

A Choice-Theoretic Model of Single-Family Mortgage Default

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Abstract: A choice-theoretic model of single-family mortgage default has been developed in environments in which put option models do not apply. Such environments can be found in the many jurisdictions and economic settings that have no legal foundation for asserting the rights associated with a put option. The model specifies a consumer choice framework for analyzing mortgage default that recognizes income-related variables, trigger events, and insolvency. The model suggests that default is primarily due to borrower insolvency, which is motivated by negative shocks to income and house prices, but not to interest rates. Empirical implications of the model are consistent with many observed characteristics of mortgage default that are inconsistent with, or otherwise difficult to explain by, option-based models.

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I. Introduction

During the past decade it has become commonplace to view single-family mortgage default as a put option according homeowners the right to demand that lenders purchase their home in exchange for mortgage elimination.¹ In many settings, however, a variety of issues serve to question this view of mortgage default.

Put option models have no legal foundation in many jurisdictions. Standard promissory notes confer personal liability on borrowers and permit lenders “recourse” to seek to recover default-related losses. Deficiency judgments and other legal remedies, though sharply limited in some jurisdictions, are clearly permitted in many others. Moreover, legal information and risk are subject to asymmetries because lenders generally have far more expertise and resources for dealing with default than delinquent borrowers do. These factors, along with choice-theoretic issues, point to a need for alternative models.

Consumer theory traditionally ascribes a central role to borrower income, savings, and other forms of wealth, yet put option models reserve no role for these variables. Theory normally posits that various forms of personal wealth are fungible, which precludes separation of homeowner equity from other assets when describing consumer actions. In contrast, put option models treat home equity as separable from other borrower assets. Hence, they take mortgage default to be independent of insolvency and default on other obligations.²

A variety of empirical regularities also point to the need for a broader framework. Unsecured borrowing and savings patterns along with personal credit ratings have been shown to play a role in mortgage default.³ Although tests generally confirm the importance of homeowner equity, they also find that other variables, such as borrower income and mortgage type, help

explain mortgage default.⁴ Similarly, rating agencies tend to place borrower credit risk, mortgage type, and other variables alongside real estate equity in their models of mortgage default.⁵

This paper develops a choice-theoretic model of single-family mortgage default. In an effort to make the model broadly applicable, the topic of personal bankruptcy is deferred to another discussion. Note too, that for the most part, the exhaustion of borrower wealth is considered to be synonymous with insolvency.

The paper is organized as follows: Section II examines legal issues that necessitate alternative models and the environments in which they should be considered. Section III presents a choice-theoretic model of mortgage default applicable in these environments and consistent with standard elements of consumer theory. Section IV applies the model to identify fundamental determinants of default. Section V extends the analysis to explore the interaction of the primary sources of risk. Section VI discusses empirical implications of the choice-theoretic model. Section VII summarizes the results and conclusions.

II. Legal Issues

In many jurisdictions treating mortgage default as a put option is inconsistent with five aspects of mortgage law.⁶ First, standard promissory notes promulgated by the Federal Home Loan Mortgage Corporation (FHLMC) and the Federal National Mortgage Association (FNMA) require each person signing the notes to be “fully and personally obligated to keep all of the promises” of the note. Personal liability has legal as well as financial dimensions. Legally, personal liability links mortgage liability to other borrower assets and liabilities, thereby enabling mortgage creditors to place claims on other forms of borrower wealth in the event of default.

Financially, personal liability distinguishes homeowner equity in real estate from ownership of corporate equity which is characterized by limited liability. In this regard, Merton's, (1973) insight that corporate equity, may be viewed as a put option, which is justified by the limited liability of corporate equity, does not apply to the personal liability of home equity.

Second, standard contractual terms do not support the rights associated with a put option. Although standard FHLMC-FNMA contracts grant borrowers an option to prepay or "call" a mortgage prior to maturity, they also grant lenders the right to demand payment of all outstanding principal and interest and to be reimbursed for reasonable costs, fees, and expenses incurred in enforcing the note, such as attorney's fees. Furthermore, borrowers waive certain rights to demand that the lender perform certain acts, such as "accelerating" payment of amounts due upon default. In general, borrowers contract an obligation to honor the debt, whereas lenders contract the right, but not the obligation, to pursue foreclosure. To the extent that borrowers have an "option" to default, exercising the option constitutes a breach of the standard note and mortgage contracts that may impart personal liability for damages to the borrower.

Third, lenders have at least limited rights to pursue deficiency judgments or other legal remedies for recovering default-related losses, although the procedures vary considerably from one jurisdiction to another.⁷ States with "judicial foreclosure" permit deficiency judgments at the time of foreclosure, whereas "nonjudicial foreclosure" states require separate legal action. Other legal exigencies might also apply, such as strict notice requirements and time limits, rights of redemption, and rules requiring that the "fair market value" of the property be used as the basis for the deficiency. Several states either formally prohibit deficiency judgments on residential real estate or maintain an antideficiency environment in some other manner.⁸ Whatever the

jurisdictional and legal issues, most states permit some form of deficiency pursuit, as can be seen in corporate policies on deficiency judgments at national mortgage intermediaries, such as FHLMC and FNMA, and among numerous private sector agents specializing in collection.⁹

The fourth point is that home equity cannot be separated from other borrower assets and liabilities. Borrowers can contract second or other subordinated debts that impair home equity in a fashion similar to the first-mortgage liability: for example, subordinated claims must be paid at a voluntary sale and they possess acceleration right in the event of default. Also, liens on the borrower's home may be attached by a variety of other creditors, such as suppliers of labor or materials and taxing authorities. Most states provide unsecured creditors with the right to obtain "judgment liens" for other types of claims, which become liens against all debtor real estate of the county in which docketing or recording occurs.¹⁰ Given that the location of a debtor's residence is normally well known to creditors, it is a convenient target for claims.¹¹

Fifth, the foregoing points are reinforced by asymmetries in legal information and risk. Most lenders have extensive legal expertise and procedures for dealing with delinquent borrowers and with the legal requirements of each jurisdiction. In addition, home mortgages create personal liability for borrowers and otherwise favor the lender's position. Few borrowers can match this legal expertise and knowledge of jurisdictional foreclosure requirements or find grounds for asserting limits on their liability. Such a one-sided relationship may leave borrowers with little hope of winning disputes over liability, even in jurisdictions with pervasive anti-deficiency environments.

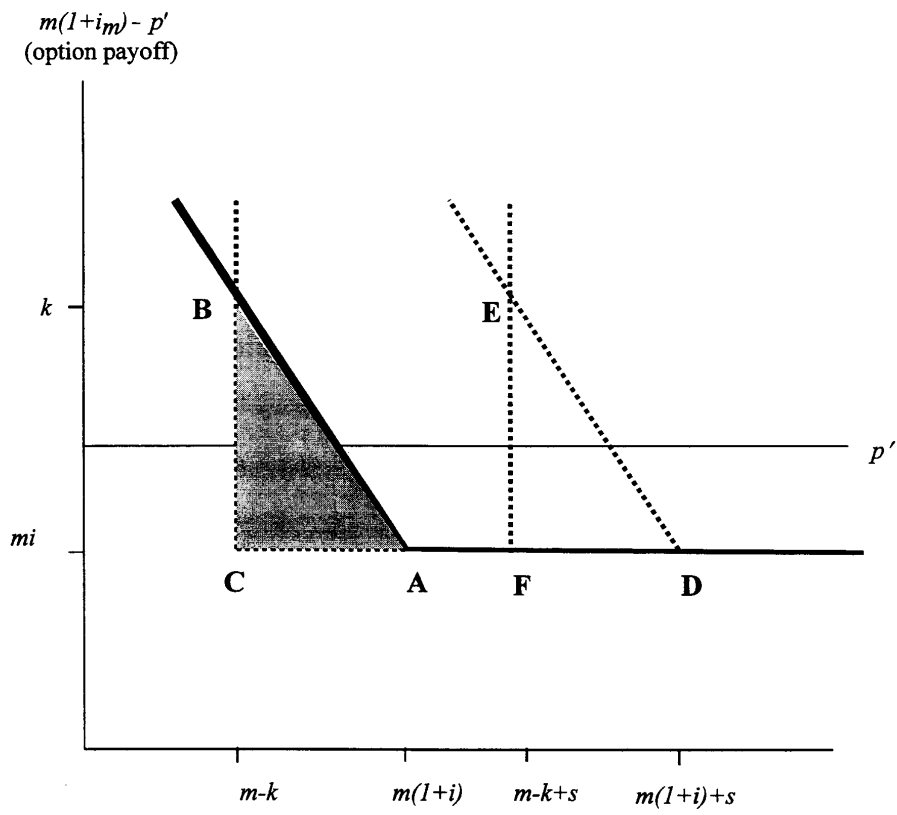
Figure 1 illustrates several legal issues that arise when mortgage default is treated as a put option. Assume that the borrower possesses home equity whose value is determined by variable

house prices (p') coupled with a fixed mortgage (m) and fixed interest rate (i). That is, equity equals $p' - m(1+i)$. Other wealth is the interest used to service the mortgage debt mi plus an arbitrary constant (k). The solid line shows first-mortgage default treated as a put option. This is a standard put option payoff schedule rising dollar for dollar as house prices fall below mortgage values.¹² Default occurs only to the left of A, with the result that wealth increases along AB. This option payoff applies when no subordinated claims exist and in jurisdictions with pervasive anti-deficiency environments. In other jurisdictions, the cost of a deficiency judgment is approximated as the difference between mortgage liability and house price, so put values along AB imply deficiencies in the shaded region ABC, which is bounded by k wealth. The cost or risk of a deficiency judgment thereby equals the economic benefit of the put option as long as k is available to support the judgment. A subordinated claim (s) shifts the put payoff from AB to DE. In this case, the judgment region undergoes a similar shift, from ABC to DEF. No put payoff applies to borrowers who perceive a very low probability of prevailing over lenders in liability disputes.

Several attempts have been made to address the legal issues just described. It has been argued for example, that prohibitions and costs associated with the collection of deficiencies render personal liability valueless (Jones (1993)). This suggestion directly applies to the handful of states with predominantly anti-deficiency environments. However, it carries less weight as the strength of the anti-deficiency environment declines owing to the presumption of lender legal expertise. Even if pursuit imposes additional notice requirements or bidding procedures, lender

Figure 1

Mortgage Default Option Payoff



legal advisers can be expected to be aware of these requirements and capable of meeting them. More important, many states clearly permit the pursuit of deficiency judgments, so personal liability is expected to have value in these jurisdictions.

It has also been pointed out that some lenders do not, as a matter of policy, pursue deficiency judgments. The Federal Housing Authority for one, has supported such a policy for many years (Jones, 1993). To the extent that borrowers are aware of such a policy and confident of its enforcement, personal liability again becomes valueless, and put option models can be justified. If borrowers are unaware of these conditions, personal liability applies, and alternative models should be considered. Of course, alternatives are also justified for lenders who pursue judgments.

Expanding on this argument, some have claimed that deficiency judgments are generally not an issue because related lawsuits are “rare.”¹³ However, little empirical evidence exists to confirm the “rarity” of pursuit and how it should be interpreted remains unclear. Lenders should not be expected to pursue claims when the deficiency is small or the borrower has few resources to honor the liability.¹⁴ In such cases, pursuit will be infrequent if borrowers choose to default only as a last resort, after all wealth is exhausted. That is, infrequent pursuit may be due to the insolvency of the defaulting borrower, not to the lack of lender interest or sophistication. Borrowers with significant wealth may continue to expect full pursuit of their deficiencies even as they observe infrequent pursuit of the deficiencies of others.

Another approach is to treat deficiency judgments and other legal risks as transaction costs.¹⁵ These costs reduce the value of the option exercise but are otherwise consistent with the interpretation of default as a put. Unfortunately, this view is difficult to reconcile with the nature

of related risks. As shown in Figure 1, the cost of a deficiency judgment equals or offsets the value of an option exercise: that is, judgment costs rise with option value. Moreover, the likelihood of a judgment depends on state law, so expected costs are analogous to dummy variables that either apply or do not apply, depending on the requirements of each jurisdiction. Since only a handful of states promote pervasive antideficiency environments, the argument has limited application.

In sum, treating mortgage default as a put option can be justified in the several states where antideficiency restrictions are pervasive and in situations involving lenders or servicers who do not pursue deficiencies as a matter of policy. Conversely, it cannot be justified in many other legal and servicer environments. Whether one setting or the other constitutes the bulk of the mortgage market is an empirical issue. The point here is that there are compelling legal grounds for developing alternatives to put option models in substantial parts of the mortgage market.

III. The Model

Consider a three-period pure exchange model with no taxes. Individuals are endowed with time 0 income, part of which is invested in equity of a unit of perpetual real estate financed by a fixed-rate mortgage underwritten at current income (y_0) and prices. 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.¹⁶ 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 a rational 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.

Borrowers have three broadly defined options for revising mortgage choice after the initial period. First, a refinance option (R_t) grants borrowers the periodic right to recontract the mortgage at lower rates in the event rates fall. To add a practical element, it is assumed that exercise of the refinance option requires that the underwriting variables, income, and real estate prices at least equal their initial amounts. Under these conditions, the option may be written as

$$R'_t(m_0(i_0-i'_t) \mid y'_t \geq y_0, p'_t \geq p_0) = \begin{cases} \max(0, m_0(i_0-i'_t)) & \text{if } y'_t \geq y_0 \text{ and } p'_t \geq p_0 \\ 0 & \text{if either } y'_t < y_0 \text{ or } p'_t < p_0 \end{cases},$$

where $m_0(i_0-i'_t)$ is the periodic interest savings due to option exercise. Second, borrowers can also move to a new residence (M_t) that has no income or real estate price constraints but requires transactions costs (MT).¹⁷ The move option may be written as

$$M'_t(m_0(i_0-i'_t) - MT) = \max(0, m_0(i_0-i'_t) - MT).$$

Third, borrowers can default (D_t). Since default entails movement to another residence along with credit impairment, default transaction costs (DT) must be greater than the costs of a simple move, MT .¹⁸ The option may be written as

$$D'_t(m_0(i_0-i'_t) - DT) = \max(0, m_0(i_0-i'_t) - DT),$$

where $DT > MT$. Since all options have the same interest rate sensitivity, borrowers exercise only the most valuable option at any point in time, that is, $\max[R'_t, M'_t, D'_t]$.

Given that rational expectations project initial income and prices to all future periods, the refinance, move, and default options have no value, and individual choice is described by

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

$$\text{S.T. } c_0 = y_0 - (p_0 - m_0) + b_0 \quad (1)$$

$$c_1 = y_0 - m_0 i_0 - b_0 i_0 + b_1 \quad (2)$$

$$c_2 = y_0 + (p_0 - m_0(1+i_0)) - (b_0 + b_1)(1+i_0) \quad (3)$$

$$c_0, c_1, c_2 > 0, \quad (4)$$

where (2) and (3) are cash-flow and terminal conditions, respectively.¹⁹

Textbook treatments of the individual's choice focus on first- and second-order conditions required for a solution, such as "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 a solution are met for all reasonable parameter values, which implies, through (4), that the borrower is solvent throughout the term of the model.

The genesis of this analysis is the point where actual income and prices diverge from expectations, which is *ex post* to the individual's initial choice. The role of default may be traced through a revised choice that responds to adverse changes in the sources of uncertainty, y_1' , p_1' , and i_1' during period 1. Changes in period 2 are omitted for notional ease. Since the individual must honor debt obligations contracted in period 0, the revised problem may be viewed as a two-period choice with debt constraints imposed by prior optimizations:

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

$$\text{S. T. } c_1' = y_1' - m_0 i_0 - b_0 i_0 + b_1' + \max[R_1', M_1', D_1'] \quad (2')$$

$$c_2' = y_1' + (p_1' - m_0(1+i_0)) - b_0(1+i_0) - b_1'(1+i_1') + \max[R_1', M_1', D_1'] \quad (3')$$

$$c_1', c_2' > 0. \quad (4')$$

Interior solutions ($c_1', c_2' > 0$) are assumed to imply solvency, whereas corner solutions ($c_1', c_2' = 0$) imply insolvency or the exhaustion of wealth.

Equations (2') to (4') recognize two distinct motivations for mortgage default. The first is the option-theoretic notion that default is an unusual type of refinance option facilitating an increase in wealth through a reduction in the mortgage coupon rate. This “strategic” default option is exercised solely on the basis of interest rates and the value of the option with respect to the value of other options capable of achieving similar savings. Hence the exercise is independent of income, other borrowings (savings), default on other obligations, and insolvency. Indeed, the increase in wealth arising from exercise of the option implies a reduction in the risk of insolvency. Since exercise of the strategic default option presumes borrower solvency, lenders are expected to pursue all legal remedies needed to collect the mortgage debt $m_0(1+i_0)$. The model therefore applies wherever deficiency judgments can be and are commonly pursued and wherever borrowers assume personal liability on the basis of asymmetric legal information.

The second motivation for default is insolvency. If any form of wealth declines unexpectedly, consumption is financed by savings, borrowings, or other forms of wealth substitution. Wealth is exhausted when consumption is no longer possible in any period in which extant obligations are being honored. The exhaustion of wealth is presumed to be synonymous with insolvency, mortgage default, and default on all other borrower obligations. In line with the consumer-theoretic principle that alternative forms of wealth are substitutes (the “independence” axiom), mortgage default is one aspect of a broad decline in consumer financial health. Hence the model is also consistent with the legal ability of mortgage creditors to place claims on other

forms of borrower wealth and the ability of nonmortgage creditors to place claims on home equity.

A natural incongruity exists between the strategic and insolvency motivations for default. Strategic default increases borrower wealth, which reduces the likelihood of default due to insolvency. Strategic default is independent of income and other wealth-related variables as well as default on other obligations, whereas insolvency default is directly tied to all wealth-related variables and occurs in concert with default on other obligations. The failure of option-based models to recognize insolvency as a motivation for mortgage default represents a limitation that is inconsistent with standard elements of consumer theory.

IV. Fundamental Determinants of Default

The fundamental determinants of default are variables capable of independently motivating default. As such, they may be identified by examining independent changes to the primary sources of risk, y_1' , p_1' , and i_1' . For example, holding rates constant ($i_1' = i_0$), the following analysis is simplified by recognizing that default will never occur if period 1 income and price expectations are either realized or exceeded ($y_1' \geq y_0$ and $p_1' \geq p_0$) owing to the satisfaction of (4).

The role of falling income in cash-flow condition (2') provides a natural starting point for the analysis because the failure to meet contractual debt obligations is what initiates foreclosure. In this regard, it is heuristic to define a “trigger” event as an unanticipated shortfall in income such that income is not sufficient to meet periodic debt obligations: that is, $y_1' - m_0i - b_0i < 0$ in (2').²⁰ Trigger events imply that solvency can be maintained only by borrowing against

anticipated future income or wealth, and that default occurs if borrowings are insufficient to meet contractual debt obligations. Trigger events may also be viewed as negative shocks to income that are strong enough to force the use of borrowings or savings to prevent default.

The role of trigger events may be illustrated by examining a specific event. Holding other variables constant ($p_1' = p_0$ and $i_1' = i_0$), let $y_1' \rightarrow 0+$ for the resource constraints (2') to (4'):

$$\lim_{y_1' \rightarrow 0+} c_1' = -m_0 i_0 - b_0 i_0 + b_1'$$

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

Solvency in period 1 requires borrowings against period 2 wealth to at least equal $m_0 i_0 + b_0 i_0$, so default obtains if

$$\begin{aligned} (m_0 i_0 + b_0 i_0)(1+i_0) &> p_0 - m_0(1+i_0) - b_0(1+i_0) \\ b_0(1+i_0)^2 &> p_0 - m_0(1+i_0)^2. \end{aligned} \quad (5)$$

Default occurs 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 default 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 and no income ($b_0 = y_1' = 0$) does negative equity become the sole requirement for default. A priori, negative equity is neither a necessary nor a sufficient condition for default, and default may occur when equity is positive, even in the absence of sale-related transactions costs.

The importance of trigger events transcends their use as a heuristic device. Since equation (5) obtains for constant real estate prices and interest rates, income-related shocks constitute an independent class of default-related motivations. Owing to the simplicity of the framework, a wide variety of events can be included, such as expense-related shocks (unforeseen medical, legal, or other expenses), along with loss of employment or other direct shocks to income. Trigger events thus represent a distinct, broad class of default motivations.

The fact that income shocks are significant by no means suggests that real estate equity plays no role. Holding other variables constant ($y_1' = y_0$ and $i_1' = i_0$), a price shock of $p_1' \rightarrow 0+$ implies

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

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

Default occurs if period 1 residual savings ($b_1' < 0$), invested at the rate i_0 , are insufficient to meet period 2 obligations:

$$\begin{aligned} (-y_0 + m_0 i_0 + b_0 i_0)(1+i_0) &> y_0 - m_0(1+i_0) - (b_0)(1+i_0) \\ y_0(2+i_0) &< m_0(1+i_0)^2 + b_0(1+i_0)^2. \end{aligned} \quad (6)$$

Default is chosen when income is insufficient to honor contracted debt obligations, including negative equity implied by the mortgage liability, $m_0(1+i_0)^2$. Negative borrowings ($b_0 < 0$) reduce the income threshold needed to support the mortgage liability without changing the nature of the default decision. These results confirm that declining house prices act as a motivation for default and that negative equity is neither a necessary nor a sufficient condition for default.

The independent role of interest rates is especially interesting as it raises the possibility of strategic default through the option variable $\max[R_1', M_1', D_1']$. Holding other variables constant ($y_1' = y_0$ and $p_1' = p_0$), declining rates increase borrower wealth as the refinance, move, and strategic default options come in-the-money. However, since borrowers will always choose the option with the highest value, and transaction costs impair the value of M_1' and D_1' , the refinance option is always preferred. Put another way, the refinance option is favored over the move and strategic default options because it offers a lower-cost means of gaining the same value from declining rates. This result obtains for any level of move or default transaction costs greater than zero, so the level of transactions costs are of secondary importance. In any event, exercise of the refinance option increases wealth with respect to the initial choice problem depicted in equations (2) to (4), so it cannot motivate insolvency default due to satisfaction of (4).

In the case of rising rates, the refinance, move, and strategic default options fall out-of-the-money while having no impact 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 of the initial choice of (2) to (4), except for a new period 1 residual, b_1' , based on the new rate i_1' . Given an interior solution to (2) to (4) for any i_0 , a solution must also exist for any $i_1' > i_0$, implying solvency for all rate increases. Rising rates may change the optimal level of nonmortgage borrowing (saving) but cannot motivate insolvency if sufficient wealth exists prior to the rate increase to meet all obligations.

V. Interactive Effects

The coincident variation of combinations of y_1' , p_1' , and i_1' may be classified into two groups: one containing only the fundamental variables (y_1' and p_1') and the other either of the fundamental variables and interest rates (y_1' or p_1' combined with i_1').

As might be expected, a decline in the two fundamental variables raises the likelihood of default. Holding rates constant ($i_1' = i_0$)

$$\lim_{(y_1', p_1') \rightarrow (0+, 0+)} c_1' = -m_0 i_0 - b_0 i_0 + b_1',$$

$$\lim_{(y_1', p_1') \rightarrow (0+, 0+)} c_2' = -m_0(1+i_0) - (b_0 + b_1')(1+i_0),$$

and the decision to default simplifies to the requirement that $b_0 > -m_0$. That is, default can only be averted if the borrower saves more in period 0 than the mortgage liability. Presumably, this level of savings is rare, so it seems reasonable to expect a dramatic coincident decline in income and house prices to virtually guarantee default. However, exceptions are possible in the event that savings are sufficient to maintain solvency.

A decline in income and interest rates introduces the possibility of strategic default.

Holding prices constant ($p_1' = p_0$),

$$\lim_{(y_1', i_1') \rightarrow (0+, 0+)} c_1' = -m_0 i_0 - b_0 i_0 + b_1' + M_1'$$

$$\lim_{(y_1', i_1') \rightarrow (0+, 0+)} c_2' = p_0 - m_0(1+i_0) - (b_0 + b_1')(1+i_0) + M_1'.$$

The shock to income coupled with limits on the refinancing option cause the move option to become the preferred alternative for gaining value from lower rates. Exercise of the strategic

default option is forgone in favor of the less costly move option. However, insolvency remains a possibility, as shown by combining the above limits:

$$b_0(1+i_0)^2 > p_0 - m_0(1+i_0)^2 + M_1'(2+i_0), \quad (7)$$

which is identical to (5) except for the additional value of the move option, $M_1'(2+i_0)$. The general conclusions surrounding (5) continue to hold, although the level of unsecured borrowings required for insolvency must be larger by the value of the move option. Whereas declining wealth caused by declining income increases the likelihood of insolvency, increased wealth due to declining rates has the opposite effect. The strategic default option is never exercised because it is the highest cost alternative for gaining wealth from declining rates.

Combining a decline in interest rates and house prices is especially interesting as it is cited in option-based discussions. Holding income constant ($y_1' = y_0$)

$$\lim_{(p_1', i_1') \rightarrow (0+, 0+)} c_1' = y_0 - m_0 i_0 - b_0 i_0 + b_1' + M_1',$$

$$\lim_{(p_1', i_1') \rightarrow (0+, 0+)} c_2' = y_0 - m_0(1+i_0) - (b_0 + b_1')(1+i_0) + M_1'.$$

Exercise of the strategic default option is again forgone in favor of the less costly move option, the exercise of which increases wealth. Default due to insolvency occurs when

$$y_0(2+i_0) + M_1'(2+i_0) < m_0(1+i_0)^2 + b_0(1+i_0)^2, \quad (8)$$

which extends (6) to include the additional value of the move option, $M_1'(2+i_0)$. Declining wealth associated with declining house prices is at least partly mitigated by increasing wealth caused by declining rates. The income and borrowing thresholds required for insolvency are necessarily reduced by the addition to wealth arising from lower rates and exercise of the move option. The strategic default option is never exercised because lower-cost alternatives are available.

The roles of interest rates and unsecured borrowings should also be mentioned. Since these variables are found throughout the various conditions for default, they clearly affect default by establishing constraints that interface with shocks to y_1' and p_1' to motivate insolvency. The variables may also act as signals in the absence of complete information on changes in y_1' and p_1' . In the case of declining interest rates, a default observed when the refinance option is in-the-money ($i_1' < i_0$) may be the result of unobserved negative shocks to either y_1' or p_1' . For similar reasons, default might also be associated with an increase in other borrowings. However, if the fundamental determinants of default are fully identified, both variables should cease to provide empirical significance.

To summarize, mortgage default is due primarily to insolvency in legal and economic settings for which the choice-theoretic model applies. Income and real estate prices are fundamental determinants of default because shocks to either variable may erode homeowner wealth to the point of insolvency. Declining interest rates cannot independently motivate insolvency because they increase wealth through the refinance option. Although homeowners possess a strategic default option capable of capturing a portion of the value of declining rates, this option is never exercised as long as refinance and move options provide less expensive alternatives for generating the same value. Therefore, to the extent that a two-variable paradigm explains mortgage default, the relevant variables are income and house prices, not interest rates and house prices.

VI. Empirical Issues

As explained earlier, alternatives to option-based models appear to be warranted in most jurisdictions. The empirical implications of the choice-theoretic model are of particular interest here, as they pertain to observations and regularities that are inconsistent with, or otherwise difficult to explain by, option-based models. These include the following:²¹

1. Many borrowers who default cite the reason as loss of income, divorce, and other tragic events bearing no apparent relation to changes in the value of home equity.
2. Large percentages of delinquent borrowers cure their delinquencies prior to foreclosure.²²
3. Bifurcated default patterns have not been observed. Low levels of default have been reported throughout the United States in all economic environments, whereas universal default has not been observed in areas characterized by extended periods of declining house prices.²³
4. Empirical tests fail to uncover a consistent relationship between interest rates and default.
5. Empirical tests often uncover significant relationships between default and unemployment, income, or other variables having no clear role in option-based models.
6. Mortgage default is closely associated with default on other borrower obligations.
7. An active market exists for mortgages with original LTVs of up to 125 percent.

The choice-theoretic model provides a framework for understanding these characteristics of mortgage default. To begin with, trigger events help to explain default arising from loss of

employment, divorce, and other tragic events that independently affect income. The central role ascribed to trigger events is highly consistent with borrower's reports that income-related shocks are common reasons for default.²⁴

Building on Friedman (1957), trigger events may vary based on two types of income-related shocks. The first is a shock to current income that induces a similar shock to anticipated future income ("permanent" income), as occurs when an occupation becomes obsolete and causes long-term loss of employment. The "rational" adaptation of income assumed in (2') to (4') reflects these changes. Permanent shocks greatly increase the likelihood of default because they imply cash-flow problems in future as well as current periods. The second type of shock is a temporary event that does not affect permanent income, such as a temporary layoff. These shocks are less problematic because they constrain only current cash flows, and have little impact on future income or the ability to borrow against that income.²⁵

The "permanence" of income shocks leads large percentages of delinquent borrowers to cure their delinquencies before default. The fact that temporary income shocks are relatively common accounts for the high 30- and 60-day single-family delinquencies.²⁶ Foreclosure may occur only for successions of temporary shocks and for permanent shocks. In option models, however, the fundamental determinants of default are changes in house prices and interest rates, which implies that a primary motivation of cures is directional changes to these variables.²⁷ Although option models may be extended to include liquidity constraints or other factors to explain observed delinquency patterns, they focus primarily on shocks to interest rates and house prices and thus provide little insight into these patterns.²⁸

Income-related variables also account for the lack of bifurcated default patterns. Since borrower-specific income shocks are possible in any region at any time, defaults should be minimal at every meaningful level of aggregation (states, cities, etc.) and for any period or rate of house price appreciation. Similarly, significant numbers of local populations typically retain their employment and income during periods of declining house prices, so universal default should never be observed, even at low levels of aggregation and at LTVs implying negative equity.

Put option models unanimously posit that interest rates are as closely related to default as house prices. However, empirical evidence has failed to consistently support this hypothesis.²⁹ As discussed earlier, the choice-theoretic model suggests that interest rates do not motivate default, although they may be found to correlate with default absent complete information on shocks to income and house prices.

Although empirical work has failed to verify a clear role for interest rates, it commonly finds other significant variables to be inconsistent with option-based models. For example, recent tests include dummy variables for specific states, unemployment, income, and income growth.³⁰ Less technical analyses, as well as rating agency models, tend to stress a broader range of variables, including property type, mortgage type and purpose.³¹ Variables along these lines are generally inconsistent with put option models, but consistent with the choice-theoretic notion that borrower income, savings, and borrowings combine with real estate equity to explain default.

That other aspects of borrower financial health may play a role in default is suggested by the close association between mortgage default and default on other obligations. As already mentioned, option-based models treat mortgage choice as separable from other aspects of

borrower health; by contrast the choice model implies that delinquencies for all types of debt should be closely linked. The choice model is most consistent with increasing use of borrower credit scores in automated underwriting and high-risk lending activities, such as those discussed by Mahoney and Zorn (1996) or Lieberman (1996).

Mortgages with LTVs as high as 125 percent are also anomalous to put option models. Although these mortgages are typically subordinated interests, option-based hypotheses extend to them and imply that they should virtually always default. However, Lieberman (1996) finds a number of issuers populating this market in the belief that “borrower capacity and credit quality” mitigate the risk of “negative borrower equity.” Between 1990 and 1995 average annual charge-offs on related securitizations were a modest 3–6 percent. While high-LTV mortgages remain a relatively new product and credit quality has not yet been fully tested, they serve as a market statement that real estate equity is not the only determinant of mortgage default.

A final comment relates to previous tests of income-related variables. While these variables are found significant in many tests, they nevertheless often fail to capture the full impact of income and income-related shocks. For example, one variable, income at origination, fails to reflect changes to income following origination in the same manner that LTV at origination fails to reflect changes in house prices. This is especially a problem for income because large shocks may occur at any time following origination.³² Another measure, average income at county, state, or other levels, may remain unchanged even as significant numbers of borrowers experience income shocks. Alternatives reflecting recent changes to individual income are much preferred to either income at origination or average income at almost any level of aggregation.

II. Conclusion

Although mortgage default is now widely treated as a put option, there is little basis for asserting the rights associated with a put in many jurisdictions. In these environments the cost or risk to borrowers arising from lender pursuit of remedies erases the primary economic benefit of treating mortgage default as a put option while justifying the development of alternative models of mortgage default.

The choice-theoretic model proposed here is generally consistent with mortgage laws in many jurisdictions as well as the notion that home equity is substitutable with other forms of income and wealth. The model attributes mortgage default to borrower insolvency. Variables related to income and real estate price variables are identified as the fundamental determinants of default because they precipitate insolvency through the erosion of wealth. The substitutability of income, borrowings, and other forms of wealth implies that negative equity is neither a necessary nor a sufficient condition for default, even in the absence of sale-related transactions costs. Declining interest rates cannot independently motivate default due to insolvency because they act to increase wealth through the refinance option. Although homeowners possess a strategic default option capable of capturing a portion of the value of declining rates, they will not exercise this option as long as refinance and move options provide less expensive alternatives for generating the same value. Therefore, to the extent that a two-variable paradigm explains mortgage default wherever put option models are not applicable, the fundamental variables are income and house prices, not interest rates and house prices.

The model developed here appears to explain many empirical characteristics of mortgage default that are inconsistent with, or otherwise difficult to explain by, option-based models. The

model echoes reports by defaulted borrowers that blame their default on loss of income, divorce, and other tragic events having no apparent relation to homeowner equity. The model also explains other findings, ranging from the observation that delinquent borrowers commonly cure their delinquencies before foreclosure to a market of mortgages with LTVs of up to 125 percent. The model therefore promises considerable empirical application while offering a framework for understanding default in environments for which put option models do not apply.

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Notes

¹ The proposition was first suggested by Asay (1978), then extended and popularized by Foster and Van Order (1984). A recent sample of literature can be found in Schwartz and Torous (1992), Kau et al. (1992, 1993, and 1995), Kau and Keenan (1995), Vandell (1995), and Deng (1997).

² As emphasized by Lekkas, Quigley and Van Order (1993) and Quigley and Van Order (1995), “the virtue of the contingent claims model is its simplicity.” Only variables relating to option exercise should have an impact on the default decision, and there are no costs to default other than losing the house. Given this perspective, it is not surprising that many option-based discussions cited in note 1 include no mention of borrower insolvency. Vandell (1995) provides an exception with a call to “understand better the role that solvency plays in mortgage default.”

³ See Monsen (1996) or Mahoney and Zorn (1996).

⁴ Early tests are performed by von Furstenburg and Green (1984) and Campbell and Deitrich (1983). Recent work includes that of Wilson (1995); Jones, Hayssen, and Schneider (1995); Deng, Quigley, and Van Order (1995); Monsen (1996); Phillips, Rosenblatt, and Vanderhoff (1996); Case and Shiller (1996), and Deng (1997).

⁵ Jones et al. (1995) describe a model used by Duff and Phelps in which risk is based on negative equity, mortgage type (fixed-versus-adjustable-rate), borrower credit quality, occupancy, and other variables. Similar models can be found in Fitch (1993) and Moody's (1990). Mahoney and Zorn (1996) describe automated underwriting technology that takes a similar approach.

⁶ More extensive legal analysis may be found in Dunaway (1995), chaps. 12-14, and Nelson and Whitman (1993), chaps. 7-8. U.S. Department of Housing and Urban Development (1996), chap. 6, provides an overview of the subject.

⁷ For legal discussions of foreclosure and deficiency judgments, see Nelson and Whitman (1993), §§ 8.1-8.3. Apart from deficiency judgments, lenders may also obtain a judgment on the personal obligation (note) and enforce it by levy upon any property of the borrower. A third alternative is to protect the contract in the mortgage agreement. For example, the Veterans Administration contracts an indemnity certifying that the borrower is legally obligated to make the mortgage payments called for by the mortgage contract.

⁸ Jurisdictional variations detailed by Dunaway (1995), appx. 14A, show California, Arizona, and Alaska as three states with pervasive antideficiency environments. At least two additional states (Montana and Oregon) broadly prohibit deficiency judgments for purchase money mortgages. South Dakota also restricts the area of purchase money mortgages, but only when the mortgagee is also the vendor; i.e., the seller is doing the financing.

⁹ For example, FNMA's servicing requirements, dated August 31, 1994, state that "the servicer should diligently seek out, and recommend to Fannie Mae, appropriate cases in which the pursuit of a deficiency judgment should be considered." FHLMC requirements, as of May 1, 1996, require that servicers "identify and recommend appropriate cases where the pursuit of deficiency judgments

is in FHLMC's best interest." More than 20 private specialists participated in the Resolution Trust Corporation's (later the Federal Deposit Insurance Corporation's) 1994 limited partnership program to resolve approximately \$7 billion (face value) of judgments, deficiencies, and charge-offs. Information on participants in this program is available through the FDIC's Public Information Center.

¹⁰ See Crandall, Hagedorn, and Smith (1991), § 6.05[2]. Further docketing is required to acquire liens in other counties of the state in which the judgment is rendered.

¹¹ Residential real estate also has drawbacks as a mechanism for satisfying claims. Litigation and other legal action is costly and time consuming. Although it is possible for any party with an interest in the real estate to redeem, it is often unlikely that any would do so as long as first- or second-mortgage interests precede their claim. If the borrower remains current on secured obligations, other lien holders may be forced to wait until sale before collecting on the claim.

¹² This application treats the entire interest payment *mi* as the option premium, which limits the discussion to option-related issues. Though it is widely accepted that the mortgage rate contains real and inflation components alongside a premium for default risk, these elements need not be considered for purposes of this discussion.

¹³ See Kau and Keenan (1995) or Case and Shiller (1996).

¹⁴ The FNMA Servicing Guide cites a variety of factors to consider, such as the amount of the deficiency, the cost of pursuing the judgment in relation to the amount of the deficiency, and the probability of a favorable judgment.

¹⁵ See Cunningham and Hendershott (1984) or Hendershott and Van Order (1987). Ambrose, Buttiner, and Capone (1997) specify an option-based model that includes the cost of deficiency judgments as a probabilistic event.

¹⁶ 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 his or her consumption account, with no cash flow exchange. Individuals might otherwise rent their residential investments to other parties, while using rents received to support rents paid for real estate services from other investors.

¹⁷ The right to move is widely acknowledged and contractually supported by the prepayment and "due on sale" clauses of the standard FHLMC-FNMA note and mortgage. The move option represents an alternative to default that does not involve either a breach of contract or personal liability for damages. Move options are generally not acknowledged in option-based models of mortgage default, although they can be found in many prepayment discussions. See, for example, Archer, Ling, and McGill (1996); Abrahams (1997); and Elmer and Haidorfer (1997).

¹⁸ Capone (1994) develops a model of foreclosure choice that includes the option to move. This model finds property sale preferred to foreclosure for reasonable parameter values.

¹⁹ The three-period model is easily extended to include an arbitrary number of period 1 cash flows or period 2 terminal conditions. See, for example, Fama and Miller (1971), chap. 1.

²⁰ Although the term “trigger” event has been used often, it is typically not formally defined or linked to specific income or wealth-related variables. For example, Riddiough (1991) and Deng (1997) integrate trigger events into option-based models as stochastic shocks, but fail to specify the economic character of the events or their link to wealth-related variables.

Previous references to trigger events appear to view them as synonymous with default but independent of interest rates and house prices. However, the choice-theoretic framework raises questions regarding this approach. Holding house prices and interest rates constant, will a given trigger event, such as unemployment, cause default for all borrowers? The choice-theoretic model suggests that unemployment will impact borrowers differently based on differences in other borrowings (savings). If trigger events are defined as always causing default, then their magnitude must differ by borrower to account for varying wealth positions.

This paper views trigger events as a broad class of income- or expense-related events that cause periodic liquidity problems. This 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 a single-period shock has less impact on borrower choice.

²¹ Additional concerns are raised by Lekkas, Quigley and Van Order (1993) and Quigley and Van Order (1995) findings that loss severity is closely related to the initial loan-to-value (LTV) ratio.

²² See delinquency statistics in “National Delinquency Survey,” published by the Mortgage Bankers Association of America (MBA). These data show 30-day delinquencies about 4 to 5 times higher than 60-day delinquencies, 60- and 90-day delinquencies about equal, and 90-day delinquencies about 2 times higher than foreclosures. This pattern of declining rates is observed throughout the history of the MBA data.

²³ Although little empirical work has examined this issue, a variety of data strongly suggest minimal, bifurcation. MBA data over the past 15 years show that state foreclosure rates almost never exceed 1 percent (usually below 0.5 percent), with material delinquencies and foreclosures in all states every quarter. Defaults and foreclosures are continuously observed even in states experiencing house appreciation for periods as long as a decade. See, for example, state house price indexes for Oregon and Washington published by the Office of Federal Housing Enterprise Oversight. Jones, Hayssen, and Schneider (1995) cite cumulative default rates of only 13% as representing the “extremely severe” economic conditions of Houston during the 1982–88 period.

²⁴ See Gardner and Mills (1989) or Ambrose and Capone (1996a).

²⁵ The mechanics of a temporary shock can be seen by replacing y_1' with y_0 in (3') and adding y_0 to the right-hand side of (5). The role ascribed to temporary shocks is consistent with Capone's (1994) point that delinquency may be used as a method of financing consumption.

²⁶ Elmer and Haidorfer (1997) note that multifamily mortgages have lower 30- and 60-day delinquency rates than single-family mortgages, but higher 90-day, foreclosure, and real estate-owned rates. This observation, coupled with the notion that multifamily mortgages are often contracted on a nonrecourse basis, suggests that they may provide an appropriate setting for applying put option models to the analysis of mortgage default.

²⁷ This view provides an appealing backdrop to the Ambrose and Capone (1996b) theme that liquidity constraints are a key aspect of single-family delinquencies. Indeed, the choice-theoretic model provides a formal framework for understanding the motivation and nature of liquidity constraints.

²⁸ See Ambrose and Capone (1996b).

²⁹ See Phillips, Rosenblatt, and Vanderhoff (1996); Lekkas, Quigley, and Van Order (1993), Quigley and Van Order (1995); and Jones (1993).

³⁰ See Deng (1997); Case and Shiller (1996); and Philips, Rosenblatt, and Vanderhoff (1996).

³¹ See Monsen (1996); Wilson (1995); and the references in footnote 5.

³² The volatility of borrower income is expected to be much higher than the volatility of individual house prices. Borrower income might fall to zero, or rise dramatically, within a few months (or even days) following mortgage origination. In contrast, house prices usually change little in similar time periods and otherwise tend to move slowly over time.