House-Price Expectations, Alternative Mortgage Products, and Default

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Abstract

Rapid house-price depreciation and rising unemployment were the main drivers of the huge increase in mortgage default during the downturn years of 2007 to 2010. However, mortgage default was also partly driven by an increased reliance on alternative mortgage products such as pay-option ARMs and interest-only mortgages, which allow the borrower to defer principal amortization. The goal of this paper is to better understand the forces that spurred use of alternative mortgages during the housing boom and the resulting impact on default patterns, relying on a unifying conceptual framework to guide the empirical work.

The conceptual framework allows borrowers to choose the extent of mortgage "backloading," the postponement of loan repayment through various mechanisms that constitutes a main feature of alternative mortgages. The model shows that, when future house-price expectations become more favorable, reducing default concerns, mortgage choices shift toward alternative contracts. This prediction is confirmed by empirical evidence showing that an increase in past house-price appreciation, which captures more favorable expectations for the future, raises the market share of alternative mortgages. In addition, using a proportional-hazard default model, the paper tests the fundamental presumption that backloaded mortgages are more likely to default, finding support for this view.

[†]*The views expressed in this paper are those of the authors and do not necessarily reflect those of the Federal Reserve Bank of Philadelphia or the Federal Reserve System. This paper is available free of charge at http://www.philadelphiafed.org/research-and-data/publications/working-papers.*

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1. Introduction

Rapid house-price depreciation and rising unemployment were the macroeconomic drivers of the huge increase in mortgage default during the downturn years of 2007 to 2010. However, mortgage default was also associated with an increased reliance on alternative mortgage products (AMPs). These AMPs include pay-option adjustable-rate mortgages (option ARMs), which are ARMs that allow negative amortization, and interest-only (IO) mortgages (usually ARMs), which defer principal amortization for an initial period of five to 10 years. Compared to standard fixed-rate mortgages (FRMs), AMPs had substantially worse repayment performance during the downturn.

In previous work (Brueckner, Calem, and Nakamura (2012)), we analyzed the genesis of another important factor leading to the surge in defaults during the housing downturn: the relaxation of underwriting standards associated with subprime lending. The theoretical model in that paper showed how more-favorable expectations regarding future house-price appreciation can spur relaxation of underwriting standards by easing concerns about potential default, and the paper's empirical results supported this prediction.

The present paper makes the same argument with regard to the growing use of AMPs, which were widely viewed as lacking the credit risks of subprime loans. We argue that, when rapid house-price appreciation is expected, the higher default risk still inherent in these contracts is mitigated, encouraging their use. As in the prior paper, we provide theoretical and empirical analysis supporting this view. Together, the papers demonstrate that, once the housing bubble gained momentum, the favorable price expectations it generated fed the decline of underwriting standards and the use of AMPs, setting the stage for a surge in defaults once prices started to fall.

Our conceptual framework extends the model of Brueckner, Calem, and Nakamura (2012) (hereafter BCN), which explains loosened underwriting as a consequence of evolving price expectations. We modify this framework to allow borrowers to choose the extent of mortgage "backloading," the postponement of loan repayment through various mechanisms that constitutes a main feature of AMPs. By postponing mortgage payments, greater backloading is more likely to generate negative equity when house prices fall, making default risk higher for AMPs.[1] However, as house-price expectations become more favorable, with future price gains perceived as more likely by both borrowers and lenders, the riskiness of AMPs lessens, spurring their use. Whereas this argument would also apply to traditional ARMs, especially those (as is frequently the case) that have relatively low, initial "teaser" interest rates, AMPs represent a more extreme case of backloading that should be observed in borrower choices when house prices are rising fastest.[2]

This argument is consistent with empirical evidence that we develop in two directions. We first examine the connection between the market share of AMPs and house-price appreciation. We find that, irrespective of whether the loans are retained on bank balance sheets or packaged into Agency or non-Agency securities, growth of alternative mortgages is positively associated with prior appreciation in house prices and other favorable economic indicators, similar to the association between high-risk subprime lending and house-price growth observed by BCN. We also find that, in the areas with the steepest rises in house prices, alternative mortgages are favored over traditional ARMs.

Next, in order to test the underlying presumption that alternative mortgages are more likely to default, we examine repayment performance during the downturn across the spectrum of mortgage contracts.[3] We find substantially higher default rates for the alternative contracts, again irrespective of whether the mortgages are retained on bank balance sheets or packaged into securities. Results from a multivariate Cox proportional-hazard model demonstrate that these differences exist even after controlling for the effects of the initial rise and subsequent fall in house prices, for regional differences in unemployment, and for standard credit-quality measures such as FICO score and interest rate spread. These results confirm that backloaded mortgages

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[1]In our stylized, two-period model, the higher default risk of AMPs is a direct consequence of the impact of backloading on negative equity. Empiricallyminded readers might argue that insufficient time had elapsed on most AMPs (particularly those originated after 2005) at the onset of the housing downturn for this feature to have had a substantial impact on accumulated equity relative to traditional mortgage products. However, our model more generally implies that the decision to backload depends on an expectation that the future value of the home will suffice to repay the mortgage, and a reversal of these expectations (arising from a decline in house prices) provides an incentive to default.

[2] Unlike in, for example, Keys et al. (2009), this argument does not depend on agency problems, which cause lenders to be indifferent to the likelihood of repayment of the credit instrument.

[3] Our empirical analysis focuses on the prime and near-prime market segments, reflecting the composition of our sample.

are riskier, being more prone to default than traditional contracts. Moreover, as the AMP loans held in portfolio did not perform substantially better than the securitized loans, the role of agency issues in spurring risky mortgage lending appears weak in this context.

The present paper contributes to the large prior literature on mortgage choice, which is extensively referenced in Brueckner (2000) and in the recent paper by Chiang and Sa-Aadu (2013). Much of that literature focuses on the choice between fixed and adjustable-rate mortgages, recognizing that borrower interestrate risk is absent with FRMs but present with ARMs. Our framework, by contrast, ignores the fact that AMPsusually involve interestrate risk, focusing instead on the backloading feature of these contracts.

Chiang and Sa-Aadu (2013) share some aspects of the present focus by using simulation methods to analyze the choice of alternative mortgages. Additional previous papers that analyze mortgage choice in a model that includes default are those of Posey and Yavas (2001) and Campbell and Cocco (2003), which focus on the choice between traditional fixed and adjustable-rate mortgages, as well as that of LaCour-Little and Yang (2010).

Like the present paper, LaCour-Little and Yang (2010) develop a model of alternative mortgage products while presenting an empirical analysis of contract choice that includes a connection to prior house-price appreciation. To a more limited extent, they also analyze default performance. Despite the broad similarities to this paper, we use different theoretical and empirical models, employ a more broadly representative data set, and provide more detailed analysis of repayment performance.[4]

Our empirical findings are consistent with LaCour-Little and Yang's evidence that favorable house-price expectations helped drive the rise in AMPs, and we identify other factors that spurred the use of these contracts.Whereas their evidence is primarily limited to Bear Stearns securitizations, our substantially larger data set permits us to evaluate the empirical importance of prior price appreciation in contract choice for a large portion of the overall U.S. housing market, including loans held in bank portfolios. Indeed, a substantial volume of AMPs

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[4]The theoretical framework in LaCour-Little and Yang (2010) is relatively complex and incorporates both income shocks (payment-driven default risk) and houseprice shocks (equity-driven default risk), thus requiring numerical analysis. It portrays reduction in default risk associated with adverse income shocks as the primary incentive for choosing an interest-only loan. Thus, the model implies (somewhat counterintuitively and in contrast to the empirical results in our paper) that higher expected income growth makes an AMP less attractive. In contrast, default risk in our model is solely equity driven, and the model remains agnostic on the relationship of AMP choice to expected income growth.

was present in bank portfolios at the onset of the financial crisis, and these loans played an important role in bank losses during the crisis. At the end of 2010, according to Inside Mortgage Finance (2013), U.S. banks and thrifts held $1.8 trillion in mortgage loans on their portfolios, of which nearly 13 percent were in default at the time.

Our empirical work on default shows that AMPs had higher default rates than other types of contracts with comparable measured credit quality, while pointing out that bank portfolios of AMPs performed, broadly speaking, as badly as securitized AMPs. The empirical analysis of default in LaCour-Little and Yang (2010), by contrast, is mainly devoted to analyzing default risk conditional on the choice of an AMP, not to comparing default risk between AMPs and other types of contracts. In addition, their data are limited to 2007 and earlier, prior to the peak years of the mortgage crisis,whereas our analysis of repayment performance extends through the first quarter of 2012.

Another related paper is that of Cocco (2013), who uses British data to show that AMP borrowers expected higher future income growth than users of traditional mortgages, a finding that parallels some findings of LaCour-Little and Yang (2010). In addition, Barlevy and Fisher (2011**)** examine backloaded mortgages from a different perspective, arguing that lenders preferred to make these mortgages to encourage prepayment.

The paper is organized as follows. Section 2 presents the simple theoretical framework that formalizes the notion of backloading, demonstrating the link between favorable house-price expectations and backloading of mortgage repayments through use of AMPs. Section 3 demonstrates empirically the link between expected house-price appreciation and reliance on AMPs. Section 4 presents the default analysis, and section 5 offers conclusions.

2. Model

In this section, the model of Brueckner (2000) is adapted to analyze the effect of house-price expectations on the choice of nontraditional mortgages by borrowers. Brueckner's earlier model analyzed only the choice of loan size in the presence of borrower default, but the framework can be recast to study the choice of mortgage backloading, the key feature of nontraditional contracts, in a setting with default.

The model has two periods, 0 and 1. At the beginning of period 0, the borrower purchases a house of value P_0 with a 100 percent mortgage (this no-down-payment assumption is used only for convenience). At the end of the period, the borrower makes his first mortgage payment, denoted M_0. In period 1, the mortgage contract requires a second payment, denoted M (for simplicity, period-1 values are not subscripted). Mortgage backloading corresponds to ashift in the payment burden toward period 1, with a decrease in M_0 and an increase in M .

The value of the purchased house changes stochastically between the periods, and if the value drops sufficiently, then default is the right decision for the borrower. To write the borrower's default rule, let P denote the period-1 house value and C denote "default costs." These costs include the cost from impairment of the borrower's credit rating following default, the moving costs that must be incurred following foreclosure, and any other costs of failing to honor the mortgage contract. Default is optimal when $P - M \leq -C$, or when housing equity $P - M$ is negative and larger in absolute value than default costs. Rearranging this condition, the default rule can be written as

(1) $$P \leq M - C,$$

where $M - C$ is the "default" price, the house price below which default occurs. With backloading raising the value of M, the default rule in (1) is more easily satisfied for a backloaded mortgage since the default price is then higher. Therefore, backloading raises the riskiness of a mortgage by making default more likely. The riskiness of a loan also depends on the default costs C of the borrower. When C is low, the borrower defaults more easily, with (1) more easily satisifed for a given M, so that low-C individuals are risky borrowers. Note that while the default rule in (1) emphasizes equity (relative to default costs) as the driving force, the rule allows trigger events to play a role in default.[5]

Using this rule, Brueckner (2000) assumed that heterogeneous default costs are private information to borrowers and analyzed the resulting distortion of the mortgage market equilibrium. Brueckner, Calem and Nakamura (2012), by contrast, assumed that C is observable to lenders (being captured by the borrower's credit rating) and portrayed subprime lending as a

[5]A trigger event could affect the value of C, thereby generating default without a change in P. For example, moving costs would normally be an element of C, since a move is necessary following default and eviction. But if the borrower loses his or her job, then a move is necessary regardless of whether or not default occurs, and moving costs no longer are an element of C. With C then falling, the default condition (1) may now hold with P unchanged, leading to default. Stated differently, the need to move may have restrained default for a borrower with negative equity, but a job loss (which necessitates a move in any case) makes negative equity more prominent in the default decision.

reduction in the minimum C (or credit rating) required to obtain a loan. Although default costs are notcentral to the current analysis, this observability assumption will be maintained.

Expectations about period-1 house prices, which shape perceptions of the likelihood of default, govern the writing of mortgage contracts in period 0. These house-price expectations, which are assumed to be common across borrowers and mortgage lenders, are summarized in the density function $f(P,\delta)$, where δ is a shift parameter that moves the density to the right, in the direction of higher P values. The cumulative distribution function is given by $F(P,\delta)=\int_0^P f(P',\delta)dP'$, and it is assumed that δ shifts this function in the sense of first-order stochastic dominance. In other words, $F_\delta(P,\delta)\le 0$ is assumed to hold, where the subscript denotes partial derivative, indicating that an increase in δ reduces (or leaves unchanged) the probability that P lies below any particular value. The purpose of the analysis is to determine the effect of an increase in δ on the choices of M_0 and M.

To answer this question, we specify the borrower utility and lender profit functions and characterize borrower indifference curves and the lender zero-profit locus in (M, M_0) space. The chosen mortgage contract corresponds to a point of tangency between an indifference curve and the zero-profit locus, and we analyze the effect of a higher δ on the location of this tangency.

Letting η denote the lender's discount factor, the present value of profit is written

$$\pi \equiv -P_0 + M_0 + \eta\left[\int_0^{M-C} Pf(P,\delta)dP + \int_{M-C}^{\infty} Mf(P,\delta)dP\right]. \tag{2}$$

To understand (2), observe that the lender makes a loan outlay of P_0 at the beginning of period 0, receiving the first payment of M_0 at the end of the period. In period 1, the lender receives the contracted payment M if P is above the default price $M-C$, which induces the borrower to repay the loan. Otherwise, the lender receives the house value P instead of M, capturing it via foreclosure and resale of the house (foreclosure costs are assumed to be zero). The term in brackets is thus the lender's expected period-1 revenue in the presence of potential default.

Setting π in (2) equal to zero gives the lender's zero-profit locus, the collection of (M, M_0) pairs that yield zero discounted profit. The slope of this locus is found by totally differentiating the resulting equation. Leibniz'srule, along with (1), yields the derivative of π with respect to *M:*

(3) $\pi_M = \ \eta\,\{\ f(M-C,\delta)[(M-C)-M]+\int_{M-C}^{\infty} f(P,\delta)dP = -Cf(M-C,\delta)+1-F(M-C,\delta)\ \}$

This expression is ambiguous in sign, reflecting two opposing forces: A higher M raises the return to the lender when default does not occur (positive second term inside the brackets) while making default more likely (negative first term.)

For simplicity, we assume that the first term is dominant over the relevant range of P_0 and M, so that the lender's return is increasing in M. If we use the π_M expression in (3) and notethat $\pi_{M_0} = 1$, the slope of the zero-profit locus (equal to $-\pi_M/\pi_{M_0}$) is given by

(4) $$\frac{\partial M_0}{\partial M_{|\pi}} = -\,\eta[1-F(M-C,\delta)-Cf(M-C,\delta)] < 0.$$

indicating that the zero-profit locus is downward sloping and confirming the expected trade-off between M and M_0.

This trade-off emerges unambiguously if the distribution of P is uniform with support $[\underline{P}+\delta, \overline{P}+\delta]$, so that the density is $1/(\overline{P}-\underline{P})$ over this range. Then $F(M-C,\delta) = (M-C-(\underline{P}+\delta))/(\overline{P}-\underline{P})$, and (3) reduces to

(5) $$\frac{\partial M_0}{\partial M_{|\pi}} = -\,\eta\,\frac{(\overline{P}+\delta-M)}{(\overline{P}-\underline{P})} < 0,$$

where the inequality follows because $M < \overline{P}+\delta$, with *M* being smaller than the largest possible P (otherwise default would be certain). Although the curvature of the zero-profit locus is ambiguous in general, inspection of (5) shows that the locus is convex in the uniform case, as shown in Figure 1 (in other words, (5) becomes less negative as M increases, moving down the locus).

Borrowers are assumed to be risk neutral, with utility given by the present value of wealth. Letting the discount factor (which could differ across borrowers) be denoted by θ and letting Y denote the expected present value of income, utility is equal to

(6) $$u = Y - M_0 + \theta\left[-\int_0^{M-C} Cf(P)dp + \int_{M-C}^{\infty}(P-M)f(P)dP\right].$$

Note that the borrower loses C when default occurs, but that the increment to wealth when the mortgage is repaid equals the borrower's equity in the house, $P-M$. Setting u equal to a constant and totally differentiating the resulting equation with respect to M using Leibniz's rule, the terms involving the limits of integration all cancel, so that $u_M = -\int_{M-C}^{\infty} f(P)dP$. With $u_{M_0} = -1$, the slope of an indifference curve $(-u_M/u_{M_0})$ is then given by

(7) $$\frac{\partial M_0}{\partial M_{|u}} = -\theta[1-F(M-C,\delta)] < 0.$$

Indifference curves are thus unambiguously downwardsloping, and since (7) is increasing in M, the curves are convex. Note also that the curves are vertical parallel, having the same slope along any vertical line (where M is held constant). When the houseprice distribution is uniform, (7) reduces to

(8) $$\frac{\partial M_0}{\partial M_{|u}} = -\theta\frac{\overline{P}+\delta-(M-C)}{\overline{P}-\underline{P}}.$$

Since lower indifference curves (with lower values of M_0 for given M) have higher utilities, the borrower's preferred mortgage corresponds to the point on the zero-profit locus that lies on the lowest indifference curve. If the zero-profit locus is more convex than the indifference curves, such a point will lie at a tangency between the locus and an indifference curve, assuming an interior solution. Such an outcome, which is illustrated in Figure 1, is the one of interest and will be the focus of the ensuing analysis. But corner solutions are also possible. In particular, inspection of (4) and (7) shows that if $\eta \leq \theta$, so that the lender's discount factor is less than or equal to that of the borrower, then the indifference curves are steeper than the locus. The preferred mortgage then lies at the upper endpoint of the zero-profit locus, where $M_0 = P_0$ and $M = 0$. In this case, the borrower in effect buys the house outright, without using a mortgage. To focus on cases where a mortgage is used, we thus restrict our attention to borrowers for whom $\theta < \eta$.

Assuming that the relative convexity condition is satisfied, the tangency condition that determines the preferred mortgage sets (4) and (7) equal, which implies

(9) $$\Omega \equiv -(\eta-\theta)[1-F(M-C,\delta)] + \eta C f(M-C,\delta) = 0.$$

In the uniform case, this condition reduces to

(10) $$-(\eta-\theta)\frac{\overline{P}+\delta-(M-C)}{\overline{P}-\underline{P}}+\eta\frac{C}{\overline{P}-\underline{P}}=0,$$

and solving for M yields the optimal value:

(11) $$M^{*}=\overline{P}+\delta-\frac{\theta C}{\eta-\theta}.$$

Therefore, the optimal M equals the maximum house value minus a positive constant times default costs C, which is observable to the lender and thus reflected in the mortgage terms offered to the borrower. It can be verified that the relative convexity condition holds in the uniform case, so that the tangency point given by (11) is a utility maximum. In particular, it is easily seen that the indifference curve slope in (8) is less (more) negative than the zero-profit locus slope in (5) as $M<(>)\,M^{*}$, confirming the pattern shown in Figure 1.

In the uniform case, the optimal value of M_0 can be derived by substituting (10) into the zero-profit condition and solving. The optimal value (assumed to be positive) is

(12) $$M_0^{*}=P_0-\eta\left[\frac{\overline{P}+\underline{P}}{2}+\delta+\left(1-\left[\frac{\theta}{\eta-\theta}\right]^{2}\right)\frac{C^{2}}{2(\overline{P}-\underline{P})}\right].$$

Note that an increase in the borrower's discount factor θ, which indicates a greater preference for future contributions to wealth, reduces M^{*} and raises M_0^{*}, as intuition would suggest. An increase in default costs reduces M^{*}, but M_0 could rise or fall with C, depending on the size of θ relative to η. If $\theta<\eta/2$, then the term multiplying C in (11) is positive and a higher C reduces M_0, so that a lessrisky borrower receives a mortgage with lower payments in both periods. If $\eta>\theta>\eta/2$, however, then C's coefficient is negative, and a higher C raises M_0. The lessrisky borrower's lower M is then accompanied by a higher M_0.

The solutions in (11) and (12) show the effect on the optimal mortgage contract of a shift in houseprice expectations. In the uniform case, a favorable shift in expectations corresponds to an increase in δ, which shifts P's uniform distribution to the right. The effect of a higher δ can beseen directly from (11) and (12), which show that M^{*} rises and M_0^{*} falls as δ increases. Therefore, a favorable expectations shift leads the borrower to choose a mortgage that is more backloaded, with a higher M and lower M_0. With backloading a main feature of alternative mortgage products, the prediction is that morefavorable price expectations increase the use of AMPs.[6]

To investigate the effect of a higher δ in the general case, without imposing a distributional assumption, (9) is totally differentiated with respect to M and δ. The relative convexity condition requires $\Omega_M > 0$, but satisfaction of this inequality is not guaranteed in general and must be assumed. Carrying out the differentiation of (8) yields

$$\frac{\partial M}{\partial \delta} = -\frac{\Omega_\delta}{\Omega_M} = -\frac{(\eta - \theta)F_\delta(M - C, \delta) + \theta C f_\delta(M - C, \delta)}{\Omega_M}. \tag{13}$$

From above, the stochastic dominance assumption implies $F_\delta < 0$. If $f_\delta(M - C, \delta) < 0$ holds as well, so that the density shifts down at the default price $M - C$ as δ increases, then (13) is positive. M then rises with a favorable expectations shift, just as in the uniform case, and it can be shown that M_0 falls.[7]Summarizing yields:

> **Proposition.** *When the house-price distribution is uniform, a favorable shift in the distribution raises the extent to which the optimal mortgage is backloaded. Thus, a favorable expectations shift increases the use of alternative mortgage products. The same conclusion holds in general if the relative convexity condition is satisfied and if the expectations shift reduces the height of the house-price density at the default price.*

Thus, as a favorable shift in price expectations reduces anticipated default by making condition (1) less likely to hold, borrowers opt for an offsetting change in the pattern of mortgage payments. An increase in M, which reverses the effect of the shift by raising the likelihood of default, becomes optimal. In effect, the borrower responds to the morefavorable price environment by opting for a riskier mortgage.

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[6]If the zero-profit locus is concave, a corner solution with $M_0 = 0$ is likely to arise. In this case, the expectations shift would not change the nature of the mortgage contract (which would still be fully backloaded); it would only change the magnitude of *M*.

[7]Performing integration by parts on the first integral, the bracketed term in (2) reduces to $-CF(M - C, \delta) - \int_{\underline{P}}^{M-C} F(P, \delta)dP + M$. The derivative of this expression with respect to δ is

$$-CF_\delta(M - C, \delta) - \int_{\underline{P}}^{M-C} F_\delta(P, \delta)dP + [1 - F(M - C, \delta) - Cf(M - C, \delta)]\frac{\partial M}{\partial \delta},$$

which is positive when the zero-profit locus is downward sloping (see (3)). With the bracketed expression in (2) thus rising with δ, M_0 must fall.

More technically, it can be shown that the zero-profit locus shifts downward as δ increases. In addition, it can be seen from (5) and (8) that the indifference-curve family and the zero-profit locus both become steeper at any given M as δ increases. The reason is that the resulting lower chance of default means that an increase in M is more beneficial to the lender (more harmful to the borrower), requiring a larger offsetting movement in M_0. However, because $\eta > \theta$ holds, the zero-profit locus steepens by more than the indifference curves, making it steeper than the curve intersecting it at the old value of M. But as can be seen from (5) and (8), moving to a larger M reduces the steepness of the indifference curves and the locus, and once M has risen by the amount δ, both slopes are back at their original values and thus again equal, restoring the tangency. Therefore, M must rise, moving the mortgage contract down the new zero-profit locus until a tangency is reached.

3. Empirical Evidence on the Use of Alternative Mortgage Products

In this section, we analzye panel data on the market share of newly originated ARMs and AMPs by county and quarter of origination, over the 2004-07 period. The panel data set is constructed from widely used, loan-level data collected by the vendor Loan Processing Systems (LPS) from the largest mortgage servicing companies. The underlying loan-level data contain over 16 million mortgages (compared to the 97,000 loans in LaCour-Little and Yang (2010)). These data are used to create 18,823 county-quarter observations.

Table 1 reports some characteristics of the county-quarter data; in particular, it is noteworthy that 8 percent of bank portfolios are interest-only ARMs and 12 percent are option ARMs, while private securitized loans are 10 percent interest-only and 8 percent option ARMs. Thus, bank portfolios and securitized loans reflect roughly similar proportions of these contracts; moreover, the proportions are substantially larger than for the Agency securitized market, which had only 3 percent (interest-only ARMs) and 1 percent (option ARMs) shares.

Because our data set comes from the largest mortgage servicers, it tends to represent the loans of the lenders with contractual relationships with those servicers. This pattern is advantageous in terms of detecting selection issues (lenders' decisions as to whether to hold loans in portfolio or to sell them). At the same time, the data tend to underrepresent subprime mortgage lenders and, as a consequence, private securitized loans, which represent only 10 percent of our sample. Within our sample, subprime mortgages are present in appreciable numbers only among the private securitized loans.

We estimate a set of regression equations relating the market share of each product category to recent house-price appreciation (a proxy for expected future house-price changes) and other indicators of economic conditions. These indicators include the log of state per capita income and the regional consumer confidence index of the Conference Board for the prior quarter. Attention is restricted to conventional mortgage contracts, with FHA and other government-insured mortgages excluded from the estimation sample.

Our measure of house-price inflation over the prior year uses county-level data from FirstAmerican CoreLogic for all single-family combined (attached and detached) units.[8] The variable equals the four-quarter percentage change in the index, lagged four quarters (that is, the percentage change in the index between eight and four quarters prior to the current quarter).[9] A higher percentage change is assumed to generate a price-expectations shift like that portrayed in the theoretical model.

Equations are estimated for each of the following product categories: one-, two-, and three-year ARMS, interest-only ARMs, and pay-option ARMs. Although interest-only FRMs were another type of alternative mortgage product originated during this period, they were relatively uncommon and hence not conducive to panel-data analysis. In addition, an equation is estimated for the aggregate share of one-, two-, and three-year ARMs plus AMPs (IO, including both ARM and FRM, and pay-option ARM). In computing these market shares, we omitted fixed-rate mortgages and ARMS with longer initial fixed-rate periods (typically five, seven, and 10 years).

Two alternative specifications of these equations are estimated: one that includes a lagged dependent variable, and another that replaces the lagged dependent variable with a county fixed effect. Quarter fixed effects are included in each specification. As noted in the introduction, we conduct the empirical analysis separately for mortgages retained on bank balance sheets, mortgages sold to Fannie Mae and Freddie Mac (packaged into Agency securities), and

[8] We also ran regressions excluding both attached units and distressed sales and found only small differences; these regressions are available upon request.

[9] Price endogeneity was a serious issue in our previous paper, given that weakened underwriting standards (subprime lending) increased the pool of mortgage borrowers, with a consequent effect on the demand for housing and thus prices. Since the present focus is instead on the market shares of different types of mortgage contracts, which presumably have a smaller impact on demand and thus on prices, endogeneity is less of a concern. Therefore, lagging our prior appreciation measure by one quarter is a sufficient precaution.

mortgages placed into private (non-Agency) mortgage-backed securities. We segment the data in this way because the mortgage contracts might differ systematically along unobserved dimensions based on whether they were originated for a bank's own portfolio or for Agency or private securitization.

Results are reported in Table 2, with panels a, b, and c corresponding to the three investor-type classifications. The regression results are consistent with the framework developed in the previous section, whereby more optimistic house-price expectations encourage use of contracts with a greater degree of payment backloading. In particular, the results indicate that the aggregate market share of ARMs and AMPs increases with expected house-price appreciation, as proxied by past appreciation. Market shares of the individual AMP contracts, the interest-only and pay-option ARM products, also increase with expected house-price appreciation, while the share of one-, two-, or three-year ARMs declines for two of the three investor types, consistent with the stronger inclination toward backloading in the presence of more favorable price expectations.

This pattern is highly robust, holding regardless of whether the regressions use the lagged market-share variable or county fixed effects. In addition, since the pattern emerges regardless of the investor type, the concern that house-price expectations might have different effects depending on whether the mortgages were destined for bank portfolios or the two different securitization channels is not confirmed. Regardless of the destination of the mortgages, more favorable expectations lead to greater backloading in the chosen contracts.

The effects of the economic-conditions indicators are also similar across the regressions, mostly following the same pattern regardless of mortgage destination or whether county fixed effects are used in place of the lagged dependent variable. A higher county income increases the market shares of AMPs, while usually reducing the traditional-ARM share (this latter effect is positive, however, in two cases). The effect of higher consumer confidence usually follows the income effect, raising the AMP shares except in two cases. Evidently, better income prospects make borrowers more comfortable with the postponement of mortgage payments inherent in AMPs, with lenders concurring.

4. Empirical Evidence on Mortgage Default by Contract Type

In this section, we test the fundamental presumption of the conceptual framework, namely, that backloaded mortgages are more likely to default. To do so, we examine the repayment performance through March 2012 of all conventional mortgages originated in the 2004-07 period and contained in the LPS database. We estimate a loan-level, proportional-hazard model of default, which is defined as the first incidence of the loan becoming 60 days past due. The model relates default to mortgage contract type and a variety of control variables. Again, we conduct the empirical analysis separately for mortgages retained on bank balance sheets, mortgages sold to Fannie Mae and Freddie Mac (packaged into Agency securities), and mortgages placed into private mortgage-backed securities. This empirical analysis was conducted with a 10 percent random sample of the underlying data set, yielding over 1.6 million observations, as seen in Table 3. Ten percent of the loans are private securitized, 66 percent Agency securitized, and 24 percent held in bank portfolios.

The unit of observation for the hazard model estimation is loan account and month. Each account's payment status is tracked each month, until a termination occurs due to 60-day delinquency, prepayment, or end of the sample period. Prepayments are treated as censored observations, like loans surviving to the end of the period. The delinquency hazard equations take the "proportional hazard" form:

(14) $$h(t \mid X) = \eta(t)\exp(\beta_1 X_1 + \cdots + \beta_p X_p).$$

The hazard rate $h(t|x)$ in (1) is the rate of delinquency at time t conditional on an account surviving until t and conditional on a vector of covariates X. Its relation to the cumulative survival probability $S(t|X)$ is $h(t \mid X) = d\log S(t \mid X)/dt$.

Under the proportional-hazard formulation in (1), the hazard rate consists of a baseline hazard rate $\eta(t)$ that depends only on the survival time and is multiplied by a function of the covariates. The advantage of this approach is that it does not impose any restrictions on baseline hazard rates. Moreover, estimates of the coefficients β_1 through β_p can be obtained by maximizing the partial likelihood function without any need to estimate the baseline hazard rates.[10] This approach is taken since we are concerned not with the baseline hazard but with testing relationships between the hazard rate and economic covariates.

[10] See Allison (1995).

We control for unobserved factors associated with different origination channels, using indicators for the retail (bank) and nonretail (wholesale or broker) origination channels, respectively, and interactions of these indicators with contract type. We also control for the deterioration in underwriting standards during 2005 through 2007, as demonstrated in prior studies, by including dummy variables for each of these origination vintages. In addition, we control for the origination FICO score; if this score is missing from the data (the case for about 25 percent of observations), it is set equal to zero and an indicator variable for missing FICO is set equal to 1 (and 0 otherwise). Additional control variables include property and occupancy type; a jumbo-loan indicator and its interactions with origination vintage (except in the Agency securitized model); interest-rate spread measures, and a servicer-reported subprime loan indicator (except in the bank portfolio model, where it was found to be nonpredictive).

We also control for economic conditions affecting the default probability by including the contemporanous loan-to-value ratio, as measured by updating the origination loan-to-value ratio using the county CoreLogic house-price index. In addition, we control for local house-price and employment conditions. Specifically, we include the county-level annual house price lagged four quarters (as in the other empirical model), along with the county-level unemployment rate change from the prior quarter. General financial market and macroeconomic conditions that influence default along with the competing risk of prepayment are captured by a yield curve measure (gap between 10-year and three-month Treasury rates). Changes in the yield curve could be viewed as influenced by the monetary policy response to mortgage market and other macroeconomic conditions, raising endogeneity concerns, but dropping this measure does not materially affect the coefficients (results are available upon request).

While it is important to control for macroeconomic factors and general risk factors, we believe it is less important to control for risk measures that correlate with degree of backloading such as presence of a "piggyback" second lien, low or no documentation of income, or "cash out" at origination.[11] We can view the results as reflecting all factors contributing to the degree of backloading associated with a given contract type, including the interest rate and principal repayment structure as well as associated factors such as piggyback seconds.

[11] Presence of a second lien is not reported, and loan purpose is imperfectly reported in the data. Documentation type, also imperfectly reported, may also be viewed as potentially related to backloading, as low-documentation borrowers often overstated their income in order to obtain a larger mortgage than they could afford to repay should expectations of rising incomes and home prices fail to materialize.

Results are presented in Table 4, using as the baseline mortgage category five-, seven- or 10-year ARMs. The results strongly support the hypothesis that the backloading of mortgage payments inherent in ARMs and AMPs was associated with an elevated default likelihood during the housing market downturn. The estimated coefficients on each of the alternative product-type indicators (interest only and pay-option ARM) and their interactions with origination channel are positive and statistically significant. In addition, these contracts have an estimated hazard ratio at least 35 percent higher than in the baseline category. In most cases, the hazard ratios on AMPs are twice or more those of the baseline category. The ARMs with shorter initial-rate periods (one, two, or three years) also are found to have significantly higher defaul probabilities, although the effects are generally smaller than those estimated for the AMPs.

Generally, the nonretail channel is seen to have a higher default frequency than the retail channel, consistent with potential agency issues tied to broker or wholesale channels and also with findings from some prior studies.[12] Higher default rates of AMPs are indicated for both origination channels.

Among the other important covariates, a higher FICO score reduces the default hazard, as does a steepening of the yield curve; investor loans and loans on two-to-four-unit properties are quicker to default; and the hazard is raised by a higher unemployment rate and a higher LTV (the default category is above 150 percent). Finally, faster prior house-price appreciation lowers the default hazard, as expected.

Our final question is whether the riskiest mortgages were off-loaded from lender portfolios through securitization. To answer this question, we establish the relative riskiness of loans in bank portfolios and Agency or private securitization by placing them within a single proportional-hazard estimation. Mortgages are distinguished by investor type i (bank portfolio, B, private securitized, P, and agency securitized, A), by mortgage type j (fixed rate, option ARM, interest-only ARM, etc.), and by channel type k (retail, other). The dummy variable for holder type i is $\delta_{i,}$ the dummy for mortgage type j is δ_j, the dummy for channel type k is δ_k,and additional covariates are X_l.

We then can rewrite equation 14 as

$$h(t \mid X) = \eta(t) \exp(\sum_i \alpha_i \delta_i + \sum_j \sum_k \lambda_{ijk} \delta_i \delta_j \delta_k + \sum_l \rho_l X_l). \quad (15)$$

[12] See, for example, Jiang, Nelson, and Vytlacil (2009).

Note from the second summation in (15) that mortgage-type/channel effect is allowed to vary by investor type. The total impact of a given holder-mortgage-channel combination on the mortgage's average default hazard is $\alpha_i + \lambda_{ijk}$. If the default hazard of bank portfolio mortgages of type *j* in channel *k* were less than that of private securitized loans of the same mortgage and channel type, the inequality $\alpha_B + \lambda_{Bjk} < \alpha_P + \lambda_{Pjk}$ would hold.

Table 5 shows the coefficient estimates for bank portfolio loans along with private- and Agency-securitized loans. In the first three columns, the first row shows the α_P and α_B coefficients, with Agency-securitized loans being the baseline (α_A is set equal to zero).The remaining elements in the first three columns are the λ_{ijk} coefficients. The hazard also includes the other covariates from Table 4, but their coefficients (being quantitatively similar to those in Table 4) are omitted.

Columns 4 and 5 show the significance tests on the differences $\alpha_B + \lambda_{Bjk} - (\alpha_P + \lambda_{Pjk})$ and $\alpha_B + \lambda_{Bjk} - (\alpha_A + \lambda_{Ajk})$, tests that show whether the bank portfolio hazard is significantly different from the private- and Agency-securitized hazards, respectively. It can be seen that, broadly speaking, bank portfolio loans have a higher default hazard than both types of securitized loans.[13] In each case, 10 out of 13 of the mortgage/channel combinations have significantly positive λ coefficients, with the remaining three being significantly negative. These exceptions are, in the retail channel, interest-only ARMs and, in both channels, interest-only FRMs (these FRMs represent less than 1 percent of the banks' overall mortgage portfolios).

Various factors may influence the decision whether to securitize a mortgage, including incentives related to private information, and it is not the purpose of this paper to delve into why portfolio loans appear to have performed more poorly. The estimation results suggest, however, that banks did not systematically off-load the riskiest AMP loans through securitization. Thus, it appears that adverse selection with respect to loan sales did not play a major role in encouraging AMP lending activity.[14] Rather, it appears that expectations of continuing house-price inflation may have led lenders to believe that these products had lower risk than proved to be the case.[15]

[13]This conclusion follows by adding the dummy coefficient in either the second or third column to the coefficient of any of the product-channel interactions and comparing it to the product-channel interaction coefficient from the first column.

[14]Of course, the analysis does not rule out adverse selection with respect to contract choice by borrowers as a contributing factor to higher default rates among AMP borrowers.

[15]Finally, we note that higher conditional default rates or hazard rates for a given contract type do not necessarily

5. Conclusion

While the work of Brueckner, Calem, and Nakamura (2012) studied the link between subprime lending and house-price expectations, this paper studies the related link between price expectations and the use of alternative mortgage products. These contracts, which involve backloading of mortgage payments, are risky, being more likely to generate negative borrower equity when house prices fall, thus encouraging default. The paper argues that, as expectations become more favorable, with future price gains perceived as more likely, the riskiness of alternative contracts lessens, encouraging their use.

This hypothesis has been tested using county-level data, relying (like BCN) on past house-price appreciation as a proxy for price expectations. The results confirm the main prediction, showing that rapid past price appreciation generates a higher market share for AMPs. In addition, the paper confirms the underlying presumption regarding the riskiness of alternative products by showing, through use of a proportional-hazard model, that default is more likely to occur under these contracts. Moreover, both sets of results are consistent across the three major classifications of mortgage holder: bank portfolio, Agency, and private securitized.

The paper thus contributes to the large and growing literature on the U.S. housing crisis (see BCN for extensive references). It extends BCN's argument that more favorable price expecations fed market developments that worsened the eventual downturn. While BCN's focus was on the relaxed underwriting standards associated with subprime lending, the current paper has studied the adoption of alternative mortgage products as another response to shifting price expectations. This work adds a new perspective to research on the housing crisis, contributing to a deeper understanding of this important economic event.

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generate higher cumulative default rates, to the extent that the contract type is associated with faster prepaymentthat leaves behind a smaller but riskier pool. However, a separate hazard analysis of prepayment (available upon request) indicates that prepayment rates of interest only and option ARM mortgages were no faster than more traditional products, particularly after 2007 when mortgage delinquency was rising. Moreover, delinquency was largely occurring within the population of homeowners whose homes were "underwater", while prepayment was occurring in the population of homeowners with equity in their properties, minimizing the "competing risk" (survivor bias) impact of prepayment on default, controlling for factors affecting the amount of equity. This delinking of prepayment and default during the crisis period was reflected in strong negative correlation of cumulative default and deliquency rates across states (details available upon request).

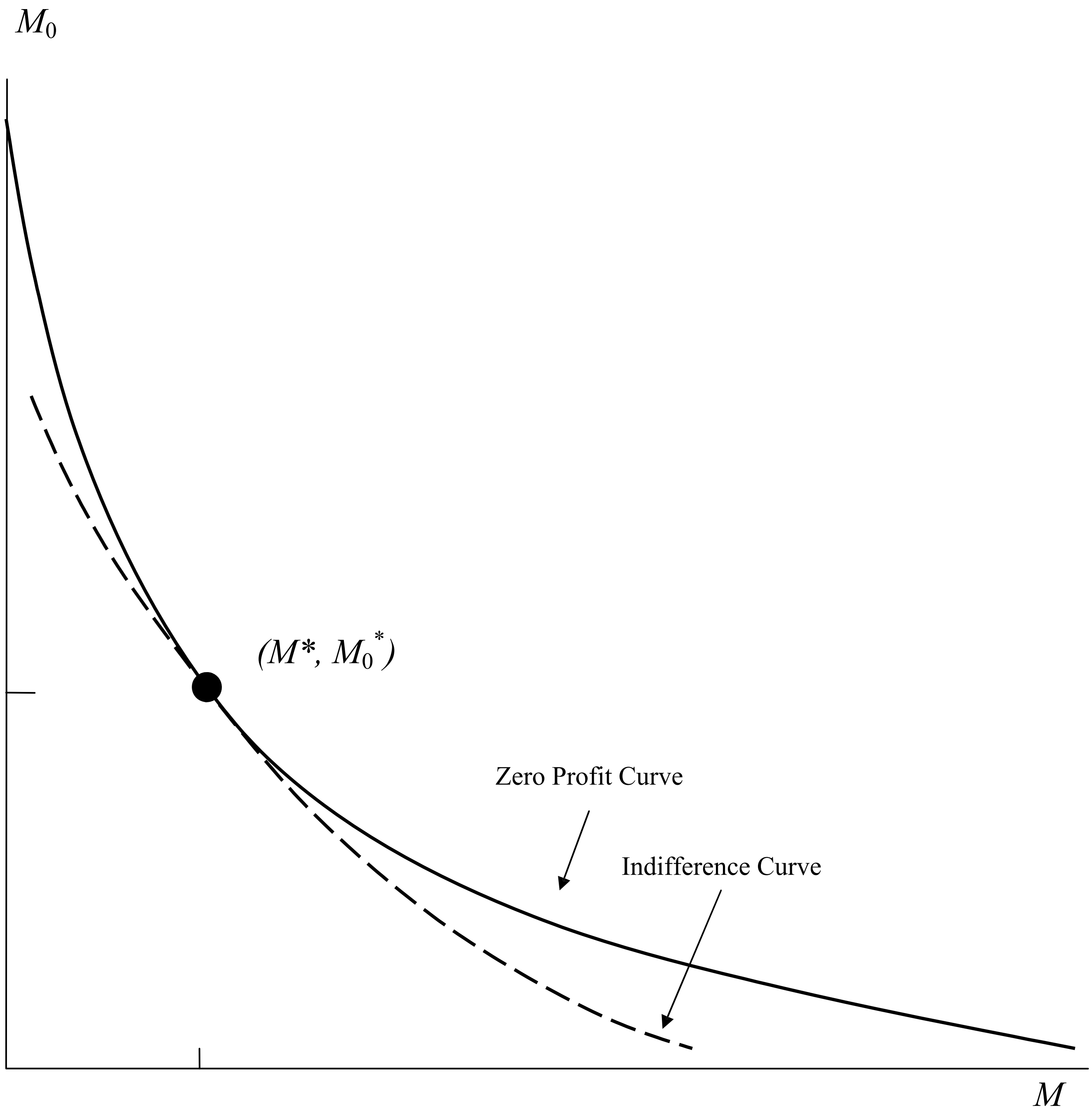

Figure 1: Optimal Mortgage Contract

Table 1:Summary Statistics

a. Bank Portfolio

Summary Statistics			
	N	Mean	SD
Share of all ARM and nontraditional	18565	0.321	0.223
Share of interest-only ARM	18565	0.078	0.112
Share of option ARM	18565	0.124	0.140
Share of 1-, 2- or 3-year ARM	18565	0.119	0.138
Prior year HPI change	18332	0.075	0.062
Log of real per capita personal income	18565	10.451	0.127
Consumer confidence index	18565	99.264	18.712

b. Agency Securitized

Summary Statistics			
	N	Mean	SD
Share of all ARM and nontraditional	18820	0.052	0.055
Share of interest-only ARM	18820	0.028	0.041
Share of option ARM	18820	0.009	0.020
Share of 1-, 2- or 3-year ARM	18820	0.016	0.023
Prior year HPI change	18579	0.074	0.062
Log of real per capita personal income	18819	10.451	0.127
Consumer confidence index	18819	99.205	18.696

c. Private Securitized

Summary Statistics			
	N	Mean	SD
Share of all ARM and nontraditional	18343	0.335	0.232
Share of interest-only ARM	18343	0.100	0.126
Share of option ARM	18343	0.085	0.109
Share of 1-, 2- or 3-year ARM	18343	0.150	0.157
Prior year HPI change	18114	0.075	0.062
Log of real per capita personal income	18342	10.452	0.127
Consumer confidence index	18342	99.310	18.677

Table 2: Product Type Regressions

a. Bank Portfolio

	Regressions (2004Q1 – 2007Q4) with Time Dummies				Regressions (2003Q1 – 2007Q4) with Time Dummies and County Fixed Effects			
	All ARM and AMP	**IOARM**	**Option ARM**	**ARM (1-year, 2/28, or 3/27)**	**All ARM and AMP**	**IOARM**	**Option ARM**	**ARM (1-year, 2/28, or 3/27)**
Constant	-1.645** (0.135)	-1.133** (0.080)	-1.594** (0.095)	1.480** (0.092)	-6.892** (1.159)	-3.209** (0.710)	-1.875** (0.580)	-1.809* (0.833)
Prior year HPI change	0.391** (0.026)	0.190** (0.016)	0.337** (0.018)	-.182** (0.016)	0.120** (0.037)	0.080** (0.025)	0.140** (0.028)	-.099** (0.024)
1-year lag of dependent variable	0.414** (0.010)	0.457** (0.015)	0.334** (0.011)	0.139** (0.013)				
Log of real per capita personal income	0.171** (0.013)	0.104** (0.007)	0.158** (0.009)	-.123** (0.009)	0.672** (0.112)	0.300** (0.069)	0.190** (0.056)	0.182* (0.081)
Consumer confidence index	0.0008** (0.0001)	0.0009** (0.0001)	0.0004** (0.0001)	-.0008** (0.0001)	0.0011** (0.0003)	0.0012** (0.0002)	-.00010 (0.0002)	-.0000 (0.0002)
County dummies	No	No	No	No	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	14205	14205	14205	14205	18332	18332	18332	18332
R-squared	0.424	0.317	0.346	0.228	0.259	0.212	0.182	0.091

Standard errors are in parentheses.
Significance: **1%, *5%
The regressions use robust standard errors.

b. Agency Securitized

	Regressions (2004Q1 – 2007Q4) with Time Dummies				Regressions (2003Q1 – 2007Q4) with Time Dummies and County Fixed Effects			
	All ARM and AMP	**IOARM**	**Option ARM**	**ARM (1-year, 2/28, or 3/27)**	**All ARM and AMP**	**IOARM**	**Option ARM**	**ARM (1-year, 2/28, or 3/27)**
Constant	-.518** (0.031)	-.382** (0.023)	-.154** (0.012)	-.004** (0.011)	-1.107** (0.353)	-1.007** (0.287)	-.395** (0.093)	0.295* (0.121)
Prior year HPI change	0.186** (0.007)	0.124** (0.005)	0.062** (0.003)	0.011** (0.002)	0.124** (0.014)	0.076** (0.012)	0.040** (0.006)	0.009* (0.004)
1-year lag of dependent variable	0.630** (0.012)	0.663** (0.013)	0.525** (0.017)	0.096** (0.013)				
Log of real per capita personal income	0.049** (0.003)	0.034** (0.002)	0.015** (0.001)	0.003** (0.001)	0.102** (0.034)	0.093** (0.028)	0.036** (0.009)	-.027* (0.012)
Consumer confidence index	0.0003** (0.000)	0.0003** (0.000)	0.00005 ** (0.000)	-.00002** (0.000)	0.0008** (0.000)	0.0004** (0.000)	0.0003* * (0.000)	0.0001** (0.000)
County dummies	No	No	No	No	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	14850	14850	14850	14850	18579	18579	18579	18579
R-squared	0.543	0.580	0.369	0.449	0.276	0.373	0.184	0.326

Standard errors are in parentheses.
Significance: **1%, *5%
The regressions use robust standard errors.

c. Private Securitized

	Regressions (2004Q1 – 2007Q4) with Time Dummies				Regressions (2003Q1 – 2007Q4) with Time Dummies and County Fixed Effects			
	All ARM and AMP	**IOARM**	**Option ARM**	**ARM (1-year, 2/28, or 3/27)**	**All ARM and AMP**	**IOARM**	**Option ARM**	**ARM (1-year, 2/28, or 3/27)**
Constant	-1.289** (0.116)	-1.196** (0.080)	-.737** (0.070)	1.167** (0.090)	-.173 (1.028)	-.616 (0.780)	-2.124** (0.448)	2.567** (0.934)
Prior year HPI change	0.259** (0.022)	0.219** (0.0150)	0.314** (0.013)	-.346** (0.017)	0.160** (0.032)	0.168** (0.025)	0.237** (0.021)	-.246** (0.031)
1-year lag of dependent variable	0.220** (0.012)	0.533** (0.017)	0.314** (0.014)	0.212** (0.012)				
Log of real per capita personal income	0.145** (0.011)	0.105** (0.008)	0.077** (0.007)	-.084** (0.008)	0.016 (0.010)	0.047 (0.076)	0.204** (0.043)	-.235** (0.090)
Consumer confidence index	0.00004** (0.000)	0.0009** (0.000)	0.00006 (0.00005)	-.0009** (0.000)	0.0009** (0.0003)	0.002** (0.0002)	-.0001 (0.0001)	-.0006** (0.0002)
County dummies	No	No	No	No	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	13973	13973	13973	13973	18114	18114	18114	18114
R-squared	0.448	0.450	0.336	0.325	0.534	0.400	0.332	0.254

Standard errors are in parentheses.
Significance: **1%, *5%
The regressions use robust standard errors.

Table 3: Summary Statisticsfor Default Data Set

	Private Securitized		Agency Securitized		Bank Portfolio	
Variables	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Vintage 2005	0.324	0.468	0.200	0.400	0.205	0.404
Vintage 2006	0.276	0.447	0.182	0.386	0.167	0.373
Vintage 2007	0.102	0.303	0.215	0.411	0.233	0.423
Other ARM nonretail channel	0.023	0.151	0.018	0.133	0.084	0.277
FRM retail channel	0.180	0.384	0.423	0.494	0.261	0.439
FRM nonretail channel	0.219	0.414	0.438	0.496	0.108	0.310
Option ARM retail channel	0.044	0.205	0.008	0.087	0.080	0.271
Option ARM nonretail channel	0.152	0.359	0.008	0.091	0.176	0.381
Interest-only ARM retail	0.070	0.256	0.018	0.132	0.049	0.216
Interest-only ARM nonretail channel	0.106	0.308	0.021	0.142	0.100	0.300
Interest-only FRM retail	0.010	0.098	0.006	0.075	0.004	0.061
Interest-only FRM nonretail channel	0.035	0.183	0.012	0.109	0.005	0.068
1-year ARM retail channel	0.015	0.122	0.007	0.085	0.007	0.085
1-year ARM nonretail channel	0.020	0.142	0.001	0.026	0.003	0.053
2- or 3- year ARM retail channel	0.027	0.163	0.004	0.063	0.022	0.147
2- or 3- year ARM nonretail channel	0.062	0.240	0.004	0.066	0.035	0.184
Origination FICO score	623.4	232.6	623.1	256.9	649.7	208.1
Dummy variable for missing FICO	0.115	0.319	0.140	0.347	0.086	0.281
Indicator variable for jumbo loan	0.346	0.476			0.270	0.444
Indicator for original term to maturity < 30 years	0.074	0.262	0.212	0.409	0.121	0.326
Indicator for 2-to-4-unit property	0.036	0.186	0.020	0.142	0.020	0.141
Indicator for unknown occupancy status	0.081	0.273	0.068	0.251	0.062	0.241
Indicator for second home	0.030	0.170	0.032	0.177	0.035	0.183
Indicator for investor property	0.103	0.304	0.053	0.223	0.067	0.250
Subprime loan indicator (self-reported by servicer)	0.104	0.305				
Yield curve measure (gap between 10- and 3-month Treasury rates)	1.679	1.371	1.841	1.340	1.706	1.342
Average spread between note rate and 3-month Treasury rate interacted with ARM indicator	0.450	1.212	0.139	0.597	0.813	1.370
Average spread between note rate and 10-year Treasury rate interacted with FRM indicator	0.797	1.086	1.370	0.886	0.755	1.166
Change in county unemployment rate over prior 12 months	0.118	0.294	0.118	0.296	0.109	0.293
Indicator for updated LTV<50	0.110	0.313	0.201	0.401	0.172	0.377

percent						
Indicator for updated LTV 50-60 percent	0.088	0.283	0.115	0.319	0.104	0.306
Indicator for updated LTV 60-70 percent	0.135	0.342	0.144	0.351	0.145	0.352
Indicator for updated LTV 70-80 percent	0.209	0.406	0.188	0.391	0.185	0.389
Indicator for updated LTV 80-90 percent	0.153	0.360	0.131	0.338	0.133	0.340
Indicator for updated LTV 90-100 percent	0.095	0.293	0.084	0.277	0.097	0.296
Indicator for updated LTV 100-110 percent	0.064	0.245	0.050	0.218	0.064	0.244
Indicator for updated LTV 110-130 percent	0.077	0.266	0.048	0.214	0.061	0.239
Indicator for updated LTV 130-150 percent	0.036	0.186	0.022	0.148	0.024	0.152
Log of annualized change in county HPI through previous quarter	-0.007	0.038	-0.004	0.036	-0.004	0.038
Number of observations	167688		1099194		398006	

Table 4: Proportional-Hazard Model of Default (60-day delinquency)

	Private Securitized	Agency Securitized	Portfolio	Pooled
Variables	**Parameter (SE) Hazard Ratio**	**Parameter (SE) Hazard Ratio**	**Parameter (SE) Hazard Ratio**	**Parameter (SE) Hazard Ratio**
Vintage 2005	1.200*** (0.022) 3.320	1.123*** (0.018) 3.075	0.448*** (0.023) 1.565	1.004*** (0.012) 2.73
Vintage 2006	1.975*** (0.023) 7.208	1.852*** (0.021) 6.376	0.697*** (0.023) 2.009	1.658*** (0.012) 5.247
Vintage 2007	2.468*** (0.027) 11.801	2.585*** (0.023) 13.258	0.743*** (0.025) 2.102	2.239*** (0.013) 9.383
Other ARM nonretail channel	0.431*** (0.041) 1.539	0.100** (0.032) 1.106	0.299*** (0.044) 1.348	0.281*** (0.022) 1.325
FRM retail channel	-1.178*** (0.041) 0.308	-0.493*** (0.046) 0.611	-0.069 (0.044) 0.934	-1.073*** (0.019) 0.342
FRM nonretail channel	-1.043*** (0.041) 0.353	-0.328*** (0.046) 0.72	0.037 (0.048) 1.038	-1.011*** (0.019) 0.364
Option ARM retail channel	0.829*** (0.040) 2.292	1.687*** (0.053) 5.402	1.168*** (0.043) 3.215	1.112*** (0.021) 3.041
Option ARM nonretail channel	1.086*** (0.038) 2.964	1.960*** (0.050) 7.101	1.577*** (0.041) 4.842	1.42*** (0.018) 4.137
Interest-only ARM retail channel	0.700*** (0.039) 2.01	1.943*** (0.048) 6.978	0.300*** (0.041) 1.35	0.895*** (0.019) 2.448
Interest-only ARM nonretail channel	1.140*** (0.038) 3.126	2.033*** (0.048) 7.638	0.829*** (0.037) 2.29	1.239*** (0.018) 3.452
Interest-only FRM retail channel	0.839*** (0.047) 2.313	2.115*** (0.051) 8.286	0.359*** (0.077) 1.431	0.954*** (0.024) 2.595
Interest-only FRM nonretail channel	1.019*** (0.039) 2.77	2.140*** (0.049) 8.503	0.581*** (0.067) 1.789	1.090*** (0.020) 2.976
1-year ARM retail channel	-0.265*** (0.066) 0.767	-0.239*** (0.006) 0.787	0.408*** (0.073) 1.504	0.026 (0.037) 1.026
1-year ARM nonretail channel	0.247*** (0.053) 1.280	0.172 (0.170) 1.188	0.662*** (0.086) 1.939	0.220*** (0.039) 1.246
2- or 3-year ARM retail channel	0.398*** (0.040) 1.488	0.280*** (0.069) 1.323	0.592*** (0.054) 1.808	0.461*** (0.025) 1.585
2- or 3- year ARM nonretail channel	0.873*** (0.037) 2.394	0.499*** (0.061) 1.647	0.608*** (0.045) 1.836	0.673*** (0.020) 1.961
Origination FICO score	-0.003*** (0.000) 0.997	-0.005*** (0.000) 0.995	-0.008*** (0.000) 0.992	-0.005*** (0.000) 0.995
Dummy variable for missing FICO	-3.094*** (0.051) 0.045	-4.068*** (0.047) 0.017	-5.499*** (0.067) 0.004	-4.243*** (0.031) 0.014
Indicator variable for jumbo loan	-0.175*** (0.028) 0.84		0.033 (0.032) 1.033	0.175*** (0.019) 1.192

Jumbo loan interacted with 2005 vintage	0.075* (0.031) 1.078		-0.015 (0.04) 0.985	-0.162*** (0.022) 0.851
Jumbo loan interacted with 2006 vintage	0.207*** (0.031) 1.230		-0.026 (0.04) 0.975	-0.087*** (0.022) 0.917
Jumbo loan interacted with 2007 vintage	0.265*** (0.034) 1.304		0.107** (0.037) 1.113	0.014 (0.022) 1.015
Indicator for original term to maturity < 30 years	-0.007 (0.026) 0.993	-0.487*** (0.018) 0.614	-0.003 (0.024) 0.997	-0.271*** (0.012) 0.762
Indicator for 2-to-4-unit property	0.123*** (0.019) 1.13	0.187*** (0.021) 1.205	0.296*** (0.032) 1.344	0.182*** (0.013) 1.199
Indicator for unknown occupancy status	0.202*** (0.011) 1.224	0.145*** (0.011) 1.155	0.206*** (0.023) 1.229	0.116*** (0.007) 1.123
Indicator for second home	0.003 (0.019) 1.003	0.008 (0.016) 1.008	-0.198*** (0.031) 0.82	-0.018 (0.011) 0.982
Indicator for investor property	0.153*** (0.012) 1.166	0.120*** (0.012) 1.128	0.104*** (0.020) 1.11	0.142*** (0.008) 1.152
Subprime loan indicator (self-reported by servicer)	0.259*** (0.011) 1.296			0.003 (0.009) 1.003
Yield curve measure (gap between 10- and 3-month Treasury rates)	-0.457*** (0.006) 0.633	-0.524*** (0.006) 0.592	0.015* (0.007) 1.016	-0.431*** (0.003) 0.650
Average spread between note rate and 3-month Treasury rate interacted with ARM indicator	0.088*** (0.006) 1.092	0.380*** (0.011) 1.462	0.175*** (0.006) 1.191	0.148*** (0.003) 1.160
Average spread between note rate and 10-year Treasury rate interacted with FRM indicator	0.499*** (0.006) 1.647	0.637*** (0.006) 1.891	0.279*** (0.007) 1.322	0.555*** (0.003) 1.743
Change in county unemployment rate over prior 12 months	0.517*** (0.018) 1.677	0.118*** (0.020) 1.125	0.762*** (0.020) 2.143	0.503*** (0.011) 1.654
Indicator for updated LTV < 50 percent	-1.862*** (0.032) 0.155	-3.436*** (0.042) 0.032	-1.987*** (0.035) 0.137	-2.452*** (0.019) 0.086
Indicator for updated LTV 50-60 percent	-2.837*** (0.058) 0.059	-2.880*** (0.038) 0.056	-2.35*** (0.044) 0.095	-2.715*** (0.025) 0.066
Indicator for updated LTV 60-70 percent	-2.140*** (0.032) 0.118	-2.396*** (0.026) 0.091	-2.054*** (0.035) 0.128	-2.256*** (0.017) 0.105
Indicator for updated LTV 70-80 percent	-1.564*** (0.020) 0.209	-1.959*** (0.018) 0.141	-1.63*** (0.028) 0.196	-1.818*** (0.012) 0.162
Indicator for updated LTV 80-90 percent	-1.226*** (0.015) 0.293	-1.644*** (0.014) 0.193	-1.205*** (0.024) 0.30	-1.454*** (0.009) 0.234
Indicator for updated LTV 90-100 percent	-0.993*** (0.013) 0.371	-1.327*** (0.013) 0.265	-0.925*** (0.023) 0.397	-1.136*** (0.008) 0.321
Indicator for updated LTV 100-110 percent	-0.700*** (0.012) 0.497	-1.005*** (0.012) 0.366	-0.702*** (0.023) 0.495	-0.827*** (0.008) 0.437
Indicator for updated LTV 110-130 percent	-0.465*** (0.010) 0.628	-0.685*** (0.011) 0.504	-0.477*** (0.021) 0.621	-0.56*** (0.007) 0.571

Indicator for updated LTV 130-150 percent	-0.195*** (0.011) 0.823	-0.319*** (0.011) 0.727	-0.26*** (0.024) 0.771	-0.254*** (0.008) 0.776
Log of change in county HPI over prior 12 months	-4.004*** (0.117) 0.018	-6.614*** (0.121) 0.001	-1.569*** (0.154) 0.208	-4.199*** (0.073) 0.015
Number of observations	398,006	1,099,194	167,688	1,664,888
Number (and %) censored	310,927 (78%)	1,010,625 (92%)	127,832 (76%)	1,449,384 (87%)

***Significant at 0.1 % **Significant at 1% level *Significant at 10 % level

Table 5: Relative Proportional Hazards of Default: ARMs and AMPs for Agency and Private Securities and Bank Portfolio

	Agency Securitized (default category)	Private Securitized	Bank Portfolio	Bank Portfolio Relative to Private Securitized	Bank Portfolio Relative to Agency Securitized
	Parameter (SE) Hazard Ratio	**Parameter (SE) Hazard Ratio**	**Parameter (SE) Hazard Ratio**	**Parameter Hazard Ratio**	**Parameter Hazard Ratio**
Holder dummy	--	0.231(0.037)*** 1.260	0.489(0.039)*** 1.630	NA	NA
ARM nonretail channel	0.108 (0.033)*** 1.114	0.269(0.041)*** 1.309	0.337(0.044)*** 1.400	0.326*** 1.385	0.718*** 2.050
Fixed rate retail channel	- 1.006(0.026)*** 0.366	- 1.069(0.036)*** 0.343	-0.518(0.039)*** 0.596	0.809*** 2.246	0.977*** 2.656
Fixed rate nonretail channel	- 0.836(0.026)*** 0.433	- 1.010(0.036)*** 0.364	-0.527(0.041)*** 0.590	0.741*** 2.098	0.798*** 2.221
Option ARM retail channel	0.879(0.037)*** 2.408	0.896(0.037)*** 2.450	1.219(0.041)*** 3.384	0.581*** 1.788	0.829*** 2.291
Option ARM nonretail channel	1.162(0.032)*** 3.195	1.107(0.034)*** 3.026	1.752(0.038)*** 5.765	0.903*** 2.467	1.079*** 2.942
Interest-only ARM retail channel	1.105(0.028)*** 3.021	0.774(0.035)*** 2.168	0.358(0.040)*** 1.430	-0.158*** 0.854	-0.258*** 0.773
Interest-only ARM nonretail channel	1.172(0.028)*** 3.228	1.167(0.034)*** 3.212	0.948(0.037)*** 2.582	0.039 1.040	0.265*** 1.303
Interest-only FRM retail channel	1.229(0.033)*** 3.419	0.833(0.044)*** 2.300	-0.011(0.073) 0.989	-0.586*** 0.557	-0.751*** 0.472
Interest-only FRM nonretail channel	1.236(0.029)*** 3.441	1.036(0.036)*** 2.818	0.150(0.062)** 1.162	-0.628*** 0.534	-0.597*** 0.550
1-year ARM retail channel	-.015(0.060)* 0.858	- 0.238(0.066)*** 0.788	0.803(0.071)*** 2.233	1.299*** 3.666	1.307*** 3.695
1-year ARM nonretail channel	0.195(0.170) 1.215	-0.090(0.051)* 0.914	1.317(0.085)*** 3.733	1.665*** 5.286	1.611*** 5.008
2- or 3-year ARM retail channel	0.224(0.069)** 1.250	0.076(0.038)** 1.079	1.382(0.052)*** 3.982	1.564*** 4.778	1.647*** 5.191
2- or 3- year ARM nonretail channel	0.385(0.061)*** 1.469	0.442(0.034)*** 1.556	1.132(0.043)*** 3.101	0.948*** 2.581	1.236*** 3.442
Number of observations: 1,664,888					
Number (and %) censored: 1,449,384 (87%)					

***Significant at 0.1 % **Significant at 1% level *Significant at 10 % level

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