

Insolvency, Trigger Events, and Consumer Risk Posture  
in the Theory of Single-Family Mortgage Default\*

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Abstract

This paper integrates notions of insolvency, trigger events, and consumer risk posture into the theory of single-family mortgage default. It presents a traditional consumer- or choice-theoretic framework that recognizes common elements of mortgage optionality alongside insolvency, income, house price, and interest rate variables. Two motivations for mortgage default, insolvency and exercise of a strategic option, are identified and compared under alternative settings. The model suggests that insolvency is a primary motivation for default. Broader measures of consumer financial health appear to provide better measures of the likelihood of default than do narrow measures based solely on home or mortgage value. Adverse shocks to income and house prices, but not interest rates, also affect default and insolvency through the erosion of personal wealth. Empirical evidence supporting the hypotheses developed is provided along with an analysis of the aggregate time series of mortgage default.

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## **I. Introduction**

During the past decade it has become commonplace to view single-family mortgage default as a put option, whereby homeowners demand that lenders purchase their homes in exchange for mortgage elimination.<sup>1</sup> The great advantage of this approach is that it emphasizes optionality embedded in home mortgages in a relatively simple two-state framework of house prices and interest rates, both of which can be observed and tested.<sup>2</sup>

Despite the appeal of two-state option models, empirical specifications of mortgage default are increasingly divorced from those implied by option theory. While all tests confirm a central role for home equity, the evidence has not consistently supported the expected role of other variables implied by the theory, such as interest rates.<sup>3</sup> Empirical work otherwise persistently supports a significant role for a variety of variables that are difficult to reconcile with the two-state paradigm. For example, recent tests include unemployment, income, income growth, and dummy variables for specific states.<sup>4</sup> The two-state theme is also difficult to reconcile with many mortgage market characteristics, such as the use of payment- and/or debt-to-income ratios in standard underwriting, use of borrower credit scores in automated underwriting, and the recent rise in origination of mortgages with LTVs as high as 125 percent.<sup>5</sup> Indeed, these perspectives generally point to a need to consider the roles of income shocks, debt, credit, and other aspects of personal solvency in the default story.

Vandell (1995) follows this theme by stressing the need for a better “micro-level understanding” of the roles of “trigger” events (such as unemployment) and solvency in mortgage default. What is the role of insolvency in a micro-economic framework that recognizes elements of mortgage optionality? Can the notion of trigger events be formally defined and incorporated in such a framework? Specifications along these lines may improve our

understanding of mortgage default by linking the disparate influences of individual financial characteristics, such as borrowing, savings, and insolvency, to house prices, home equity and other option-related variables.

This paper explores the roles of insolvency, trigger events, and house prices in a model of consumer choice that incorporates elements of mortgage optionality. In an effort to specify a broadly applicable model, we treat the exhaustion of borrower wealth as synonymous with insolvency. The legal issues associated with the topic of personal bankruptcy are thereby not dealt with in this paper.

The paper is organized as follows. Section II develops a model of mortgage default that incorporates elements of mortgage optionality alongside the notion of insolvency in a traditional consumer- or choice-theoretic framework. Section III formally defines trigger events and explores the micro-economic conditions whereby they interact with optionality and otherwise motivate default. Sections IV and V extend the model to examine the roles of house prices and interest rates, respectively, in the default story. Section VI presents the results of tests of the empirical content of the theory by explaining long-term mortgage default trends with variables relating to insolvency, trigger events, house prices, interest rates, and other variables. Section VII concludes.

## **II. Insolvency as a Motivation for Default**

Consider a three-period pure exchange model with no taxes. Individuals are endowed with time 0 income, a portion of which is invested in equity of a unit of perpetual real estate financed by a fixed-rate mortgage ( $m_0$ ) underwritten at current income ( $y_0$ ) and current prices ( $p_0$ ). It is assumed that implicit rents earned from real estate equity are fully consumed in the

period received, and that periodic consumption ( $c_t$ ) is recorded net of these earnings.<sup>6</sup> Initial income, real estate prices, and interest rates are known but may differ from future realized values ( $y'_t$ ,  $p'_t$ , and  $i'_t$ ). Expectations are determined by an adaptive process whereby  $y_{t+1} = y'_t$ ,  $p_{t+1} = p'_t$ , and  $i_{t+1} = i'_t$ . Unsecured borrowing ( $b_t > 0$ ) and lending ( $b_t < 0$ ) are residuals that smooth intertemporal consumption.<sup>7</sup> Creditors of unsecured borrowings possess the right to attach claims to other borrower assets in the event of default.

Given that expectations project initial prices to all future periods, the individual begins by choosing an optimal life cycle consumption pattern as follows:

$$\begin{aligned} \max \quad & U(c_0, c_1, c_2) & (1) \\ \text{(in } & c_0, c_1, c_2) \end{aligned}$$

$$\text{S.T.} \quad c_0 = y_0 - (p_0 - m_0) + b_0$$

$$c_1 = y_0 - m_0 i_0 - b_0 i_0 + b_1$$

$$c_2 = y_0 + (p_0 - m_0(1+i_0)) - (b_0 + b_1)(1+i_0)$$

$$c_0, c_1, c_2 > 0,$$

where  $c_1$  and  $c_2$  represent cash flow and terminal conditions, respectively.<sup>8</sup> Note that the terminal condition for  $c_2$  requires that net borrowings equal zero.

Textbook treatments of the individual's choice focus on first-and second-order conditions required for a solution, such as the condition that the optimal marginal rate of substitution in consumption is determined by the market rate  $i$ . However, our interests are satisfied by assuming that the traditional requirements for an interior solution are met for all reasonable parameter values. More important, interior solutions may be interpreted as conditions of solvency because consumption occurs in all periods. If the consumer always prefers to reduce consumption in return for eliminating an expectation of insolvency, then corner solutions are not,

at this point, possible. Moreover, if actual income, prices, and rates match expectations, the actual and anticipated life cycles are identical, and solvency obtains throughout the life cycle.

The choice problem changes in response to adverse period 1 changes in the sources of uncertainty,  $y_1'$ ,  $p_1'$ , and  $i_1'$ .<sup>9</sup> These unexpected shocks change the exogenous inputs to the choice problem while raising the possibility of exercise of either of two mortgage termination options.<sup>10</sup>

The most straightforward option is the right to refinance a mortgage in the event rates fall. This option may be viewed as paying a present value interest savings of  $V_1'(m_0(i_0 - i_1'))$ . This option is exercised only if the value of interest savings exceeds refinance transaction costs ( $RT$ ), so the refinance option value ( $R_1'$ ) is represented as:

$$R_1' = \max (0, V_1'(m_0(i_0 - i_1')) - RT).$$

(2)

A more complex option is the “strategic” ability to default ( $D_1'$ ). The value of this option is conditioned on the legal environment where the borrower resides. Standard mortgage notes create personal liability on the part of borrowers, thereby permitting lenders to pursue other borrower assets to mitigate default-related losses. Nevertheless, the legal ability to pursue claims varies by jurisdiction, and the willingness to pursue them varies by lender (guarantor). Many jurisdictions permit pursuit of deficiency judgments or other legal remedies, and many lenders pursue these claims when doing so is economically beneficial. In contrast, other jurisdictions maintain pervasive anti-deficiency or other “pro-consumer” legal environments, and some lenders elect not to pursue their legal rights as a matter of policy.<sup>11</sup>

The dichotomous legal environment may be represented as a dummy variable  $N$  reflecting the presence or absence of borrower liability (recourse versus nonrecourse):<sup>12</sup>

$$N = \begin{cases} 1 & \text{if legal or lender policy conditions create the effect of a nonrecourse loan,} \\ 0 & \text{otherwise.} \end{cases}$$

In both legal environments, the value of the strategic default option increases as rates decline in the same manner as the refinance option, although default transaction costs ( $DT$ ) exceed those of refinancing ( $DT > RT$ ) because of credit impairment or other default-related costs. Other factors, however, vary with the legal environment. If conditions create the effect of a nonrecourse loan ( $N=1$ ), strategic default facilitates a borrower gain equal to the difference between the amount of the mortgage (including unpaid interest accrued prior to foreclosure) and the market value of the home,  $\max(0, m_0(1+i_0) - p_1')$ .<sup>13</sup> In the opposite case of recourse ( $N=0$ ), borrowers are liable for the full remaining mortgage debt, including accrued interest and all other costs borne by lenders, so no benefit accrues to strategic default apart from the interest savings associated with refinance. The value of the strategic default option value ( $D_1'$ ) may therefore be written as

$$D_1' = \max(0, V_1'(m_0(i_0 - i_1')) - DT + N \max(0, m_0(1+i_0) - p_1')). \quad (3)$$

The consumer revises his/her choice by adapting to actual period 1 income and price variables,  $y_1'$ ,  $p_1'$ , and  $i_1'$ . If the refinance and strategic default options fall out-of-the-money ( $\max[R_1', D_1'] = 0$ ), then period 0 debt remains and the revised choice reconfigures (1) to a two-period optimization with debt constraints from prior commitments,

$$\max_{(c_1', c_2')} U'(c_1', c_2') \quad (\max[R_1', D_1'] = 0) \quad (4a)$$

$$\begin{aligned} \text{S. T. } c_1' &= y_1' - m_0 i_0 - b_0 i_0 + b_1' \\ c_2' &= y_1' + (p_1' - m_0(1+i_0)) - b_0(1+i_0) - b_1'(1+i_1') \end{aligned}$$

$$c_1', c_2' > 0.$$

The refinance option comes into the picture if the option is in-the-money and exceeds the value of the default option ( $\max[R_1', D_1'] = R_1' > 0$ ). Assuming that the refinance changes only the mortgage rate, leaving mortgage principal unchanged, the two-period choice becomes

$$\begin{aligned} \max \quad & U'(c_1', c_2') && (\max[R_1', D_1'] = R_1' > 0) && (4b) \\ \text{(in } & c_1', c_2') \end{aligned}$$

$$\begin{aligned} \text{S. T.} \quad & c_1' \mid R_1' = y_1' - m_0 i_0 - b_0 i_0 + b_1' + R_1' \\ & c_2' \mid R_1' = y_1' + (p_1' - m_0(1+i_1')) - b_0(1+i_0) - b_1'(1+i_1') \\ & c_1' \mid R_1', c_2' \mid R_1' > 0. \end{aligned}$$

The strategic default option is chosen when it exceeds the value of the refinance option. Exercise of the default option implies a need for replacement housing in period 2, which may be assumed to cost a rental rate of  $m_0 i_1'$ , leaving choice determined by

$$\begin{aligned} \max \quad & U'(c_1', c_2') && (\max[R_1', D_1'] = D_1' > 0) && (4c) \\ \text{(in } & c_1', c_2') \end{aligned}$$

$$\begin{aligned} \text{S. T.} \quad & c_1' \mid D_1' = y_1' - m_0 i_0 - b_0 i_0 + b_1' + D_1' \\ & c_2' \mid D_1' = y_1' - m_0 i_1' - b_0(1+i_0) - b_1'(1+i_1') \\ & c_1' \mid D_1', c_2' \mid D_1' > 0. \end{aligned}$$

Thus the period 1 choice problem varies with the value of alternative termination options.

As was true in (1), interior solutions to the revised choice problems are interpreted as conditions of solvency. However, optimizing (4a) through (4c) does not always generate interior solutions. Adverse shocks of sufficient magnitude may combine with existing debt constraints to generate corner solutions; these signify the exhaustion of wealth, or insolvency.

The prospect of insolvency introduces a second motivation for mortgage default. The choice-theoretic framework allows consumers to adjust to adverse shocks by financing consumption with savings, borrowings, or other forms of wealth substitution. Insolvency results when the borrower's wealth declines to the point that consumption is no longer possible if mortgage and other debt obligations are honored. Insolvency represents a condition of deteriorating wealth that interacts with all wealth-related variables and implies the coincident default of all types of debt, including mortgages. Insolvency also represents a non-unique solution to the choice problem, so preference orderings of alternative insolvency conditions are not possible. Moreover, small changes to the wealth of an insolvent individual may have no impact on an insolvency solution or on the consequent default decision.

Exhibit 1 illustrates the role of insolvency in a choice framework. The outer quadrant reflects gross income, with interest payments required on period 0 debt depicted in the shaded region at the origin. Since consumption in periods 1 and 2 is effectively constrained by the need to honor these payments, the interior consumption choice may be viewed as nested within the gross income paradigm. Budget constraint  $A$  reflects the initial anticipated consumption choice based on period 0 prices and income. The initial choice anticipates positive borrowings in period 1 ( $b_1 > 0$ ) based on period 2 anticipated wealth. An unanticipated period 1 negative shock to income or other forms of wealth shifts the budget constraint to, for example, either  $B$  or  $C$ . Constraint  $B$  reflects a condition of solvency because it offers feasible consumption possibilities in the remaining periods. Constraint  $C$  implies insolvency because it falls outside the feasible consumption region. That is, moving to  $C$  results in a non-unique "solution" to the consumer's choice, involving default on all types of debt.



The prospect of insolvency gives rise to the notion of consumer risk posture. Note that the nested feasible consumption region in Exhibit 1 is inversely related to the size of the shaded region representing the consumer's interest burden. That is, increasing period 0 leverage increases the shaded region of required interest rate payments while decreasing the nested feasible consumption region. Increasing leverage necessarily limits the consumer's effective choice set in subsequent periods. This implies that the magnitude of prior financial commitments directly interacts with the size of unexpected shocks to determine the likelihood of insolvency. For example, the shaded region in Exhibit 1 might be increased, and the feasible consumption region reduced, to the point that constraint  $B$  falls outside the feasible region. In this case, shocks that move the consumer from  $A$  to  $B$  would motivate insolvency. Therefore, small shocks may be sufficient to push highly leveraged (low-savings) consumers to insolvency, while large shocks are required for consumers with low leverage (high savings).

In contrast to default by insolvency, strategic default involves exercising an in-the-money option whose value exceeds the value of other termination options. This option represents a hedge or cap against the reduction in wealth due to falling house prices. However, the hedge has value only if the exercise of the option is part of an interior solution to the revised period 1 choice. That is, an incentive exists to exercise the strategic option only if it leaves the consumer in the feasible consumption region, such as on constraint  $B$  in Exhibit 1. If exercising the option leaves the consumer in the nonfeasible region, such as on constraint  $C$ , then insolvency obtains regardless of option exercise, and no marginal benefit accrues to exercise. Default motivated by strategic option exercise must, therefore, be associated with the region of solvency, or it cannot be distinguished from default due to insolvency.

### III. Trigger Events and Shocks to Income

Since insolvency is a consequence of declining wealth, financial shocks that reduce wealth necessarily relate to insolvency. In this regard, the role of falling income provides a natural starting point for identifying factors that are likely to motivate insolvency, given the central role of income in the cash flow conditions found in (4a) - (4c).

Given that failure to meet contractual debt obligations is necessary to initiate foreclosure, it is heuristic to define a “trigger” event as an unanticipated shortfall in income such that income is no longer sufficient to meet periodic debt obligations, i.e.,  $y_1' - m_0i - b_0i < 0$  in (4a) through (4c).<sup>14</sup> Per this definition, the choice model suggests that trigger events cause individuals to fall back on other sources of wealth in order to maintain solvency, such as borrowing against future income or wealth. Insolvency occurs if borrowings are insufficient to support current contractual debt obligations. The magnitude of any specific event either may or may not be sufficient to motivate default, and the same event may affect consumers differently because of differences in their borrowings (savings) or other forms of wealth.

The independent role of trigger events may be explored by holding house prices and interest rates constant ( $p_1' = p_0$  and  $i_1' = i_0$ ). The refinance and strategic default options necessarily remain out-of-the-money, choice (4a) applies, and insolvency remains as the only form of default in all legal environments. Letting  $y_1' \rightarrow 0+$  in choice (4a), the resource constraints become

$$\lim_{y_1' \rightarrow 0+} c_1' = -m_0i_0 - b_0i_0 + b_1'$$

$$\lim_{y_1' \rightarrow 0+} c_2' = p_0 - m_0(1+i_0) - (b_0 + b_1')(1+i_0).$$

Solvency in period 1 requires borrowings against period 2 wealth to at least equal  $m_0i_0 + b_0i_0$ , so default obtains if

$$(m_0i_0 + b_0i_0)(1+i_0) > p_0 - m_0(1+i_0) - b_0(1+i_0)$$

$$b_0(1+i_0)^2 > p_0 - m_0(1+i_0)^2,$$

(5)

that is, if borrowings from previous periods exceed homeowner equity. Positive borrowings ( $b_0 > 0$ ) imply that equity is positive at the point of indifference, whereas negative borrowings ( $b_0 < 0$ ) imply insolvency when negative equity falls below savings. Positive equity has no consumption value if it is insufficient to cover borrowings, and negative equity does not motivate default as long as savings are sufficient to support the mortgage liability. Only in the special case of no borrowings or income ( $b_0 = y_1' = 0$ ) does negative equity become the sole requirement for default.

Equation (5) serves as a basis for asserting that income shocks play a central role in the mortgage default story. Since the results obtain for constant real estate prices and interest rates, and in recourse as well as nonrecourse legal environments, income-related shocks represent an independent class of events that may motivate default in any jurisdiction. The analysis has a general character in the sense that it applies to explicit income shocks, such as unemployment or divorce, as well as to expense-related shocks, such as unforeseen medical or legal bills.<sup>15</sup>

Equation (5) also specifies the “risk posture” theme that the effect of shocks must be considered in the context of previously contracted leverage and wealth positions. For a given income shock, higher levels of debt, and/or lower savings, serve to increase the likelihood of insolvency. The magnitude of the trigger required to motivate insolvency is thereby inversely related to the consumer’s leverage or savings positions, with larger (smaller) trigger shocks

required for individuals with smaller (larger) leverage positions. From another perspective, consumers with seasonal or volatile incomes represent relatively high risk of insolvency for a given leverage or savings position.

#### IV. Shocks to House Prices

In any legal environment, house prices falling below their initial amounts erodes the initial home equity and shifts the budget constraint in Exhibit 1 to the left. This loss of wealth could, in theory, be sufficient to invoke insolvency default, in which case the analysis in the preceding section applies. However, such a result seems unlikely in the light of standard underwriting practices, so it is assumed that solvency obtains despite the loss of initial home equity, e.g., on constraint  $B$  in Exhibit 1.

The remaining impact of falling house prices varies with the legal environment. In a legal environment with recourse, these rights grant mortgage lenders legal authority to recover all default-related losses, except those associated with the interest savings of refinance. This is the case of  $N=0$  in (3), which may be restated to show that the value of the strategic default option,

$$D_1' = R_1' - DT + RT,$$

(6)

is always less than the value of the refinance option  $R_1'$  as long as  $DT > RT$ . Since borrowers will choose the option with the highest value, the refinance option is always preferred. That is, the strategic default option is never exercised and the choice problem (4c) plays no role in mortgage default, regardless of the level of house prices or interest rates.

While falling house prices may fail to induce strategic default in recourse environments, they may nevertheless play a role in explaining insolvency default. This can be examined by exploring the effect of a large independent decline in house prices ( $y_1' = y_0$  and  $i_1' = i_0$ ) on the required level of income and wealth. With rates constant, choice problem (4a) applies and a shock of  $p_1' \rightarrow 0+$  implies that the choice constraints simplify to

$$\lim_{p_1' \rightarrow 0+} c_1' = y_0 - m_0 i_0 - b_0 i_0 + b_1'$$

$$\lim_{p_1' \rightarrow 0+} c_2' = y_0 - m_0(1+i_0) - (b_0 + b_1')(1+i_0).$$

Insolvency occurs if period 1 residual savings ( $b_1' < 0$ ), invested at rate  $i_0$ , are insufficient to meet period 2 obligations (just past  $c_1' = c_2' = 0$ ):

$$\begin{aligned} (-y_0 + m_0 i_0 + b_0 i_0)(1+i_0) &> y_0 - m_0(1+i_0) - (b_0)(1+i_0) \\ y_0(2+i_0) &< m_0(1+i_0)^2 + b_0(1+i_0)^2. \end{aligned}$$

(7)

That is, insolvency default obtains, approximately, if income is insufficient to honor contracted debt obligations, including negative equity implied by the mortgage liability,  $m_0(1+i_0)^2$ . The income needed to support these obligations is smaller if the individual has period 0 savings ( $b_0 < 0$ ) to help meet the commitments, and it is larger if the initial period was one of borrowing ( $b_0 > 0$ ). Only in the special case of no borrowings and no income ( $b_0 = y_0 = 0$ ) does negative equity become the sole requirement for default. These results confirm declining house prices as a motivation for default while pointing out that negative equity is, a priori, neither a necessary nor a sufficient condition for default. The results also reiterate the “risk posture” theme that

consumer leverage closely interacts with wealth shocks to determine the likelihood of insolvency as a motivation for mortgage default.

The role of house prices is complicated in nonrecourse legal environments because lenders cannot seek satisfaction of default-related losses from other borrower assets. This is the case of  $N=1$  in (3), which implies that the value of the strategic default option,

$$D_1' = R_1' - DT + RT + \max(0, m_0(1+i_0) - p_1'), \quad (8)$$

exceeds the value of the refinance option  $R_1'$  when  $\max(0, m_0(1+i_0) - p_1') - DT > RT$ , and choice (4c) applies. As the default option comes in-the-money, it hedges the consumer against the risk of falling house prices. Default option payoff increases dollar-for-dollar as house prices fall, thereby preventing further erosion of wealth because of declining house prices. Since the strategic default option will always be exercised in lieu of insolvency, as well as in some instances in the region of solvency, the likelihood of default must be higher in a nonrecourse environment than in a recourse environment, where the strategic default option does not exist. Moreover, this result suggests that characteristics of strategic default, such as the independence of default from changes in income and from default on other obligations, should be observed in nonrecourse, but not recourse, legal environments.

Of course, if default transaction costs are high, the strategic default option may never pay off in the feasible consumption region and the only possible form of default is insolvency, e.g., constraint  $C$  in Exhibit 1 may obtain. Conversely, low default transaction costs increase the likelihood of constraints, such as  $B$ , falling in the feasible region, thereby retaining strategic default as a response to declining house prices. Given the heavy emphasis on strategic default in previous theoretical models (see note 1), this analysis will assume that default transaction costs

are low, so strategic default remains as a viable economic option in nonrecourse environments. Nevertheless, it should be kept in mind that high transaction costs can preempt exercise of the strategic default option even in nonrecourse environments, thereby limiting the relevance of strategic default in any discussion of mortgage default. Put another way, while the relevance of strategic default is limited by legal and transaction cost considerations, insolvency represents a universal form of default that is largely unrelated to transaction costs and can result from a variety of shocks.

## **V. Shocks to Interest Rates**

Interest rate shocks affect consumer choice in two ways. The first is the rate of time preference or the slope of the budget constraint in Exhibit 1. Absent optionality, a traditional model of consumer choice applies, whereby falling interest rates flatten the budget constraint, and rising rates make the slope steeper. Since changing only the slope of the budget constraint leaves the consumer in the region of solvency, rate changes in any reasonable scenario cannot motivate insolvency in a consumer choice framework.

The second effect recognizes that optionality introduces wealth effects associated with the strategic default and prepayment options. An unexpected decline in interest rates increases the value of the refinance and strategic default options regardless of whether the legal environment is recourse versus nonrecourse. However, since the decline in rates increases the value of the two options by the same amount, and the transaction costs of refinance are lower than the costs of default, the refinance option always has higher net value. That is, the value of the refinance option dominates the value of the strategic default option, and choice (4b) obtains.

The rise in option value due to declining rates increases consumer wealth, which shifts the budget constraint outward with respect to the constraints found in (1). Thus the solution to (4b) must be preferred to (1), so  $c_1' | R_1' \geq c_1$  and  $c_2' | R_1' \geq c_2$ . The wealth increase resulting from exercise of the refinance option implies that insolvency default can not result from the independent decline in rates. Since this result obtains for any level of default transaction costs greater than the refinance transaction cost ( $DT > RT$ ), the level of default transactions costs is of secondary importance.

In the case of rising rates, the refinance and strategic default options fall out-of-the-money while having no effect on previously contracted obligations. The new choice constraints,

$$c_1' = y_0 - m_0 i_0 - b_0 i_0 + b_1'$$

$$c_2' = y_0 + (p_0 - m_0(1+i_0)) - b_0(1+i_0) + b_1'(1+i_1'),$$

are almost identical to those found in the initial choice (1), except for a new period 1 residual,  $b_1'$ , based on the new rate  $i_1'$ . Given an interior solution to (1) for any  $i_0$ , a solution must also exist for any  $i_1' > i_0$ , implying solvency for all rate increases. In terms of Exhibit 1, rising rates change both the slope of the budget constraint and the optimal level of nonmortgage borrowing (saving) but fail to motivate either strategic or insolvency default if sufficient wealth exists prior to the rate increase to meet all anticipated obligations.

Therefore, the choice model suggests that interest rates should not be expected to play a direct role in the default story. Rate changes cannot independently motivate insolvency and are more likely to motivate exercise of the prepayment option than the strategic default option. Indeed, the wealth increase associated with declining rates (refinance option exercise) implies a reduction in the risk of insolvency and default.



## **VI. An Empirical Perspective**

A key theme of the choice-theoretic model is the notion that insolvency represents a primary motivation for mortgage default in all jurisdictions. Since a consumer's home is only one piece of the consumer's total financial picture, mortgage default must be considered in the context of other leverage, wealth, and consumption decisions. Wealth and leverage are fungible, so shocks to any form of wealth can spill over to affect mortgage default and must otherwise be considered alongside the consumer's total financial risk posture. Interest rates do not represent a primary determinant of default because rate fluctuations subsequent to the contracting for a fixed-rate mortgage cannot independently cause otherwise-solvent individuals to become insolvent.

Unfortunately, the ability to test the choice model is limited by the fact that key information is often not available at the loan, regional, or other levels at which mortgage default is commonly analyzed. For example, while information on borrower financial position is collected at mortgage origination, it is typically not updated on an ongoing basis as the loan seasons. In the event of default, servicers might update selected information, such as credit scores, but are not likely to acquire complete financial data on the borrower and retain it in a database. While information along these lines may one day become available, thereby facilitating more complete tests of the choice model, they are not available to this study.

Regardless of problems associated with testing the choice model, an empirical perspective can nevertheless be gleaned from several sources. First, many elements of the choice model appear consistent with observed or documented characteristics of default. For example, the model emphasizes the importance of declining house prices and the erosion of borrower

equity as a primary source of default risk, an importance that has been confirmed by many empirical studies, e.g., see footnote 4. The central role ascribed to trigger events is highly consistent with statements by borrowers that income-related shocks are among the most common reasons for default, as quoted in Gardner and Mills (1989) and Ambrose and Capone (1996). The choice model emphasis on income and debt is also consistent with the widespread use of payment- and/or debt-to-income ratios as standard underwriting criteria. Moreover, increasing use of borrower credit scores in automated underwriting and high-LTV lending activities suggests a central role for income- and credit-related variables.

Ad hoc observations aside, more formal tests of the choice model can be facilitated by an analysis of mortgage default at the aggregate level. This focus is made possible by the fact that data are often available at the aggregate level that are not available at loan, city, state, or other levels on a consistent basis. For example, consumer savings and leverage are aggregated in Federal Reserve Board Flow of Funds statistics but are not available at regional, state, or other lower levels. Generally, data available at the city, state or other regional levels are also available at the aggregate level, but information available at the aggregate level may not be available at other lower levels.

A comparison of mortgage default rates with personal bankruptcy rates provides a preliminary test of the model. Although there are many legal issues at the nexus between mortgage default and personal bankruptcy, the choice model clearly views the two events as growing from a common root of financial distress.<sup>16</sup> Both events reflect deteriorating financial health motivated by the erosion of personal wealth interacting with consumer risk posture. Although legal issues undoubtedly cloud the cross-sectional relation between mortgage default

and personal bankruptcy, the choice model nevertheless suggests that the two time series should have comparable aggregate trends.

Exhibit 2 compares aggregate personal bankruptcy rates with an extended time series of conventional foreclosure rates constructed by Elmer and Seelig (1998). These data point to a relatively consistent trend in personal bankruptcy and mortgage foreclosure rates for most of the past 25 years. With the exception of 1997, when personal bankruptcy rates spiked up, and the early 1980s when they trended downward, personal bankruptcy and mortgage foreclosure rates have moved in a comparable manner.

A more formal empirical perspective may be gleaned from regression analysis of the long-term aggregate foreclosure rate trend illustrated in Exhibit 2. While the complete series extends from 1950 to 1997, regressions are performed over the 1959–1997 segment in order to ensure the availability of variables that do not extend throughout the entire period as well as the use of lagged variables that influence foreclosure rates for several years following loan origination. This approach balances the need to test a variety of independent variables and effects with the need to retain enough observations to draw meaningful conclusions. As a technical matter, the regression analysis suppresses the intercept because foreclosure rates approached zero in the 1950s. Also, since autocorrelation is present in the time series being examined, the regressions utilized the Yule-Walker method of estimation.<sup>17</sup> Exhibit 3 provides summary statistics for all variables employed.

The regression results are shown in Exhibit 4. The first specification represents a relatively traditional model of mortgage default that explains foreclosure rates with variables closely associated with home equity. Two primary effects considered, house appreciation (HA3) and loan-to-value ratio (LTV3), are constructed as 3-year moving averages in an effort to capture

lag effects and avoid problems of nonstationarity.<sup>18</sup> Other variables are measured on a contemporaneous basis, such as unemployment rates (UN), 10-year Treasury rates (10YT) and personal savings rates (PSAV). Consistent with previous models, the LTV and house appreciation variables support the notion that the diminution of home equity plays a central role in the foreclosure story. The significant unemployment rate variable suggests a role for trigger events, whereas the savings rate variable recognizes a possible role for broader measures of personal financial effects.<sup>19</sup> Consistent with the choice model, the 10-year Treasury rate is not significant.

The second specification begins to test the role of broader measures of household leverage by adding the household liabilities-to-assets ratio (LI/AS) and removing the interest rate variable. As the results show, LI/AS is highly significant and has the correct sign while the proportion of the variance explained by this equation is greater than equation (1). The home price appreciation (HA3) and personal savings rate (PSAV) are also significant and have the expected signs. However the LTV variables and the unemployment rate are no longer statistically significant, suggesting that broader measures of personal financial leverage may be more closely related to mortgage default than is the loan-to-value ratio at the time a loan is made.

Specification 3 extends the test by adding the business failure rate (BFAIL) as an alternative to the unemployment rate, which was found to be insignificant in the previous specification. The addition appears effective, as BFAIL is significant and a marginal improvement appears in the explanatory power of the regression.<sup>20</sup> The inclusion of the business failure rate causes the house appreciation and personal savings variables to drop from significance. The broader measure of personal leverage, LI/AS, remains significant.

In the fourth specification, adding the percentage of disposable income spent on casino gambling (GAM) causes the equation to more readily capture the effects of insolvency, financial risk, and trigger events. All of the remaining variables that were significant in the third specification continue to be statistically significant and have their expected signs. Therefore, while these regression results are far from conclusive, it is nevertheless clear that they support the notion that mortgage default is influenced by broader measures of household financial health that reflect the deterioration of consumer wealth. Thus the choice-theoretic model of default presented earlier provides a viable medium for developing refutable hypotheses regarding the determinants of mortgage default.

## **VII. Conclusion**

The choice-theoretic model developed in this paper provides an alternative view of mortgage default that integrates disparate notions of income shocks (trigger events), strategic default, and insolvency in a traditional micro-economic framework. It shows that income and real estate price shocks, along with insolvency, can be expected to play central roles in mortgage default. The substitutability of income, borrowings, and other forms of wealth suggests that negative equity is neither a necessary nor a sufficient condition for default, even in the absence of sale-related transaction costs. Strategic default remains a possibility, but only in anti-deficiency or other nonrecourse legal environments. The role of declining interest rates is often ambiguous because they act to offset other adverse shocks by increasing wealth through the refinance option. Therefore, adverse shocks to house prices and income emerge as the two variables most fundamentally related to default.

The choice model is consistent with a number of ad hoc default characteristics and serves as a basis for testing refutable hypotheses in several areas. The similar trend between personal bankruptcies and mortgage foreclosures provides ad hoc support for the choice model because most previous models fail to identify any relation between these two variables. The model also ascribes a central role to income shocks and insolvency, while reserving a role for credit-related variables at the borrower level. Thus the choice model provides a unique view of mortgage default that can be distinguished from previous models on theoretical as well as empirical grounds.

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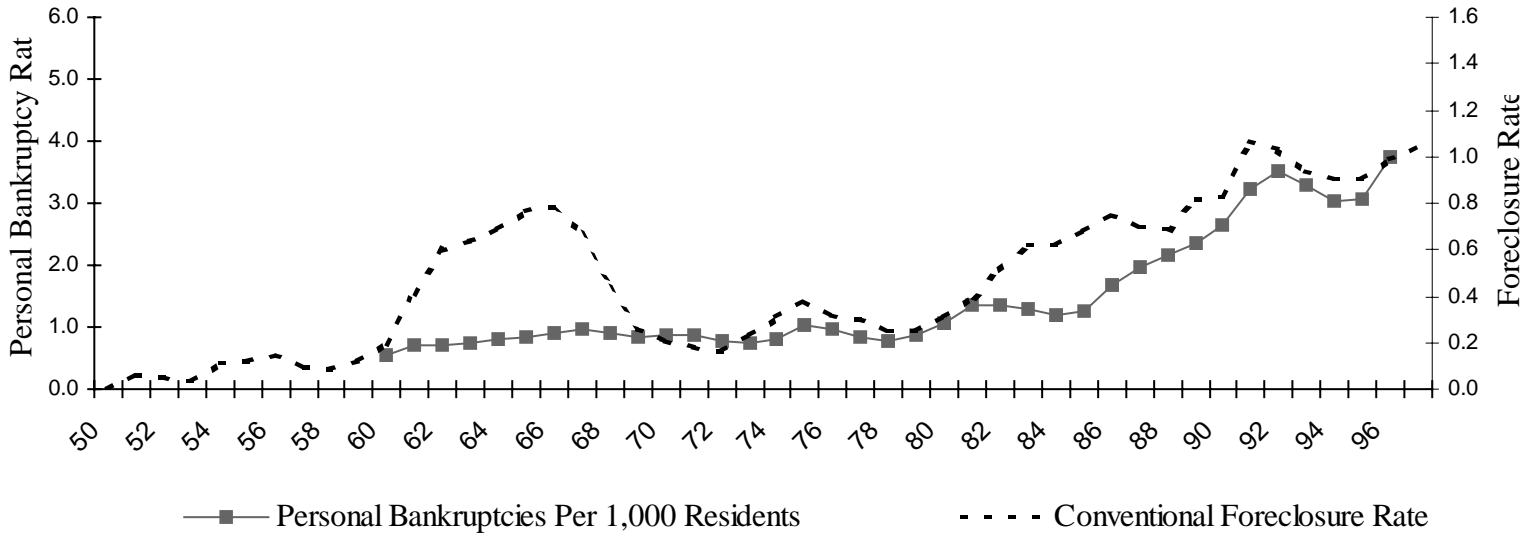
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## Exhibit 2 Personal Bankruptcy Versus Mortgage Foreclosure Rates



*Source:* Mortgage foreclosure rates are described in Elmer and Seelig (1998), while personal bankruptcy rates are from the U.S. Census.

Exhibit 3  
Variable Definitions, Means, and Standard Deviations: 1959–1997

Variable	Definition	Mean	Standard Deviation
FOR	Conventional mortgage foreclosure rate*	0.56%	0.29%
10YT	10-year Treasury bond rate	7.38%	2.57%
UN	Unemployment rate	6.08%	1.45%
LTV3	Three-year moving average of the loan-to-value ratio on conventional mortgages index, 1972 = 1.0	0.95	0.11
HA3	Three-year moving average of the house appreciation as measured by the shelter component of the CPI	5.13%	3.60%
PSAV	Personal savings as a percentage of disposable income	7.12%	1.56%
LI/AS	Household liabilities divided by household assets		0.13      0.02
BFAIL	Business failure rate per 1,000 firms	65.97	28.87
GAM	Consumption of casino gambling divided by disposable income	0.18	0.15

\*See Elmer and Seelig (1998) for a detailed description of this data series.

Exhibit 4  
Analysis of Single-Family Mortgage Foreclosure Rates: 1959–97

Independent Variable	Specification			
	(1)	(2)	(3)	(4)
10YT	0.021 (0.93)		-0.019 (-1.29)	-0.024 (-1.66)
UN	0.070 (2.46)**	0.021 (1.00)		
LTV3	0.507 (2.70)**	-0.238 (1.43)		
HA3	-0.034 (-2.04)**	-0.026 (-2.35)**	-0.006 (-0.58)	-0.005 (-0.50)
PSAV	-0.047 (-2.11)**	-0.031 (-2.04)**	-0.022 (-1.67)	0.001 (0.10)
LI/AS		7.796 (5.46)*	4.527 (3.98)*	2.828 (2.28)**
BFAIL			0.005 (3.75)*	0.004 (3.16)*
GAM				0.692 (2.22)**
R <sup>2</sup>	0.85	0.90	0.92	0.91
df	32	32	32	31

*Note:* t-statistics are in parentheses. A single asterisk indicates statistical significance at the 1 percent level, a double asterisk indicates significance at the 5 percent level, and a triple asterisk indicates significance at the 10 percent level. All regressions are estimated using the Yule–Walker method to correct for second-order autocorrelation.

## Endnotes

<sup>1</sup> The proposition was first suggested by Asay (1978), then extended and popularized by Foster and Van Order (1984). A sample of related literature can be found in Hendershott and Van Order (1987), Schwartz and Torous (1992), Kau et al. (1992 and 1993), Kau and Keenan (1995), and Vandell (1995).

<sup>2</sup> As emphasized by Lekkas et al. (1993) and Quigley and Van Order (1995), “the virtue of the contingent claims model is its simplicity.” Only variables relating to option exercise should impact the default decision, and there are no costs to default other than loss of the house.

<sup>3</sup> See Phillips et al. (1996), Lekkas et al. (1993), Quigley and Van Order (1995), and Jones (1993).

<sup>4</sup> See Deng (1997), Phillips et al. (1996), and Case and Shiller (1996).

<sup>5</sup> A discussion of automated underwriting technology can be found in Mahoney and Zorn (1996). Mortgages with LTVs above 100 percent are a relatively recent development, but their growth has been significant. Lieberman (1996) discusses this market for sub-prime loans and related credit criteria. Rating agency models, such as Jones et. al (1995), Fitch (1993), and Moodys (1990), have generally tended to recognize mortgage type (fixed- versus adjustable-rate), borrower credit quality, occupancy, and other variables alongside equity as determinants of default. Monsen (1996) and Wilson (1995) also emphasize variables along these lines in analyses of recent default patterns.

<sup>6</sup> This assumption arises from the notion that single-family real estate is a required consumption good that simultaneously serves as an investment. Implicit rents received by the individual’s investment account are matched by implicit payments from the consumption account, with no cash flow exchange. Individuals might otherwise rent their residential investments to other parties while using income received to support rents paid for real estate services from other investors.

<sup>7</sup> A more sophisticated stochastic model would incorporate consumers’ expectations regarding changes in future income into the functional relationships for unsecured borrowing and saving. However, this added complexity is unnecessary for the purposes of this analysis.

<sup>8</sup> The three-period model is easily extended to include an arbitrary number of period 1 cash flows or period 2 terminal conditions, e.g., see chapter 1 of Fama and Miller (1972) or Hirschleifer (1970).

<sup>9</sup> For notational ease, shocks in period 2 are omitted from the analysis.

<sup>10</sup> A third termination option, the right to move, is not developed here, because of its added complexity. Elmer (1997) formally models this option in the restricted setting of recourse legal

environments. More general discussions of the effect of the option on prepayments can be found in Abrahams (1997) and Archer, Ling, and McGill (1996).

<sup>11</sup> See Elmer (1997) or Jones (1993) for more extensive discussion of related legal issues. In brief, a nonrecourse environment can be justified in a limited number of states that harbor pervasive anti-deficiency legal environments, such as Alaska, Arizona, and California, and for lenders or guarantors that do not pursue deficiency judgments as a matter of policy, such as the Federal Housing Authority. Most of the remaining environments appear to support recourse rights for lenders.

<sup>12</sup> Ambrose, Buttimer, and Capone (1997) formally model the risk of a deficiency judgment in an option-based framework, but emphasize deficiency judgment probabilities only up to 50 percent. Our approach views deficiency judgments as dummy variables that either apply or do not apply in each jurisdiction. This view has the advantage of contrasting default behavior over the full range of environments by recognizing either a 0 or 100 percent probability of a deficiency judgment.

<sup>13</sup> Note that the interest rate term effectively accounts for the value of “free rent” often referenced in option-based discussions. This economic benefit accrues only in nonrecourse legal environments because recourse environments permit lenders to include accrued interest as part of the debt against which a judgment is determined. That is, the borrower’s mortgage liability grows throughout delinquency at the contracted rate of interest, so rent is not free.

<sup>14</sup> This paper views trigger events as a broad class of income- or expense-related events that cause periodic liquidity problems. The approach makes sense in a two-period model because there is little distinction between short- and long-term results. However, the approach has less appeal in extended models with many periods, where short- versus long-term implications may vary significantly.

<sup>15</sup> For example, the analysis may be viewed as a micro-foundation for the inclusion of income-related variables in stochastic frameworks, such as developed by Yang et al. (1998). Moreover, defining the income variable  $y_1'$  to be net of subsistence consumption facilitates recognition of unexpected medical and legal expenses as well as food, clothing, and other items necessary for survival. In this context, an unexpected increase in any subsistence expense would be reflected in the model as a negative income shock.

<sup>16</sup> Mortgages are treated differently from other types of debt in personal bankruptcy because the lender has a security interest in the real estate collateral. Moreover, most states have homestead exemptions that allow homeowners who declare bankruptcy to keep at least a portion of the equity in their principal residence subject to the first mortgage lien. In these instances, individuals experiencing financial hardship might find it advantageous to default on all obligations except their mortgage and declare bankruptcy. Therefore, while mortgage foreclosure and personal bankruptcy are both distress-related events, they are not necessarily coterminous events.

<sup>17</sup> See Judge et al. (1985) for a discussion of this technique for dealing with autocorrelation. In addition, unit root tests were conducted for nonstationarity of the data. To correct for these problems certain variables were omitted and moving averages of other variables were used.

<sup>18</sup> Similar results were obtained using moving averages over longer as well as shorter periods, and using lagged values of the home appreciation and LTV variables.

<sup>19</sup> Consistent results were found when the first difference of unemployment was regressed against the first difference of the foreclosure rate. However, this specification was rejected because of the informational content loss and evidence of over differencing. For further discussion of these types of issues, see Harvey (1990).

<sup>20</sup> This finding is also supported by first differenced equations.