers with greater amounts of liquid assets available to exhibit lower default probabilities. The expected influence of a coborrower with positive income on default probabilities is much more difficult to determine. Within the existing data set, many of the applications exhibiting coborrowers are joint applications by husbands and wives. On the surface, the presence of a coborrower with positive income would seem to provide additional income to satisfy the obligation in the event the primary borrower encounters financial distress. This is the classic case and logic behind the creation and existence of cosigned loans. This logic suggests that the presence of positive coborrower income would make the loan safer. On the other hand, many couples often rely on both spouses' incomes to qualify for the loan on the house they desire. Under this scenario, if either spouse were to become (even temporarily) unemployed, the couple may have difficulty satisfying the required debt service payments and encounter financial distress. Furthermore, in situations where the coborrower is not simply a spouse contributing additional income to help qualify for the mortgage, the presence of a coborrower may be an indication that the primary borrower is of less-than-perfect credit quality. Therefore, given the ambiguous nature of the expected sign on coborrower income, we view coborrower status as simply a control variable in the regressions which follow.

Loan terms have also been linked to default probabilities, and the existing data set allows us to control explicitly for two of these parameters as well. For example, the data set includes information on the amortization term of the loan (*AMORT*) and whether the original loan balance exceeded conventional secondary market guidelines pertaining to loan size (*i.e.*, a jumbo loan flag: *JUMBO*). Previous research by Titman (1992) demonstrates that when firms have private information about their production efficiency, "good risk" firms may well choose shorter term financing. Conversely, "bad risk" firms may well choose longer term financing to effectively lock in their borrowing costs before

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time frames (*e.g.*, week/month of origination). Finally, we note that in numerous conversations with the underwriting lender it was impressed upon us that the underwriting practices did not include risk-based pricing. Rather, individual loan applications were compared to the company's basic underwriting model and were either approved or rejected without substantive modification. In sum, we find no evidence to suggest that our empirical results are an artifact of more stringent underwriting standards applied to higher risk mortgage applications.

the market recognizes the inherent riskiness of the organization. Similarly, with respect to loan size, Milde and Riley (1988) formally document how risk can be either positively or negatively related to loan balances, depending upon the firm's production function.

Analysis

To empirically test the proposition that the effect (on LTV) of default risk factors depends upon borrower default costs, we specify an interaction regression model that includes product terms:

$$\begin{aligned} LTV = {} & \beta_0 + \beta_1 DFCOST + \beta_2 NOADDINC + \beta_3 TOTDEBT + \beta_4 LIQUID \\ & + \beta_5 SELFEMP + \beta_6 AMORT + \beta_7 JUMBO + \beta_8 INTEREST \\ & + \beta_9 UNEMP + \beta_{10} DFCOST * NOADDINC \\ & + \beta_{11} DFCOST * TOTDEBT + \beta_{12} DFCOST * LIQUID \\ & + \beta_{13} DFCOST * SELFEMP + \beta_{14} DFCOST * AMORT \\ & + \beta_{15} DFCOST * JUMBO + \beta_{16} ENTRY90Q1 + \cdots \\ & + \beta_{21} ENTRY91Q2 + \varepsilon \end{aligned} \tag{6}$$

In this model, a test of our contingency hypotheses entails examining the coefficients to the interaction regressors (*e.g.*, $DFCOST * SELFEMP$). Consistent with Allison (1977), we specify a hierarchical model, that is, one in which all main effects are included in the equation. In general, a multiplicative interaction model is an appropriate and flexible approach to testing whether the relationship between an independent variable, X_1, and a dependent variable, Y, is moderated by a contingent variable X_2. It is easy to see from Equation (1) that the partial derivative of LTV with respect to any specific risk factor is a function of default cost. For example, the marginal effect of self-employment status (*SELFEMP*) on LTV is given by

$$\frac{\partial LTV}{\partial SELFEMP} = \beta_5 + \beta_{13} DFCOST \tag{7}$$

indicating that the effect of *SELFEMP* on LTV is moderated by, or contingent upon, borrower default cost (*i.e.*, *DFCOST*).

The estimated coefficients from a multiplicative interactive model fitted to our data are presented in Table 3. The overall F-test indicates a significant regression so that the global null hypothesis is rejected. As outlined above, the parameters

Table 3 ■ Estimated regression model coefficients.[a]

Variable	Dependent Variable: *LTV* Beta Coefficient	*T*-statistic
INTERCEPT	72.62	2.8***
DFCOST	41.87	3.9***
NOADDINC	−0.95	−0.9
TOTDEBT	0.10	1.4
LIQUID[b]	−0.01	−1.8*
SELFEMP	1.66	1.5
AMORT	4.33	2.0**
JUMBO	−2.41	−2.2**
INTEREST	0.14	0.0
UNEMP	−0.59	−0.7
DFCOST ∗ *NOADDINC*	9.11	2.0**
DFCOST ∗ *TOTDEBT*	−0.76	−4.2***
DFCOST ∗ *LIQUID*	0.01	0.5
DFCOST ∗ *SELFEMP*	−13.79	−2.2**
DFCOST ∗ *AMORT*	−24.11	−2.9***
DFCOST ∗ *JUMBO*	3.33	0.9
No. of observations	859	
Model R^2 with 22 *DF*	0.119 ($p < .0001$)	

[a]The estimated model also includes the six indicator variables (*ENTRY90Q1* to *ENTRY91Q2*) identifying the quarter of loan origination. All of the estimated entry time parameters are statistically insignificant.
[b]To a greater degree of precision, the beta coefficient for *LIQUID* is −0.0133, with a standard error of 0.0073 ($t = -1.8$; $p = 0.07$).
***Statistically significant at the .01 level; **statistically significant at the .05 level; *statistically significant at the .10 level.

of interest in evaluating our contingent hypotheses are the interaction terms of the estimated model. Consistent with expectations, the coefficient for the interaction regressor *DFCOST* ∗ *SELFEMP* is negative ($b_{13} = -13.79$). Applying the fitted model (Equation (6)) to a "typical" borrower, we find that when default costs are high (*DFCOST* = 1), riskier self-employed borrowers (*SELFEMP* = 1) have loans with *LTV*s of 65.7%, while safer non-self-employed borrowers (*SELFEMP* = 0) have *LTV*s of 77.8%, that is, 12.1 percentage points higher.[23]

[23] The specific values of *LTV* obtained from the model depend upon how a base case borrower is defined. We select a baseline case in which a "typical" borrower is assumed to have a conventional 30-year fixed-rate, non-jumbo loan, a 30% total debt ratio and liquid assets equal to one year's income. Additionally, it is assumed that the borrower is self-employed, and that the loan is not supported by income from a formally designated coborrower. The loan is assumed to have originated during the first quarter of 1990. The interest and unemployment rate variables are set at their means.

The same estimated marginal effect of self-employment on LTV can be calculated from Equation (7), obtained by setting $b_5 = 1.66$, $b_{13} = -13.79$ and *DFCOST* to 1. Turning to the low default cost scenario ($DFCOST = 0$), the estimated coefficients indicate that the *LTV* for riskier self-employed borrowers ($SELFEMP = 1$) is 74.4%, compared to an *LTV* of 72.7% for non-self-employed borrowers ($SELFEMP = 0$). Since the coefficient for *SELFEMP* is not statistically significant (*i.e.*, H_0: $b_5 = 0$ is not rejected), Equation (7) may be construed as zero. Summarizing, when default costs are high (as measured by potential damage to the borrower's credit rating), self-employed borrowers select loans with significantly lower *LTV*s than their non-self-employed counterparts. At the same time, when default costs are low, self-employed borrowers do not select loans with (statistically) discernibly different *LTV*s from non-self-employed borrowers.

Similarly, the negative coefficient estimate for the interaction variable $DFCOST * TOTDEBT$ ($b_{11} = -0.76$) indicates that the relationship between debt ratio and *LTV* is not constant across the low and high default cost scenarios. Consider the interaction between debt ratio and default cost for debt ratio limits of 5% and 45%. Applying Equation (6), when default costs are high ($DFCOST = 1$), high-debt-burden borrowers ($TOTDEBT = 45\%$) have loans with *LTV*s of 55.8%, while low-debt-burden borrowers ($TOTDEBT = 5\%$) have *LTV*s of 82.2%. As above, this 26.4 percentage point difference may be readily obtained from Equation (7).[24] In the low cost default scenario ($DFCOST = 0$), the estimated coefficients indicate that the LTV for low-debt-burden borrowers is lower than that for those with high debt burdens (71.9% compared to 75.9%, respectively). However, the insignificant coefficient for b_3 indicates that this is not a statistically discernible difference (*i.e.*, when $DFCOST = 0$, the partial derivative in Equation (2) is calculated to be 0).

The interaction regressor $DFCOST * AMORT$, examining how amortization terms may be moderated by default costs, carries a significantly negative coefficient ($b_{14} = -24.11$). As discussed, Titman (1992) suggests that safer borrowers choose shorter term loans. As expected, in our empirical model safe borrowers ($AMORT = 0$) choose higher *LTV*s (85.5% vs. 65.7%) than risky borrowers ($AMORT = 1$) when default costs are high. The same estimated marginal effect of *AMORT* on LTV can be calculated from Equation (7), obtained by setting $b_6 = 4.33$, $b_{14} = -24.11$ and *DFCOST* to 1. In contrast to the previous two interactions examined, however, the null hypothesis, H_0: $b_6 = 0$, is rejected.

[24] In the high default cost scenario, the partial derivative of *LTV* with respect to *TOTDEBT*, from Equation (7), is −0.66. This effect, multiplied by (45% − 5%), yields 26.4%.

Thus, in the low default cost case, the difference in *LTV* of 4.3 percentage points between (riskier) long-term borrowers (74.4%) and safer short-term borrowers (70.1%) is statistically significant.

Summarizing the findings to this point, the results with respect to the interaction terms *DFCOST* ∗ *SELFEMP*, *DFCOST* ∗ *TOTDEBT* and *DFCOST* ∗ *AMORT* are consistent with the predictions of the theory, and they suggest that a separating equilibrium across borrower risk types and default costs may well exist. On the null side, the interaction regressors *DFCOST* ∗ *LIQUID* and *DFCOST* ∗ *JUMBO* are not significantly related to LTV in the model.

Finally, the interaction term examining the moderating effect of high default costs on positive coborrower income (*DFCOST* ∗ *NOADDINC*) exhibits a significantly positive coefficient ($b_{10} = 9.11$). When default costs are high, loans with coborrower income (*NOADDINC* = 0) have *LTV*s of 57.5%, while loans without such income (*NOADDINC* = 1) have *LTV*s of 65.7%, a difference of 8.2 percentage points. In the low-default-cost scenario, the *LTV* for loans with coborrower income is 75.4%, compared to an *LTV* of 74.4% for loans without coborrower income. However, given that H_0: $b_2 = 0$ is not rejected, this latter difference is not statistically significant. As noted previously, conflicting hypotheses exist as to the expected relationship between additional income (*i.e.*, from coborrowers) and default risk. Working from the paradigm that joint applications are riskier than sole borrower loans, either because a cosigner was necessary to vouch for the credibility of the primary applicant or because both spousal incomes are necessary to qualify for and satisfy the loan, this result is not inconsistent with the predictions of our theoretical model.[25] On the other hand, if the presence of a coborrower with positive income serves as a reliable signal of relative borrower safety, this result is inconsistent with the predictions of our theoretical model expectations.

Summary and Conclusions

Do riskier borrowers borrow more? This investigation presents a theoretical framework which explains a fundamental disconnect between industry perceptions of default risk proxies and ultimate borrower behavior. Specifically, while conventional wisdom within the mortgage underwriting industry posits that loan-to-value ratios should be positively associated with the probability of default for a given loan, previous empirical evidence has not uniformly supported this contention. To explain this discrepancy, we offer a signaling model of

[25] Given that the vast majority of joint applications within this data set come from husbands and wives, this result would appear to support our focal hypotheses.

borrower default risk, conditional on default costs, under asymmetric information. Within this framework, we demonstrate that when default costs are high, there exists a separating equilibrium in which safe borrowers self-select higher loan-to-value ratios than risky borrowers. Conversely, when default costs are low, the separating equilibrium predicts risky borrowers will self-select into higher loan-to-value ratios. This low-default cost equilibrium is consistent with the traditional view of default risk increasing with loan-to-value ratios. Supporting this theoretical framework, our investigation presents empirical results that are consistent with the predictions of our model.

These findings imply lenders need to recognize that a borrower's choice of LTV provides a qualified signal about that borrower's default riskiness. Specifically, both managers and academicians must recognize that the relationship between LTV and borrower default risk is contingent upon default costs. In this paper we have empirically tested this contingent relationship in the context of residential mortgage lending markets. Given the potential applicability of this conceptual framework to the commercial market, the literature would be well served by additional and more direct tests of this model using commercial data. For example, in the commercial lending context, loan-to-value ratios and debt service coverage ratios are fundamentally the same concept, as declines in the property's net operating income will reduce both the value of the property and the ability of the borrower to satisfy the outstanding debt service obligations. Thus, if a borrower anticipates a drop in future *NOI* (and hence an increase in *LTV* and decrease in *DSCR*), when default costs are high she may well desire a relatively small loan to ensure that *NOI* is sufficient to avoid default.[26]

In the interim, we believe our findings provide a potentially useful way of conceptualizing the relationship between LTV and default risk. Going forward, we believe further examination of the interactions among various borrower risk measures including (but not limited to) ARMs versus FRMs, short-term versus long-term amortization schedules, coupon rate and origination point combinations and other instruments would be warranted. While Dunn and Spatt (1999) examine many of these issues using arbitrage methods, the literature may be well served by the examination of these variables as alternative signaling instruments (to LTV) of borrower risk type.

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