Credit Scoring and Mortgage Securitization: Implications for Mortgage Rates and Credit Availability

December 21, 2000

Andrea Heuson
Associate Professor of Finance
University of Miami
Box 248094
Coral Gables, FL 33134

Aheuson@miami.edu
(305) 284-1866 Office
(305) 284-4800 Fax

Wayne Passmore
Assistant Director
Federal Reserve Board
Mail Stop 93
Washington, DC 20551

Wayne.passmore@frb.gov
(202) 452-6432 Office
(202) 452-3819 Fax

Roger Sparks
Associate Professor of Economics
Mills College
5000 MacArthur Blvd.
Oakland, CA 94613-1399

Sparks@mills.edu
(510) 430-2137 Office
(510) 430-2304 Fax

We wish to thank Steve Oliner, David Pearl, Tim Riddiough, Robert Van Order, Stanley Longhofer, and an anonymous referee for helpful comments on previous drafts of this paper. We take responsibility for all errors.

Credit Scoring and Mortgage Securitization: Implications for Mortgage Rates and Credit Availability

Abstract

This paper develops a model of the interactions between borrowers, originators, and a securitizer in primary and secondary mortgage markets. In the secondary market, the securitizer adds liquidity and plays a strategic game with mortgage originators. The securitizer sets the price at which it will purchase mortgages and the credit-score standard that qualifies a mortgage for purchase. We investigate two potential links between securitization and mortgage rates. First, we analyze whether a portion of the liquidity premium gets passed on to borrowers in the form of a lower mortgage rate. Somewhat surprisingly, we find very plausible conditions under which securitization fails to lower the mortgage rate. Second, and consistent with recent empirical results, we derive an inverse correlation between the volume of securitization and mortgage rates. However, the causation is reversed from the standard rendering. In our model, a decline in the mortgage rate causes increased securitization rather than the other way around.

I. Introduction

This paper develops a model of the primary and secondary mortgage markets. The primary market is competitive, consisting of numerous originators and a continuum of borrowers with differing default probabilities. In the secondary market, a monopolist sells mortgage-backed securities, which yield a liquidity benefit, in exchange for mortgages offered by originators. The monopolist/securitizer sets both the price for these mortgages and the credit-quality standard that qualifies a mortgage for purchase. Although credit scoring ensures that originators do not enjoy an information advantage over the securitizer, they do enjoy a "first-mover advantage" in selecting which qualifying mortgages to sell. The main purpose of the analysis is to shed light on how securitization affects the interest rate paid by borrowers and the availability of mortgage credit.

Historically, originators of residential mortgages have had two distinct advantages vis-a-vis mortgage securitizers. First, originators had better information about the creditworthiness of borrowers and their risks of default on mortgages. Originators processed loan applications and followed trends in local real estate markets, thereby acquiring knowledge about the riskiness of local borrowers' income streams and the market values of properties. Second, originators had a first-mover advantage in the selection of mortgages to keep in their portfolios. Each originator unilaterally chose which qualifying mortgages to pass on to the securitizer.

With the recent advent of automated underwriting, much of the informational advantage has disappeared. As the argument goes, computerized credit scoring gives the securitizer more accurate and timely information about borrower creditworthiness.[1] On the other hand, the first-mover advantage endures because originators still decide whether or not to securitize each qualifying mortgage. Furthermore, the evidence suggests that mortgage securitizers are aware of the originator's first-mover advantage;[2] such awareness is a precondition for strategic interaction.

While credit scoring improves the quality of information, securitization conveys an important benefit to mortgage originators (or lenders). By holding a mortgage-backed security rather than the mortgage itself, lenders achieve greater liquidity. A key question is whether this benefit gets passed on to borrowers. Specifically, does the liquidity benefit of securitization translate into a lower mortgage rate and/or greater access to credit? To investigate, we begin by developing a baseline model of borrower and lender behavior in a competitive mortgage market without mortgage securitization.

---

[1] Somewhat paradoxically, however, automated underwriting can have a negative impact on securitizer profits, as shown in Passmore and Sparks (2000).

[2] The chairman of Fannie Mae was quoted in a speech to mortgages bankers: "If the risk profile of mortgages you deliver to us differs substantially from the risk profile of your overall book of business, then we will have no choice but to believe we have been adversely selected." Jim Johnson, as quoted in "Comment: Wholesale Lending Leaves Mortgage Out of the Loop," *American Banker,* October 31, 1995.

Although the baseline model serves as a useful benchmark for comparison, it does not adequately capture the institutional structure of U.S. mortgage markets. Consequently, we extend the model by adding a mortgage securitizer who behaves strategically. The extended model builds on work by Passmore and Sparks (1996), who demonstrate that a mortgage securitizer can reduce an originator's screening of loans—thus reducing the volume of poorer-quality mortgages passed on to the securitizer—by raising the interest rate offered on the mortgage-backed securities that the securitizer swaps for mortgages.

Several studies ascribe market benefits to asset securitization. In a paper promoting the development of government-sponsored mortgage securitization, Jones (1962) points to improved liquidity as a key effect. More recently, Black, Garbade, and Silber (1981) and Passmore and Sparks (1996) argue that the implicit government guarantee enhances liquidity.[3] Within general asset markets, Greenbaum and Thakor (1987) show that banks, by selling loans rather than funding them through deposits, can provide a useful signal of loan quality. Hess and Smith (1988) show that asset securitization is a means of reducing risk through diversification. Boot and Thakor (1993) demonstrate that this diversification may improve information. When assets are assembled in portfolios, the payoff patterns that they yield are easier to evaluate because diversification eliminates asset idiosyncrasies. Donahoo and Shaffer (1991) and

[3] Gorton and Pennacchi (1990), Amihud and Mendelson (1986), and Merton (1987) show that there are trading gains associated with increased liquidity.

Pennacchi (1988) suggest that banks securitize assets in order to lower reserve and capital requirements and thereby reduce financing costs.

Recent research also highlights several potential drawbacks to asset securitization. Securitization may aggravate problems of asymmetric information concerning the credit quality of loans. Passmore and Sparks (1996) emphasize adverse selection, which gives originators an informational advantage over a mortgage securitizer. Pennacchi (1988) stresses moral hazard, which arises because the bank has less incentive to monitor and service loans after they are sold.

The present paper deviates from the earlier model of Passmore and Sparks (1996) by assuming that the securitizer is well informed about credit quality. The securitizer observes each mortgage applicant's credit score, which is a perfect signal of the applicant's probability of not defaulting on a mortgage. In addition, we allow the securitizer to choose both the interest rate offered on mortgage-backed securities and the credit score standard that borrowers must meet to qualify their mortgages for securitization.[4] The underwriting standard represents another tool that the securitizer may use to influence the credit quality of the securitized mortgage pool. Finally, we introduce a continuum of no-default probabilities.

Our primary finding is that mortgage securitization does not necessarily lower the equilibrium mortgage rate. While mortgage securitization does alter the placement of mortgages between the originator and the securitizer, it may leave unchanged the cost of holding the marginal mortgage. In this case, the

[4] `Calomiris, Kahn, and Longhofer (1994) allow lenders to set both the price and a cutoff standard.

originator's unaltered marginal profitability condition determines the equilibrium mortgage rate, and the presence of a securitizer offering a liquidity premium does not affect that rate.

Our results also suggest a reinterpretation of recent empirical evidence concerning a negative correlation between mortgage rates and the volume of securitization. Researchers generally interpret this correlation as indicating causation in that greater securitization reduces mortgage rates. Kolari, Fraser, and Anari (1998), for example, conclude that an increase of 10-percent in the proportion of mortgages securitized will decrease yield spreads on home loans by approximately 20 basis points. Our model, in contrast, predicts that a decline in mortgage rates causes the volume of securitization to rise, a reversal of causation from previous interpretations.[5]

Throughout this paper, we abstract from the issues of prepayment risk and mortgage insurance. Although these are significant features of U.S. mortgage markets, we wish to focus on the liquidity premium and the assumption of credit risk by a third party. Therefore, we assume that potential mortgage borrowers differ from one another only in their probabilities of defaulting on a mortgage.

---

[5] In addition to Kolari, Fraser, and Anari (1998), see Black, Garbade, and Silber (1981), who argue that the pass-through program sought to reduce yields on mortgages by improving their marketability. The growth of securitization coincides with the standardization of mortgage contracts and the creation of a national mortgage market during the 1980s; untangling these trends, some of which likely lower the cost of originating mortgage credit, is difficult. Todd (2000) finds that securitization is uncorrelated with mortgage rates but is inversely correlated with mortgage origination fees.

The next section of the paper presents a baseline model of borrower and lender behavior in a competitive market with perfect information. Section III presents the extended model, while section IV offers concluding remarks.

II. The Baseline Model: Without Securitization

Let the probability of a household not defaulting on a mortgage be denoted by q, and assume that the q's are distributed according to a continuous, differentiable, and single-peaked density function $f(q)$ defined over the line interval $[0,1]$. In both the baseline and extended models, we assume that $f(q) > 0 \;\forall\, q \in (0,1)$,[6] that the distribution of qs is public knowledge, and that each mortgage applicant's no-default probability is publicly observed. The key difference is that in the extended model, a securitizer commits to purchasing all mortgages meeting a credit-score standard.

Under the assumption of risk neutrality, a mortgage originator will offer a mortgage to any applicant who incrementally adds to the lender's expected profit. Formally, an applicant will be offered a mortgage if and only if

$$qr + (1-q)r_d \geq r_f\,, \tag{1}$$

where q is the applicant's probability of not defaulting on the loan, r is the

---

[6] An example of a probability density function meeting these assumptions is the beta density function: $f(q) = \dfrac{\Gamma(\alpha_1+\alpha_2)}{\Gamma(\alpha_1)\Gamma(\alpha_2)} q^{\alpha_1-1}(1-q)^{\alpha_2-1}$ for 0< q <1 and $f(q) = 0$ otherwise.

mortgage rate received by the lender if the borrower does not default,[7] r_d is the expected return to the lender if the borrower does default, and r_f is the expected return on an alternative investment. We assume $r_f > r_d$ so that lenders do not profit from mortgage default. Writing (1) as an equality and solving for r, we obtain the lowest mortgage rate the lender is willing to accept as a function of the applicant's no-default probability:

$$r_{\min} = r_d + \frac{(r_f - r_d)}{q}. \qquad (2)$$

Equation (2) is the inverse supply function, which is decreasing in q and r_d but increasing in r_f.

Now consider the decision facing a mortgage applicant. Denoting the expected benefit to an applicant from possessing a mortgage by r_b, and the cost of defaulting on a mortgage by r_c, then an applicant will apply for a mortgage if and only if the benefit is at least as great as the cost, or

$$qr + (1 - q)r_c \leq r_b, \qquad (3)$$

---

[7] We assume that the mortgage rate is uniform across borrowers even though they have different credit risks. To justify this assumption, we point to common practice. Originators typically make the mortgage rate contingent upon loan qualification but not upon the applicant's actual credit score. See Leeds (1987). There are many plausible reasons why banks charge rates that are not fully contingent upon borrower credit risk. A uniform rate may be an efficient means of risk sharing between a risk-neutral lender and risk-averse applicants who are initially uninformed about their true default probabilities. This explanation is suggested by Calomiris, Kahn, and Longhofer (1994), p. 670. Another possible reason is that it may be costly to verify and enforce risk-based contracts, particularly when government regulators are trying to discourage discrimination in credit markets. For example, the courts may have difficulty sorting out whether an originator who charges a higher rate to a minority or low-income borrower is practicing discrimination or efficient risk pricing.

Even when risk-based pricing does occur, it generally takes form as a discontinuous step function rather than as a continuous function of the credit risk distribution. The lender divides applicants into risk categories, for example, low, medium, and high (but acceptable), and then charges a single rate within each category.

where we assume that $r_b < r_c$, so borrowers do not expect to gain from default.

Setting (3) as an equality and solving for r, we may write the maximum mortgage rate the applicant is willing to pay for the loan as:

$$r_{\max} = r_c - \frac{(r_c - r_b)}{q}. \qquad (4)$$

Equation (4) is the inverse demand function, which is increasing in q and r_b but decreasing in r_c.[8]

To make mortgages mutually agreeable to some borrowers and lenders, we assume that $r_b > r_f$. Similarly, to prevent default from being mutually beneficial, we assume that default is expected to cost the borrower more than it benefits the lender, i.e., $r_c > r_d$. Combining all of our assumptions on parameter values, we have:

$$r_c > r_b > r_f > r_d. \qquad (5)$$

If there are many price-taking lenders, we may equate (2) and (4) to solve for the market-equilibrium, no-default probability, q^*, which is the probability of not defaulting for the marginal borrower obtaining a mortgage:

$$q^* = 1 - \frac{(r_b - r_f)}{(r_c - r_d)}. \qquad (6)$$

[8] By contrast, in Stiglitz and Weiss (1981), the maximum interest rate that borrowers are willing to pay decreases with the credit quality of borrowers. In their model, borrowers with higher default risk take greater investment risks that earn higher expected returns. Hence, these borrowers are willing to pay higher interest rates on loans. In our model, on the other hand, the rate of return on borrowed funds is constant across potential borrowers and not related to default probabilities (i.e., r_b is independent of q). Furthermore, we assume that default is sufficiently costly for borrowers so that those with higher risks of default (lower q) have less willingness to pay for mortgages.

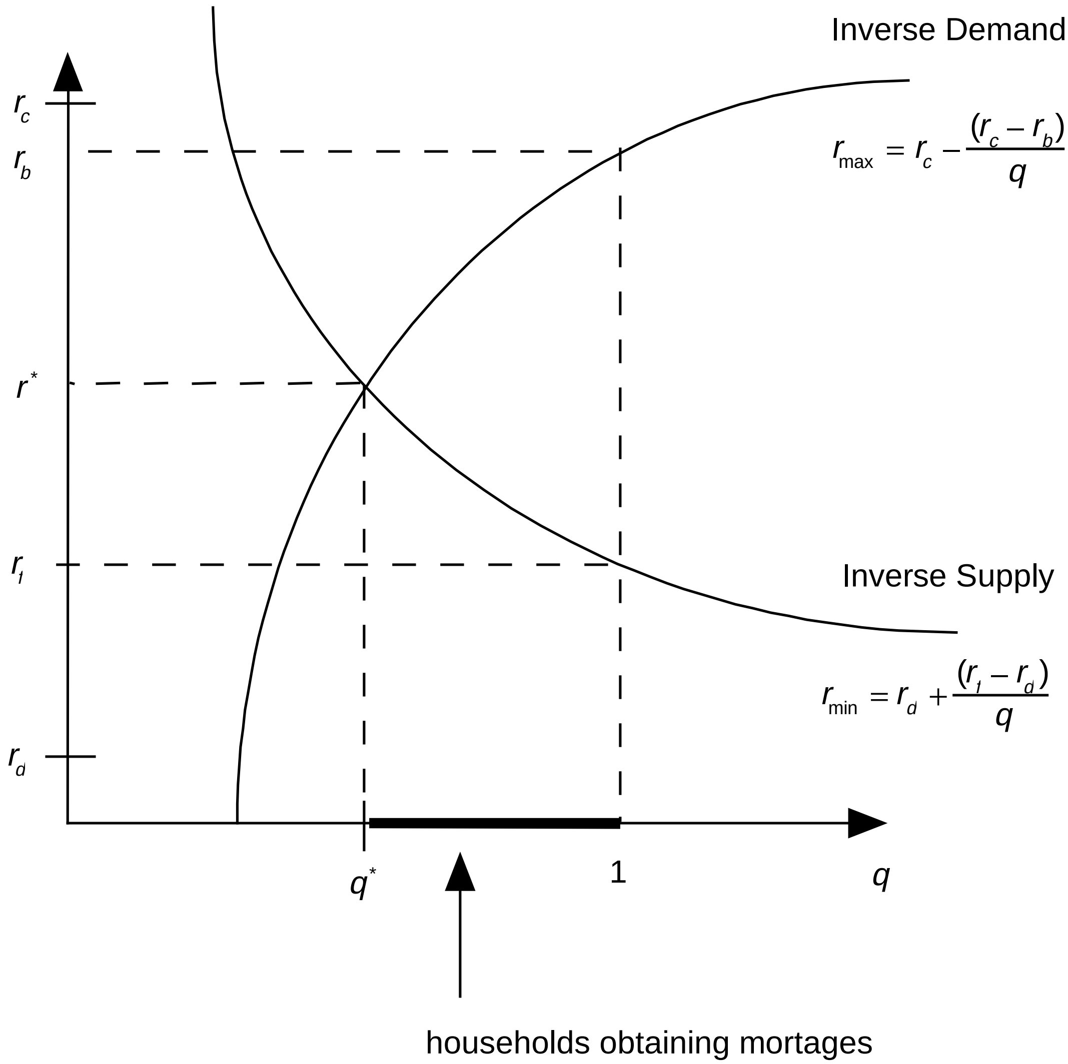
Note that (5) and (6) imply $q^* \in (0,1)$. Substituting (6) into (2) or (4), we find the market equilibrium mortgage rate[9]

$$r^* = r_d + \frac{(r_f - r_d)(r_c - r_d)}{(r_c - r_b + r_f - r_d)}, \qquad (7)$$

which from (5) implies that $r^* \in (r_d, r_c)$. We may illustrate the market equilibrium by graphing the inverse supply and demand functions, i.e., equations (2) and (4), as in figure 1. The graph shows the equilibrium mortgage rate r^* and the equilibrium marginal no-default probability q^*. Households obtaining mortgages are those with no-default probabilities contained by the line interval $[q^*, 1]$. Next, we extend the model to encompass securitization in the secondary market.

[9] This equilibrium concept implies that originators earn positive profits in equilibrium. They earn zero profit on the marginal borrower and positive profit on the inframarginal borrowers, since each borrower pays the same mortgage rate. Although we have not modeled a process in which these profits are competed away, there are several possibilities. Competition in providing loan services, in obtaining access to land for branches, in advertising, and in general rent-seeking behavior may cause "fixed costs" (i.e., costs that are independent of borrower credit risk) to rise high enough to soak up any positive profits.

Figure 1: Equilibrium in the Baseline Model



III. The Extended Model: Credit Scoring and Securitization

A. Model Structure

We now modify the baseline model by adding a mortgage securitizer[10] who is willing to bear the credit risk of mortgages that meet certain conditions. We assume that the securitizer has the same information as do mortgage originators about the default risks of borrowers, but originators (whom we shall also refer to as banks) choose which mortgages to hold in their own portfolios and which ones to securitize.

Suppose that banks and the securitizer make sequential decisions over three periods. In period 1, the securitizer specifies two contractual terms for swapping a mortgage for a mortgage-backed security (MBS): an interest rate r_s offered on the MBS, and a credit standard $\overline{q}$ that the mortgages must meet in order to qualify for securitization.[11] Also during this period, banks receive loan applications and information about the applicants' creditworthiness. This information includes applicants' loan default probabilities, which are disclosed to both banks and the securitizer.

Using information on borrower default probabilities, a bank in period 2 attempts to maximize profits by taking action on submitted mortgage

---

[10] By assuming a monopolist securitizer, our model abstracts from the actual market structure for fixed-rate conforming loans in the United States, where Fannie Mae and Freddie Mac are duopolists. In our judgment, this abstraction represents a reasonable trade-off between realism and tractability. However, an extension to duopoly would be a promising path for future modeling.

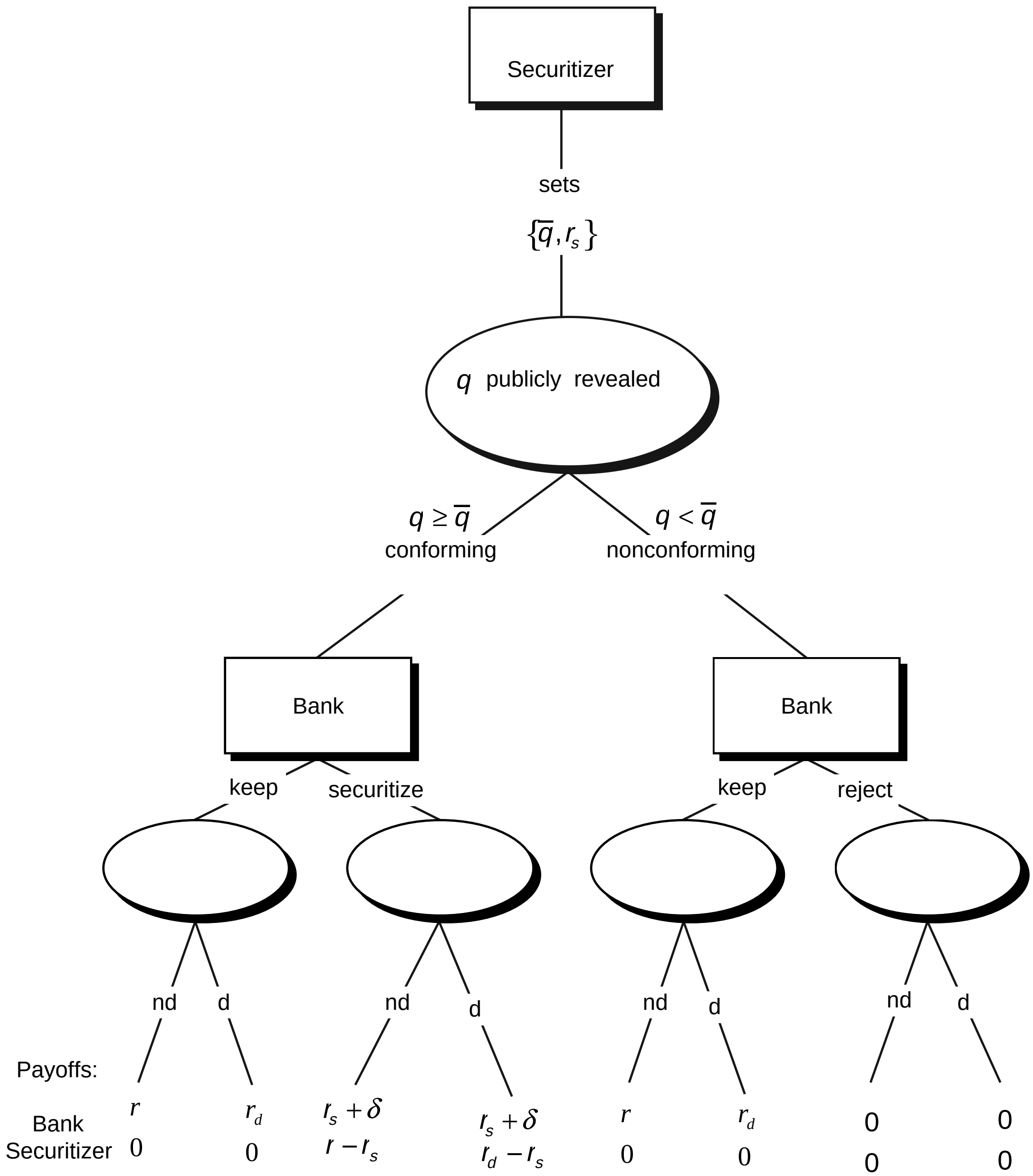
[11] The securitizer simply issues pass-through securities that are immediately swapped with the banks that originated the mortgages. Thus, the guaranteed interest payments from the securitizer to the originator are self-funded out of the pool of securitized mortgages.

applications. Some mortgages are granted and held in the bank's portfolio; others are granted and immediately traded for mortgage-backed securities; and the remaining applications are rejected.

In period 3, borrowers either default on their mortgages (in which case the rate of return to the mortgage holder is r_d) or pay them back in full. At the end of this period, all parties receive their payoffs.

The sequential game played between the securitizer and the bank is depicted in figure 2. The securitizer first chooses $\overline{q}$ and r_s. Then, both bank and securitizer observe applicant default probabilities. For conforming mortgages, the bank decides either to sell the mortgage to the securitizer (securitize) or hold the mortgage in its own portfolio (keep). For mortgages that do not meet the securitizer's standards, the bank's choice is either to keep the mortgage in its portfolio or to reject the application (reject). Finally, the borrower either defaults (d) or does not default (nd) on the loan, and the bank and securitizer receive the payoffs.

Figure 2: The Game Between the Securitizer and the Bank



The return on a defaulted mortgage is r_d, while the return on a nondefaulted mortgage is r. The total return to the bank from securitizing a mortgage is $r_s + \delta$, where $\delta > 0$ is the value of liquidity to the bank from holding a mortgage-backed security as opposed to the mortgage itself, or the "liquidity premium."

Let the number of households be denoted by $N > 0$. Following the baseline model, we assume that household probabilities of not defaulting on a mortgage are distributed according to the density function $f(q)$ defined over the interval $[0,1]$. The distribution of qs is public knowledge, and each household knows its own no-default probability, which is a random draw from the density. Given its draw, a household decides whether to apply for a mortgage. As in the baseline model, we assume that households are rational, applying for mortgages only if the expected benefits exceed the expected costs of doing so. A household applies only if:

$$r_b \geq qr + (1-q)r_c, \tag{8}$$

which implies

$$q \geq \frac{r_c - r_b}{r_c - r} \equiv \gamma, \tag{9}$$

where γ is the lower bound on the distribution of no-default probabilities for applicants.[12] Households with no-default probabilities lower than γ do not apply for mortgages.

---

[12] We continue to assume that $r_c > r_b$; also note that a nontrivial equilibrium requires $r_b > r$, which from (9) implies $\gamma \in (0,1)$.

We define a conforming loan (that qualifies for securitization) as one whose credit score is at least as great as a threshold $\overline{q}$ set by the securitizer.[13] Since credit scores in this model are perfect indicators of no-default probabilities, it follows that applications with $q < \overline{q}$ do not qualify for securitization. The proportion of households that qualify for securitization is given by $[1 - F(\overline{q})]$ for $\overline{q} \in [0,1]$, which is decreasing in the credit standard $\overline{q}$.

B. The Bank's Problem

The bank will either grant the mortgage and keep it in portfolio, grant the mortgage and immediately trade it for a mortgage-backed security, or reject the application. For the securitizer to induce banks to originate and securitize any mortgages, the return from securitization must be at least as great as the alternative return; otherwise, banks will prefer their alternative investment. Consequently, we impose the parameter restriction: $r_s + \delta \geq r_f$.

Consider a bank's choice of which action to take with a mortgage application. The bank rejects the loan application if

$$q < \frac{(r_f - r_d)}{(r - r_d)} \equiv q_{\min} \text{ and } q < \overline{q}. \tag{10}$$

The first inequality in (10) implies that holding the mortgage is not profitable for the bank, while the second inequality says that the mortgage does not qualify for securitization. Choice (10) and subsequent choices are illustrated in figure 3.

The bank accepts and holds the mortgage if

[13] We analyze the determination of $\overline{q}$ later.

$$q > \frac{(r_s + \delta - r_d)}{(r - r_d)} \equiv q' \tag{11}$$

or if

$$q \geq q_{\min} \text{ and } q < \overline{q}\,. \tag{12}$$

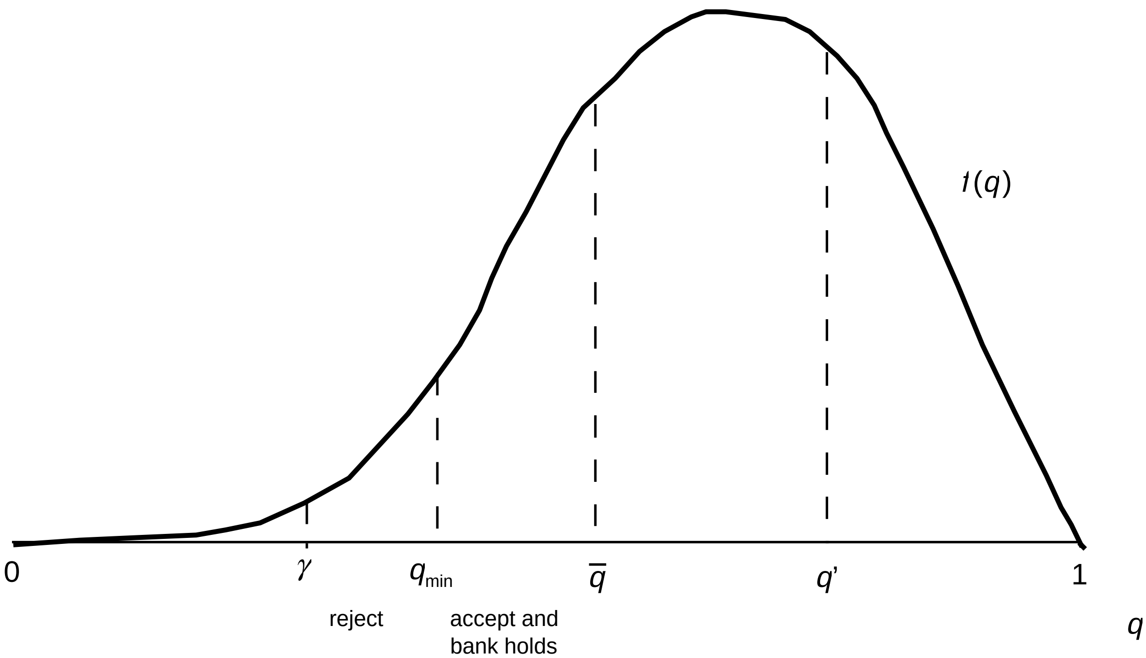
Condition (11) implies that it is more profitable for the bank to hold the mortgage than to securitize it, whereas (12) says that the bank finds the mortgage profitable to hold but the mortgage does not qualify for securitization.

Finally, the bank accepts and securitizes the mortgage if

$$q \leq q' \text{ and } q \geq \overline{q}\,. \tag{13}$$

In case (13), the mortgage is profitable for the bank to securitize and the mortgage qualifies for securitization. In this instance, the securitizer receives mortgages that are conforming but not sufficiently attractive to be retained by the bank. Conditions (11) and (13) reflect the cherry picking that results from the bank's first-mover advantage. Of the qualifying mortgages, the bank retains the higher-quality ones, satisfying (11), and sells the lower-quality ones, satisfying (13).

Figure 3: Partitioning the Distribution of Borrowers



Note that if $\bar{q} \le q_{\min} < q'$, then the marginal mortgage is securitized. We next analyze the securitizer's problem of choosing the interest rate r_s and credit standard $\bar{q}$ that maximize profits.

C. Securitizer Behavior

Suppose the securitizer, while taking r and r_f as given, chooses $\bar{q}$ and r_s to maximize profits:[14]

$$\max_{(\bar{q},r_s)} \quad \pi_S = N\int_{\bar{q}}^{q'} f(q)\left[qr + (1-q)r_d - r_s\right] dq, \tag{14}$$

[14] By assuming that the mortgage rate is taken as given, we are treating the securitizer as a price-taker in the primary mortgage market but a monopolist in the secondary market. It is straightforward to establish that the solution to the securitizer's problem is an interior solution unless further parameter restrictions are imposed.

where the term inside the square brackets of (14) is the securitizer's expected profit from a securitized mortgage with no-default probability q.[15]

Assuming positive solutions for $\overline{q}$ and r_s, we compute the following first-order conditions:

$$\frac{\partial \pi_S}{\partial \overline{q}} = -Nf(\overline{q})[\overline{q}r + (1-\overline{q})r_d - r_s] = 0 \quad \text{and} \tag{15}$$

$$\frac{\partial \pi_S}{\partial r_s} = \frac{N}{(r - r_d)} f(q')[q'r + (1-q')r_d - r_s] - N\int_{\overline{q}}^{q'} f(q)dq = 0, \tag{16}$$

where we recall from (11) that $q' = \frac{(r_s + \delta - r_d)}{(r - r_d)}$. By prior assumptions, $N, f(\overline{q}) > 0$, which imply in (15) that:

$$\overline{q} = \frac{(r_s - r_d)}{(r - r_d)}. \tag{17}$$

Equation (17) shows that $\overline{q}$ is set so that the securitizer would earn zero profit by securitizing the marginal qualifying mortgage, which is a standard condition for profit maximization.

Using (11) and (17), we may rearrange (16) to obtain:

$$f\left(\frac{r_s + \delta - r_d}{r - r_d}\right)\frac{\delta}{(r - r_d)} = \left[F\left(\frac{r_s + \delta - r_d}{r - r_d}\right) - F\left(\frac{r_s - r_d}{r - r_d}\right)\right], \tag{18}$$

[15] The securitizer here is assumed to have the status of a government-sponsored enterprise, which can convert one dollar of mortgages into one dollar of assets and still create the liquidity premium. In contrast, a purely private-sector securitizer would need to purchase credit enhancements or create a senior/subordinated debt structure to minimize investors' credit risk concerns and create a liquidity premium. This latter case is discussed at length in Passmore, Sparks, and Ingpen (2000).

an equation with one endogenous variable, r_s, because the solution for $\bar{q}$ comes from (15). Equation (18) has a standard economic interpretation. The guaranteed rate r_s is set so that the marginal net revenue from raising r_s (left side) equals the marginal cost to the securitizer (right side). Increasing r_s raises q' by the factor $\frac{1}{(r-r_d)}$ and induces banks to securitize additional mortgages, thereby generating marginal net revenue of $f\left(\frac{r_s+\delta-r_d}{r-r_d}\right)\delta$.[16] The right side of (18) represents the marginal cost of raising r_s because the securitizer pays a higher price for all securitized mortgages.

To derive the key comparative static results for the securitizer's choice problem, we briefly examine the second-order conditions associated with (14). Substitution of (17) into (16) eliminates $\bar{q}$ as an explicit choice variable and allows us to state second-order conditions applicable to the single choice variable r_s. After making this substitution, we differentiate the resulting expression with respect to r_s. Then, we impose the condition that this derivative be less than zero:

$$f' \frac{\delta}{(r-r_d)} - f + f^0 < 0, \qquad (19)$$

[16] The marginal net revenue from raising r_s is $MR = f(q')[q'r + (1-q')r_d - r_s]$. Substitute (11) into this expression to get $MR = f(q')\left[\frac{(r_s+\delta-r_d)}{(r-r_d)}(r-r_d) + r_d - r_s\right] = f(q')\delta$.

where $f^{'}$ denotes the first derivative of the pdf evaluated at $\frac{r_s+\delta-r_d}{r-r_d}$, f is the pdf evaluated at $\frac{r_s+\delta-r_d}{r-r_d}$, and f^0 is the pdf evaluated at $\frac{r_s-r_d}{r-r_d}$. In section A of the appendix, we derive another second-order condition:

$$f^{'}<0. \tag{20}$$

Thus, (19) and (20) are second-order conditions for the choice of r_s to maximize the securitizer's profits.

We now address a comparative static question: How does the securitizer's choice of MBS rate r_s respond to movements in the market interest rate r? Taking the differential of (18) with respect to r_s and r, we find

$$\left[f^{'}\frac{\delta}{(r-r_d)}-f+f^0\right]dr_s-\left\{\frac{(r_s-r_d)}{(r-r_d)}\left[f^{'}\frac{\delta}{(r-r_d)}-f+f^0\right]+f^{'}\frac{\delta^2}{(r-r_d)^2}\right\}dr=0. \tag{21}$$

Since the term inside the two sets of square brackets in (21) is negative by (19) and $f^{'}<0$ by (20), we have

$$\frac{\partial r_s}{\partial r}>0. \tag{22}$$

That is, the securitizer responds to increases in the mortgage rate by raising the MBS rate. Using (21) and (22), we may differentiate (17) to find

$$\frac{\partial \bar{q}}{\partial r}=\frac{\frac{\partial r_s}{\partial r}(r-r_d)-(r_s-r_d)}{(r-r_d)^2}=\frac{f^{'}\delta^2}{(r-r_d)^3}\left[\frac{1}{\left[\frac{f^{'}\delta}{(r-r_d)}-f+f^0\right]}\right]>0, \tag{23}$$

which shows that the securitizer raises the credit standard in response to increases in the mortgage rate. The intuition for this result is appealing. Knowing that a rise in the mortgage rate induces originators to retain some additional high-quality mortgages (i.e., q' declines), the securitizer responds by raising the MBS rate to counter this increased cherry picking. But the higher MBS rate raises the securitizer's costs of purchasing mortgages, making some low-quality mortgages unprofitable to purchase. The securitizer raises the credit standard to exclude those mortgages from the conforming pool.

D. The Supply of Credit Under Securitization

To investigate the supply side of the primary market, we now graph $\overline{q}$ as a function of r. Taking limits of (23), we find: $\lim_{r \to r_d} \frac{\partial \overline{q}}{\partial r} = \infty$ and $\lim_{r \to \infty} \frac{\partial \overline{q}}{\partial r} = 0$. Consequently, the graph of $\overline{q}(r)$ from (17), taking into account the dependence of r_s on r from (18), has the general shape shown in figure 4 (though it is not necessarily everywhere strictly convex to the origin). The function $\overline{q}(r)$ shows the securitizer's willingness to accept mortgages for securitization as a function of r.

Another aspect of mortgage supply in the primary market is the bank's willingness to securitize mortgages as opposed to rejecting them and earning r_f. For this securitization choice not to lower the bank's profits, the weak inequality

$$r_s + \delta \geq r_f \tag{24}$$

must hold. To graph (24) in (q, r) space, we substitute (17) into (24) and obtain[17]

[17] Equation (17) gives the securitizer's choice of $\overline{q}$ as a function of r_s. Solving (17) for r_s, we obtain the maximum r_s the securitizer would pay for credit standard $\overline{q}$: $r_s = \overline{q}(r - r_d) + r_d$. Substitution of this expression into (24) yields (25).

$$\bar{q} \geq \frac{r_f - \delta - r_d}{r - r_d} \equiv \bar{\bar{q}}, \qquad (25)$$

which shows the condition for the bank to choose securitization over rejection of the mortgage application. The graph of $\bar{\bar{q}}(r)$ is shown in figure 4.

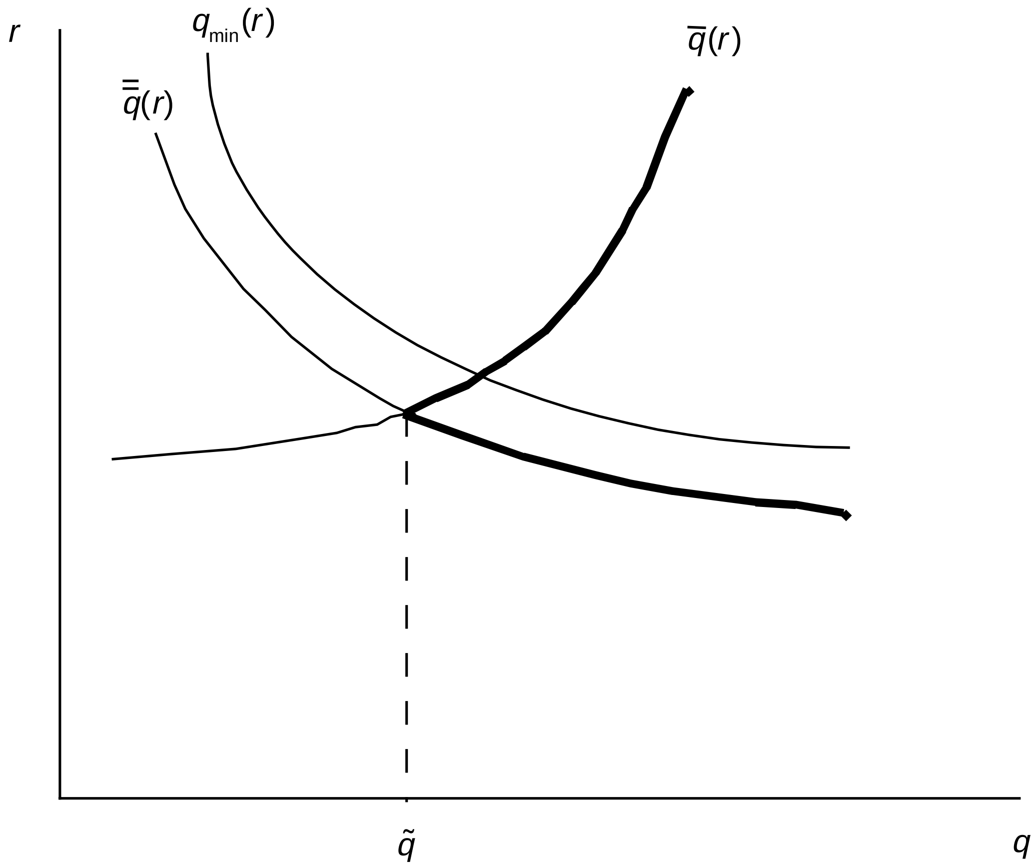
The final component of market supply derives from the bank's willingness to hold mortgages rather than reject them, as expressed in (2). Solving (2) for q, we have

$$q_{\min} = \frac{r_f - r_d}{r - r_d}, \qquad (26)$$

which is interpreted as the minimum no-default probability that causes the bank to hold rather than reject the mortgage. By comparing (25) and (26), we see that $\bar{\bar{q}}(r)$ lies $\frac{\delta}{r - r_d}$ units to the left of $q_{\min}(r)$. Through this mechanism, the liquidity premium affects supply conditions in the primary market.

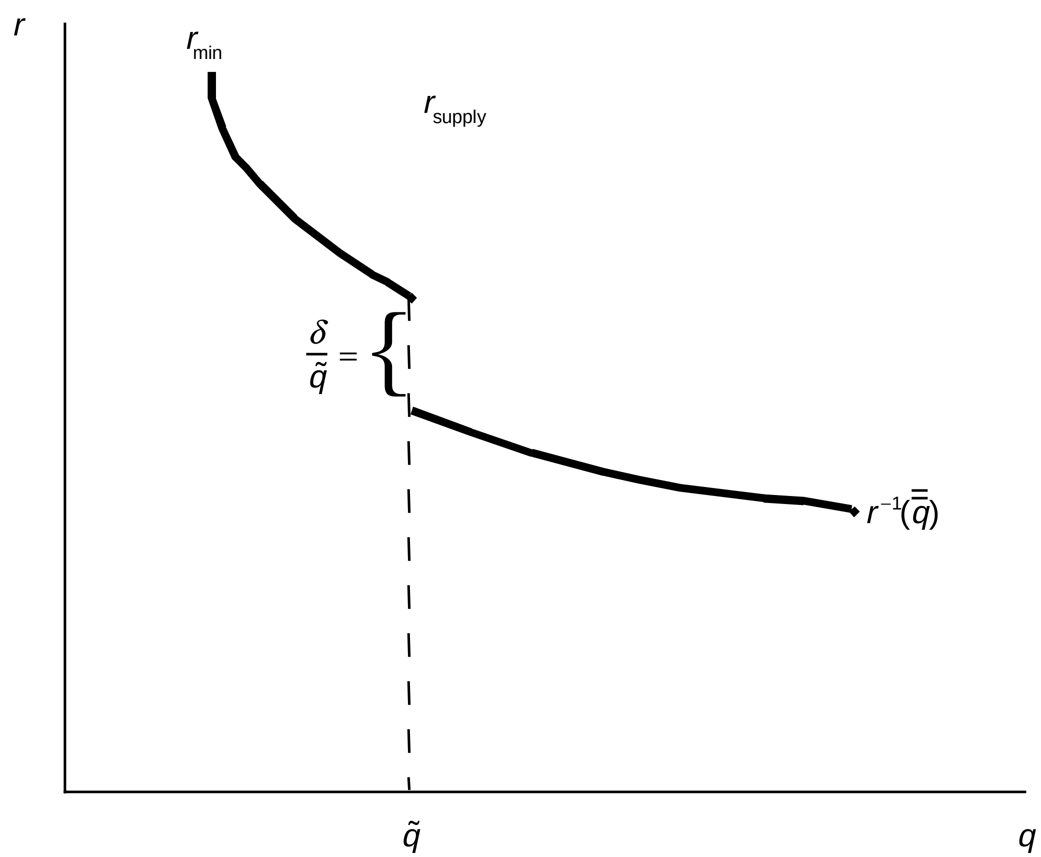
For a mortgage to be securitized, both the bank and the securitizer must be willing to exchange the mortgage (with its risk of default) for payment of a guaranteed rate r_s. At any mortgage rate r, the willingness of both parties to securitize the mortgage is given by the right envelope of $\bar{q}(r)$ and $\bar{\bar{q}}(r)$, shown in bold, or the "short side" of the market. The bold segments of $\bar{q}(r)$ and $\bar{\bar{q}}(r)$ thus show the marginal securitized mortgage as a function of r.

Figure 4: Components of Supply in the Extended Model



We derive the inverse supply function by finding the set of lowest mortgage rates for which a mortgage is offered and held (by either the bank or the securitizer). For $q \geq \tilde{q}$, the lowest rate is given implicitly by the $\bar{\bar{q}}(r)$ function. In that range of no-default probabilities, the securitizer is willing and able to hold mortgages at a lower mortgage rate than are banks. In addition, banks are willing to securitize these mortgages rather than reject them. On the other hand, for $q < \tilde{q}$, the lowest mortgage rate is given implicitly by $q_{\min}(r)$. In the range $q < \tilde{q}$, the securitizer and the bank do not find a mutually agreeable $(r_s, \bar{q})$ combination for securitizing the marginal mortgage. Essentially, the securitizer balks at the idea of holding high-risk mortgages (with no-default probabilities $q < \tilde{q}$).

Figure 5: Inverse Supply in the Extended Model



Let $r^{-1}(\bar{\bar{q}})$ be defined implicitly by (25), and recall that r_{min} is given by (2). The inverse supply function, r_{supply}, is then r_{min} for $q < \tilde{q}$ and $r^{-1}(\bar{\bar{q}})$ for $q \geq \tilde{q}$, as shown in figure 5. The discontinuity at $\tilde{q}$ shows that securitization lowers the marginal cost of supplying mortgages to borrowers with good credit risk (in the range $q \geq \tilde{q}$). However, securitization has no effect on the supply of mortgages to borrowers with poor credit risk (in the range $q < \tilde{q}$). The size of the discontinuous jump from $r_{\min}$ to $r^{-1}(\overline{\overline{q}})$ depends directly on the size of the liquidity premium and is equal to $\frac{\delta}{\tilde{q}}$.[18]

E. Market Equilibrium

In the extended model, the presence of a securitizer does not alter the willingness of potential borrowers to pay for mortgages. As in the baseline model, the maximum mortgage rates that households are willing to pay depend on the cost of default, the benefit of owning a home, and the households' probabilities of not defaulting on the loan. Since these parameters are not altered by introducing a securitizer, the inverse demand function for mortgages remains unchanged between the baseline and extended models, and is given by (4). We have already shown how the presence of a securitizer affects the inverse supply function.

In an equilibrium of the extended model, the securitizer's choices of $\overline{q}$ and r_s must satisfy (15) and (16). Additionally, the mortgage market must be in equilibrium:

$$r_{\text{supply}} = r_{\max}, \tag{27}$$

where $r_{\max}$ is given by (4). When these three conditions are satisfied, they jointly determine a market equilibrium $(\hat{r}, \hat{q}, \hat{\overline{\overline{q}}}, \hat{r}_s)$, consisting of a mortgage rate, marginal no-default probability on an originated loan, credit standard, and MBS rate. We

[18] This is derived from (2) and (25) solved for r. Substitute $\tilde{q} = \overline{\overline{q}} = q$ into both expressions to solve for the vertical discontinuity at $\tilde{q}$.

are interested in whether the equilibrium mortgage rate of the extended model $\hat{r}$ is less than the equilibrium rate for the baseline model r^*.

Two possible cases are depicted in figures 6 and 7.[19] In figure 6, the inverse demand function $r_{\max}$ intersects the inverse supply function r_{supply} to the right of $\tilde{q}$. A new equilibrium emerges at $B = (\hat{q}, \hat{r})$, and it involves a lower mortgage rate and greater volume of mortgages than at point A, the equilibrium without securitization. In this case, a portion of the liquidity premium is transferred to borrowers, and borrower surplus increases by area ABC. In the new equilibrium, more borrowers qualify for loans, and all borrowers obtain loans at a lower mortgage rate. As the graph shows, these benefits are more likely to occur when $r_{\max}$ is relatively low. Furthermore, the size of the impact on the mortgage rate is directly related to the size of δ.

To gain additional insight, we include in figure 6 the graphs of $\overline{q}(r)$, from (17), and $q'(r) = \overline{q}(r) + \dfrac{\delta}{(r - r_d)}$, from (11) and (17). At the new equilibrium, the bank securitizes mortgages in the interval $[\hat{q}, q']$ and holds mortgages in the interval $(q', 1]$. In this case, securitization conveys benefits to borrowers because the marginal mortgage is securitized.

---

[19] A third possible case arises if the inverse demand function passes through the discontinuous portion of the inverse supply curve. Analysis of this case would require refining the notion of equilibrium used in the paper.

Figure 6: Securitization Lowers the Mortgage Rate and Raises the Volume of Mortgages

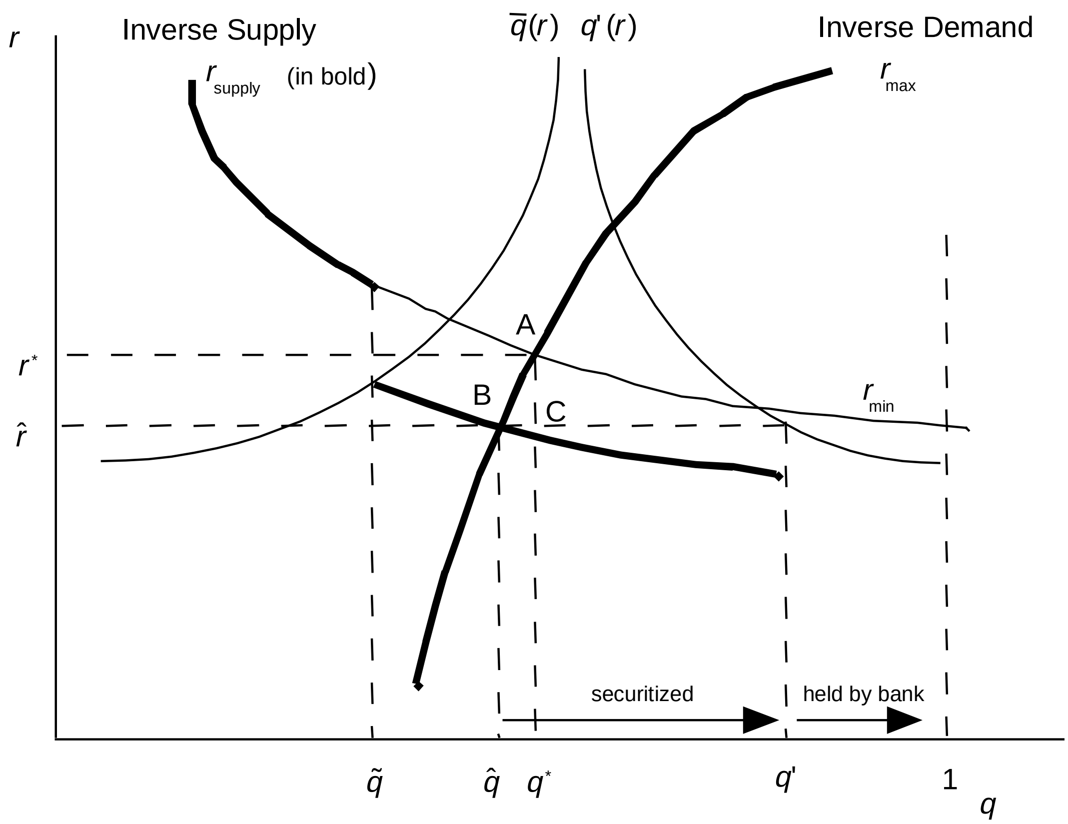


Figure 7 illustrates the case in which securitization has no effect on the mortgage rate and volume of mortgages since the function $r_{\max}$ intersects the inverse supply curve to the left of $\tilde{q}$. In this case, the equilibrium remains at point E (q^*, r^*) because the demand for mortgages is high. High-risk borrowers (with no-default probabilities below $\tilde{q}$) are willing to pay mortgage rates that induce the banks to hold the marginal mortgage rather than securitize it. Hence, mortgage supply conditions are unchanged at the margin.

At the equilibrium (q^*, r^*), the bank holds in its portfolio the marginal mortgage and all mortgages in the interval $[q^*, \bar{q})$. The bank securitizes mortgages in the interval $[\bar{q}, q']$, while keeping those in the interval $(q', 1]$. The securitizer's impact in this case is simply to securitize mortgages that previously were held in the banks' portfolios, but none of the liquidity premium is passed on to mortgage borrowers. Notably, the equilibrium in figure 7 does not involve securitization of the marginal accepted mortgage.[20]

The results illustrated in figures 6 and 7 provide some clues about the conditions under which securitization is likely to affect the mortgage rate and access to mortgage credit. In figure 6, the demand for mortgage credit is relatively low and securitization lowers the mortgage rate. Since the marginal borrower is a good credit risk, the securitizer is willing to securitize that mortgage and pass through the liquidity benefit to all borrowers. Conversely, in figure 7, the demand for credit is high and securitization has no effect on the mortgage rate because the marginal borrower is a poor credit risk.

F. Risk-Based Mortgage Rates

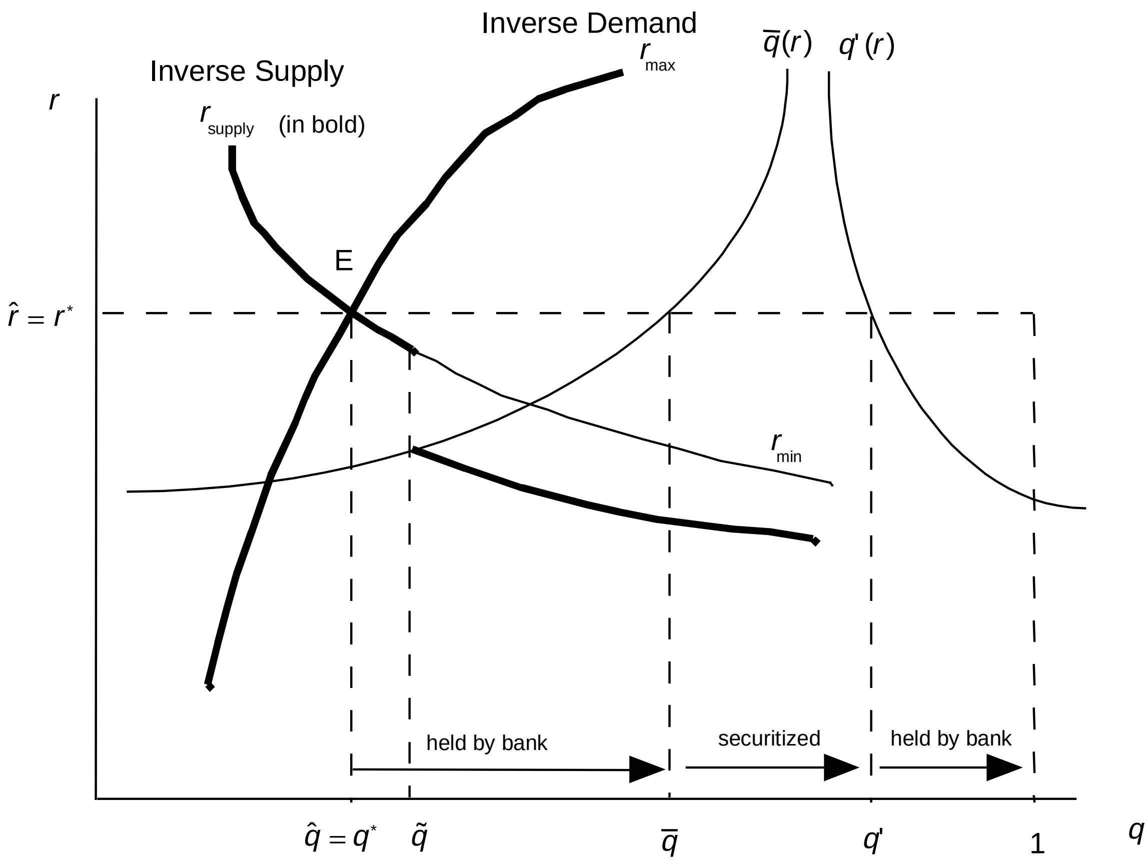
The results shown in figures 6 and 7 are derived under the assumption that borrowers pay a uniform mortgage rate. However, borrowers in U.S. markets sometimes pay rates that vary with risk classification (defined by credit-score intervals), with borrowers in higher-risk classes paying higher rates. This raises the question of how our results would be affected if banks in the model charged rates that are similarly contingent on borrower risk.

---

[20] Empirically, this seems to be the case. A potentially fruitful empirical approach would be to test whether the marginal mortgage is securitized over various segments of the business cycle, thereby providing insight into the conditions under which securitization may, according to our model, be effective in lowering mortgage rates and expanding loan access.

Figure 7:

Securitization Has No Effect on the Mortgage Rate and Volume of Mortgages



Consider the limiting case in which borrowers negotiate a continuum of mortgage rates along the r_{min} function (without securitization) and the r_{supply} function (with securitization), as depicted in figures 6 and 7.[21] That is, each borrower obtains a mortgage at the lowest interest rate banks are willing to offer

[21] A pure continuum of prices does not appear to exist in the market. Instead, there are rate clumps. Thus, our limiting case gives the greatest possible leeway for securitization to affect the primary market, and the actual effects are likely to be less.

for no-default probability q.[22] How does this pricing scheme affect the impact of securitization on mortgage rates and credit availability?

There is no effect on credit access because the equilibrium conditions for the marginal borrower remain unchanged. Under the stated scheme for risk-based pricing, the equilibrium volume of mortgages remains at q^* (where $r_{\min} = r_{\max}$) and $\hat{q}$ (where $r_{\text{supply}} = r_{\max}$), as shown in figures 6 and 7. Consequently, securitization expands credit access only for the conditions of figure 6 but not those of figure 7.

Now consider the impact on mortgage rates. In figure 6, securitization lowers mortgage rates for all borrowers by shifting downward the continuum of risk-based rates. Initially, rates are given by the portion of the $r_{\min}$ function to the right of point A. Then, securitization causes the rate structure to shift downward to the portion of the r_{supply} function to the right of point B.

In figure 7, securitization has an impact on risk-based rates for some borrowers but not others. Borrowers with no default probabilities in the interval $(\tilde{q},1]$ benefit from a downward shift in their rate structure. But higher-risk borrowers in the interval $[\hat{q},\tilde{q})$ reap no benefits from securitization. Their rate structure remains the portion of the r_{supply} function between $\hat{q}$ and $\tilde{q}$.

The discussion above indicates that even the most finely-graduated scheme for risk-based pricing does not fundamentally alter our results on the rate impacts of securitization. With risk-based rates, securitization confers rate

[22] This pricing scheme yields mortgage rates that vary continuously and inversely with credit scores (and no-default probabilities) while causing bank profits to be zero.

reductions to a group of lower-risk borrowers.[23] However, securitization may not reduce rates for higher-risk borrowers and therefore may not affect the prevailing mortgage rate.[24] Further, the risk-based scheme does not modify the effects of securitization on credit availability. Next, we investigate several properties of equilibrium with a uniform mortgage rate.

G. Propositions

Proposition 1 below identifies conditions under which securitization does not affect equilibrium.

Proposition 1: The case in which securitization has no effect on the equilibrium mortgage rate is more likely to arise for larger values of r_b and smaller values of r_c and δ.

Proof: See section B of the appendix.

Proposition 1 tells us that the liquidity premium does not pass through to borrowers in the form of a lower mortgage rate when mortgage demand is high and/or the liquidity premium is low. The next proposition highlights the securitizer's choice of r_s as pivotal in determining whether the liquidity premium passes through to borrowers in the form of a lower mortgage rate.

[23] These benefits are diluted if rates are a step function of credit-score intervals.

[24] By 'prevailing' mortgage rate we mean the rate advertised by banks. This rate generally applies to the marginal borrower, while inframarginal borrowers are sometimes able to negotiate lower rates.

Proposition 2: Securitization will either increase the volume of mortgage loans and lower the mortgage rate, in which case $r_s < r_f$, or it will leave both the volume of loans and interest rate unchanged, in which case $r_s > r_f$.[25]

Proof: If securitization does affect equilibrium, then $\overline{q} < q_{\min}$ because the marginal mortgage is securitized. Using (17) and (10), we obtain $\overline{q} < q_{\min} \Rightarrow r_s < r_f$. The proof for the case of no effect follows similarly. QED

Proposition 2 suggests an empirical test to indicate whether securitization affects mortgage-market outcomes. Time periods in which the guaranteed rate exceeds than the banks' cost of funds (i.e., $r_s > r_f$) are only consistent with securitization having no effect (figure 7). On the other hand, $r_s < r_f$ is only consistent with securitization having some effect (figure 6).

Proposition 2 tells us that mortgage rates are unaffected by securitization if $r_s > r_f$. If one compares interest rates on mortgage-backed securities to the cost of funds for banks, this inequality appears to hold. However, a more appropriate comparison would adjust for the prepayment risk embedded in mortgage-backed securities and then compare the "option-adjusted spread" to the banks' cost of funds.[26]

Even with this adjustment, problems in measuring the marginal cost of bank funds make it difficult to determine whether r_s exceeds r_f. For smaller

---

[25] A positive liquidity premium makes it possible to have $r_s < r_f$ in equilibrium. However, $r_s \geq r_f - \delta$ is required for securitization in equilibrium.

[26] In addition, the mortgage-backed security might provide diversification benefits that are not considered here.

banks, the marginal cost of funds might be best measured using the yield on uninsured deposits, whereas for larger banks, the marginal cost of funds would be better measured by subordinated debt. Regardless, such measurements are complex and beyond the scope of this paper.

The potential ineffectiveness of securitization in lowering mortgage rates raises a puzzling issue. Numerous empirical studies find an inverse correlation between the volume of mortgages securitized and mortgage rates. This evidence is frequently construed to imply that increases in securitization reduce mortgage rates. Based on this interpretation, it is tempting to infer that, despite the theoretical possibility of ineffectiveness, the empirically-relevant case is securitization having some effect on mortgage rates. To address this issue, we now analyze how the volume of securitization changes with the mortgage rate for the case in which securitization has no effect on the mortgage-market equilibrium.

Proposition 3: If securitization has no effect on the mortgage-market equilibrium, then the volume of securitization varies inversely with the mortgage rate.

Proof: If securitization has no effect, on equilibrium, then the volume of securitization is given by[27]

$$V = N\int_{\bar{\bar{q}}}^{q'} f(q)dq . \qquad (28)$$

[27] For the case in which securitization does affect equilibrium, as shown in figure 6, the volume of securitization is not necessarily inversely related to the mortgage rate. In this instance, the volume of securitization is determined by integrating from $\bar{\bar{q}}$ to q', both of which are decreasing in r.

We have already shown that $\overline{q}$ varies directly with r in (23). A rise in r induces the securitizer to raise $\overline{q}$, which tends to decrease the volume securitized. But we also need to investigate how q' varies with r. Differentiating (11) and using (23), we find[28]

$$\frac{\partial q'}{\partial r} = \frac{\frac{\partial r_s}{\partial r}(r - r_d) - (r_s + \delta - r_d)}{(r - r_d)^2} = \frac{\partial \overline{q}}{\partial r} - \frac{\delta}{(r - r_d)^2} < 0, \qquad (29)$$

indicating that q' declines with r. A rise in r thus causes $\overline{q}$ to increase (27) and q' to decrease (29), thereby decreasing the proportion of mortgages securitized as the gap between q' and $\overline{q}$ shrinks. The proposition is proved by substituting (23) and (29) into the derivative of (28) with respect to r. Differentiating (28), we have $\frac{\partial V}{\partial r} = Nf(q')\frac{\partial q'}{\partial r} - Nf(\overline{q})\frac{\partial \overline{q}}{\partial r} < 0$, by (23) and (29). QED

The proof of proposition 3 demonstrates that changes in the mortgage rate affect the securitizer's choice of MBS rate, which in turn affects the upper and lower bounds of no-default probabilities in the securitized pool, q' and $\overline{q}$. However, notice that the gap between these probabilities $(q' - \overline{q})$ is determined by the securitizer's choice of $\overline{q}$. From (11) and (17), $q' - \overline{q} = \frac{\delta}{(r - r_d)}$, showing that the interval length of no-default probabilities (credit scores) in the securitized pool varies with parameters exogenous to the securitizer. For example, a rise in

---

[28] The sign of (29) is derived by substituting (23) into (29), simplifying, and then using the result from section C of the appendix that at the optimum $t > t^0$.

the liquidity premium induces the securitizer to expand the gap between highest and lowest credit scores in the pool; a rise in the mortgage rate has the opposite effect.

Given the choice of $\overline{q}$ from (17), we now illustrate in figure 8 the securitizer's profit-maximizing choice of r_s as characterized in (18). Geometrically, profit maximization involves setting r_s, which determines both q' and $\overline{q}$, to maximize the slope of the line segment from point A to point B, the hypotenuse of a right triangle with fixed base length $\overline{AC} = \frac{\delta}{(r - r_d)}$.[29] Intuitively, the securitizer chooses r_s to maximize the volume of securitization, $F(q') - F(\overline{q})$, given the credit-score range for the securitized pool, $\frac{\delta}{(r - r_d)}$, where that range is constrained by cherry-picking incentives. To use an analogy, the securitizer sets r_s to maximize the "catch" of securitized mortgages, given that the size of the "net" is constrained.

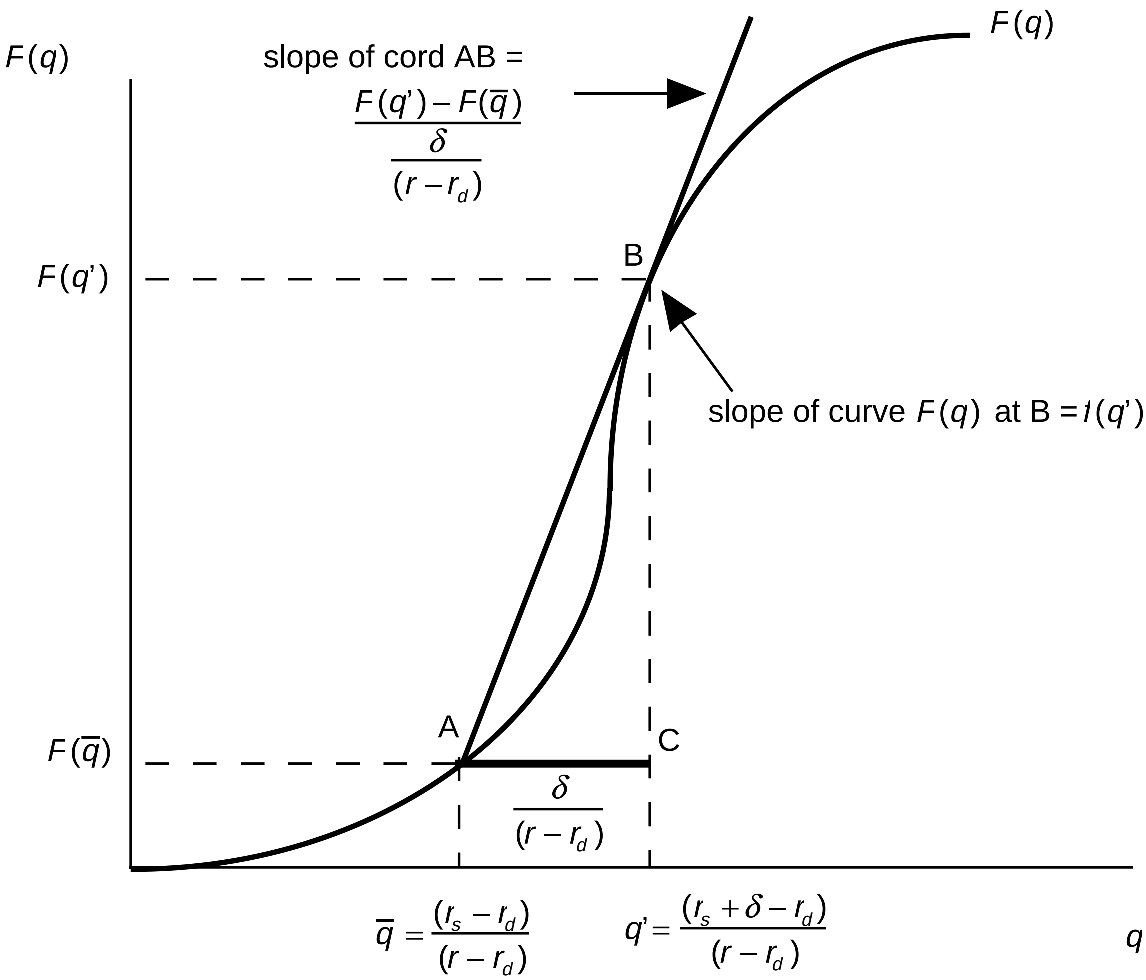
On the basis of figure 8, it is straightforward to show the comparative static effect stated in proposition 3. As r rises, the base length $\overline{AC}$ contracts. The securitizer responds by raising r_s, which raises $\overline{q}$ and lowers q'. (Though not shown in figure 8, points A and B would move closer together, with a tangency between their new cord and the cdf at point B.) Since the changes in r

[29] Further explanation is provided in section C of the appendix.

and r_s cause $\overline{q}$ to increase and q' to fall, the volume of securitization, $F(q') - F(\overline{q})$, falls.

The strategic interaction that lies behind proposition 3 is again cherry picking and its mitigation. As the mortgage rate rises, so does the expected return from holding mortgages, and the securitizer anticipates correctly that originators will want to hold onto additional high-quality mortgages. That is, q' declines. Raising the MBS rate helps boost q' back toward its original level. However, it does not pay for the securitizer to undo all of the extra cherry picking; thus, on net, q' declines. At the same time, the securitizer's profitability weakens at the opposite end of the credit spectrum, where the solution is to elevate the credit standard $\overline{q}$.

Figure 8: The Securitizer's Profit-Maximizing Choice of r_s



IV. Conclusion

In this paper, we analyze two models of the residential mortgage market. The baseline model is constructed under the assumptions of perfect information, a large number of borrowers and lenders, and the absence of a secondary market. Not surprisingly, it yields results characteristic of a competitive market. To add realism, we extend the model to include the presence of a securitizer who behaves strategically toward mortgage originators.

The securitizer offers lenders additional liquidity (in the form of a mortgage-backed security) and a guaranteed interest rate on a mortgage-backed security in exchange for the risky return from individual mortgages. But the securitizer, aware of lenders' incentives in selecting mortgages for securitization, sets the MBS rate and an underwriting standard on the mortgages it will accept, in order to mitigate the cherry-picking problem. The "liquidity premium" from securitization acts as a subsidy to originators on their inframarginal mortgage borrowers, but it does not necessarily alter the opportunity cost of serving the marginal borrower. Yet this marginal cost determines the equilibrium mortgage rate at the point of intersection with the borrowers' marginal benefit function. This theoretical result suggests that the liquidity premium from securitizing mortgages may have little or no effect on mortgage rates.

The model sheds light on the economic conditions under which securitization is likely to have an impact on mortgage rates and access to mortgage credit. If the demand for credit is relatively high in the model, then securitization has no effect on the mortgage rate and loan volume. If conditions are at the opposite extreme, then securitization lowers the mortgage rate and improves credit access. These results suggest that securitization may exacerbate fluctuations in mortgage rates, lowering rates only when they would otherwise be low.[30]

Our work also suggests that securitization may reduce the impact of a downturn in the demand for mortgages. If conditions are such that securitization

[30] This implication is empirically testable.

does not impinge on the mortgage rate, then a decrease in loan demand may cause a large drop in the mortgage rate (due to the discontinuity of supply). In this instance, loan volume is contracted by less than it would be in a competitive market without a securitizer.[31] It would be interesting to test for this effect empirically.

Our model carries an important implication for empirical work on the relationship between securitization and mortgage rates. The negative correlation between mortgage rates and the volume of securitized mortgages may be the result of causation running from the mortgage rate to securitization volume, rather than the other way around. Here, empirical tests of causality would provide valuable evidence on the veracity of our model's implications.

Our work raises questions about whether mortgage-market participants can adapt their contractual relationships for mutual gain. For example, are there contracting mechanisms for removing the barrier that sometimes prevents the liquidity premium from being passed through as a lower mortgage rate for borrowers? One contracting approach would be to attack the cherry-picking problem, which derives from the originator's first-mover advantage in selecting mortgages to keep in portfolio. In the setting of a repeated game, the securitizer could use future rewards, sanctions, and/or promises of repeat business to discourage originators from cherry picking the highest-quality mortgages. But, while such strategies would improve outcomes for the securitizer, they would not necessarily affect the conditions for supplying the marginal borrower. Another

[31] One empirical study suggests that FNMA had a countercyclical effect on the mortgage market during the 1980s. See Kaufman (1988).

approach would be for the securitizer and bank to offer risk-related guaranteed rates and mortgage rates, respectively. But such contingent contracts may not bring about efficient risk sharing and may complicate policies for deterring lending discrimination.

Bibliography

Amihud, Yakov, and Haim Mendelson. “Asset Pricing and the Bid-Ask Spread.” Journal of Financial Economics 17 (December 1986) 223-249.

Black, Deborah G., Kenneth D. Garbade, and William L. Silber. May 1981. “The Impact of the GNMA Pass-through Program on FHA Mortgage Costs,” Journal of Finance 36 (May 1981), 457-469.

Boot, Arnoud W. A. and Anjan V. Thakor. “Security Design.” Journal of Finance 48 (September 1993), 1349-1378.

Calomiris, Charles, Charles Kahn, and Stanley Longhofer. “Housing-Finance Intervention and Private Incentives: Helping Minorities and the Poor.” Journal of Money Credit and Banking 26 (August 1994, part 2), 634-678.

Donahoo and Shaffer. “Capital Requirements and the Securitization Decision.” Quarterly Review of Economics and Business 4 (1991), 12-23.

Gorton, Gary and George Pennacchi. “Financial Intermediaries and Liquidity Creation.” Journal of Finance 45 (March 1990), 49-72.

Greenbaum, Stuart I. and Anjan V. Thakor. “Bank Funding Modes: Securitization versus Deposits.” Journal of Banking Finance 11 (September 1987), 379-402.

Hess, Alan C. and Clifford W. Smith. “Elements of Mortgage Securitization.” Journal of Real Estate Finance and Economics 1 (1988), 331-346.

Jones, Oliver. “The Development of an Effective Secondary Mortgage Market.” Journal of Finance (1962), 358-370.

Kaufman, Herbert M. 1988. “FNMA’s Role in Deregulated Markets: Implications from Past Behavior.” Journal of Money, Credit and Banking 20 (November 1988), 673-683.

Kolari, James W., Donald R. Fraser, and Ali Anari. “The Effect of Securitization on Mortgage Market Yields: A Cointigration Analysis,” Journal of Real Estate Economics 26 (1998), 677-693.

Leeds, E. M. “Why are Mortgage Rates So Uniform?” Atlantic Economic Journal 15 (July 1987), 33-41.

Merton, Robert C. “A Simple Model of Capital Market Equilibrium with Incomplete Information.” Journal of Finance 42 (July 1987), 483-510.

Passmore, Wayne and Roger Sparks. “Automated Underwriting and the Profitability of Mortgage Securitization,” Journal of Real Estate Economics 28 (2000), 285-305.

Passmore, Wayne and Roger Sparks, and Jamie Ingpen. “GSEs, Mortgage Rates and Mortgage Securitization,” unpublished manuscript (January 2000).

Passmore, Wayne and Roger Sparks. “Putting the Squeeze on a Market for Lemons: Government-Sponsored Mortgage Securitization.” Journal of Real Estate Finance and Economics 13 (1996), 27-43.

Pennacchi, George G. “Loan Sales and the Cost of Bank Capital.” The Journal of Finance 43 (June 1988), 375-396.

Stiglitz, Joseph, and Andrew Weiss. “Credit Rationing in Markets with Imperfect Information.” American Economic Review 71 (June 1981), 393-410.

Todd, Steven. “The Effects of Securitization on Consumer Mortgage Costs.” unpublished manuscript (January 2000).

Appendix

A. Derivation of $f' < 0$

To satisfy second-order conditions for a maximum, the quadratic associated with the Hessian matrix

$$H = \begin{bmatrix} \dfrac{\partial^2 \pi_s}{\partial \overline{q}^2} & \dfrac{\partial^2 \pi_s}{\partial \overline{q} \partial r_s} \\ \dfrac{\partial^2 \pi_s}{\partial r_s \partial \overline{q}} & \dfrac{\partial^2 \pi_s}{\partial r_s^2} \end{bmatrix} \tag{A.1}$$

must be negative definite. Taking the second partial derivatives of (15) and (16), we find that negative definiteness requires

$$\frac{\partial^2 \pi_s}{\partial \overline{q}^2} = -Nf'(\overline{q})[\overline{q}r + (1-\overline{q})r_d - r_s] - (r - r_d)Nf(\overline{q}) < 0 \qquad \text{and} \tag{A.2}$$

$$\frac{\partial^2 \pi_s}{\partial r_s^2} = f'(q')\frac{N}{(r - r_d)^2}[q'r + (1-q')r_d - r_s] < 0. \tag{A.3}$$

Given that the term in brackets of (A.2) is zero by (15) and that $q' > \overline{q}$ and $r > r_d$, the term in brackets of (A.3) must be strictly positive. This implies that

$$f'(q') < 0. \tag{A.4}$$

B. Proof of Proposition 1.

Securitization has no effect on equilibrium if $q^* < \tilde{q}$, where $\tilde{q}$ is determined by setting (17) equal to (E.2), or $\overline{q} = \overline{\overline{q}}$, which implies

$$r_s(r) = r_f - \delta. \tag{B.1}$$

In (B.1), $r_s(r)$ is described by (21) and (22). Let $\tilde{r}$ be the value of r where (B.1) holds. From (22), r_s is increasing in r. It then follows that $\tilde{r}$ is increasing in r_f and decreasing in δ: $\tilde{r}(\overset{+}{r_f},\overset{-}{\delta})$.[32] Substituting $\tilde{r}(\overset{+}{r_f},\overset{-}{\delta})$ in for r in (E.2), we obtain

$$\tilde{q} = \frac{\left[r_f - \delta - r_d\right]}{\left[\tilde{r}(\overset{+}{r_f},\overset{-}{\delta}) - r_d\right]}. \tag{B.2}$$

Equation (B.2) thus yields $\tilde{q}(r_f, \delta, r_d)$. Using (6) and (B.2), we may write

$$q^* < \tilde{q} \Leftrightarrow 1 - \frac{(r_b - r_f)}{(r_c - r_d)} < \frac{\left[r_f - \delta - r_d\right]}{\left[\tilde{r}(\overset{+}{r_f},\overset{-}{\delta}) - r_d\right]} \Rightarrow \tilde{r}(\overset{+}{r_f},\overset{-}{\delta})(r_c - r_d - r_b + r_f) < r_c(r_f - \delta) + \delta r_d. \tag{B.3}$$

From the last inequality in (B.3), we may bring r_b and r_c together on one side of the inequality so that

$$q^* < \tilde{q} \Rightarrow r_f - r_d - \frac{\delta r_d}{\tilde{r}(\overset{+}{r_f},\overset{-}{\delta})} < r_b - (1-\alpha) r_c, \tag{B.4}$$

where $\alpha = \dfrac{r_f - \delta}{\tilde{r}(\overset{+}{r_f},\overset{-}{\delta})} \in (0,1)$ because $r_s \le r \Rightarrow r_f - \delta < \tilde{r}$. We may conclude that combinations of r_b and r_c satisfying (B.4) are associated with equilibrium being unaffected by securitization. In terms of proposition 1, (B.4) shows that a high value of r_b and/or low value of r_c make the inequality more likely to hold.

---

[32] We note that the value of $\tilde{r}$ also depends on the shape of the pdf $f(q)$.

Similarly, using the last inequality in (B.3), we may collect the terms involving δ and write

$$q^* < \tilde{q} \Rightarrow \frac{\delta(r_d + r_c) - r_c r_f}{\tilde{r}(\overset{+}{r_f}, \overset{-}{\delta})} < r_b - r_c + r_d - r_f. \qquad \text{(B.5)}$$

The second inequality in (B.5) is more likely to hold as δ becomes smaller. Hence, we have shown that $q^* < \tilde{q}$ is more likely for larger values of r_b, for smaller values of r_c, and for smaller values of δ.[33] QED

[33] The magnitudes of r_d and r_f also affect the type of equilibrium achieved, but these effects depend on the specific shape of $f(q)$. For example, both q^* and $\tilde{q}$ are decreasing in r_d, but the magnitude of $\frac{\partial \tilde{q}}{\partial r_d}$, found by differentiating (B.2), depends on the gap between $\tilde{r}$ and $(r_f - \delta)$, which we cannot solve for explicitly without knowing the functional form of $f(q)$. Similarly, q^* is increasing in r_f, but the effect of changes in r_f on $\tilde{q}$ is indeteminant.

C. Derivation that $f > f^0$ at the securitizer's profit-maximizing choice of r_s

Substitute (11) and (17) into (18). After rearranging, we get

$$f(q') = \frac{F(q') - F(\bar{q})}{q' - \bar{q}} \tag{C.1}$$

Alternatively, consider the problem of choosing q' to maximize $\frac{F(q') - F(\bar{q})}{q' - \bar{q}}$ given the value of $\bar{q}$. The first-order condition for this problem is

$$f(q')(q' - \bar{q}) = F(q') - F(\bar{q}), \tag{C.2}$$

which is equivalent to (C.1), demonstrating that profit maximization implies maximizing $\frac{F(q') - F(\bar{q})}{q' - \bar{q}}$. In other words, we can think of the securitizer, given $\bar{q}$, choosing r_s (and hence q') to maximize the volume of securitization, $F(q') - F(\bar{q})$, per unit of credit score range in the securitized pool, $q' - \bar{q}$.

Let the profit-maximizing choice of q' be denoted by q'^*. We have established that q'^* maximizes $\frac{F(q') - F(\bar{q})}{q' - \bar{q}}$ at the point where

$$f(q'^*) = \frac{F(q'^*) - F(\bar{q})}{q'^* - \bar{q}}. \tag{C.3}$$

Note that

$$f(\bar{q}) = \lim_{q' \to \bar{q}} \frac{F(q') - F(\bar{q})}{q' - \bar{q}}, \tag{C.4}$$

which must be smaller than (C.3) because (C.3) yields the maximized value of $\frac{F(q') - F(\bar{q})}{q' - \bar{q}}$. Since (C.4) > (C.3), we have $f(q'^*) > f(\bar{q})$, i.e.,

$$f > f^0. \tag{C.5}$$

QED