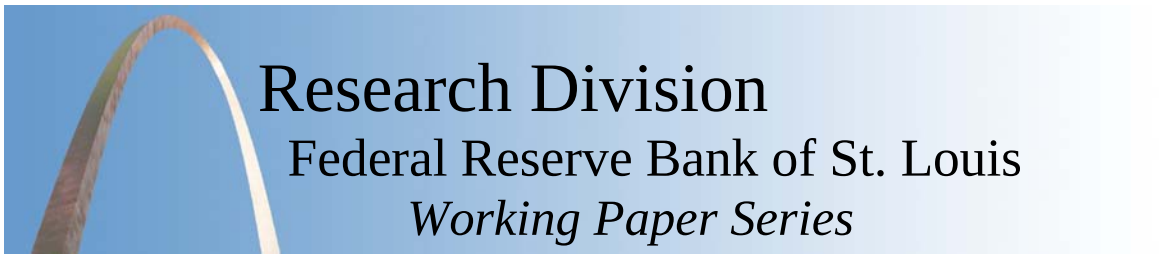


# Subprime Mortgage Design

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Working Paper 2008-039E
http://research.stlouisfed.org/wp/2008/2008-039.pdf

October 2008
Revised October 2011

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# Subprime Mortgage Design*

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August 2011

**Abstract**

This paper offers evidence on the design of subprime mortgages as bridge-financing products. We show that the viability of subprime mortgages was uniquely predicated on the appreciation of house prices over short-horizons. High rates of early prepayments on subprime mortgages are suggestive of the use of prepayments as an exit option. This paper argues that high early defaults on post-2004 originations can be explained when one considers high early prepayment rates for pre-2004 originations.

JEL Codes: G21, D82, D86.

*We are grateful to Franklin Allen, Eric Bond, Gordon Dahl, Mara Faccio, Jim Hamilton, Michael McCracken, Bruce Mizrach, Sangsoo Park, Dan Thornton, Dave Wheelock, Paul Willen, Paul Wilson, and Thierry Tressel for helpful comments and suggestions and to Byran Noeth and Yuman Tam for excellent research assistance. We would also like to thank the seminar participants of Rutgers University and the conference participants at the 45th Annual Conference on Bank Structure and Competition at the Federal Reserve Bank of Chicago, the Banking and Financial Intermediation Conference at the European Banking Center in Tilburg University, The Financial Crisis Conference at the Yale International Center, Summer Research Conference in Finance at the Indian School of Business, and the 9th Annual Bank Research Conference at the FDIC.

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# 1 Introduction

The collapse of the U.S. subprime mortgage market is one of the landmark events in recent financial history. Existing research has concentrated efforts on the centrality of securitization and the role of underwriting in explaining the demise of the subprime mortgage market.[1] However, not much is known about the rationale behind the design and origination of subprime mortgages. The purpose of this paper is to present evidence on the uniqueness of subprime mortgage design, especially as a means of "bridge financing" or credit accommodation. Our aim is to explain the boom and bust in the subprime mortgage market in light of the evidence from loan-level data on subprime mortgage contracts.

Subprime lending contracts were meant to provide mortgage financing for borrowers who would otherwise be denied prime avenues of conventional finance. Given the high risk associated with lending to such borrowers, most lenders prefer to be exposed to such risk over short horizons only. Subprime mortgages attempted to resolve these issues by forming a credit accommodation product over short horizons (Gorton, 2008). The proposed solution was to exploit the capital gains from house price appreciation over short horizons for mutual benefit of borrowers and lenders. The borrower benefits from temporary credit accommodation, and the monthly payments over a period of rising house prices allow borrowers to build up equity in their homes. *Ceteris paribus*, the borrower becomes less risky for subsequent mortgages. In short, subprime mortgages were designed to be rolled over and each time the horizon was deliberately kept short to limit the lender's exposure to such high-risk borrowers.

We begin by presenting five pieces of evidence on subprime originations. First, over 70% of subprime originations for each cohort (year of origination) are refinances of existing mortgages. Second, a growing and significant majority of these originations were *hybrid-ARM* products designed to reset into a fully indexed rate after two or three years.[2] Significantly, this reset is designed to be a step-up (but hardly ever a step down), so as to increase the payment burden and essentially force a refinancing of the loan. Third, most subprime originations included prepayment penalties with the penalty term expiring no sooner than the reset date on the hybrid-ARM.[3] Fourth, contrary to conventional wisdom,

[1] For details on the literature on subprime mortgages, see GAO (2010).

[2] A hybrid-ARM product includes an initial fixed-rate mortgage (FRM) at a *teaser rate* typically for a period of two or three years. It then shifts from the fixed payment schedule at a pre-specified reset date to a rate equal to a specified *index* (like LIBOR) plus a *margin*, just like any ordinary adjustable rate mortgage (ARM).

[3] This meant that the contract ensured that the penalty would be in effect at least as long as the borrower

teaser rates on hybrid-ARMs were not low when compared with those available on other mortgage products—prompting the borrower to seek refinancing at the earliest opportunity. In short, the mortgage was designed to ensure that subprime borrowers continue to make monthly payments at the high closing rates before they could refinance into another mortgage. Finally, most *defaults* on subprime mortgages, especially those originated in years 2006 and 2007 occur early—within the first two years of origination.[4] Consequently, much of the attention in this paper is focused on explaining such high early defaults.[5]

We demonstrate that such high early defaults on post-2004 originations can be explained when one considers high early *prepayment* rates of pre-2004 originations.[6] We find high prepayment rates for subprime mortgages especially for pre-2004 originations. Significantly, high prepayment rates for subprime mortgages are hardly surprising because refinancing was an integral part of the mortgage design. What is surprising is that (1) these prepayments occur early in the life of the mortgage and that (2) low interest rates have not always been the motivation behind prepayments (refinances) in the subprime market. First, it is important to recall that building up home equity is critical to the success of subprime mortgage design. Subprime lenders used prepayment penalties to postpone this eventuality in an effort to build up home equity for the borrower. However, in spite of prepayment penalties, we find that a significant proportion of subprime borrowers prepaid early. Second, the notable examples of high early prepayment are hybrid-ARM products originated in 2003, a year of historically low interest rates. As much as 83% of surviving hybrid-ARMs originated in 2003 were prepaid by the end of 2007.[7] The corresponding percentage for FRMs is 63%. Significantly, these numbers suggest not only high early prepayment rates on all product types but also that the low-interest-rate environment around 2003-2004 did not play a large role in the prepayment behavior of subprime mortgages.

was required to pay the teaser rate on the hybrid-ARM.

[4] For the purposes of this study, a mortgage is defined to be in default if it records a 90-day delinquency event (Cowan and Cowan, 2004). Alternative definitions of default, like 60-day delinquency or foreclosure, yield qualitatively similar results.

[5] The high early default rates on originations of 2006 and 2007 (which were yet to reset) have ruled out rate resets as a cause of the debacle.

[6] A mortgage is said to be prepaid in the event that the property is sold off or the original loan is refinanced. It is important to mention that most comprehensive databases, and consequently most empirical work on mortgages, typically do not distinguish between the two modes of prepayment.

[7] Presumably, some of these prepayments were refinances and, if so, they are likely to have refinanced into higher mortgage rates post-2004. The 6-month LIBOR (the index rate on over 80 percent of subprime ARMs) during 2003 ranged from a high of 1.37 percent in January 2003 and low of 1.08 percent in June 2003. The LIBOR increased steadily from 1.16 percent in March 2004 to 5.35 percent in September 2007.

Such high and early prepayments are suggestive of the use of prepayments as exit options by distressed borrowers. Post-delinquency, prepayment can be used as an exit option, presumably as a means to avoid foreclosure. In addition, this option can also be used before the borrower becomes delinquent on the mortgage as a means to avoid delinquency. We find compelling evidence on both counts. First, among the originations that register a 30-day (or a 60-day) delinquency within the first two calendar years, the proportion of mortgages that are subsequently either paid off or go into foreclosure is noticeably high but not significantly different across cohorts. Second, the proportion of originations that either register a 30-day delinquency within the first 18 months or are non-delinquent and prepaid within that period is also high but again not significantly different across cohorts.

Remarkably, while these early payment patterns do not change across cohorts, their composition does. Our results clearly show a pattern of high early prepayment rates on subprime mortgages for earlier cohorts and a sharp drop in these early prepayment rates for originations of later cohorts, especially during 2006-2007. Needless to say, the sharp drop in early prepayment rates is accompanied by a sharp increase in delinquency rates. Likewise, a sharp decline in post-delinquency prepayment rates during 2006-2007 has led to a sharp rise in the foreclosure rate. This result is robust across the different categories of occupancy, product type, and loan purpose. Moreover, the result holds regardless of whether we track originations over a given loan age or particular calendar dates and whether we consider post-delinquency or pre-delinquency behavior.

In light of this evidence, the paper demonstrates the centrality of economic conditions, especially house price growth, as drivers of payment patterns on subprime mortgages. We use a competing-risk hazard model to demonstrate how house price growth since origination and its interaction with credit variables influence prepayment and default hazards on subprime mortgages. For example, among subprime originations in the highest credit score quartile, the default hazard on those with low and negative house price growth can vary between 18 and 25 times the default hazard on those with above-median changes in house price growth since origination. Correspondingly, the prepayment hazard for those with low and negative house price growth can vary between 0.26 and 0.38 times the default hazard on those with above-median changes in house price growth since origination. More generally, our results confirm that even among borrowers of similar credit quality, those originations that experience low or even negative house price growth have drastically higher default and lower prepayment hazards in comparison with those originations that

experienced high house price growth.

From the point of view of our analysis of mortgage design and at least from the perspective of individual lenders and borrowers entering into subprime contracts, house price patterns have been treated as exogenous. In this regard, we are motivated largely by Shiller (2008), who argues that the most important single element in the house price boom is, as he puts it, the social contagion of boom thinking.[8] He argues (p.48):

> Other factors are widely cited as the cause of the housing boom.... to a large extent, these other factors are themselves substantially a product of the bubble, and not exogenous factors that caused the bubble.

As is well known, there was a strong and persistent appreciation in house prices in almost all U.S. metropolitan areas from 1995 to 2006, followed by a sharp downturn (see Figure 1).[9] In a regime of rising house prices, borrowers can avoid default by prepaying their loans (either through a refinance or a property sale). Moreover, if the house price appreciation is sufficiently large, a borrower can recover the costs of refinancing and even choose to extract equity. However, this option is no longer available when prices do not appreciate. Consequently, borrower defaults began to increase sharply in 2006, when house prices ceased to appreciate.

Recent work has attempted to explain defaults in subprime mortgages as occurring because of lax underwriting. The dominant explanation for the subprime crisis has been that securitization led to a severe weakening in underwriting standards over the past few years, eventually causing a downturn in this market (Dell'Arricia et al. 2008; Demyanyk and Van Hemert, 2009; Keys et al. 2009). However, evidence on lax underwriting for subprime mortgages due to the originate-to-distribute channel has been mixed (Bhardwaj and Sengupta, 2009; Elul, 2009; Agarwal et al., 2011). This paper departs from this debate and proposes an alternative hypothesis for the boom and bust in the subprime mortgage market.

Earlier work has alluded to the prepayment hypothesis presented in this paper (Cutts and van Order, 2005 and Pennington-Cross and Chomsisengphet, 2007). It is well established that subprime borrowers face significant liquidity constraints (Adams et al. 2009).

[8] Gimeno and Martínez-Carrascal (2010) provide macroeconomic evidence in support of this effect using Spanish data. For a more general equilibrium treatment of house price determination in this environment, see Hott (2011).

[9] The date for the peak on housing prices and the extent of the fall in home prices varies depending on the home-price index used (Aubuchon and Wheelock, 2008).

While this can imply that prepayment rates on subprime mortgages are higher than prime mortgages, these rates are relatively less sensitive to cyclical movements in the interest rate (Cutts and Van Order, 2005). Hurst and Stafford (2003) find that families experiencing a negative income shock or those that are severely liquidity constrained are 25% more likely to refinance than otherwise similar households. Moreover, there is evidence suggesting that some households extract equity even in times of rising interest rates, primarily with the motive of consumption-smoothing (Stanton, 1995; Agarwal, Driscoll, and Laibson, 2002). For more than a decade, increased financial awareness, lender competition, financial innovations, and structural changes in the mortgage market have significantly increased a household's ability to refinance a mortgage at very low costs (Bennett, Peach, and Persitiani, 2001).[10] However, it is important to note that a decrease in property values makes it difficult for households to refinance mortgages and take advantage of declining interest rates (Caplin, Freeman, and Tracy, 1997).

Section 2 presents a timeline on subprime lending that provides a brief overview from its origins to its current state. Section 3 provides the summary evidence on the unique design on subprime mortgages and their reliance on house price appreciation. In Section 4, we provide detailed evidence on a high rate of prepayments and the heavy use of early prepayments as exit options in the subprime market. Section 5 provides details on the estimation and results and Section 6 concludes.

# 2 A Timeline on Subprime Lending

## 2.1 Definition of Subprime and Data Sources

As a starting point of this analysis, we note that there is no universally accepted definition of subprime lending. Some studies have defined subprime lending in terms of borrowers, thereby classifying all loans originated to borrowers of "poor credit quality" as subprime loans. Operationally, any definition of "poor credit quality" involves selecting borrowers on the basis of credit history or alternatively some threshold credit score. However, this definition does not capture the fact that many borrowers with good credit history (scores) also made use of the subprime market. Alternatively, the definition on subprime can be based on lenders, thereby classifying all loans originated from a particular lender as

[10] Figure 2 illustrates the decline in one component of transactions cost—namely, points and fees levied as a proportion of the conventional loan amount. These costs declined from 2.5 percent in 1983 to roughly 0.4 percent in 2006.

subprime. The Department of Housing and Urban Development (HUD) has maintained a list of predominantly subprime lenders since 1993.[11] These lenders are known to specialize in the origination of subprime loans with high fees and interest rates. However, it is also true that the same lenders made loans to prime borrowers. More important, using this definition omits a significantly large number of subprime loans that were originated by prime lenders.

A third definition classifies all loans packaged into a subprime MBS as subprime mortgages. Like most other segments of the U.S. mortgage market (namely, Agency, Jumbo, and Alt-A), this definition classifies the loan according to the credit enhancement required in the secondary market. More importantly, it is based on a market-used classification as opposed to ad hoc criteria based on lender or borrower characteristics. In what follows, this study uses the third MBS definition of subprime.

Our principal data source is the ABS Database from the Corelogic-LoanPerformance (hereafter, LP) data repository containing loan-level data on securitized mortgages.[12] This is the largest and the most comprehensive mortgage securities data repository for non-prime mortgages. We restrict our analysis to loan-level data on over nine million first-lien securitized subprime mortgages originated between 1998 and 2006.

## 2.2 Early Years

Using the MBS definition of subprime has one obvious limitation. Given that the widespread securitization of subprime mortgages is a fairly recent phenomenon, this definition of subprime fails to include non-prime mortgages originated in the pre-securitization era. However, it is important to emphasize that subprime mortgages are not a recent phenomenon and were in existence before their rapid growth in the late 1990s and early 2000s.

In the years following the Great Depression, efforts were made to standardize existing mortgages into a long-term (20 years), fixed-rate, level-payment, self-amortizing mortgage (see Green and Wachter, 2005, for details). The dominant position of the standard mortgage developed under the auspices of the federal government, specifically the Federal Housing Administration (FHA), which was created in 1934 to insure and thereby enhance the liquidity of such home mortgages (Quigley, 2006). In an effort to stimulate housing construction during the postwar years, the FHA significantly liberalized its terms for

[11] See http://www.huduser.org/portal/datasets/manu.html for details.

[12] Details on this database—its evolution, coverage, and comparison with other mortgage databases—are available in GAO (2010).

providing insurance.[13] By so doing, the FHA created the first non-traditional mortgages (NTMs)—the precursor to modern day subprime mortgages (Pinto, 2010).

### 2.3 Origins of Subprime

Chomsisengphet and Pennington-Cross (2006) argue that the growth of NTMs into non-prime products is largely due to a sustained period of deregulation in the 1980s and 1990s, which affected both demand and supply of mortgage finance. First, the Depository Institutions Deregulation and Monetary Control Act (DIDMCA), adopted in 1980, extended the favorable variable rate ceiling to all lenders and thereby preempted all state usury ceilings for first-lien loans. As a result, lenders who wanted to charge higher rates had new incentives to refinance first mortgages, rather than to offer junior-lien mortgages that were subject to state usury laws. In effect this law helped create the most common type of subprime loans—namely, refinances of first-lien mortgages. Next, the Alternative Mortgage Transaction Parity Act (AMPTA) of 1982 permitted the use of variable interest rates and balloon payments, thereby overriding many state laws that prevented the use of non-conventional mortgages. Finally, the Tax Reform Act of 1986 increased the demand for mortgage debt because it prohibited the deduction of interest on consumer loans, yet allowed interest deductions on mortgages for a primary residence as well as one additional home (Chomsisengphet and Pennington-Cross, 2006). According to the authors (p. 38), it "made even high-cost mortgage debt cheaper than consumer debt for many homeowners," thereby facilitating debt consolidation. Each of the three laws above contributed to the growth of non-prime lending in the form of cash-out refinances as a means of consolidation of other (more expensive) consumer debt.

During the late 1970s and the early 1980s, the dominant non-conforming loan originators were savings and loan institutions, whose traditional business was originating 30-year fixed-rate mortgages funded by retail deposits and other short-term financing. Bruskin et al. (2000) observe that the vast majority of non-conforming mortgages were traded as unsecuritized "whole loans." Sellers in this market were typically unrated or non-investment-grade entities that also serviced these loans and retained the subordinated interest. They argue that two pieces of legislation in the mid-1980s provided a significant boost for the

[13] These efforts raised the maximum term of the mortgage to 30 years and also raised the loan-to-value ratio to 95 percent (from the initial maximum of 80 percent). With time, the share of FHA loans dwindled due to loan size caps and private mortgage insurers (PMIs) started taking their place.

non-agency MBS market.[14] The issuers in this market included mortgage lenders and conduit operations, large originators of non-conforming loans, and banks and thrifts as well. It was around this time that issuers began to sell the subordinated classes of securities that were earlier retained by the originator. These subordinated classes of securities were unrated and conservatively priced because investors had little historical data to enable pricing to risk.

Non-agency MBS issuance grew from 3% of all MBS in 1986 to 16% in 1992. Annual issuance quadrupled between 1990 and 1993 but declined thereafter as refinancing activity dried up as a result of a rise in interest rates. This led originators to broaden their base to subprime segments and use specialized programs involving high LTV loans (informally referred to as "125"s).[15] The growth of this subprime segment suffered from the sovereign debt crises around 1997-1998. Pullback from those investing in such securities dried up financing for lenders who relied on securitization to finance their lending operations; these conditions severly affected originations of subprime mortgages. In summary, it is clear that many of the events of the current subprime crises were witnessed before, albeit on a much smaller scale and with lesser impact.

### 2.4 Mortgage Products and Securitization

A concurrent development to the growth of subprime mortgages was the increasing popularity of hybrid-ARM mortgages. These products were developed in the 1980s and originally structured for Jumbo mortgages. Over time and with the development of the 3/1, 5/1, and 7/1 hybrid varieties, hybrid-ARM products grew in popularity not only for jumbo but for the agency market as well.[16] However, product securitization of hybrid-ARMs was slow to develop. Most accounts put the development of hybrid-ARM securitization in the late 1990s.[17] Hybrids have used a variety of indices. The one-year current maturity Treasury

[14] These include the Secondary Mortgage Market Enhancement Act (1984), which allowed for shelf-registration of non-agency MBS, and the Real Estate Mortgage Investment Conduit Legislation of 1987, which allowed subordination as a credit enhancement technique for any type of mortgage. Most of the discussion here follows Bruskin et al. (2000).

[15] As the name suggests, such loans are partially unsecured consumer loans with a LTV ratio of 125%. Naturally, these were typically offered to borrowers of good credit quality with rates of roughly 500 to 600 basis points above conforming mortgages. For more details, see Bruskin et al. (2000).

[16] A "3/1" implies a teaser (fixed) rate for the first three years of the mortgage and subsequently, an ARM loan that resets every year.

[17] As Bhattacharya et al. (2005, p. 260) point out, "Conforming hybrid-ARM issuance was $128 billion in the first nine months of 2004 which represented about 27.5% of 30-year fixed rate issuance. In contrast, in 1998, issuance of hybrid ARMs was only 1.7% of 30-year fixed rate issuance. Jumbo hybrid ARMs exhibited

(CMT) yield was the predominant index of choice before 2001. However, the discontinuation of the one-year Treasury bill brought LIBOR-indexed hybrids into prominence. Another reason for LIBOR-indexed hybrids was securitization, since LIBOR naturally appeals to many institutional investors. As a result, the LIBOR-indexed hybrids were non-existent at the end of 2000 but prominent by 2002 (Westhoff and Srinivasan, 2006). This is true for both prime and non-prime products.

Securitization of subprime hybrid-ARMs also grew around this period. It is important to note that the development of the hybrid-ARM product in general was not unique to subprime mortgages. Using data from various sources, we observe that hybrid-ARM products in subprime were also not confined to securitized products alone. These data are presented in Tables A.1-A.3 in the Appendix. For example, we find that less than 5% of portfolio loans originated before 2000 were hybrid-ARM products. However, at the peak of the subprime securitization boom in 2005, over 63% of portfolio B & C grade (subprime) loans originated were hybrid-ARM products. Although securitization may well have aided and abetted the popularity of subprime hybrid products, *prima facie* evidence suggests that the emergence and growth of hybrid-ARM products was not a purely securitization phenomenon.

The exponential growth in these hybrid mortgage products has been attributed to several factors. On the demand side, one conjecture is that such products appealed to a younger demographic with possible expectations of relocating or trading up or looking for relatively low monthly payments as a means of qualifying for a mortgage (Emmons et al., 2011). In addition, their growth is often attributed to a sharp increase in the steepness of the yield curve around 2001. The 10-year/2-year spread that averaged -22 basis points in 2000, averaged in excess of 200 basis points around 2002. As Bhattacharya et al. (2005, p. 261) observe, this raised the affordability of hybrid products: "the attractiveness of ARMs results from the fact that borrowers attain the security of three to five years of fixed payments at rates significantly lower than those of 30-year fixed-rate mortgages." In the next section, we elaborate on the design of such products. We also find evidence that hybrid-ARM products typically involve originations with higher credit risk attributes (see Section 3.1).

Among hybrid-ARM products, it appears that the popularity of the 2/28 mortgage was centered on the subprime segment (Haughwout et al., 2009).[18] We provide a heuris-

a similar magnitude of growth in this period."

[18] A "2/28" is a hybrid-ARM with a teaser (fixed) rate for the first two years of a 30-year mortgage term.

tic explanation behind the rapid growth of this product, a formal treatment behind the optimality of 2/28 mortgages for subprime borrowers is left to future research. In comparison with other hybrid products, the 2/28 offered earlier prepayment, thereby reducing investors' risk-exposure to shorter horizons (Schultz et al., 2006). At the same time, this product was likely better aimed at engaging the borrower over a sufficient length of time and consequently building enough home-equity to refinance (see Section 3 for details). However, data limitations do not permit us to determine whether the 2/28 was preferred because of superior RMBS performance or simply because it could generate higher origination volumes. It is likely that the global shortage of safe securities was the central force behind the creation of complex financial instruments and engineering to generate premium-rated securities from a pool of subprime mortgages (Caballero, 2010). At a time when securitization was singularly involved in bridging the gap between the rise in demand for (safe) securities and "the expansion of its natural supply," lenders may have aggressively promoted this product as "the minimum resistance path for the safe-assets imbalance to release its energy" (Caballero, 2010, p.3).

### 2.5 The current state of the market

In the aftermath of the current mortgage crisis of 2006-2007, private-label securitization of non-prime mortgages has ceased. With a sharp decline in benchmark rates, the share of ARM products as a proportion of all securitized mortgages has also declined sharply from a peak of 45 % in 2006 to 9.5 % in 2010. Furthermore, this period witnessed a complete disappearance of non-traditional mortgage products such as hybrid-ARMs, option-ARMs, and interest only ARMs (Noeth and Sengupta, 2011). As explained below, these products made up a significant proportion of the securitized subprime market before 2008. Interestingly, there has been a revival of subprime mortgages in the form of portfolio loans made by a handful of private investment firms (Androitis, 2011). While these loans allow for lower credit scores and flexible documentation requirements, they have increased downpayment requirements significantly. More importantly, some of these loans appear to have a balloon structure requiring a borrower to amortize or refinance after five to seven years.

# 3 Mortgage Design

Table 1 presents the distribution of loans by product type and year of origination (cohort). To simplify classification over a very broad range of product types in the market, we define these products as ARM2 and ARM3, respectively. As seen from Table 1, the subprime mortgage market comprises mainly three product types: FRM, ARM2 (which includes the hybrid 2/28 mortgage product), and ARM3 (which includes the hybrid 3/27).[19] Over the years, the hybrid-ARM products came to dominate originations in the subprime market. Since most of the troubled mortgages belonged to this product segment, we examine this segment more closely.

Table 2 presents a summary of the interest rates on subprime mortgage contracts at the time of loan origination. The second and third columns give us the unconditional means of the closing rate on ARM and FRM products, respectively. The fourth column gives us the mean on margins for loans of a given cohort, which on average has been a little more than 6 % for such loans. The fifth and sixth columns give us the (unconditional) mean of the minimum and the maximum interest rates that could be charged over the lifetime of these contracts. The last column indicates that, for an overwhelming majority of subprime loans, the closing teaser rate was the lifetime minimum that would be charged on such mortgages.

Essentials of the role of interest rates in subprime mortgage design can be obtained from Table 2. Evidently teaser rates on hybrid-ARM products were not significantly lower when compared with closing rates on other products for subprime mortgages. In fact, we do not find any significant difference between the unconditional means of closing rates on FRMs and hybrid-ARMs. This is true for originations of all cohorts in our sample period (1998-2007). Typically however, teaser rates on hybrid-ARMs are lower than borrowers of a given risk profile are likely to receive on other comparable products, which would suggest some degree of self selection into hybrid-ARM contracts by borrowers with higher risk characteristics.

Second, the closing rate on an overwhelming majority of hybrid-ARM originations is equal to the minimum rate for the lifetime of the mortgage. While this is not surprising, it is important to point out that this restriction ensures that the loan resets to the indexed rate could only be a "step up" but not a "step down." Third, these closing rates on subprime

[19] Not all ARM2 and ARM3 mortgages have a thirty-year maturity period. Therefore, while 2/28s and 3/27s make up the majority of loans in these two categories, they do not constitute all such loans.

mortgages (both ARMs and FRMs) are significantly lower than those on other subprime markets (such as subprime auto-loans). For example, Adams et al. (2009) report that the average interest rate (APR) on subprime auto loans in their sample is 26.2 %. As explained below, this distinction is critical for understanding the design of subprime mortgages.

The pricing of subprime mortgage products raises some important questions. First, why were interest rates on subprime mortgages significantly lower than those on other subprime markets, like those on auto loans? Second, why do hybrid-ARM subprime products have resets that step up but do not step down? To answer these questions, our analysis follows the theory on mortgage design as presented in Gorton (2008). In what follows, we provide empirical evidence in support of this hypothesis, arguing that, at least from the perspective of individual lenders and borrowers entering into subprime contracts, house price patterns can be treated as exogenous.

As will be shown below, default rates on subprime mortgages even for the best cohorts were significantly high. Therefore, while the interest rate on such mortgages can be set to price the risk (like that on subprime auto loans), it is not likely that such a rate is affordable for subprime borrowers. This is because mortgage payment obligations are significantly higher than payments for other forms of consumer debt, including auto loans. In addition, we observe that, unlike auto loans, the underlying values of the collateral on residential subprime mortgages were appreciating in price. This would give an otherwise distressed subprime borrower the option to prepay the mortgage (either refinance or sell the property) and avoid default. In short, the basic idea of the subprime loan recognizes that the dominant form of wealth of low-income households is potentially their home equity. Therefore, unlike subprime auto loans, subprime mortgages could have registered significantly lower default rates through prepayment if the underlying collateral appreciated in value. As a result, mortgage products could be offered at significantly lower rates than auto loans.

Gorton (2008) argues that lenders avoided exposing themselves to long-term contracts (such as thirty-year mortgages) because of the high risk profile of subprime borrowers. They did this by placing terms and conditions on the loan that would ideally force the borrower to return to the lender at shorter intervals. In a nutshell, the fully indexed rate that the borrower is required to pay at the time of the teaser rate reset was designed to be a step up so that the borrower had a strong incentive to refinance the loan.

This hypothesis helps answer the second question posed above. The hybrid-ARM product with teaser rates and step up reset is essentially designed to limit the lender's exposure to a mortgage significantly shorter than thirty years. Furthermore, over 70 % of subprime

originations were refinances and a majority of these were cash-out refinances. From the borrower's perspective, the subprime mortgage contract was viewed as a means to tide over temporary liquidity constraints. It is important to remember that subprime borrowers are otherwise unable to access more conventional sources of financing because of their impaired and imperfect credit histories. These features suggest that subprime mortgage contracts have the elements of a bridge-financing loan for borrowers facing liquidity constraints.

The view that these products were originally intended as bridge-financing is corroborated in policy documents as well:

> These products originally were extended to customers primarily as a temporary credit accommodation in anticipation of early sale of the property or in expectation of future earnings growth. However, these loans have more recently been offered to subprime borrowers as credit repair or affordability products.[20]

Importantly, subsequent legislation has made it mandatory that the borrower's repayment ability should be judged by his ability to pay the fully indexed rate and not the teaser:

> For all nontraditional mortgage loan products, an institution's analysis of a borrower's repayment capacity should include an evaluation of their ability to repay the debt by final maturity at the fully indexed rate, assuming a fully amortizing repayment.[21]

Obviously, the above design raises doubts as to the long-run viability of such mortgage products. Gorton (2008) argues that the mortgage design sought to benefit from house price appreciation over short horizons. In a period of rising house prices, borrowers can build up equity in their homes and become less risky, ceteris paribus, on subsequent mortgages. This allows them to refinance at a lower rate (on the subsequent mortgage), which also reduces the likelihood of default. Presumably, this would require multiple refinances till the borrower is eligible for more conventional sources of financing. Critical to the success of this design is that the borrower does not refinance early and extract equity. This is achieved by including a prepayment penalty on the mortgage contract.

Table 3 presents the summary data on prepayment penalties, prepayment terms, and their relation to reset dates. Columns (1) and (2) show that the approximately 60% to75%

[20] Board of Governors of the Federal Reserve System (2007).
[21] Board of Governors of the Federal Reserve System (2006).

of FRMs and 70% to 80% of ARMs include prepayment penalties. These summary findings can be used to corroborate Gorton's hypothesis. If true, then for a majority of these loans the prepayment term should not expire before the reset date. That is, the penalty would compel borrowers to continue making payments until the reset date, at which time the borrower could opt to prepay (refinance). Indeed, that is exactly what we find for over 90 % of such loans (Column 3). Interestingly, the prepayment term ends exactly on the reset date for a majority of loans and this proportion seems to increase over the years in our sample period (Column 5). For loans in which the prepayment term expires before the reset date, the length of the term (in months) is on average half the duration for which the teaser rate is in effect (Column 4). Conversely, for loans in which the prepayment term is longer, it is on average at least 1.5 times lengthier (Column 7). The results in Tables 2 and 3 demonstrate the rationale behind the design on subprime mortgages. Most importantly, they demonstrate that the viability for an overwhelming majority of subprime contracts was predicated on the appreciation of home prices.

### 3.1 Product Choice and Interest Rates

To model consumer product choice and margin requirements on subprime products, we use the Heckman's (1979) two-step estimation procedure (results shown in Table 4). In the first step we use a selection equation (probit) to model the choice of a hybrid-ARM product over the FRM product (Column 1, Table 4). The second step is a least squares regression determining the margin requirement on hybrid-ARM products (Column 2, Table 4). In addition to location and property characteristics, both equations use origination characteristics as covariates. Notably, however, there are some endogeneity issues with these specifications since most loan contract terms are co-determined. This caveat would apply to interpretations of causality here.

As reported in Table 4, coefficients have the expected signs and are highly significant across the different specifications. In comparison with FRMs, hybrid-ARM loans are more likely to be originations with lower origination FICO, higher LTV, and prepayment penalties but without full documentation (see Column (1)). Evidently, owner-occupied and second-home properties are less likely to be financed with hybrid-ARM products than investment properties. This would suggest that ex ante there is a self-selection of observably riskier originations into hybrid-ARMs. In the second stage, we estimate an OLS regression on the determinants of the *margin* on hybrid products. In addition to the covariates in the

first stage, we use a dummy variable that takes the value one if the product type was an ARM2 and zero otherwise. Interestingly, the coefficient on the ARM2 dummy is negative and significant, showing that ARM2 loans were more attractive than other hybrid-ARM products in terms of lower margin rates on the product. As in the first stage, all coefficients are statistically significant and have the expected sign. For example, margin requirements are lower for originations with higher FICO scores, owner-occupied properties (as opposed to investor properties), and full documentation for the mortgage.

From the standpoint of the mortgage contract design, margin requirements should ideally reflect borrower risk. However, if our conjecture on mortgage design is correct, then most borrowers would seek to prepay the mortgage on or around the reset date. To the extent that borrowers expect to prepay around or near the reset date, it is the closing rate (the teaser rate for hybrid-ARM products) on the mortgage rather than the margin rate that is likely to be more relevant to borrower origination choice. In any event, both the margin and the closing rate should ideally reflect credit risk on the origination. To test this further, we define the variable *Mortgage Rate Spread* as the difference between the closing rate on the mortgage and the 6-month LIBOR average for the origination month. Column (3) in Table 4 reports the OLS estimates for this spread on the set of origination characteristics discussed above. Indeed, the coefficient estimates for the *Mortgage Rate Spread* are similar in sign and magnitude to those for the *Margin* estimates in Column (2).

These results would suggest that both the *Spread* and the *Margin* capture similar effects of origination characteristics. However, ARM2 products have lower margin rates in comparision with ARM3 products, whereas in comparison with FRM products ARM2 and ARM3 products on average have a marginally higher *Spread*. Moreover, we see little evidence of lower *Margin* or *Spread* in exchange for prepayment penalties on originations. On the contrary, originations with higher rates are more likely to have prepayment penalties on them. Given our earlier results, this could well be a reflection of penalties and higher rates being correlated on riskier originations. However, without identification of demand and supply effects, it is difficult to attribute causality or optimality of such arrangements. These regressions are best viewed in terms of the equilibrium relationship between contract terms (product types and mortgage rates) on the one hand and origination characteristics on the other.

# 4 The Evidence on Subprime Prepayments

Table 5 summarizes prepayment behavior in the subprime mortgage market. The numbers denote the proportion of surviving mortgages (i.e., those not in *default*) by product type that were prepaid within 12 months from the year of origination. The period of study in each case is from the time of origination to the end of a calendar year up to the first two, three, or four calendar years after the year of origination.[22] For example, 38 % of all surviving FRM loans originated in 1998 were prepaid by the end of 2001. Three trends are immediately obvious from the data. First, the prepayment rates for ARMs are higher than those for FRMs of the same cohort. Second, for mortgages originated between 1998 and 2003, the prepayment rates continue to increase progressively over time. This is true across all product types. Third, for mortgages originated after 2004, there has been a decline in the prepayment rates, and this has been particularly severe for the years 2006 and 2007.

Following our analysis of mortgage design in the previous section, we should witness a high refinance rate for subprime originations in our data. Indeed the evidence points to the critical role of prepayments in the subprime mortgage market. Moreover, as stated previously, prepayment can be an exit option for distressed borrowers, and this option can be used either before the borrower becomes delinquent on the mortgage, as a means to avoid delinquency, or, after delinquency, as a means to avoid foreclosure.

To provide a more detailed picture of these trends, we track the following loan status variables over time: delinquency, prepayment, and foreclosure. For each cohort (year of origination), we record loans that experience a delinquency (as a fraction of total originations) within the first two calendar years after the year of origination. We do this separately for loans that experience a 30-day and a 60-day delinquency over these periods. Among these delinquent loans, we tabulate those that were prepaid and those that went into foreclosure. Table 6 presents these summary results for owner-occupied subprime originations.[23] The pattern that emerges is robust across occupancy categories, loan purpose, and product type and is summarized as follows:

1. Both 30-day and 60-day delinquencies are higher for loans originated after 2004.
2. Loans that register a 30-day delinquency are more likely to prepay than loans that

[22] Our choice of calendar year over the more conventional method of presenting the distribution by loan age here is motivated by much of the commentary on this market arguing that conditions started worsening after a calendar date.

[23] Owner-occupied originations comprise over 90 percent of all originations for each cohort in our sample period (1998-2007).

record a 60-day delinquency in the same period.

3. There is an increase in foreclosure rates on delinquent loans for originations after 2004, especially during 2006-2007.

4. Finally, and perhaps most importantly, there is a sharp decline in prepayment rates for post-2004 originations, especially during 2006-2007.

Clearly, prepayments and foreclosures can be viewed as exit options following a delinquency. Interestingly, the total of early prepayments and foreclosures post-delinquency (obtained by adding up the percentages in panels B and C of Table 6) for each cohort does not reveal an increasing trend. Stated differently, the percentages of delinquent loans that were either prepaid or went into foreclosure are not significantly different over our sample period. Remarkably, however, there is a sharp drop in the proportion of early prepayments accompanied by a sharp rise in the proportion of foreclosures for post-2004 originations, especially during 2006 and 2007.

However, this still does not address the concern that delinquencies are marginally higher for post-2004 originations. To explain this feature of the data, we adopt a similar approach, but this time by studying pre-delinquency repayment behavior. In Figures 3-5 we present, for the first 18 months since origination, the percentage of mortgages for every cohort that either (1) registered a 30-day delinquency or (2) were prepaid before recording a 30-day delinquency. We also calculate the total fraction of loans in either of these categories. Note that the duration of study is different from the tables presented above in that we observe each loan for the first 18 months since origination rather than up to a specific calendar date. But just as observed previously, the total proportion of early prepayments and delinquencies is not significantly different over our sample period. Moreover, the pattern appears to be similar to that observed in Table 6: a significantly large fraction of total originations are prepaid early in the subprime market and this fraction drops for originations after 2004, especially during 2006-2007. Most important, these graphs show that these findings are robust across variations in product type (Figure 3), occupancy (Figure 4), and loan purpose (Figure 5).

To summarize, we find a distinct pattern of high early prepayment behavior on subprime mortgages for earlier cohorts followed by a sharp drop in early prepayment rates for later (post-2004) cohorts, especially during 2006-2007. This result holds regardless of whether we track originations over a given loan age or particular calendar dates, consider post-delinquency or pre-delinquency behavior, study repayment across the different categories of occupancy, product type, and loan purpose. Post-delinquency, the total fraction of

loans that either go into foreclosure or are paid off remain roughly the same for all cohorts. Again, the total fraction of loans that register their first delinquency or get paid off before registering a delinquency are not significantly different for all cohorts. Our data do not permit us to determine the cause of prepayment. However, prepayments are an exit option available to a distressed borrower unable to make mortgage payments. Moreover, given that a significant proportion of subprime originations came with prepayment penalties for two or more years, the trend in early prepayments is suggestive of prepayments under distress.

Why are early prepayments important to our analysis? Much of this has to do with the alternative explanations behind subprime defaults. Figures 6 plots the Kaplan-Meier default probabilities. With the exception of originations in 2003, default probabilities increased progressively for each year in the sample period. However, the default probabilities rise sharply for post-2004 originations. Notably, high default rates for 2005-2007 cohorts occur well before the loan age of 24 months, typically the reset date on ARM2 products. Clearly, a jump in the payment obligations on reset cannot be the explanation behind the crisis.[24] Following this, much of the commentary on the subprime crisis has sought to explain the high early defaults in post-2004 originations. This paper shows that high early defaults on post-2004 cohorts can be explained in terms of high early prepayment rates for the pre-2004 originations.

In contrast to Figure 6, Figures 7 plots the Kaplan-Meier prepayment probabilities. The two plots are not mirror images of each other because there is a third option for the borrowers to stay current (or delinquent). What has been omitted from these commentaries is that, for post-2004 originations, every cohort shows a progressively lower (early) prepayment probability rate than earlier cohorts for the same age on the loan (Figure 7). After two calendar years, the prepayment probabilities were 0.44, 0.46, and 0.45 for mortgage originations of 2002, 2003, and 2004 cohorts. However, the prepayment probability on originations of 2005 and 2006 cohorts are 0.36 and 0.23, respectively (note that this includes their performance during the calendar years 2006 and 2007).

[24] An earlier explanation of the subprime debacle was that originations made in the low rate environment around 2003 and 2004 were hit by a jump in the payment obligations when the rate reset to a prohibitively high indexed rate (during 2005-2007) when the rates were significantly higher.

# 5 Estimation and Results

As is standard in the literature on mortgage defaults, this section uses the competing risk hazard framework to study the determinants of default and prepayment. Default and prepayment are modeled as competing risks.[25] To formalize our argument, we split borrower repayment behavior into three possible outcomes: (1) the borrower defaults on the loan, (2) the borrower prepays, (3) the loan is current or even 30-day or 60-day delinquent. We denote the exit routes by event $j$, where the two exit events are given by subscript $j = 1, 2$. For the purposes of this analysis, we do not consider loan status (3) above as an exit event. Let $T_{ij}$ be the age (in months) at which borrower $i$ chooses event $j$. The loan performance of borrower $i$ is observed for $min_j\left(T_{ij}\right)$ and the hazard function, $h_{ij}(t)$, specifying the instantaneous probability of occurrence of event $j\,(1, 2)$ for mortgage $i$, is given as

$$h_{ij}(t) = \lim_{\Delta t \to 0} \frac{\Pr(t \leq T_{ij} < t + \Delta t | T_{ij} \geq t)}{\Delta t} \tag{1}$$

Following Cox (1972), the semiparametric representation that we estimate takes the form

$$h_{ij}(t) = h_{0j}(t) \exp(X_i \beta_j)\,, \tag{2}$$

where $h_{0j}(t)$ is the cumulative baseline hazard rate for event $j\,(1, 2)$ and $X_i$ is the vector of covariates on mortgage $i$.

Throughout the analysis and unless explicitly stated, we control for the following origination characteristics. Loan characteristics such as loan type (conventional, VA, FHA, government, etc.), loan purpose (purchase, cash-out refinance, no cash-out refinance, etc.) and term of prepayment; and property characteristics such as the number of units, property type (condo, townhouse etc.), and home value quartile to which the property belongs are included. Dummy variables for occupancy status (owner-occupied, investor-owned, or second home) and loan source (like retail, broker, realtor, etc.) and location (state in which the property is located) are also included. Finally, in all regression specifications by product type, we include dummy variables for each cohort (year of origination).

In addition, we include the variable *Fees and Points* calculated from the Freddie Mac PMM Survey, the most commonly available series for prime borrowers (Figure 2). Although

[25] A mortgage is considered to be in default if it records a 90-day delinquency event (Cowan and Cowan, 2004). As mentioned earlier, prepayments include mortgages that are paid off either because the property is sold off and loan repaid or because the existing mortgage is refinanced.

the data are collected from prime transactions, the proxy captures how transactions costs have declined in the mortgage market over this period.[26] We also include a dummy variable, *Prepayment Penalty*, that takes the value 1 if there is a prepayment penalty on the mortgage and zero otherwise. As is common in this literature, we measure the intrinsic value of refinancing by the present value annuity ratio or $PV_t$ measure proposed by Richard and Roll (1989). $PV_t$ measures the ratio of the present value of the payments on mortgage principal outstanding at time $t$ using the existing mortgage rate, $r_0$, to that using the current rate, $r_t$, available on refinance:

$$PV_t = \frac{r_0}{r_t}\left[\frac{1-(1+r_t)^{t-M}}{1-(1+r_0)^{t-M}}\right],$$

where $M$ is the maturity period in number of months (360 months for a 30-year mortgage). Note that if $r_t = r_0$, $PV_t = 1$. There is an incentive to refinance if $r_t < r_0$—that is, if $PV_t > 1$. Defining $r_t$ and $r_0$ to be the 6-month LIBOR at the time of the event and the time of origination, we create the variable *Present Value Annuity Ratio (PVAR)*. Ignoring transaction costs, we would expect the incentive to refinance to strengthen the more the $PVAR$ exceeds 1. Kau et al. (1993) suggest that interest rate volatility reduces the probability of prepayment. Following Ambrose and Sanders (2003), we define the variable *Interest Rate Volatility* as the standard deviation of the 6-month LIBOR for the previous 24 months.

The economic variables that we consider in this framework are house prices and unemployment rate in the location of the property (Fogel et al., 2011). Initially, we study two different measures of house price changes. The first is *House Price Growth* ($HPG$), which measures the growth of house prices since origination for the MSA in which the property is located. For this, we use the MSA-level repeat sales index published by the Federal Housing Finance Agency (FHFA). The second measure is year-on-year *House Price Change* ($HPY$) at the MSA-level using the same price index. In addition, $PosUnempG$ is defined as a dummy variable that takes the value 1 if there is an increase in the unemployment rate over the previous year (as measured by the MSA level unemployment data series published by the Bureau of Labor Statistics (BLS)) and zero otherwise.

Before discussing the results, we provide a summary for the organization of tables. Our baseline regression is presented in Table 8. The covariates in Table 8 include house price

[26] To the best of our knowledge, we are yet to come across a data series on fees and points in the subprime mortgage market.

growth since origination (Panel A) and year-on-year change in house prices (Panel B). The results are qualitatively similar. Non-linearities in the relationship between covariates and default are examined in Table 9. We use dummies of credit and economic variables to examine non-linearities in their relationship to default and prepayment. A list of these dummy variables is provided in Table 7. Next, we examine the effects of interactions in credit and economic variables on default and prepayment. The summary results for the effects of these interactions are reported for house price growth in Table 11 and unemployment in Table 12. For example, in Tables 11 and 12, column 1 shows hazard ratios for default on ARM2 products for interactions with house price growth (Table 11) and unemployment (Table 12). The regression results used to calculate the ratios in column 1 are presented in Table 10. The additional regression results used to calculate the ratios in columns 2-6 of Tables 11 and 12 are presented in this appendix as Table 10A-E.

**Baseline Regressions** The estimated hazard ratios for the baseline competing risk regression model are reported in Table 8. We report the hazard ratios for the three major product types–namely, ARM2, ARM3, and FRMs–under both the time-to-default and the time-to-prepayment specifications. The qualitative results appear robust across all product types for each specification; the estimated hazard ratios are highly significant in all specifications. A hazard ratio greater than 1 indicates that the increase in the relevant variable is associated with an increase in the delinquency or prepayment hazard—the converse is true for a hazard ratio that is less than 1. The covariate FICO (scaled) refers to FICO score of the mortgagor at origination divided by 100. Accordingly, the default hazard on an ARM2 product origination with a hundred-point higher FICO score is 0.466 times the default hazard on the lower FICO origination. Likewise, the hazard ratios on the dummy variable for low-documentation for ARM3 products can be interpreted to mean that ARM3 loans with less than full documentation have 1.499 times the delinquency hazard but only 0.963 times the prepayment hazard of ARM3 loans with full documentation. Not surprisingly, lack of full documentation increases the delinquency hazard but marginally reduces the prepayment hazard. From the hazard ratios in Table 8, it is obvious that increases in origination FICO and house price growth reduce the default hazard, whereas increases in LTV, *Fees and Points*, and *Interest Rate Volatility* increase the default hazard. Not surprisingly, increases in *Fees and Points*, origination FICO, *House Price Growth,* and the *PVAR* increase the prepayment hazard. At the same time, the likelihood that the origination has less than full documentation or includes a prepayment penalty reduces the

prepayment hazard.

Our object of interest here is the hazard ratios for house prices at location–namely, *House Price Growth* (*HPG*) and year-on-year *House Price Change* (*HPY*). Not surprisingly, an increase in local house prices reduces the default hazard but increases the prepayment hazard. The results are qualitatively similar for both *HPG* and *HPY*, although the effect of *HPG* on the default hazard is more pronounced. One reason for this could be that *HPG* is a better measure of capturing the effect of home equity built up on the mortgage. Notably, this result is in line with most theoretical models on mortgage default that predict a significantly large effect of built-up home equity on the hazard of default (see Daglish (2009) and references therein). Accordingly, in what follows, we restrict attention to the variable *HPG*–especially since *HPG* captures the effect of build-up in home equity on the mortgage.

**Non-linear Effects** The competing-risk hazard framework allows for the use of dummy variables to capture the non-linear effects of covariates on default and prepayment hazards. Accordingly, we split both credit and economic variables as listed in Table 7 for *House Price Growth* and LTV (Qi and Yang, 2009). The median house price growth for mortgages in our sample is roughly 8%. We split the *HPG* variable into three dummies: one each for *HPG* that is greater than the median of 8% (*HPG_>8*), *HPG* greater than 1 but less than or equal to 8% (*HPG_1_8*) or *HPG* less than or equal to 1% (*HPG_lh_1*). Note that the last dummy captures originations for which the house prices have declined since origination. In addition, we use the *PosUnempG* dummy as defined before.

The ratios in Table 9 illustrate the effects of non-linearity in the effects of covariates on default and prepayment hazard. Evidently, these non-linearities are stronger in the case of the default hazard but less pronounced for the prepayment hazard. For example, the default hazard of originations in *FICO_Q1* are around 3 times the hazard of originations in *FICO_Q4* while that for originations in *FICO_Q3* are around 1.6 times the default hazard of *FICO_Q4* originations. The corresponding hazard ratios for the prepayment hazard are around 0.85 and 0.95, respectively. Notably, increases in the default hazard caused by the movement from a lower to a higher FICO quartile is of a greater order of magnitude than decreases in the prepayment hazard. This effect is true for both credit and economic variables.

More importantly, the non-linear effects of the *HPG* dummies on default and prepayment are significantly larger than that of other covariates. The prepayment hazard for

*HPG_1_8* is almost half of that of *HPG_>8* while the *HPG_lh_1* is around a fifth of the hazard of *HPG_>8*. Clearly, low and declining house prices make it a lot harder for a subprime borrower to refinance (prepay). For all product varieties, the default hazard for *HPG_1_8* is over 6 times that of *HPG_>8* and in the case of FRMs the default hazard for *HPG_lh_1* is almost 24 times that of *HPG_>8*. This result is striking even if one considers that for ARM2 products the default hazard for *HPG_lh_1* is almost 14 times that of *HPG_>8*. However, this does not imply that the FRM product is riskier than ARM2 for *HPG_lh_1*.

At this point, it is important to note that the reported hazard ratios in Table 9 are in comparison with the baseline hazard *for the same mortgage product*. If borrowers self-selecting into ARM products are riskier ex ante than those that select into FRM products, then it is possible that the default of FRM products is significantly lower for *HPG_>8*. This was suggested from the results in Section 3.1. Since all *HPG* hazard ratios are reported in comparison with the default hazard of the same product for *HPG_>8,* then it is not surprising to see that the effect *HPG_lh_1* is more pronounced in the case of FRM loans than ARM loans. Nevertheless, what is clear is that extreme values of *HPG* can have strikingly different implications both for prepayments and defaults for subprime borrowers.

**Interaction Terms** Table 10 reports the hazard ratios on eight specifications of the time-to-default hazard for ARM2 products. Each specification reports hazard ratios for interactions between two sets of various economic and credit dummy variables. A summary of these interaction effects are presented in Tables 11 and 12. Strictly speaking, the hazard ratios in the first columns in summary Tables 11 and 12 are derived from the regression in Table 10 on ARM2 mortgages. For example, the hazard ratio of default on *Low_Doc* ARM2 products under *HPG_lh_1* is given as 18.865 in the first column and last row of Table 11. This ratio is derived from the exponential of the sum of coefficients on *Low_Doc* (0.329), *HPG_lh_1* (2.647) and *Low_Doc* HPG_lh_1* (-0.039) in column (5) of Table 10—that is, $exp(2.937) = 18.865$. A similar set of calculations help us derive the hazard ratios on interactions with unemployment growth in Table 12. The regression tables for the rest of the columns in Tables 11 and 12 are presented in an appendix to this paper.

Tables 11 and 12 reveal the non-linearity in interaction effects of economic and credit variables on the hazard of default and prepayment. For the categories chosen in Table 11, the effect of *HPG* dominates the effect of economic variables in changing the hazard of

default and prepayment. Within a given category of *HPG*, changes in the categories of the credit variable lead to smaller changes in the hazard ratios, whereas changes in *HPG* for a given category of the credit variable leads to larger changes in these ratios. For example, consider originations in *FICO_ Q3* and *HPG_ >8*. Within the category of borrowers with HPG above median, *HPG_ >8*, the default hazard of the lowest FICO quartile is less than 5 times the default hazard of the highest FICO quartile. On the other hand, within the same FICO quartile, *FICO_ Q3*, the default hazard of loans with *HPG_ 1_ 8* is more than 7 times the default hazard of loans with *HPG_ >8*. Similar trends are observed for the prepayment hazard and for *HPG* and other credit variables such as LTV and documentation.

In studying the ratios across product types in Table 11, we find that for given interactions among variables, the effect on the hazards is typically stronger for ARM3 and FRM in comparison with ARM2 products. However, this result does not imply that the ARM3 and FRM products are riskier under low *HPG*. As shown in Tables 11 and 12, the hazard ratios are in comparison with baseline values of economic and credit variables *within the same product category*. It is possible that, because of self-selection into riskier products, the baseline hazard of ARM2 products are riskier than ARM3 or FRM products.[27] In this case, it is not surprising to find default hazard ratios of higher magnitude for FRM products than for ARM2. That said, we can definitely assert that the effect of differences in *HPG* is more pronounced on default and prepayment hazards for FRM products than for ARM products.

Lastly, in comparing the interaction effects of economic variables (Table 12), it is not difficult to see that the effect of local house price growth dominates that of local unemployment. Moving within the same category of *HPG* from *NegUnempG* to *PosUnempG* increases default hazards and decreases prepayment hazards marginally. For example, within *HPG_ 1_ 8* moving from *NegUnempG* to *PosUnempG* increases default hazards from around 6 times the baseline to 7 times the baseline. On the other hand, within *NegUnempG* moving from *HPG_ 1_ 8* to *HPG_ lh_ 1* increases the default hazard from 6 times the baseline to anywhere between 12-22 times the baseline.

[27] It is also the case that ARMs have some unique risk factors due to interest-rate-dependent payment uncertainty. Under certain conditions, they are viewed as riskier loans ex post (Calem and LaCour-Little, 2004).

# 6 Conclusion

This paper provides evidence on subprime mortgage design as credit-accommodation products. It documents how legislation permitted the use of subprime originations in the form of cash-out refinances as a means of debt consolidation for liquidity-constrained and credit-impaired households. We also show that riskier households opted for subprime products that allowed temporary credit relief. At the same time, securitization provided investors with short-term exposure to high-yields on subprime products. Ultimately, for both borrower and the lender, prepayment was the desired exit option. As Shiller (2008, p.50) argues, exploiting the appreciation of house prices was the key to the viability of the subprime:

> Adjustable-rate mortgages were common because those who had been influenced by bubble thinking and wanted to get into real estate investments as heavily as possible were demanding them. The mere fact that interest payments would be going up soon did not deter them. They expected to be compensated by rapidly increasing home prices, and they believed that those higher prices would permit them to refinance at a lower rate.

The motivation behind this thinking originates from the steep rise in house prices in U.S. metropolitan areas since 1995 (see Figure 1). Contrary to most theoretical predictions, the house prices did not turn down and the housing boom continued unabated despite the recession in 2001. As Case and Shiller (2003) noted during the boom years, U.S. house prices have been rising faster than incomes and faster than other prices in virtually every metropolitan area. Yet, the growth of subprime lending continued unabated.

In the end, the basic idea of the subprime loan recognizes that the dominant form of wealth of low-income households is potentially their home equity. Therefore, unlike subprime auto-loans, subprime mortgages can register significantly lower default rates through prepayment if the underlying collateral appreciates in value. Indeed, both high and early prepayment rates sustained the subprime boom. It is also the reason why, during the collapse of subprime loan performance, most defaults occurred early. We demonstrate that such high early defaults on post-2004 originations can be explained when one considers high early prepayment rates of pre-2004 originations. In a regime of rising house prices, a financially distressed borrower can avoid default by prepayment. Naturally, defaults began to increase once house prices failed to appreciate in 2006.

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**Figure 1: Evolution of House Prices 1991-2009**
The series below show the S&P Case-Shiller Composite-10 house price index (CSXR) and the FHFA Purchase Only House Price index, all normalized to the base of 1991=100.

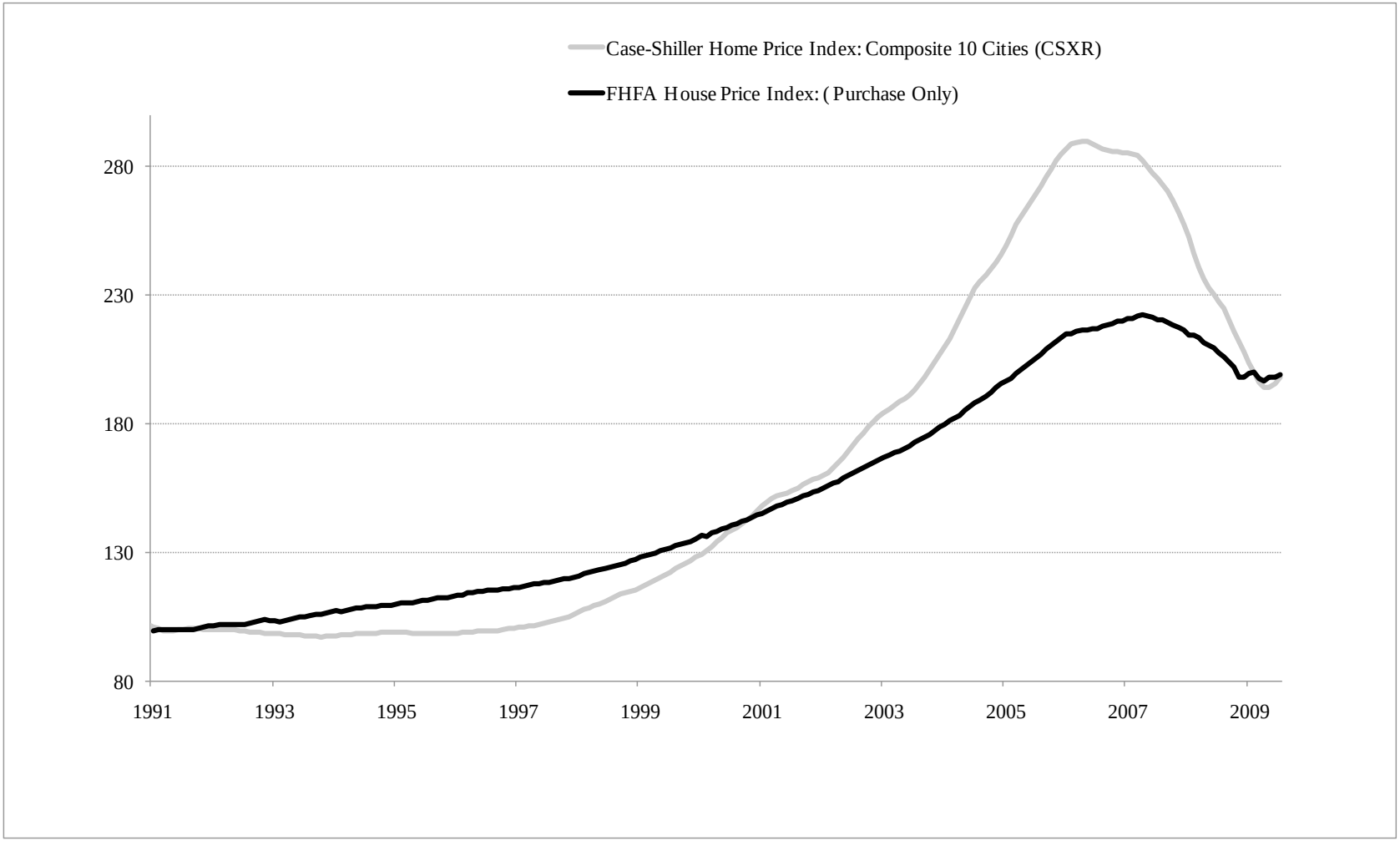
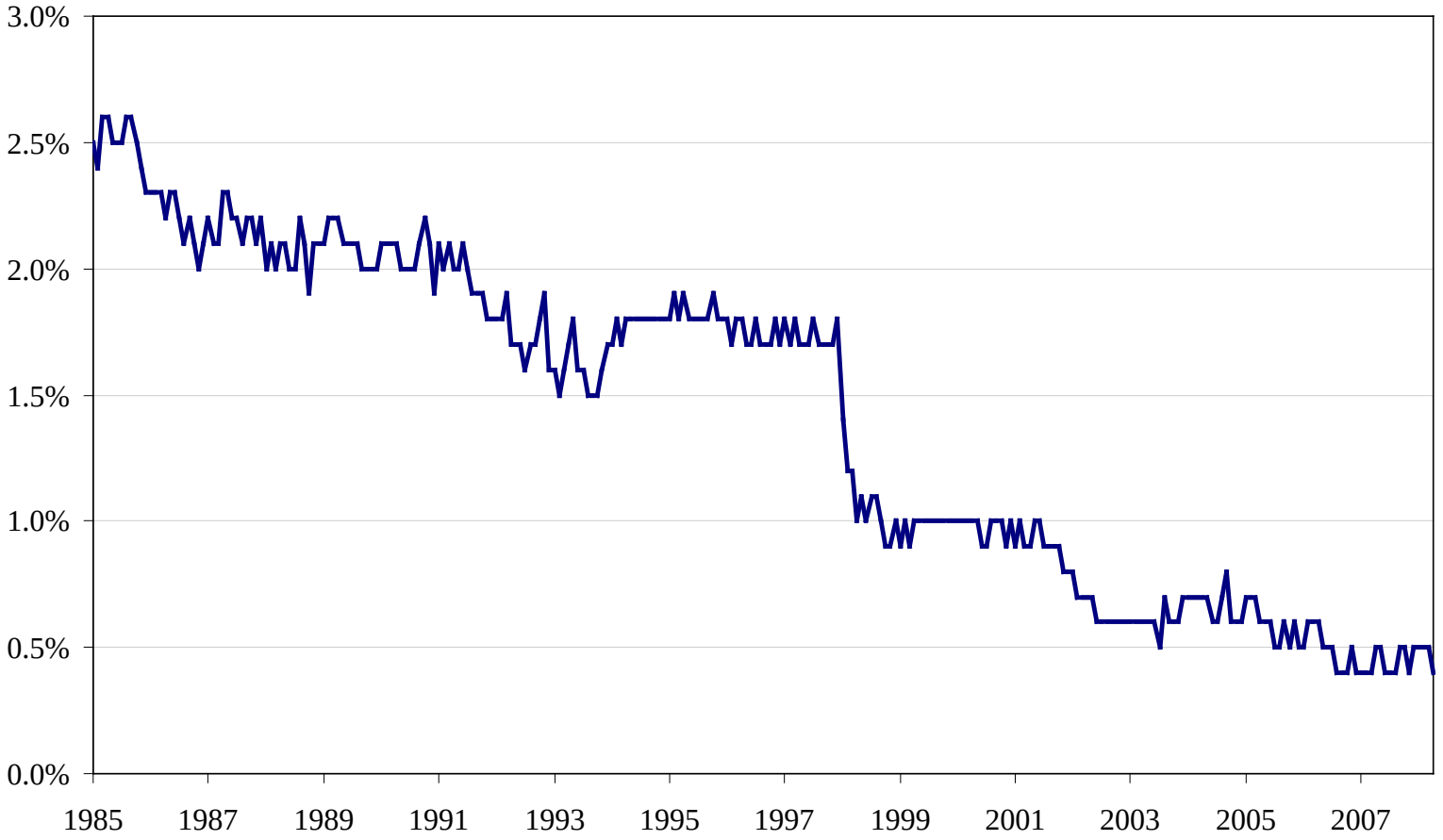


**Figure 2: Fees and Points on 30-yr Fixed Rate Mortgages**
Data based on contract interest rates on commitments for first mortgages for 30-year conventional fixed rate mortgages




Source: *Primary Mortgage Market Survey*, FHLMC (Freddie Mac).

**Table 1: Evolution of the Subprime Market (market share by product type)**

Table summarizes first lien subprime mortgages by product type as fixed or adjustable rate mortgages (FRM and ARM) for every year of origination from 1998 to 2007. The numbers give us the market share for a particular product type. ARM2 and ARM3 denote hybrid-ARM products where the *teaser rate* is fixed for two and three years respectively. *Other* product types include ARM-other, Balloon, Two-Step, GPM, GEM and GPARM. The total number denotes the number of originations in each category.

| | **Product Type** | | | | |
|---|---|---|---|---|---|
| **Year of origination** | FRM | ARM2 | ARM3 | Other | Total Number |
| **1998** | 51.33 | 26.53 | 4.52 | 17.62 | 253264 |
| **1999** | 38.88 | 29.34 | 19.21 | 12.57 | 369424 |
| **2000** | 32.58 | 43.29 | 14.78 | 9.35 | 399368 |
| **2001** | 31.70 | 48.69 | 12.44 | 7.17 | 498494 |
| **2002** | 28.37 | 54.84 | 12.62 | 4.17 | 755578 |
| **2003** | 33.57 | 52.60 | 11.37 | 2.46 | 1265769 |
| **2004** | 23.81 | 59.73 | 14.64 | 1.81 | 1922451 |
| **2005** | 18.66 | 65.48 | 13.22 | 2.64 | 2266502 |
| **2006** | 19.98 | 62.56 | 10.86 | 6.61 | 1776422 |
| **2007** | 27.59 | 50.23 | 9.92 | 12.26 | 330901 |
| Total | 25.70 | 56.73 | 12.70 | 4.87 | 9838173 |

**Table 2: Interest Rates on Subprime Loans**

The second and the third columns report the unconditional mean of the closing interest rate for originations of a particular cohort. For hybrid-ARMs this is the *teaser rate*. The number in parentheses shows the standard deviations. The (unconditional) means of margin on reset, the lifetime maximum and minimum interest rates for ARMs are given in columns 4-6 respectively. The last column gives the percent of ARMs for which the closing interest rate is equal to the lifetime minimum interest rate on the loan.

| | **FRMs** | **ADJUSTABLE RATE MORTGAGES (ARMs)** | | | | |
|---|---|---|---|---|---|---|
| | Closing Interest Rate | | Margin | Life Time Max | Life Time Min | Closing Rate is the Minimum |
| **Year of origination** | Avg. (s.d.) | | Avg. (s.d.) | Avg. (s.d.) | Avg. (s.d.) | (as % of ARM) |
| **1998** | 9.92 | 9.92 | 6.16 | 16.44 | 9.65 | 89.1% |
| | (1.6) | (1.22) | (0.88) | (1.33) | (1.5) | |
| **1999** | 10.15 | 10.08 | 6.29 | 16.46 | 9.95 | 94.2% |
| | (1.57) | (1.2) | (0.83) | (1.37) | (1.37) | |
| **2000** | 10.98 | 10.6 | 6.2 | 17.04 | 10.43 | 94.7% |
| | (1.55) | (1.28) | (0.92) | (1.5) | (1.63) | |
| **2001** | 9.71 | 9.68 | 6.36 | 16.1 | 9.5 | 91.9% |
| | (1.65) | (1.36) | (1.18) | (1.46) | (1.59) | |
| **2002** | 8.52 | 8.73 | 6.63 | 15.07 | 8.64 | 95.5% |
| | (1.44) | (1.32) | (1.32) | (1.42) | (1.42) | |
| **2003** | 7.49 | 7.74 | 6.29 | 14.07 | 7.68 | 96.0% |
| | (1.21) | (1.22) | (1.34) | (1.4) | (1.25) | |
| **2004** | 7.23 | 7.3 | 6.1 | 13.69 | 7.24 | 95.7% |
| | (1.15) | (1.16) | (1.11) | (1.23) | (1.19) | |
| **2005** | 7.43 | 7.54 | 5.96 | 13.86 | 7.42 | 93.2% |
| | (1.17) | (1.15) | (1.04) | (1.24) | (1.25) | |
| **2006** | 8.34 | 8.49 | 6.09 | 14.82 | 8.25 | 91.1% |
| | (1.3) | (1.15) | (0.91) | (1.26) | (1.41) | |
| **2007** | 8.65 | 8.6 | 6 | 14.94 | 7.93 | 76.8% |
| | (1.46) | (1.26) | (0.79) | (1.37) | (1.56) | |

**Table 3: Prepayment Term and Date of First Reset**

The *prepayment term* is the duration (in months) for which the prepayment penalty is in effect. The *First Reset Date* is the date at which the hybrid-ARM resets from the closing (teaser) interest rate to the fully-indexed interest rate. Columns (1) and (2) give the percent of mortgages by cohort that include a prepayment penalty in their contract. Column (3) shows proportion of loans for which the prepayment term ends before the first reset date expressed as a percentage of loans for which we have data on the prepayment term. Column (4) shows the difference in duration between the prepayment term and the first reset date expressed as a ratio of the durations of the two periods.

| | **FRMs** | **ADJUSTABLE RATE MORTGAGES (ARMs)** | | | | | |
|---|---|---|---|---|---|---|---|
| | Percent with Prepayment Penalty | | Prepayment Term ends before First Reset Date | | Prepayment Term ends at First Reset Date | Prepayment Term ends after First Reset Date | |
| | Percent of total loans | | Percentage[1] | Difference in duration[2] | Percentage[1] | Percentage[1] | Difference in duration[2] |
| **Year of origination** | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| **1998** | 53% | 71% | 8% | 0.49 | 57% | 35% | 1.82 |
| **1999** | 60% | 80% | 4% | 0.47 | 54% | 42% | 1.78 |
| **2000** | 61% | 85% | 4% | 0.49 | 64% | 32% | 1.89 |
| **2001** | 68% | 86% | 4% | 0.49 | 69% | 27% | 1.66 |
| **2002** | 69% | 85% | 4% | 0.48 | 76% | 21% | 1.62 |
| **2003** | 72% | 79% | 5% | 0.47 | 81% | 14% | 1.56 |
| **2004** | 75% | 74% | 6% | 0.47 | 83% | 11% | 1.55 |
| **2005** | 74% | 72% | 7% | 0.49 | 85% | 8% | 1.52 |
| **2006** | 72% | 71% | 7% | 0.50 | 88% | 5% | 1.52 |
| **2007** | 69% | 69% | 8% | 0.50 | 89% | 3% | 1.51 |

1. Expressed as a percentage of the total number of loans for which the data on prepayment term is available.
2. Expressed as a ratio of the duration of the prepayment term to the duration up to the reset date.

**Table 4: Product Choice and Interest Rates**

Columns (1) and (2) report the estimates of the Heckman two-stage procedure. Estimates of the selection equation for hybrid-ARMs over FRMs are reported in column (1). Column (2) shows OLS estimates with *Margin* as the dependent variable. Finally, column (3) reports the estimates of the least squares regression of *Mortgage Rate Spread* on origination characteristics. In addition to the covariates given below, we control for property type (dummies for single-family residence, condo, townhouse, co-operative, etc), property location (dummies for the state in which the property is located) and loan source (dummies for broker, realtor, wholesale, retail etc.) and number of units in the property. *Home Value n*th *Quartile* is a dummy that equals one if the value of the property lies in the *n*-the quartile of all property values in the data and zero otherwise.

| | Heckman Two Stage Estimates | | |
|---|---|---|---|
| | Selection (Probit) | Least Squares | Least Squares |
| *Dependent variable* | Hybrid-ARM=1 | *Margin* | *Mortgage Rate Spread* |
| | (1) | (2) | (3) |
| Intercept | 2.845 *** | 8.528 *** | 7.436 *** |
| FICO (scaled) | -0.490 *** | -0.487 *** | -0.864 *** |
| LTV | 0.019 *** | 0.004 *** | 0.006 *** |
| Low-Documentation dummy | 0.279 *** | 0.146 *** | 0.372 *** |
| Prepayment Penalty dummy | 0.160 *** | 0.052 *** | 0.122 *** |
| Fees and Points | -0.010 *** | 0.004 *** | 0.037 *** |
| Owner Occupied dummy | -0.016 *** | -0.104 *** | -0.541 *** |
| Second Home dummy | -0.085 *** | -0.041 *** | -0.394 *** |
| Home Value First Quartile | -0.410 *** | 0.329 *** | 0.906 *** |
| Home Value Second Quartile | -0.226 *** | 0.191 *** | 0.597 *** |
| Home Value Third Quartile | -0.132 *** | 0.088 *** | 0.304 *** |
| ARM2 dummy | --- | -0.214 *** | 0.020 *** |
| ARM3 dummy | --- | ---- | 0.006 ** |
| Log-Likelihood | -2482173.2 | --- | --- |
| Adjusted R-Square | --- | 0.157 | 0.223 |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 5: Prepayment Rates by Mortgage Product Type**

The numbers in the table denote the fraction of surviving loans that were paid off before they become seriously delinquent shown here by product type. The loans are organized by year of origination and the period of study for each loan extends to the end of the calendar year.

| Year of mortgage origination | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Fixed** | | | | | | | | | | |
| Up to 1 calendar year | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.09 | 0.09 | 0.08 | 0.07 | 0.06 |
| Up to 2 calendar years | 0.14 | 0.14 | 0.24 | 0.31 | 0.39 | 0.36 | 0.32 | 0.24 | 0.16 | |
| Up to 3 calendar years | 0.23 | 0.28 | 0.40 | 0.50 | 0.55 | 0.51 | 0.42 | 0.30 | | |
| Up to 4 calendar years | 0.38 | 0.44 | 0.52 | 0.61 | 0.65 | 0.59 | 0.48 | | | |
| Up to 5 calendar years | 0.50 | 0.55 | 0.60 | 0.68 | 0.70 | 0.63 | | | | |
| **ARM2** | | | | | | | | | | |
| Up to 1 calendar year | 0.04 | 0.05 | 0.07 | 0.08 | 0.10 | 0.14 | 0.17 | 0.14 | 0.11 | 0.07 |
| Up to 2 calendar years | 0.23 | 0.23 | 0.31 | 0.37 | 0.43 | 0.49 | 0.47 | 0.36 | 0.21 | |
| Up to 3 calendar years | 0.58 | 0.51 | 0.57 | 0.64 | 0.71 | 0.77 | 0.75 | 0.56 | | |
| Up to 4 calendar years | 0.68 | 0.63 | 0.67 | 0.73 | 0.78 | 0.82 | 0.78 | | | |
| Up to 5 calendar years | 0.72 | 0.70 | 0.72 | 0.76 | 0.80 | 0.83 | | | | |
| **ARM3** | | | | | | | | | | |
| Up to 1 calendar year | 0.05 | 0.05 | 0.06 | 0.06 | 0.08 | 0.12 | 0.16 | 0.14 | 0.10 | 0.07 |
| Up to 2 calendar years | 0.18 | 0.23 | 0.29 | 0.34 | 0.41 | 0.46 | 0.47 | 0.36 | 0.21 | |
| Up to 3 calendar years | 0.33 | 0.41 | 0.47 | 0.54 | 0.58 | 0.62 | 0.61 | 0.45 | | |
| Up to 4 calendar years | 0.51 | 0.57 | 0.63 | 0.70 | 0.75 | 0.79 | 0.74 | | | |
| Up to 5 calendar years | 0.59 | 0.64 | 0.69 | 0.74 | 0.79 | 0.82 | | | | |

Source: Authors' calculations from Corelogic data.

**Table 6: Repayment Behavior of Owner Occupied Households (up to two calendar years from year of origination).**
Delinquency rate is based on percentage of total loans in the sample. We consider both loans that are both 30-day and 60-day delinquent. Among the loans that are delinquent, we consider those that were prepaid and those that went into foreclosure. We do this separately for loans that were 30-day and 60-day delinquent. The second panel is prepayment rate, the number of loans prepaid expressed as percentage of loans that are delinquent in each category. The third panel is the foreclosure rate, the number of loans foreclosed expressed as percentage of loans that are delinquent in each category.

**Panel A. Delinquency Rate**
(% of total loans)

| | 30-day delinquency | | | 60-day delinquency | | |
|---|---|---|---|---|---|---|
| **Year of origination** | After 2 years | After 3 years | After 4 years | After 2 years | After 3 years | After 4 years |
| **1998** | 21% | 28% | 32% | 8% | 12% | 14% |
| **1999** | 26% | 33% | 37% | 10% | 14% | 17% |
| **2000** | 31% | 37% | 40% | 13% | 17% | 20% |
| **2001** | 33% | 39% | 41% | 13% | 18% | 20% |
| **2002** | 33% | 37% | 39% | 13% | 17% | 19% |
| **2003** | 27% | 31% | 32% | 11% | 14% | 15% |
| **2004** | 29% | 33% | 35% | 13% | 17% | 19% |
| **2005** | 34% | 42% | | 19% | 28% | |
| **2006** | 46% | | | 34% | | |

**Panel B. Prepayment Rate for delinquent loans**
(% of delinquent loans)

| | 30-day delinquency | | | 60-day delinquency | | |
|---|---|---|---|---|---|---|
| **Year of origination** | After 2 years | After 3 years | After 4 years | After 2 years | After 3 years | After 4 years |
| **1998** | 22% | 36% | 45% | 13% | 21% | 26% |
| **1999** | 22% | 36% | 46% | 13% | 20% | 26% |
| **2000** | 24% | 39% | 49% | 13% | 20% | 26% |
| **2001** | 26% | 44% | 54% | 15% | 24% | 30% |
| **2002** | 32% | 51% | 60% | 18% | 28% | 35% |
| **2003** | 35% | 53% | 60% | 20% | 30% | 35% |
| **2004** | 33% | 49% | 52% | 19% | 26% | 27% |
| **2005** | 22% | 27% | | 10% | 11% | |
| **2006** | 9% | | | 3% | | |

**Panel C. Foreclosure Rate for delinquent loans**
(% of delinquent loans)

| | 30-day delinquency | | | 60-day delinquency | | |
|---|---|---|---|---|---|---|
| **Year of origination** | After 2 years | After 3 years | After 4 years | After 2 years | After 3 years | After 4 years |
| **1998** | 11% | 15% | 19% | 29% | 36% | 42% |
| **1999** | 11% | 16% | 19% | 29% | 39% | 42% |
| **2000** | 14% | 19% | 22% | 35% | 40% | 44% |
| **2001** | 12% | 17% | 20% | 29% | 37% | 41% |
| **2002** | 11% | 16% | 19% | 29% | 36% | 39% |
| **2003** | 11% | 15% | 17% | 27% | 33% | 37% |
| **2004** | 11% | 17% | 20% | 26% | 34% | 38% |
| **2005** | 17% | 28% | | 30% | 42% | |
| **2006** | 27% | | | 36% | | |

Source: Authors' calculations using Corelogic data.

**Figure 3: Post-delinquency Behavior by Product Type (up to loan age of 18 months)**

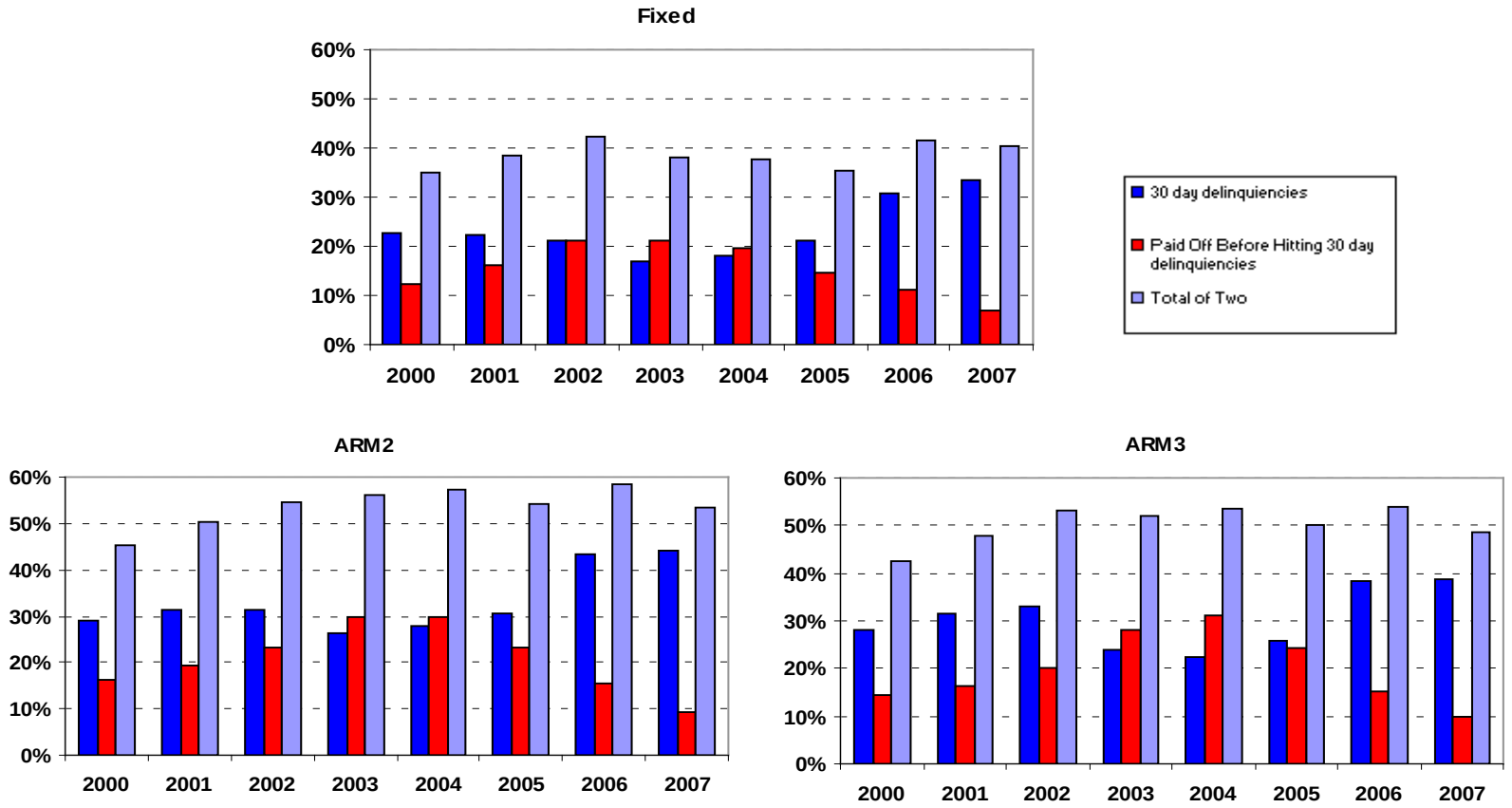


**Figure 4: Post-delinquency Behavior by Occupancy (up to loan age of 18 months)**

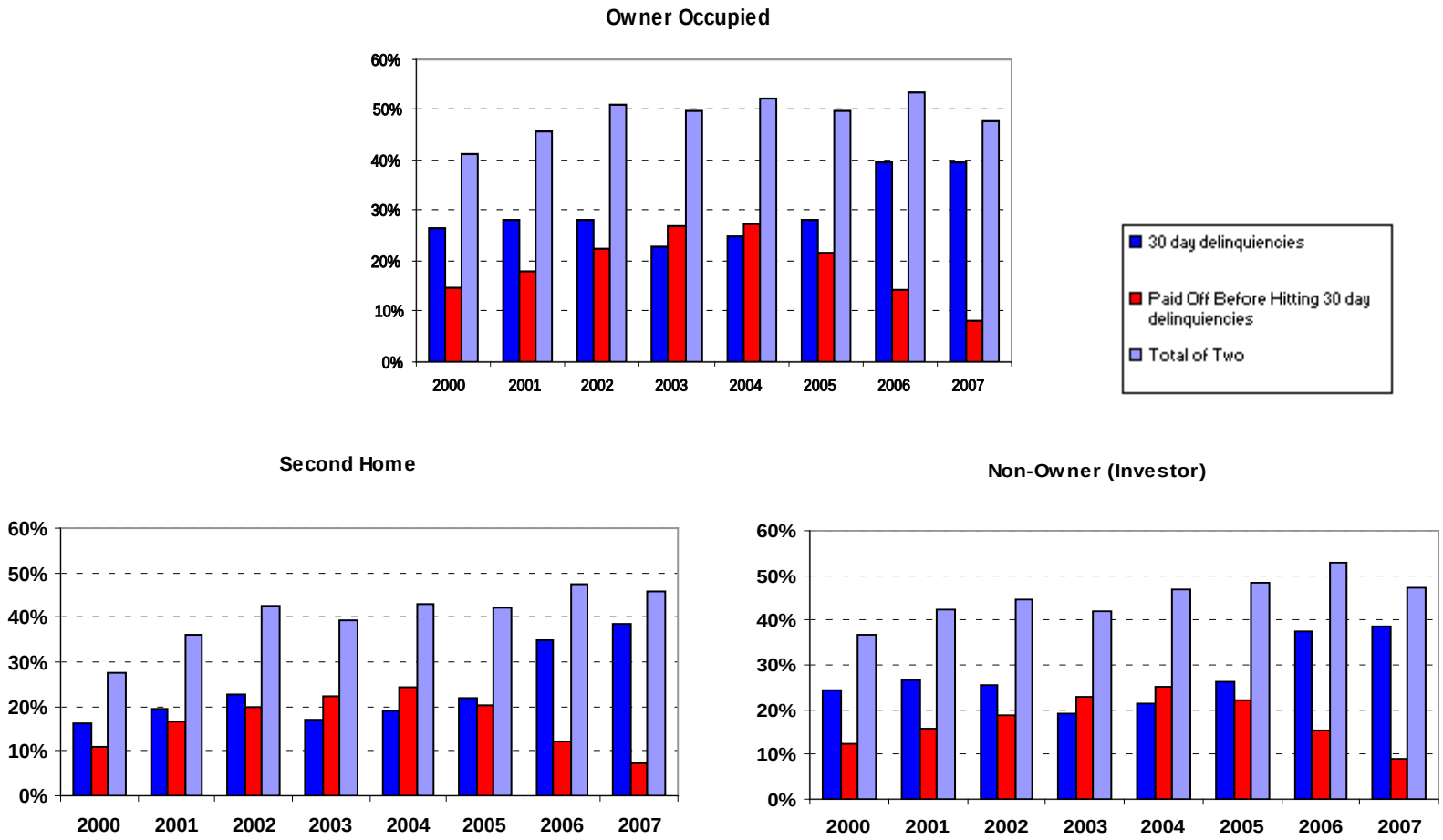


**Figure 5: Post-delinquency Behavior by Purpose (up to loan age of 18 months)**

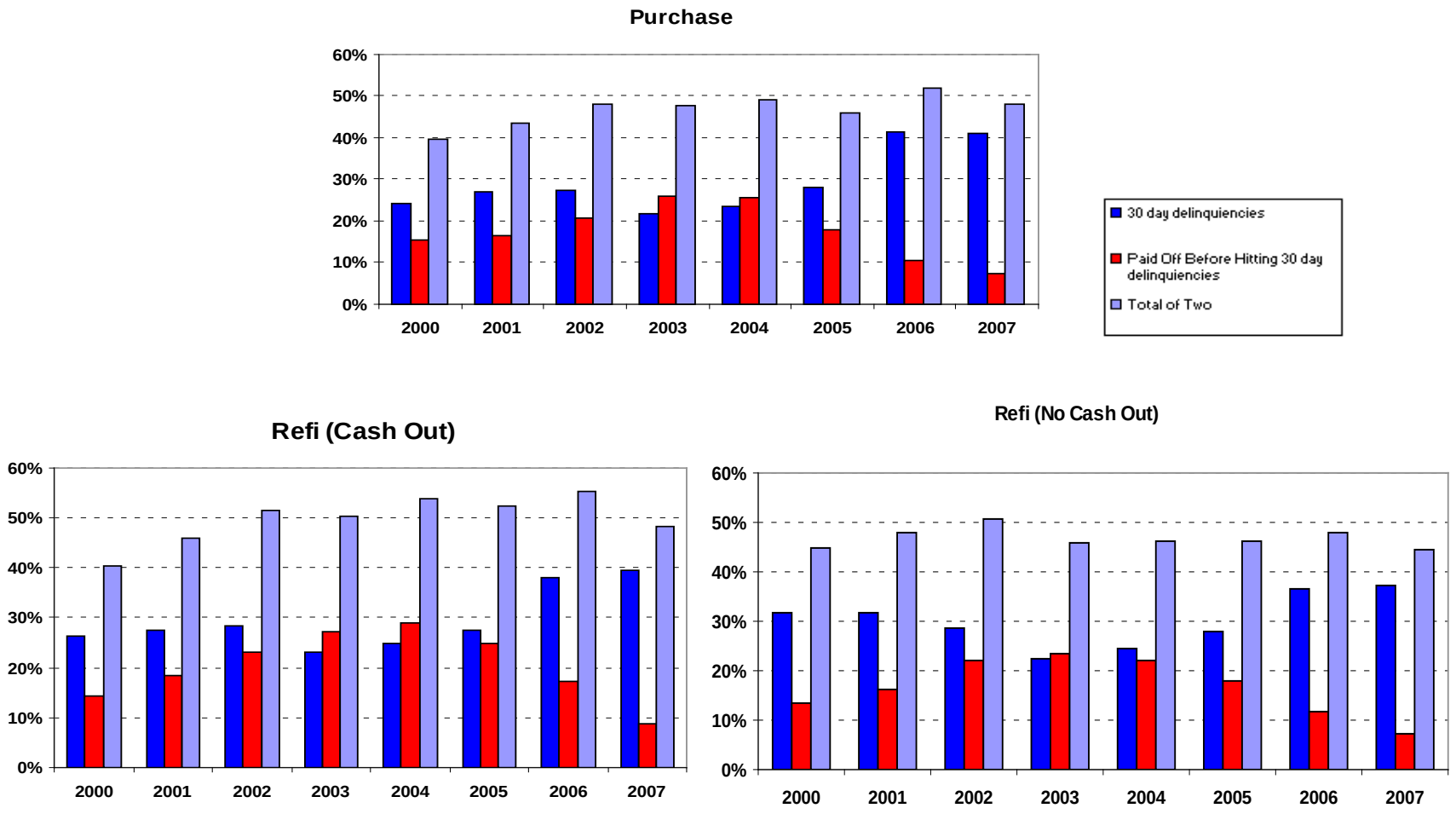


**Figure 6: Kaplan Meier Default Probabilities**

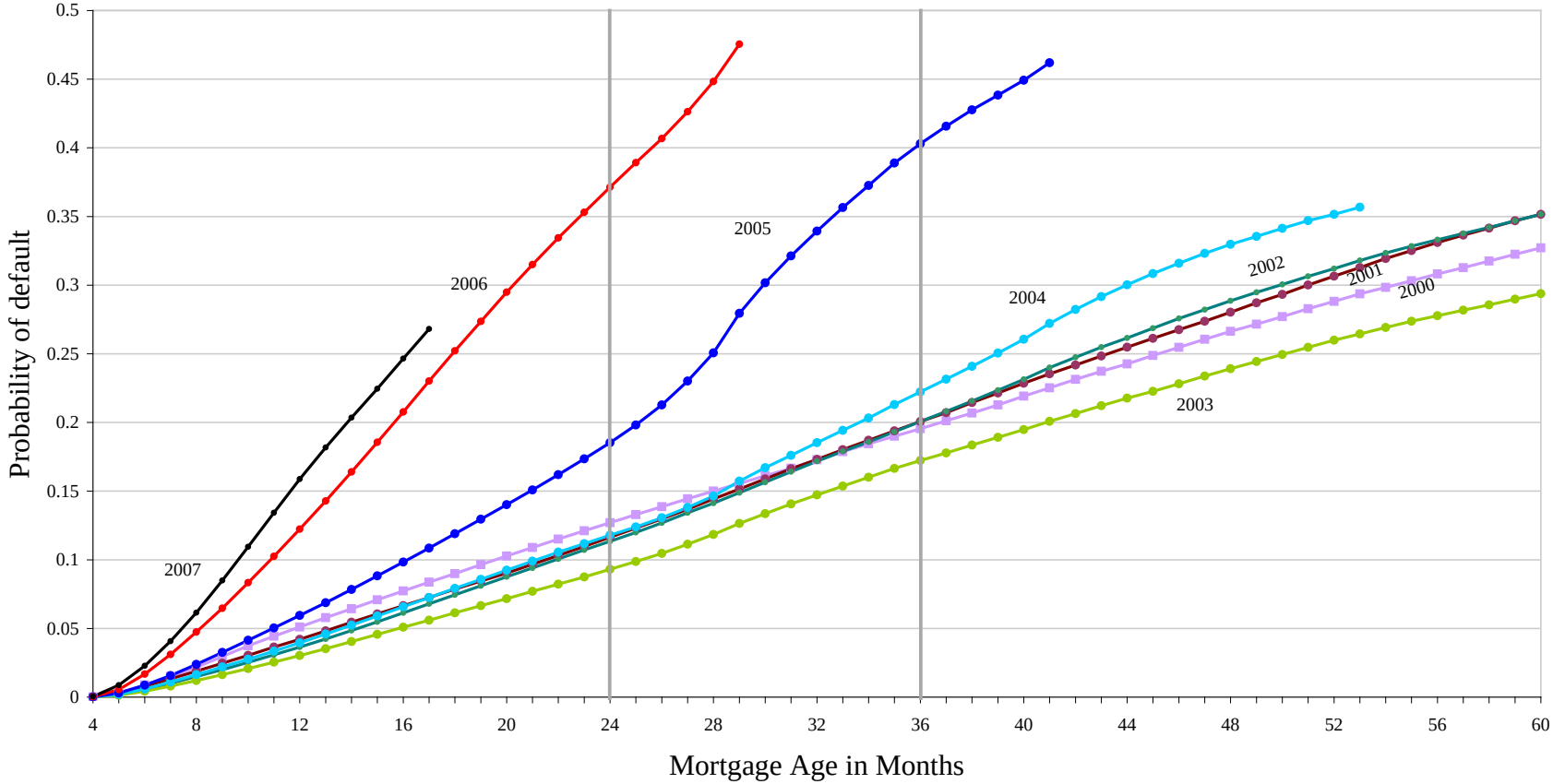


**Figure 7: Kaplan Meier Prepayment Probabilities**

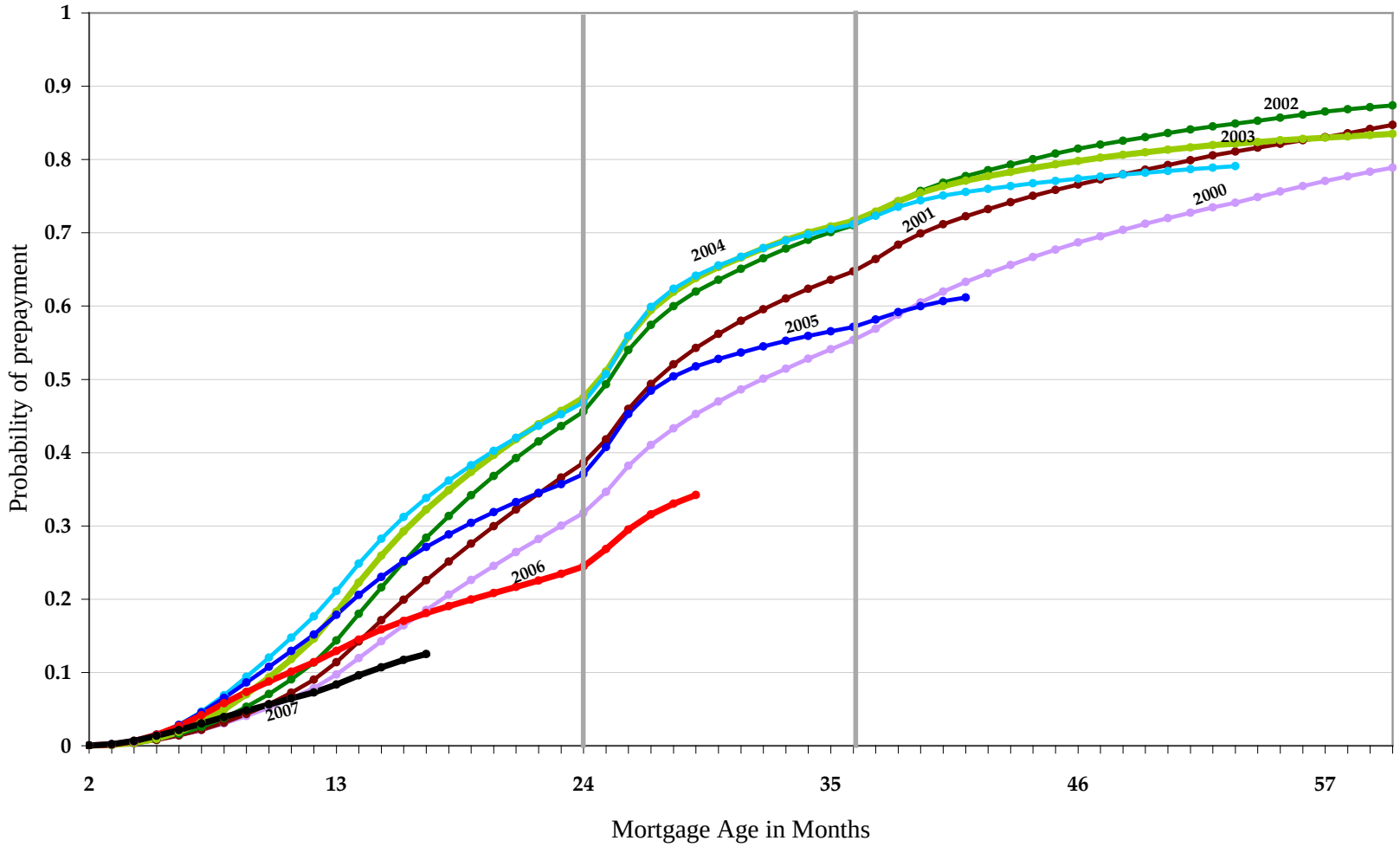


**Table 7: List of Variables**

| | |
|---|---|
| *FICO_Q1* | Dummy variable equal to one if origination FICO is in the 1st quartile and zero otherwise. |
| *FICO_Q2* | Dummy variable equal to one if origination FICO is in the 2nd quartile and zero otherwise. |
| *FICO_Q3* | Dummy variable equal to one if origination FICO is in the 3rd quartile and zero otherwise. |
| *FICO_Q4* | Dummy variable equal to one if origination FICO is in the 4th quartile and zero otherwise. |
| *LTV_7* | Dummy variable equal to one if LTV is less than 80 percent and zero otherwise |
| *LTV_8* | Dummy variable equal to one if LTV is greater than or equal to 80 but less than 90 percentand zero otherwise |
| *LTV_9* | Dummy variable equal to one if LTV is greater than or equal to 90 but less than 100 percent and zero otherwise |
| *LTV_10* | Dummy variable equal to one if LTV is greater than or equal to 100 percent and zero otherwise |
| *Low_Doc* | Dummy variable equal to one if the mortgage does not have full documentation and zero otherwise. |
| *Prep. Penalty* | Dummy variable equal to one if the mortgage includes a prepayment penalty and zero otherwise. |
| *Fees and Points* | Fees and discount points charged by the lender at settlement on a 30-yr FRM prime mortgage, taken from the Freddie Mac PMMS Survey |
| *Interest Volatility* | Standard deviation of the six-month LIBOR for the previous 24 months |
| *Present Value Annualized Ratio (PVAR)* | Measures the ratio of the present value of the payments on mortgage principal outstanding using the existing mortgage rate to that using the current rate available on refinance |
| *House Price Change (HPY)* | Percentage change in the MSA-level FHFA house price index since previous year for the MSA in which the property is located |
| *House Price Growth (HPG)* | Percentage change in the MSA-level FHFA house price index since origination for the MSA in which the property is located |
| *HPG_lh_1* | Dummy variable equal to one if *HPG*is less than or equal to 1 percent and zero otherwise. |
| *HPG_1_8* | Dummy variable equal to one if *HPG* is greater than 1 percent but less than or equal to 8 percent and zero otherwise. |
| *HPG_>8* | Dummy variable equal to one if *HPG* is greater than 8 percent and zero otherwise. |
| *PosUnempG* | Dummy variable equal to one if the MSA records and increase in the unemployment rate over the previous year and zero otherwise (Source: BLS data) |

**Table 8: Default and Prepayment Hazard Ratios by Product Type**

Panel A: Covariates include House Price Growth since Origination

| | ARM2 | | ARM3 | | Fixed | |
|---|---|---|---|---|---|---|
| | Default | Prepayment | Default | Prepayment | Default | Prepayment |
| FICO (scaled) | 0.466*** | 1.080*** | 0.507*** | 1.070*** | 0.498*** | 1.130*** |
| LTV | 1.026*** | 0.994*** | 1.024*** | 0.995*** | 1.020*** | 0.996*** |
| Low_Doc dummy | 1.501*** | 0.978*** | 1.449*** | 0.963*** | 1.337*** | 0.958*** |
| Prep. Penalty dummy | 0.999 | 0.770*** | 1.066*** | 0.753*** | 1.221*** | 0.851*** |
| Fees and Points | 1.104*** | 1.044*** | 1.118*** | 1.051*** | 1.115*** | 1.054*** |
| Interest Volatility | 1.015*** | 1.003*** | 1.013*** | 1.003*** | 1.012*** | 1.004*** |
| PVAR | 1.004*** | 1.004*** | 1.003*** | 1.004*** | 1.003*** | 1.003*** |
| House Price Growth (*HPG*) | 0.816*** | 1.087*** | 0.782*** | 1.091*** | 0.767*** | 1.038*** |
| PosUnempG dummy | 1.175*** | 0.956*** | 1.106*** | 0.961*** | 1.098*** | 0.992*** |
| LR | 827655 | 1653899 | 173637 | 434783 | 306145 | 777460 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

Panel B: Covariates include House Price year on year change

| | ARM2 | | ARM3 | | Fixed | |
|---|---|---|---|---|---|---|
| | Default | Prepayment | Default | Prepayment | Default | Prepayment |
| FICO (scaled) | 0.45*** | 1.136*** | 0.476*** | 1.122*** | 0.461*** | 1.148*** |
| LTV | 1.026*** | 0.993*** | 1.023*** | 0.994*** | 1.019*** | 0.996*** |
| Low_Doc dummy | 1.549*** | 0.955*** | 1.488*** | 0.948*** | 1.332*** | 0.954*** |
| Prep. Penalty dummy | 0.982** | 0.788*** | 1.055** | 0.778*** | 1.122*** | 0.874*** |
| Fees and Points | 1.097*** | 1.037*** | 1.113*** | 1.044*** | 1.119*** | 1.049*** |
| Interest Volatility | 1.012*** | 1.003*** | 1.009*** | 1.003*** | 1.011*** | 1.004*** |
| PVAR | 1.004*** | 1.004*** | 1.003*** | 1.003*** | 1.003*** | 1.003*** |
| House Price Change (*HPY*) | 0.981*** | 1.04*** | 0.977*** | 1.039*** | 0.958*** | 1.026*** |
| PosUnempG dummy | 1.039*** | 0.949*** | 1.07*** | 0.944*** | 1.119*** | 0.974*** |
| LR | 511964 | 1319378 | 218091 | 367496 | 107562 | 772160 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 9: Default and Prepayment Hazard Ratios by Product Type using dummy variables as covariates**

| | ARM2 | | ARM3 | | Fixed | |
|---|---|---|---|---|---|---|
| | Default | Prepayment | Default | Prepayment | Default | Prepayment |
| FICO_Q1 dummy | 3.245*** | 0.882*** | 2.97*** | 0.899*** | 3.403*** | 0.825*** |
| FICO_Q2 dummy | 2.122*** | 0.93*** | 2.038*** | 0.95*** | 2.261*** | 0.929*** |
| FICO_Q3 dummy | 1.559*** | 0.961*** | 1.557*** | 0.978*** | 1.709*** | 0.961*** |
| LTV_8 dummy | 1.391*** | 0.903*** | 1.342*** | 0.92*** | 1.386*** | 0.917*** |
| LTV_9 dummy | 1.675*** | 0.864*** | 1.609*** | 0.898*** | 1.719*** | 0.864*** |
| LTV_10 dummy | 2.476*** | 0.761*** | 2.265*** | 0.827*** | 2.332*** | 0.805*** |
| Low_Doc dummy | 1.486*** | 0.977*** | 1.444*** | 0.971*** | 1.351*** | 0.957*** |
| Prep. Penalty dummy | 1.007 | 0.763*** | 1.039 | 0.765*** | 1.166*** | 0.851*** |
| Fees and Points | 1.101*** | 1.05*** | 1.116*** | 1.057*** | 1.115*** | 1.059*** |
| Interest Volatility | 1.014*** | 1.004*** | 1.011*** | 1.004*** | 1.011*** | 1.005*** |
| PVAR | 1.004*** | 1.004*** | 1.003*** | 1.004*** | 1.003*** | 1.003*** |
| HPG_1_8 | 6.437*** | 0.445*** | 7.051*** | 0.443*** | 6.823*** | 0.589*** |
| HPG_lh_1 | 13.838*** | 0.223*** | 18.55*** | 0.204*** | 23.936*** | 0.22*** |
| PosUnempG dummy | 1.181*** | 0.963*** | 1.162*** | 0.954*** | 1.142*** | 0.994*** |
| LR | 702862 | 1448270 | 145356 | 392735 | 268049 | 807285 |
| p-value (H0: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 10: Default Hazard Ratios for ARM2 products**

| Variable | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| FICO_Q1 dummy | 3.245*** | 3.242*** | 3.228*** | 4.918*** | 3.249*** | 3.247*** | 3.328*** | 3.245*** |
| FICO_Q2 dummy | 2.122*** | 2.121*** | 2.113*** | 2.757*** | 2.123*** | 2.124*** | 2.15*** | 2.122*** |
| FICO_Q3 dummy | 1.559*** | 1.558*** | 1.554*** | 1.806*** | 1.558*** | 1.559*** | 1.577*** | 1.559*** |
| LTV_8 dummy | 1.391*** | 1.39*** | 1.074*** | 1.395*** | 1.394*** | 1.391*** | 1.391*** | 1.398*** |
| LTV_9 dummy | 1.675*** | 1.674*** | 1.171*** | 1.681*** | 1.681*** | 1.675*** | 1.676*** | 1.66*** |
| LTV_10 dummy | 2.476*** | 2.474*** | 1.848*** | 2.481*** | 2.485*** | 2.476*** | 2.475*** | 2.46*** |
| Low_Doc dummy | 1.486*** | 1.486*** | 1.479*** | 1.484*** | 1.389*** | 1.442*** | 1.485*** | 1.486*** |
| Prep. Penalty dummy | 1.007 | 1.003 | 1.006 | 1.001 | 1.006 | 1.007 | 1.006 | 1.006 |
| Fees and Points | 1.101*** | 1.101*** | 1.101*** | 1.101*** | 1.101*** | 1.101*** | 1.101*** | 1.101*** |
| Interest Volatility | 1.014*** | 1.014*** | 1.014*** | 1.014*** | 1.014*** | 1.014*** | 1.014*** | 1.014*** |
| PVAR | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** |
| HPG_1_8 | 6.437*** | 5.934*** | 5.281*** | 8.761*** | 6.149*** | 6.447*** | 6.441*** | 6.437*** |
| HPG_lh_1 | 13.838*** | 12.425*** | 7.297*** | 18.785*** | 14.119*** | 13.864*** | 13.849*** | 13.835*** |
| PosUnempG dummy | 1.181*** | 1.009 | 1.174*** | 1.181*** | 1.18*** | 1.152*** | 1.221*** | 1.175*** |
| FICO_Q1*HPG_1_8 | - | - | - | 0.602*** | - | - | - | - |
| FICO_Q1*HPG_lh_1 | - | - | - | 0.609*** | - | - | - | - |
| FICO_Q2*HPG_1_8 | - | - | - | 0.728*** | - | - | - | - |
| FICO_Q2*HPG_lh_1 | - | - | - | 0.718*** | - | - | - | - |
| FICO_Q3*HPG_1_8 | - | - | - | 0.833*** | - | - | - | - |
| FICO_Q3*HPG_lh_1 | - | - | - | 0.833*** | - | - | - | - |
| LTV_8*HPG_1_8 | - | - | 1.245*** | - | - | - | - | - |
| LTV_8*HPG_lh_lh_1 | - | - | 2.3*** | - | - | - | - | - |
| LTV_9*HPG_1_8 | - | - | 1.399*** | - | - | - | - | - |
| LTV_9*HPG_lh_1 | - | - | 2.519*** | - | - | - | - | - |
| LTV_10*HPG_1_8 | - | - | 1.337*** | - | - | - | - | - |
| LTV_10*HPG_lh_1 | - | - | 2.026*** | - | - | - | - | - |
| Low_Doc*HPG_1_8 | - | - | - | - | 1.122*** | - | - | - |
| Low_Doc*HPG_lh_1 | - | - | - | - | 0.962*** | - | - | - |
| FICO_Q1* PosUnempG | - | - | - | - | - | - | 0.945*** | - |
| FICO_Q2* PosUnempG | - | - | - | - | - | - | 0.973*** | - |
| FICO_Q3* PosUnempG | - | - | - | - | - | - | 0.975** | - |
| LTV_8*PosUnempG | - | - | - | - | - | - | - | 0.988 |
| LTV_9* PosUnempG | - | - | - | - | - | - | - | 1.022** |
| LTV_10*PosUnempG | - | - | - | - | - | - | - | 1.014 |
| Low_Doc* PosUnempG | - | - | - | - | - | 1.069*** | - | - |
| PosUnempG*HPG_1_8 | - | 1.197*** | - | - | - | - | - | - |
| PosUnempG*HP_lh_1 | - | 1.27*** | - | - | - | - | - | - |
| LR | 702862 | 703414 | 707243 | 704884 | 703300 | 702978 | 702904 | 702883 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 11: Default Hazard Ratios for interactions of House Price Growth with credit variables by product type**

| | ARM2 | | ARM3 | | Fixed | |
|---|---|---|---|---|---|---|
| Interactions of House Price Growth (HPG) | Default | Prepay. | Default | Prepay. | Default | Prepay. |
| *… with Credit Scores* | | | | | | |
| FICO in 4th Quartile and HPG > 8 (Baseline) | | | | | | |
| FICO in 4th Quartile and 1 < HPG ≤ 8 | 8.761*** | 0.509*** | 9.138*** | 0.519*** | 8.73*** | 0.734*** |
| FICO in 4th Quartile and HPG ≤ 1 | 18.785*** | 0.273*** | 23.028*** | 0.264*** | 25.18*** | 0.384*** |
| FICO in 3th Quartile and HPG > 8 | 1.806*** | 1.003 | 1.729*** | 1.021*** | 1.862*** | 1.036*** |
| FICO in 3th Quartile and 1 < HPG ≤ 8 | 13.181*** | 0.454*** | 13.994*** | 0.466*** | 14.635*** | 0.611*** |
| FICO in 3th Quartile and HPG ≤ 1 | 28.262*** | 0.222*** | 33.361*** | 0.241*** | 42.556*** | 0.28*** |
| FICO in 2nd Quartile and HPG > 8 | 2.757*** | 0.986*** | 2.561*** | 1.019*** | 2.832*** | 1.042*** |
| FICO in 2nd Quartile and 1 < HPG ≤ 8 | 17.581*** | 0.428*** | 17.667*** | 0.438*** | 18.501*** | 0.565*** |
| FICO in 2nd Quartile and HPG ≤ 1 | 37.175*** | 0.217*** | 45.696*** | 0.201*** | 64.548*** | 0.218*** |
| FICO in Bottom Quartile and HPG > 8 | 4.918*** | 0.97*** | 4.269*** | 1.010* | 4.873*** | 1.032*** |
| FICO in Bottom Quartile and 1 < HPG ≤ 8 | 25.925*** | 0.39*** | 24.771*** | 0.394*** | 26.819*** | 0.468*** |
| FICO in Bottom Quartile and HPG ≤ 1 | 56.303*** | 0.185*** | 71.657*** | 0.155*** | 110.661*** | 0.123*** |
| *… with Loan-to-Value Ratios* | | | | | | |
| LTV < 80 and HPG > 8 (Baseline) | | | | | | |
| LTV < 80 and 1 < HPG ≤ 8 | 5.281*** | 0.513*** | 6.035*** | 0.506*** | 5.979*** | 0.68*** |
| LTV < 80 and HPG ≤ 1 | 7.297*** | 0.346*** | 12.633*** | 0.302*** | 18.458*** | 0.317*** |
| 80 ≤ LTV < 90 and HPG > 8 | 1.074*** | 0.972*** | 1.121*** | 0.98*** | 1.144*** | 1.019*** |
| 80 ≤ LTV < 90 and 1 < HPG ≤ 8 | 7.061*** | 0.429*** | 7.959*** | 0.434*** | 8.267*** | 0.552*** |
| 80 ≤ LTV < 90 and HPG ≤ 1 | 18.021*** | 0.189*** | 24.431*** | 0.168*** | 33.999*** | 0.145*** |
| 90 ≤ LTV < 100 and HPG > 8 | 1.171*** | 0.954*** | 1.261*** | 0.993 | 1.358*** | 0.998 |
| 90 ≤ LTV < 100 and 1 < HPG ≤ 8 | 8.655*** | 0.398*** | 9.756*** | 0.399*** | 10.484*** | 0.488*** |
| 90 ≤ LTV < 100 and HPG ≤ 1 | 21.531*** | 0.171*** | 27.294*** | 0.165*** | 37.775*** | 0.142*** |
| LTV ≥ 100 and HPG >8 | 1.848*** | 0.89*** | 1.774*** | 0.937*** | 1.965*** | 0.961*** |
| LTV ≥ 100 and 1 < HPG ≤ 8 | 13.044*** | 0.325*** | 13.976*** | 0.357*** | 14.586*** | 0.437*** |
| LTV ≥ 100 and HPG ≤ 1 | 27.324*** | 0.149*** | 35.122*** | 0.146*** | 41.115*** | 0.178*** |
| *… with Documentation* | | | | | | |
| Full Doc Loan and HPG > 8 (Baseline) | | | | | | |
| Full Doc Loan and 1 < HPG ≤ 8 | 6.149*** | 0.463*** | 6.682*** | 0.457*** | 6.696*** | 0.601*** |
| Full Doc Loan and HPG ≤ 1 | 14.119*** | 0.227*** | 19.123*** | 0.199*** | 24.763*** | 0.211*** |
| Low Doc Loan and HPG > 8 | 1.389*** | 1.017*** | 1.317*** | 1.000 | 1.305*** | 0.977*** |
| Low Doc Loan and 1 < HPG ≤ 8 | 9.584*** | 0.42*** | 10.258*** | 0.415*** | 9.349*** | 0.546*** |
| Low Doc Loan and HPG ≤ 1 | 18.865*** | 0.219*** | 22.991*** | 0.216*** | 28.333*** | 0.248*** |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 12: Default Hazard Ratios for interactions of Unemployment with credit variables and HPG by product type**

| | ARM2 | | ARM3 | | Fixed | |
|---|---|---|---|---|---|---|
| Interactions of Unemployment Growth Dummy | Default | Prepay. | Default | Prepay. | Default | Prepay. |
| *…with House Price Growth* | | | | | | |
| NegUnempG and HPG > 8(Baseline) | | | | | | |
| PosUnempG and HPG > 8 | 1.009 | 1.007*** | 0.94*** | 0.989** | 1.004 | 1.007** |
| NegUnempG and 1 < HPG ≤ 8 | 5.934*** | 0.461*** | 6.332*** | 0.458*** | 6.433*** | 0.594*** |
| NegUnempG and HPG ≤ 1 | 12.425*** | 0.243*** | 16.318*** | 0.218*** | 22.012*** | 0.233*** |
| PosUnempG and 1 < HPG ≤ 8 | 7.17*** | 0.423*** | 7.605*** | 0.418*** | 7.449*** | 0.585*** |
| PosUnempG and HPG ≤ 1 | 15.918*** | 0.199*** | 20.709*** | 0.185*** | 27.061*** | 0.203*** |
| *…with Loan-to-Value Ratios* | | | | | | |
| LTV < 80 and NegUnempG(Baseline) | | | | | | |
| 80 ≤ LTV < 90 and NegUnempG | 1.398*** | 0.886*** | 1.323*** | 0.906*** | 1.403*** | 0.889*** |
| 90 ≤ LTV < 100 and NegUnempG | 1.66*** | 0.845*** | 1.58*** | 0.879*** | 1.689*** | 0.839*** |
| LTV ≥ 100 and NegUnempG | 2.46*** | 0.74*** | 2.22*** | 0.808*** | 2.166*** | 0.805*** |
| LTV < 80 and PosUnempG | 1.175*** | 0.93*** | 1.124*** | 0.926*** | 1.126*** | 0.961*** |
| 80 ≤ LTV < 90 and PosUnempG | 1.624*** | 0.859*** | 1.545*** | 0.869*** | 1.53*** | 0.916*** |
| 90 ≤ LTV < 100 and PosUnempG | 1.993*** | 0.826*** | 1.86*** | 0.855*** | 2*** | 0.864*** |
| LTV ≥ 100 and PosUnempG | 2.934*** | 0.731*** | 2.624*** | 0.788*** | 2.891*** | 0.774*** |
| *…Credit Scores* | | | | | | |
| FICO in 4th Quartile and NegUnempG *(Baseline)* | | | | | | |
| FICO in 3th Quartile and NegUnempG | 1.577*** | 0.954*** | 1.56*** | 0.971*** | 1.734*** | 0.946*** |
| FICO in 2nd Quartile and NegUnempG | 2.15*** | 0.926*** | 2.048*** | 0.944*** | 2.287*** | 0.912*** |
| FICO in Bottom Quartile and NegUnempG | 3.328*** | 0.874*** | 2.99*** | 0.887*** | 3.515*** | 0.793*** |
| FICO in 4th Quartile and PosUnempG | 1.221*** | 0.951*** | 1.174*** | 0.94*** | 1.196*** | 0.957*** |
| FICO in 3th Quartile and PosUnempG | 1.927*** | 0.908*** | 1.832*** | 0.912*** | 2.074*** | 0.905*** |
| FICO in 2nd Quartile and PosUnempG | 2.626*** | 0.881*** | 2.404*** | 0.887*** | 2.735*** | 0.873*** |
| FICO in Bottom Quartile and PosUnempG | 3.842*** | 0.849*** | 3.452*** | 0.858*** | 3.865*** | 0.832*** |
| *…Documentation* | | | | | | |
| Full Doc Loan and NegUnempG (Baseline) | | | | | | |
| Full Doc Loan and PosUnempG | 1.152*** | 0.959*** | 1.135*** | 0.951*** | 1.126*** | 0.989*** |
| Low Doc Loan and NegUnempG | 1.442*** | 0.972*** | 1.398*** | 0.966*** | 1.325*** | 0.95*** |
| Low Doc Loan and PosUnempG | 1.776*** | 0.942*** | 1.71*** | 0.928*** | 1.567*** | 0.954*** |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

## APPENDIX

### Hybrid-ARMs and the role of Securitization

Determining the extent of securitization in the mortgage market can be a problem primarily because of the lack of a comprehensive data source. Nevertheless, the publication *Inside MBS & ABS* provides estimates of securitization trends in the U.S. for all market segments. Table A.1 provides their estimates of percentage securitized for Conforming (Prime) originations and that for the Subprime and Alt-A segments taken together. Table A.2 provides the break-up by cohort (year of origination) for first lien subprime loans using data provided by the Lender Processing Services (LPS) database. This is the only comprehensive mortgage database that is known to distinguish between securitized and portfolio loans at the loan-level. Note that the split between the portfolio and securitized are different from the numbers quoted in Table 1. It is important to mention here that, although very large, the LPS database is not comprehensive, especially for subprime mortgages. For subprime loans, the more comprehensive data source is the Corelogic-LP data used in the paper (see GAO, 2010 for details). Therefore, for subprime mortgages, the estimates stated in Table A.1 are probably a better indicator on securitization rates.

However, since the LPS data is known to include loan-level information about securitization, we can use it to determine the distribution of product varieties for securitized and portfolio loans. To the best of our knowledge, this is the only prominent source from which we can get this information. However, it is an open question as to whether the trends in the LPS data are indicative of trends in the population of subprime loans. The distribution of subprime originations by product type is provided separately for securitized and portfolio loans in Table A.3.

Prima facie evidence provides contradicting evidence on the causality between subprime securitization and subprime product variety. Over the period of our study, 1998-2006, both portfolio and securitized loans record significant increase in the proportion of hybrid-ARM products as a fraction of the total. Therefore, while it is true that the popularity of hybrid-ARM products coincided with the increased level of private-label securitization, a similar trend is observed also for non-securitized portfolio loans as well. Before 2000, Table A.3 reports that less than 5 percent of portfolio loans were ARM2 or ARM3 products. However, at the peak of the subprime securitization boom in 2005, over 63 percent of portfolio B & C grade loans originated were hybrid-ARM products. On the other hand, the demise of subprime securitization following the crisis in 2007 (Table 2) is accompanied by the complete disappearance of hybrid-ARM products. Clearly, linkages between securitization and product variety would be a fruitful avenue of research. At this time, however, we reserve our judgment on such linkages. It is perhaps safe to say that the emergence of hybrid-ARM products were not purely a securitization phenomenon.

### Additional Regression Results

First, we will provide a summary for the organization of tables. Our baseline regression is presented in Table 8. The covariates in Table 8 include house price growth since origination (Panel A) and year-on-year change in house prices (Panel B). The results are qualitatively similar. Non-linearities in the relationship between covariates and default are examined in Table 9. We use dummies of credit and economic variables to examine non-linearities in their relationship to default and prepayment. A list of these dummy variables is provided in Table 7. Next, we examine the effects of interactions in credit and economic variables on default and prepayment. The hazard ratios for the effects of these interactions are reported for house price growth (Table 11) and unemployment (Table 12). For example, column 1 in Table 11 and Table 12 presents the hazard ratios for default on ARM2 products for interactions with house price growth and unemployment respectively. The regression results used to calculate the ratios in column 1 are presented in Table 10. The additional regression results used to calculate the ratios in columns 2-6 of Tables 11 and 12 are presented in this appendix as Tables 10A-E.

This appendix also includes results that confirm that the results for the full sample also hold if we split the sample by cohort (year of origination). Table 8A presents the results of regressions similar to that in Table 8—except it does so for ARM2 products by cohort. Notably the results are qualitatively similar to those presented in Table 8, demonstrating that what holds for the whole sample also holds for each cohort (year of origination). Results for default and prepayment by cohort for other products (ARM3 and FRM) are also similar and are presented in an Extended Appendix (pp 61-66). Note that the covariates in Table 7A include *House Price Growth* (HPG) which measures the growth in house prices since origination. We also confirm that the results by cohort are similar when using year-on-year *House Price Change* (HPY) instead of HPG—these results are not presented here but available on request. Finally, Tables 11A and 12A present the results for ARM2 products by cohort of regressions similar to that in Table 11 and 12 respectively. Again, the results for the cohort are qualitatively similar to those for the whole sample. Lastly, the results for other products, namely ARM3 and FRM by cohort, are similar and available on request.

**Table A.1 Securitization Rates and Originations by Cohort (year of Origination)**
(Available since 2001 only; Dollars in Billion)

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|
| Conforming | | | | | | | | | |
| Securitization Rate | 72.32% | 74.47% | 77.74% | 73.72% | 80.50% | 82.52% | 91.39% | 97.80% | 93.40% |
| MBS Issuance | 914.9 | 1,270.4 | 1,912.4 | 892.0 | 879.1 | 816.9 | 1,062.0 | 899.8 | 1,106.8 |
| Estimated Originations | 1,265.0 | 1,706.0 | 2,460.0 | 1,210.0 | 1,092.0 | 990.0 | 1,162.0 | 920.0 | 1,185.0 |
| Subprime and Alt-A | | | | | | | | | |
| Securitization Rate | 45.80% | 66.00% | 68.10% | 72.90% | 79.30% | 81.40% | 92.80% | 2.90% | 0.00% |
| MBS Issuance | $98.4 | $176.1 | $269.1 | $521.1 | $797.4 | $814.3 | $432.5 | $1.9 | $0.0 |
| Estimated Originations | $215.0 | $267.0 | $395.0 | $715.0 | $1,005.0 | $1,000.0 | $466.0 | $64.0 | $10.0 |

Source: Inside MBS & ABS

**Table A.2 Distribution of Subprime Originations by Cohort (year of Origination)**
(as percentage of Total Number of Loans in last row )

| **First Mortgage, Grade B or C** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** |
|---|---|---|---|---|---|---|---|---|---|
| FHLMC | 0.24% | 2.28% | 0.88% | 0.59% | 0.38% | 0.44% | 1.50% | 7.48% | 3.75% |
| FNMA | 3.57% | 14.77% | 17.56% | 20.79% | 3.74% | 2.61% | 4.61% | 11.15% | 24.85% |
| GNMA | 0.13% | 0.61% | 0.89% | 1.09% | 0.72% | 0.71% | 0.51% | 1.29% | 27.45% |
| Local Housing Authority | 0.91% | 0.80% | 0.00% | 0.00% | 0.01% | 0.34% | 0.03% | 0.91% | 0.14% |
| Portfolio | 44.98% | 37.76% | 40.98% | 32.16% | 25.81% | 47.46% | 35.85% | 44.80% | 41.17% |
| Private Securitized | 49.76% | 42.85% | 38.87% | 44.74% | 68.77% | 47.84% | 56.99% | 33.35% | 0.33% |
| Total Number of Loans | **68411** | **71134** | **141884** | **368873** | **662365** | **908231** | **862455** | **387568** | **61511** |

Source: Lender Processing Services (LPS/McDash)

**Table A.3 Distribution of Product Types of Subprime Originations by Cohort (year of Origination)**
(as percentage of Total Number of Loans in last row )

***Private Securitized: First Mortgage, Grade B or C***

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|
| FRM | 36.2% | 58.7% | 51.7% | 44.1% | 24.0% | 22.1% | 38.8% | 57.2% | 96.0% |
| ARM2 | 16.5% | 13.3% | 14.9% | 25.7% | 33.4% | 34.1% | 28.4% | 12.7% | 0.5% |
| ARM3 | 7.4% | 5.6% | 6.5% | 16.3% | 24.2% | 11.8% | 5.5% | 3.5% | 0.0% |
| ARM5 | 0.1% | 1.8% | 6.7% | 5.6% | 0.7% | 0.7% | 1.4% | 1.5% | 1.0% |
| ARM_Other | 36.8% | 15.9% | 16.9% | 6.0% | 1.6% | 6.0% | 6.3% | 11.5% | 2.0% |
| Other | 3.0% | 4.6% | 3.2% | 2.4% | 16.0% | 25.3% | 19.7% | 13.6% | 0.5% |
| Total Number of Loans | 34043 | 30479 | 55144 | 165047 | 455530 | 434464 | 491532 | 129245 | 200 |

***Portfolio: First Mortgage, Grade B or C***

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|
| FRM | 46.75% | 24.54% | 27.12% | 42.85% | 35.50% | 22.96% | 32.60% | 66.34% | 96.09% |
| ARM2 | 3.06% | 9.27% | 10.53% | 17.22% | 40.42% | 48.88% | 44.39% | 11.79% | 0.00% |
| ARM3 | 1.46% | 1.35% | 2.29% | 3.26% | 7.53% | 13.98% | 5.53% | 3.88% | 0.54% |
| ARM5 | 0.55% | 0.57% | 0.57% | 0.63% | 1.72% | 0.90% | 3.25% | 4.04% | 1.03% |
| ARM_Other | 22.92% | 57.95% | 53.90% | 33.94% | 12.29% | 1.77% | 0.79% | 0.50% | 1.00% |
| Other | 25.26% | 6.33% | 5.58% | 2.09% | 2.54% | 11.51% | 13.43% | 13.46% | 1.33% |
| Total Number of Loans | 30770 | 26859 | 58140 | 118614 | 170936 | 431036 | 309180 | 173615 | 25325 |

Source: Lender Processing Services (LPS/McDash)

**Table 8A: Default and Prepayment Hazard Ratios by cohort (year of origination) for ARM2 products**

Panel A: Default

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| FICO (scaled) | 0.705*** | 0.554*** | 0.557*** | 0.521*** | 0.487*** | 0.553*** | 0.633*** |
| LTV | 1.004*** | 1.015*** | 1.012*** | 1.019*** | 1.016*** | 1.029*** | 1.045*** |
| Low_Doc dummy | 1.115*** | 1.269*** | 1.231*** | 1.363*** | 1.272*** | 1.432*** | 1.489*** |
| Prep. Penalty dummy | 1.137*** | 1.077** | 1.206*** | 0.974 | 1.048** | 0.898*** | 0.74*** |
| Fees and Points | 1.143*** | 1.092*** | 1.043*** | 1.061*** | 1.144*** | 1.054*** | 0.957*** |
| Interest Volatility | 1.014*** | 1.022*** | 1.018*** | 0.992*** | 1.018*** | 1.104*** | 1.056*** |
| PVAR | 1*** | 1.001*** | 1.019*** | 1.031*** | 1.091*** | 1.124*** | 1.06*** |
| House Price Growth | 0.554*** | 0.618*** | 0.621*** | 0.741*** | 0.787*** | 0.815*** | 0.846*** |
| PosUnempG dummy | 1.237*** | 1.76*** | 1.562*** | 1.287*** | 1.194*** | 1.276*** | 1.067*** |
| LR | 81998 | 84980 | 123383 | 168069 | 274234 | 352733 | 87331 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

Panel B: Prepayment

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| FICO (scaled) | 1.224*** | 1.225*** | 1.207*** | 1.215*** | 1.137*** | 1.17*** | 1.14*** |
| LTV | 0.995*** | 0.994*** | 0.996*** | 0.997*** | 0.995*** | 0.991*** | 0.986*** |
| Low_Doc dummy | 0.936*** | 0.932*** | 0.935*** | 0.962*** | 0.955*** | 0.92*** | 0.915*** |
| Prep. Penalty dummy | 0.975 | 0.724*** | 0.779*** | 0.736*** | 0.753*** | 0.897*** | 0.742*** |
| Fees and Points | 1.066*** | 1.026*** | 1.007*** | 1.019*** | 1.038*** | 0.995*** | 0.982*** |
| Interest Volatility | 1.011*** | 1.011*** | 1.003*** | 0.991*** | 1.003*** | 1.018*** | 1.017*** |
| PVAR | 1.003*** | 1.003*** | 1.014*** | 1.022*** | 1.059*** | 1.062*** | 1.044*** |
| House Price Growth | 1.303*** | 1.125*** | 1.086*** | 1.117*** | 1.163*** | 1.154*** | 1.16*** |
| PosUnempG dummy | 0.817*** | 0.796*** | 1.039*** | 0.945*** | 0.918*** | 0.892*** | 1.123*** |
| LR | 79054 | 73430 | 137416 | 389744 | 798797 | 620020 | 78771 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 10A: Prepayment Hazard Ratios for ARM2 products**

| Variable | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| FICO_Q1 | 0.882*** | 0.883*** | 0.889*** | 0.97*** | 0.882*** | 0.882*** | 0.874*** | 0.883*** |
| FICO_Q2 | 0.93*** | 0.93*** | 0.94*** | 0.986*** | 0.929*** | 0.93*** | 0.926*** | 0.93*** |
| FICO_Q3 | 0.961*** | 0.961*** | 0.968*** | 1.003 | 0.961*** | 0.961*** | 0.954*** | 0.961*** |
| LTV_8 | 0.903*** | 0.903*** | 0.972*** | 0.905*** | 0.903*** | 0.903*** | 0.903*** | 0.886*** |
| LTV_9 | 0.864*** | 0.865*** | 0.954*** | 0.866*** | 0.864*** | 0.864*** | 0.864*** | 0.845*** |
| LTV_10 | 0.761*** | 0.761*** | 0.89*** | 0.759*** | 0.761*** | 0.761*** | 0.761*** | 0.74*** |
| Low_Doc | 0.977*** | 0.977*** | 0.978*** | 0.976*** | 1.017*** | 0.972*** | 0.977*** | 0.977*** |
| Prep. Penalty | 0.763*** | 0.766*** | 0.77*** | 0.761*** | 0.764*** | 0.764*** | 0.764*** | 0.763*** |
| Interest Volatility | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** |
| PVAR | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** |
| Fees and Points | 1.05*** | 1.05*** | 1.05*** | 1.05*** | 1.05*** | 1.05*** | 1.05*** | 1.05*** |
| HPG_1_8 | 0.445*** | 0.461*** | 0.513*** | 0.509*** | 0.463*** | 0.445*** | 0.445*** | 0.445*** |
| HPG_lh_1 | 0.223*** | 0.243*** | 0.346*** | 0.273*** | 0.227*** | 0.223*** | 0.223*** | 0.223*** |
| PosUnempG | 0.963*** | 1.007*** | 0.968*** | 0.963*** | 0.962*** | 0.959*** | 0.951*** | 0.93*** |
| FICO_Q1*HPG_1_8 | - | - | - | 0.789*** | - | - | - | - |
| FICO_Q1*HPG_lh_1 | - | - | - | 0.699*** | - | - | - | - |
| FICO_Q2*HPG_1_8 | - | - | - | 0.853*** | - | - | - | - |
| FICO_Q2*HPG_lh_1 | - | - | - | 0.808*** | - | - | - | - |
| FICO_Q3*HPG_1_8 | - | - | - | 0.89*** | - | - | - | - |
| FICO_Q3*HPG_lh_1 | - | - | - | 0.811*** | - | - | - | - |
| LTV_8*HPG_1_8 | - | - | 0.861*** | - | - | - | - | - |
| LTV_8*HPG_lh_lh_1 | - | - | 0.561*** | - | - | - | - | - |
| LTV_9*HPG_1_8 | - | - | 0.813*** | - | - | - | - | - |
| LTV_9*HPG_lh_1 | - | - | 0.518*** | - | - | - | - | - |
| LTV_10*HPG_1_8 | - | - | 0.712*** | - | - | - | - | - |
| LTV_10*HPG_lh_1 | - | - | 0.482*** | - | - | - | - | - |
| Low_Doc*HPG_1_8 | - | - | - | - | 0.89*** | - | - | - |
| Low_Doc*HPG_lh_1 | - | - | - | - | 0.948*** | - | - | - |
| FICO_Q1* PosUnempG | - | - | - | - | - | - | 1.022*** | - |
| FICO_Q2* PosUnempG | - | - | - | - | - | - | 1.009** | - |
| FICO_Q3* PosUnempG | - | - | - | - | - | - | 1.013*** | - |
| Low_Doc* PosUnempG | - | - | - | - | - | 1.01*** | - | - |
| LTV_8*PosUnempG | - | - | - | - | - | - | - | 1.043*** |
| LTV_9* PosUnempG | - | - | - | - | - | - | - | 1.051*** |
| LTV_10*PosUnempG | - | - | - | - | - | - | - | 1.061*** |
| PosUnempG*HPG_1_8 | - | 0.913*** | - | - | - | - | - | - |
| PosUnempG*HP_lh_1 | - | 0.812*** | - | - | - | - | - | - |
| LR | 1448270 | 1450005 | 1463141 | 1453533 | 1450091 | 1448285 | 1448312 | 1448608 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 10B: Default Hazard Ratios for ARM3 products**

| Variable | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| FICO_Q1 | 2.97*** | 2.969*** | 2.956*** | 4.269*** | 2.972*** | 2.971*** | 2.99*** | 2.971*** |
| FICO_Q2 | 2.038*** | 2.037*** | 2.029*** | 2.561*** | 2.037*** | 2.039*** | 2.048*** | 2.038*** |
| FICO_Q3 | 1.557*** | 1.557*** | 1.553*** | 1.729*** | 1.556*** | 1.558*** | 1.56*** | 1.558*** |
| LTV_8 | 1.342*** | 1.342*** | 1.121*** | 1.347*** | 1.347*** | 1.342*** | 1.342*** | 1.323*** |
| LTV_9 | 1.609*** | 1.607*** | 1.261*** | 1.617*** | 1.616*** | 1.608*** | 1.609*** | 1.58*** |
| LTV_10 | 2.265*** | 2.261*** | 1.774*** | 2.279*** | 2.276*** | 2.264*** | 2.265*** | 2.22*** |
| Low_Doc | 1.444*** | 1.443*** | 1.442*** | 1.446*** | 1.317*** | 1.398*** | 1.443*** | 1.443*** |
| Prep. Penalty | 1.039 | 1.036 | 1.037 | 1.037 | 1.036 | 1.04* | 1.039 | 1.038 |
| Fees and Points | 1.116*** | 1.116*** | 1.116*** | 1.116*** | 1.116*** | 1.116*** | 1.116*** | 1.116*** |
| Interest Volatility | 1.011*** | 1.011*** | 1.011*** | 1.011*** | 1.011*** | 1.011*** | 1.011*** | 1.011*** |
| PVAR | 1.003*** | 1.003*** | 1.003*** | 1.003*** | 1.003*** | 1.003*** | 1.003*** | 1.003*** |
| HPG_1_8 | 7.051*** | 6.332*** | 6.035*** | 9.138*** | 6.682*** | 7.062*** | 7.053*** | 7.051*** |
| HPG_lh_1 | 18.55*** | 16.318*** | 12.633*** | 23.028*** | 19.123*** | 18.587*** | 18.554*** | 18.542*** |
| PosUnempG | 1.162*** | 0.94*** | 1.157*** | 1.16*** | 1.159*** | 1.135*** | 1.174*** | 1.124*** |
| FICO_Q1*HPG_1_8 | - | - | - | 0.635*** | - | - | - | - |
| FICO_Q1*HPG_lh_1 | - | - | - | 0.729*** | - | - | - | - |
| FICO_Q2*HPG_1_8 | - | - | - | 0.755*** | - | - | - | - |
| FICO_Q2*HPG_lh_1 | - | - | - | 0.775*** | - | - | - | - |
| FICO_Q3*HPG_1_8 | - | - | - | 0.886*** | - | - | - | - |
| FICO_Q3*HPG_lh_1 | - | - | - | 0.838*** | - | - | - | - |
| LTV_8*HPG_1_8 | - | - | 1.177*** | - | - | - | - | - |
| LTV_8*HPG_lh_lh_1 | - | - | 1.726*** | - | - | - | - | - |
| LTV_9*HPG_1_8 | - | - | 1.282*** | - | - | - | - | - |
| LTV_9*HPG_lh_1 | - | - | 1.713*** | - | - | - | - | - |
| LTV_10*HPG_1_8 | - | - | 1.306*** | - | - | - | - | - |
| LTV_10*HPG_lh_1 | - | - | 1.567*** | - | - | - | - | - |
| Low_Doc*HPG_1_8 | - | - | - | - | 1.165*** | - | - | - |
| Low_Doc*HPG_lh_1 | - | - | - | - | 0.913*** | - | - | - |
| FICO_Q1* PosUnempG | - | - | - | - | - | - | 0.984 | - |
| FICO_Q2* PosUnempG | - | - | - | - | - | - | 0.988 | - |
| FICO_Q3* PosUnempG | - | - | - | - | - | - | 0.996 | - |
| LTV_8*PosUnempG | - | - | - | - | - | - | - | 1.039** |
| LTV_9* PosUnempG | - | - | - | - | - | - | - | 1.047** |
| LTV_10*PosUnempG | - | - | - | - | - | - | - | 1.052** |
| Low_Doc* PosUnempG | - | - | - | - | - | 1.077*** | - | - |
| PosUnempG*HPG_1_8 | - | 1.278*** | - | - | - | - | - | - |
| PosUnempG*HP_lh_1 | - | 1.35*** | - | - | - | - | - | - |
| LR | 145356 | 145513 | 145681 | 145670 | 145506 | 145379 | 145356 | 145363 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 10C: Prepayment Hazard Ratios for ARM3 products**

| Variable | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| FICO_Q1 | 0.899*** | 0.899*** | 0.903*** | 1.01* | 0.898*** | 0.899*** | 0.887*** | 0.899*** |
| FICO_Q2 | 0.95*** | 0.951*** | 0.958*** | 1.019*** | 0.95*** | 0.95*** | 0.944*** | 0.951*** |
| FICO_Q3 | 0.978*** | 0.978*** | 0.983*** | 1.021*** | 0.978*** | 0.978*** | 0.971*** | 0.978*** |
| LTV_8 | 0.92*** | 0.92*** | 0.98*** | 0.923*** | 0.92*** | 0.92*** | 0.92*** | 0.906*** |
| LTV_9 | 0.898*** | 0.899*** | 0.993 | 0.9*** | 0.898*** | 0.898*** | 0.899*** | 0.879*** |
| LTV_10 | 0.827*** | 0.828*** | 0.937*** | 0.825*** | 0.827*** | 0.827*** | 0.827*** | 0.808*** |
| Low_Doc | 0.971*** | 0.971*** | 0.971*** | 0.971*** | 1.000 | 0.966*** | 0.971*** | 0.971*** |
| Prep. Penalty | 0.765*** | 0.766*** | 0.767*** | 0.765*** | 0.766*** | 0.765*** | 0.765*** | 0.765*** |
| Fees and Points | 1.057*** | 1.057*** | 1.057*** | 1.057*** | 1.057*** | 1.057*** | 1.057*** | 1.057*** |
| Interest Volatility | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** |
| PVAR | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** | 1.004*** |
| HPG_1_8 | 0.443*** | 0.458*** | 0.506*** | 0.519*** | 0.457*** | 0.444*** | 0.443*** | 0.443*** |
| HPG_lh_1 | 0.204*** | 0.218*** | 0.302*** | 0.264*** | 0.199*** | 0.204*** | 0.204*** | 0.204*** |
| PosUnempG | 0.954*** | 0.989** | 0.959*** | 0.954*** | 0.954*** | 0.951*** | 0.94*** | 0.926*** |
| FICO_Q1*HPG_1_8 | - | - | - | 0.751*** | - | - | - | - |
| FICO_Q1*HPG_lh_1 | - | - | - | 0.581*** | - | - | - | - |
| FICO_Q2*HPG_1_8 | - | - | - | 0.827*** | - | - | - | - |
| FICO_Q2*HPG_lh_1 | - | - | - | 0.747*** | - | - | - | - |
| FICO_Q3*HPG_1_8 | - | - | - | 0.878*** | - | - | - | - |
| FICO_Q3*HPG_lh_1 | - | - | - | 0.894*** | - | - | - | - |
| LTV_8*HPG_1_8 | - | - | 0.876*** | - | - | - | - | - |
| LTV_8*HPG_lh_lh_1 | - | - | 0.566*** | - | - | - | - | - |
| LTV_9*HPG_1_8 | - | - | 0.795*** | - | - | - | - | - |
| LTV_9*HPG_lh_1 | - | - | 0.551*** | - | - | - | - | - |
| LTV_10*HPG_1_8 | - | - | 0.753*** | - | - | - | - | - |
| LTV_10*HPG_lh_1 | - | - | 0.516*** | - | - | - | - | - |
| Low_Doc*HPG_1_8 | - | - | - | - | 0.908*** | - | - | - |
| Low_Doc*HPG_lh_1 | - | - | - | - | 1.084*** | - | - | - |
| FICO_Q1* PosUnempG | - | - | - | - | - | - | 1.028*** | - |
| FICO_Q2* PosUnempG | - | - | - | - | - | - | 1.014* | - |
| FICO_Q3* PosUnempG | - | - | - | - | - | - | 1.015* | - |
| LTV_8*PosUnempG | - | - | - | - | - | - | - | 1.037*** |
| LTV_9* PosUnempG | - | - | - | - | - | - | - | 1.05*** |
| LTV_10*PosUnempG | - | - | - | - | - | - | - | 1.053*** |
| Low_Doc* PosUnempG | - | - | - | - | - | 1.011* | - | - |
| PosUnempG*HPG_1_8 | - | 0.924*** | - | - | - | - | - | - |
| PosUnempG*HP_lh_1 | - | 0.856*** | - | - | - | - | - | - |
| LR | 392735 | 392938 | 394936 | 394417 | 393019 | 392738 | 392748 | 392792 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 10D: Default Hazard Ratios for FRM products**

| Variable | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| FICO_Q1 | 3.403*** | 3.401*** | 3.393*** | 4.873*** | 3.4*** | 3.404*** | 3.515*** | 3.407*** |
| FICO_Q2 | 2.261*** | 2.259*** | 2.254*** | 2.832*** | 2.259*** | 2.261*** | 2.287*** | 2.262*** |
| FICO_Q3 | 1.709*** | 1.708*** | 1.707*** | 1.862*** | 1.708*** | 1.709*** | 1.734*** | 1.71*** |
| LTV_8 | 1.386*** | 1.386*** | 1.144*** | 1.391*** | 1.388*** | 1.386*** | 1.386*** | 1.403*** |
| LTV_9 | 1.719*** | 1.718*** | 1.358*** | 1.729*** | 1.721*** | 1.718*** | 1.719*** | 1.689*** |
| LTV_10 | 2.332*** | 2.329*** | 1.965*** | 2.346*** | 2.332*** | 2.333*** | 2.329*** | 2.166*** |
| Low_Doc | 1.351*** | 1.351*** | 1.35*** | 1.356*** | 1.305*** | 1.325*** | 1.351*** | 1.352*** |
| Prep. Penalty | 1.166*** | 1.166*** | 1.165*** | 1.165*** | 1.166*** | 1.166*** | 1.166*** | 1.164*** |
| Fees and Points | 1.115*** | 1.115*** | 1.115*** | 1.115*** | 1.115*** | 1.115*** | 1.115*** | 1.115*** |
| Interest Volatility | 1.011*** | 1.011*** | 1.011*** | 1.011*** | 1.011*** | 1.011*** | 1.011*** | 1.011*** |
| PVAR | 1.003*** | 1.003*** | 1.003*** | 1.003*** | 1.003*** | 1.003*** | 1.003*** | 1.003*** |
| HPG_1_8 | 6.823*** | 6.433*** | 5.979*** | 8.73*** | 6.696*** | 6.83*** | 6.834*** | 6.831*** |
| HPG_lh_1 | 23.936*** | 22.012*** | 18.458*** | 25.18*** | 24.763*** | 23.971*** | 23.978*** | 23.886*** |
| PosUnempG | 1.142*** | 1.004 | 1.141*** | 1.142*** | 1.141*** | 1.126*** | 1.196*** | 1.126*** |
| FICO_Q1*HPG_1_8 | - | - | - | 0.63*** | - | - | - | - |
| FICO_Q1*HPG_lh_1 | - | - | - | 0.902*** | - | - | - | - |
| FICO_Q2*HPG_1_8 | - | - | - | 0.748*** | - | - | - | - |
| FICO_Q2*HPG_lh_1 | - | - | - | 0.905*** | - | - | - | - |
| FICO_Q3*HPG_1_8 | - | - | - | 0.9*** | - | - | - | - |
| FICO_Q3*HPG_lh_1 | - | - | - | 0.908** | - | - | - | - |
| LTV_8*HPG_1_8 | - | - | 1.209*** | - | - | - | - | - |
| LTV_8*HPG_lh_lh_1 | - | - | 1.61*** | - | - | - | - | - |
| LTV_9*HPG_1_8 | - | - | 1.291*** | - | - | - | - | - |
| LTV_9*HPG_lh_1 | - | - | 1.507*** | - | - | - | - | - |
| LTV_10*HPG_1_8 | - | - | 1.241*** | - | - | - | - | - |
| LTV_10*HPG_lh_1 | - | - | 1.133*** | - | - | - | - | - |
| Low_Doc*HPG_1_8 | - | - | - | - | 1.07*** | - | - | - |
| Low_Doc*HPG_lh_1 | - | - | - | - | 0.877*** | - | - | - |
| FICO_Q1* PosUnempG | - | - | - | - | - | - | 0.92*** | - |
| FICO_Q2* PosUnempG | - | - | - | - | - | - | 0.972 | - |
| FICO_Q3* PosUnempG | - | - | - | - | - | - | 0.965* | - |
| LTV_8*PosUnempG | - | - | - | - | - | - | - | 0.969** |
| LTV_9* PosUnempG | - | - | - | - | - | - | - | 1.052*** |
| LTV_10*PosUnempG | - | - | - | - | - | - | - | 1.186*** |
| Low_Doc* PosUnempG | - | - | - | - | - | 1.05*** | - | - |
| PosUnempG*HPG_1_8 | - | 1.153*** | - | - | - | - | - | - |
| PosUnempG*HP_lh_1 | - | 1.225*** | - | - | - | - | - | - |
| LR | 268049 | 268131 | 268478 | 268692 | 268149 | 268064 | 268078 | 268139 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 10E: Prepayment Hazard Ratios for FRM products**

| Variable | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| FICO_Q1 | 0.825*** | 0.825*** | 0.827*** | 1.032*** | 0.825*** | 0.825*** | 0.793*** | 0.825*** |
| FICO_Q2 | 0.929*** | 0.929*** | 0.938*** | 1.042*** | 0.93*** | 0.929*** | 0.912*** | 0.93*** |
| FICO_Q3 | 0.961*** | 0.961*** | 0.966*** | 1.036*** | 0.962*** | 0.961*** | 0.946*** | 0.961*** |
| LTV_8 | 0.917*** | 0.917*** | 1.019*** | 0.921*** | 0.917*** | 0.917*** | 0.918*** | 0.889*** |
| LTV_9 | 0.864*** | 0.865*** | 0.998 | 0.867*** | 0.864*** | 0.864*** | 0.864*** | 0.839*** |
| LTV_10 | 0.805*** | 0.806*** | 0.961*** | 0.801*** | 0.805*** | 0.805*** | 0.805*** | 0.805*** |
| Low_Doc | 0.957*** | 0.956*** | 0.957*** | 0.957*** | 0.977*** | 0.95*** | 0.957*** | 0.956*** |
| Prep. Penalty | 0.851*** | 0.851*** | 0.854*** | 0.853*** | 0.851*** | 0.851*** | 0.851*** | 0.851*** |
| Fees and Points | 1.059*** | 1.059*** | 1.059*** | 1.06*** | 1.059*** | 1.059*** | 1.059*** | 1.059*** |
| Interest Volatility | 1.005*** | 1.005*** | 1.005*** | 1.005*** | 1.005*** | 1.005*** | 1.005*** | 1.005*** |
| PVAR | 1.003*** | 1.003*** | 1.003*** | 1.003*** | 1.003*** | 1.003*** | 1.003*** | 1.003*** |
| HPG_1_8 | 0.589*** | 0.594*** | 0.68*** | 0.734*** | 0.601*** | 0.589*** | 0.589*** | 0.589*** |
| HPG_lh_1 | 0.22*** | 0.233*** | 0.317*** | 0.384*** | 0.211*** | 0.221*** | 0.22*** | 0.22*** |
| PosUnempG | 0.994*** | 1.007** | 0.999 | 0.994*** | 0.994*** | 0.989*** | 0.957*** | 0.961*** |
| FICO_Q1*HPG_1_8 | - | - | - | 0.618*** | - | - | - | - |
| FICO_Q1*HPG_lh_1 | - | - | - | 0.311*** | - | - | - | - |
| FICO_Q2*HPG_1_8 | - | - | - | 0.738*** | - | - | - | - |
| FICO_Q2*HPG_lh_1 | - | - | - | 0.543*** | - | - | - | - |
| FICO_Q3*HPG_1_8 | - | - | - | 0.803*** | - | - | - | - |
| FICO_Q3*HPG_lh_1 | - | - | - | 0.702*** | - | - | - | - |
| LTV_8*HPG_1_8 | - | - | 0.797*** | - | - | - | - | - |
| LTV_8*HPG_lh_lh_1 | - | - | 0.449*** | - | - | - | - | - |
| LTV_9*HPG_1_8 | - | - | 0.72*** | - | - | - | - | - |
| LTV_9*HPG_lh_1 | - | - | 0.449*** | - | - | - | - | - |
| LTV_10*HPG_1_8 | - | - | 0.669*** | - | - | - | - | - |
| LTV_10*HPG_lh_1 | - | - | 0.585*** | - | - | - | - | - |
| Low_Doc*HPG_1_8 | - | - | - | - | 0.931*** | - | - | - |
| Low_Doc*HPG_lh_1 | - | - | - | - | 1.204*** | - | - | - |
| FICO_Q1* UnempG | - | - | - | - | - | - | 1.096*** | - |
| FICO_Q2* UnempG | - | - | - | - | - | - | 1.042*** | - |
| FICO_Q3* PosUnempG | - | - | - | - | - | - | 1.035*** | - |
| LTV_8*PosUnempG | - | - | - | - | - | - | - | 1.072*** |
| LTV_9* PosUnempG | - | - | - | - | - | - | - | 1.072*** |
| LTV_10*PosUnempG | - | - | - | - | - | - | - | 1.001 |
| Low_Doc* PosUnempG | - | - | - | - | - | 1.015*** | - | - |
| PosUnempG*HPG_1_8 | - | 0.977*** | - | - | - | - | - | - |
| PosUnempG*HP_lh_1 | - | 0.868*** | - | - | - | - | - | - |
| LR | 807285 | 807389 | 814218 | 816633 | 807690 | 807296 | 807536 | 807575 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 11A: Default Hazard Ratios for interactions of House Price Growth with credit variables by year for ARM2 products**

| Interactions of House Price Growth (HPG) | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| *… with Credit Scores* | | | | | | | |
| FICO in 4th Quartile and HPG > 8 (Baseline) | | | | | | | |
| FICO in 4th Quartile and 1 < HPG ≤ 8 | 13.903*** | 10.575*** | 11.75*** | 12.145*** | 8.272*** | 8.186*** | 11.517*** |
| FICO in 4th Quartile and HPG ≤ 1 | 23.493*** | 39.76*** | 82.483*** | 26.395*** | 10.595*** | 13.759*** | 25.255*** |
| FICO in 3th Quartile and HPG > 8 | 1.499*** | 1.46*** | 1.605*** | 1.723*** | 1.639*** | 1.588*** | 1.277** |
| FICO in 3th Quartile and 1 < HPG ≤ 8 | 19.706*** | 15.928*** | 17.851*** | 17.534*** | 11.835*** | 11.278*** | 14.662*** |
| FICO in 3th Quartile and HPG ≤ 1 | 54.209*** | 68.388*** | 110.059*** | 39.209*** | 15.531*** | 18.107*** | 31.779*** |
| FICO in 2nd Quartile and HPG > 8 | 1.887*** | 1.828*** | 2.232*** | 2.489*** | 2.37*** | 2.302*** | 2.107*** |
| FICO in 2nd Quartile and 1 < HPG ≤ 8 | 24.82*** | 19.881*** | 22.719*** | 22.538*** | 16.018*** | 14.055*** | 17.544*** |
| FICO in 2nd Quartile and HPG ≤ 1 | 101.131*** | 100.493*** | 136.253*** | 57.428*** | 22.084*** | 21.847*** | 35.512*** |
| FICO in Bottom Quartile and HPG > 8 | 2.901*** | 2.855*** | 3.472*** | 4.175*** | 4.21*** | 3.997*** | 3.292*** |
| FICO in Bottom Quartile and 1 < HPG ≤ 8 | 34.311*** | 30.153*** | 32.092*** | 30.339*** | 22.288*** | 18.628*** | 23.753*** |
| FICO in Bottom Quartile and HPG ≤ 1 | 151.311*** | 127.633*** | 198.175*** | 67.663*** | 30.36*** | 26.621*** | 43.841*** |
| *… with Loan-to-Value Ratios* | | | | | | | |
| LTV < 80 and HPG > 8 (Baseline) | | | | | | | |
| LTV < 80 and 1 < HPG ≤ 8 | 11.387*** | 10.909*** | 9.609*** | 7.363*** | 5.236*** | 4.297*** | 5.702*** |
| LTV < 80 and HPG ≤ 1 | 51.754*** | 42.393*** | 61.11*** | 14.504*** | 6.117*** | 4.849*** | 8.101*** |
| 80 ≤ LTV < 90 and HPG > 8 | 0.96 | 1.222*** | 1.182*** | 1.093*** | 1.066*** | 1.144*** | 1.323** |
| 80 ≤ LTV < 90 and 1 < HPG ≤ 8 | 12.583*** | 13.03*** | 11.964*** | 9.356*** | 6.938*** | 7.528*** | 11.989*** |
| 80 ≤ LTV < 90 and HPG ≤ 1 | 47.789*** | 63.589*** | 73.739*** | 21.694*** | 9.148*** | 12.668*** | 26.406*** |
| 90 ≤ LTV < 100 and HPG > 8 | 0.999 | 1.3*** | 1.19*** | 1.148*** | 1.084*** | 1.25*** | 1.584*** |
| 90 ≤ LTV < 100 and 1 < HPG ≤ 8 | 13.063*** | 14.508*** | 12.956*** | 11.861*** | 8.454*** | 9.444*** | 16.13*** |
| 90 ≤ LTV < 100 and HPG ≤ 1 | 55.923*** | 68.514*** | 76.51*** | 27.406*** | 12.217*** | 16.17*** | 38.547*** |
| LTV ≥ 100 and HPG >8 | 1.893*** | 2.949*** | 1.914*** | 1.485*** | 1.534*** | 1.889*** | 2.397*** |
| LTV ≥ 100 and 1 < HPG ≤ 8 | 25.557*** | 20.679*** | 17.065*** | 14.661*** | 10.456*** | 12.367*** | 24.058*** |
| LTV ≥ 100 and HPG ≤ 1 | 51.031*** | 61.666*** | 100.515*** | 38.699*** | 13.564*** | 19.606*** | 50.248*** |
| *… with Documentation* | | | | | | | |
| Full Doc Loan and HPG > 8 (Baseline) | | | | | | | |
| Full Doc Loan and 1 < HPG ≤ 8 | 12.673*** | 10.856*** | 9.949*** | 8.609*** | 6.223*** | 6.063*** | 8.972*** |
| Full Doc Loan and HPG ≤ 1 | 55.791*** | 50.519*** | 65.013*** | 21.013*** | 8.648*** | 9.704*** | 19.085*** |
| Low Doc Loan and HPG > 8 | 1.198*** | 1.3*** | 1.199*** | 1.346*** | 1.2*** | 1.386*** | 1.428*** |
| Low Doc Loan and 1 < HPG ≤ 8 | 14.416*** | 13.774*** | 12.473*** | 12.092*** | 8.272*** | 8.76*** | 13.462*** |
| Low Doc Loan and HPG ≤ 1 | 40.562*** | 48.151*** | 63.941*** | 23.953*** | 10.358*** | 13.44*** | 27.314*** |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 12A: Default Hazard Ratios for interactions of Unemployment with credit variables and House Price Growth by year for ARM2 products**

| Interactions of Unemployment Growth Dummy | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| *…with House Price Growth* | | | | | | | |
| NegUnempG and HPG > 8 (Baseline) | | | | | | | |
| PosUnempG and HPG > 8 | 1.372*** | 2.104*** | 1.784*** | 1.286*** | 0.979 | 0.981 | 0.94 |
| NegUnempG and 1 < HPG ≤ 8 | 13.41*** | 13.984*** | 11.221*** | 9.25*** | 6.713*** | 5.657*** | 8.651*** |
| NegUnempG and HPG ≤ 1 | 49.875*** | 59.013*** | 56.461*** | 15.668*** | 4.852*** | 8.863*** | 18.198*** |
| PosUnempG and 1 < HPG ≤ 8 | 15.761*** | 18.358*** | 16.235*** | 11.326*** | 6.994*** | 6.731*** | 10.224*** |
| PosUnempG and HPG ≤ 1 | 85.318*** | 90.738*** | 133.21*** | 33.791*** | 13.72*** | 10.541*** | 20.286*** |
| *…with Loan-to-Value Ratios* | | | | | | | |
| LTV < 80 and Neg. Unemp. Gr. (Baseline) | | | | | | | |
| 80 ≤ LTV < 90 and NegUnempG | 1.084*** | 1.285*** | 1.233*** | 1.217*** | 1.191*** | 1.642*** | 2.434*** |
| 90 ≤ LTV < 100 and NegUnempG | 1.112*** | 1.466*** | 1.336*** | 1.492*** | 1.391*** | 2.046*** | 3.355*** |
| LTV ≥ 100 and NegUnempG | 2.091*** | 1.94*** | 1.743*** | 1.845*** | 1.687*** | 2.694*** | 5.021*** |
| LTV < 80 and PosUnempG | 1.203*** | 1.581*** | 1.581*** | 1.285*** | 0.998 | 1.119*** | 1.097*** |
| 80 ≤ LTV < 90 and PosUnempG | 1.297*** | 1.784*** | 1.945*** | 1.586*** | 1.258*** | 1.93*** | 2.99*** |
| 90 ≤ LTV < 100 and PosUnempG | 1.417*** | 1.848*** | 2.039*** | 1.912*** | 1.498*** | 2.364*** | 4.17*** |
| LTV ≥ 100 and PosUnempG | 2.617*** | 2.557*** | 2.898*** | 2.472*** | 1.961*** | 3.11*** | 5.442*** |
| *…Credit Scores* | | | | | | | |
| FICO in 4th Quartile and NegUnempG *(Baseline)* | | | | | | | |
| FICO in 3th Quartile and NegUnempG | 1.482*** | 1.551*** | 1.551*** | 1.607*** | 1.526*** | 1.41*** | 1.295*** |
| FICO in 2nd Quartile and NegUnempG | 1.884*** | 1.972*** | 2.052*** | 2.146*** | 2.181*** | 1.794*** | 1.494*** |
| FICO in Bottom Quartile and NegUnempG | 2.68*** | 2.868*** | 2.911*** | 3.025*** | 3.309*** | 2.523*** | 2.004*** |
| FICO in 4th Quartile and PosUnempG | 1.334*** | 1.434*** | 1.7*** | 1.423*** | 1.164*** | 1.187*** | 1.199*** |
| FICO in 3th Quartile and PosUnempG | 1.978*** | 2.225*** | 2.636*** | 2.287*** | 1.776*** | 1.674*** | 1.552*** |
| FICO in 2nd Quartile and PosUnempG | 2.514*** | 2.828*** | 3.488*** | 3.054*** | 2.539*** | 2.13*** | 1.791*** |
| FICO in Bottom Quartile and PosUnempG | 3.169*** | 4.131*** | 4.533*** | 3.861*** | 3.382*** | 2.804*** | 2.211*** |
| *…Documentation* | | | | | | | |
| Full Doc Loan and NegUnempG (Baseline) | | | | | | | |
| Full Doc Loan and PosUnempG | 1.188*** | 1.353*** | 1.498*** | 1.257*** | 1.052*** | 1.136*** | 1.113*** |
| Low Doc Loan and NegUnempG | 1.082*** | 1.17*** | 1.127*** | 1.296*** | 1.238*** | 1.399*** | 1.438*** |
| Low Doc Loan and PosUnempG | 1.417*** | 1.84*** | 2.004*** | 1.801*** | 1.386*** | 1.644*** | 1.689*** |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**EXTENDED APPENDIX (NOT MEANT FOR PUBLICATION)**

**Table 8B: Default and Prepayment Hazard Ratios by cohort (year of origination) for ARM3 products**

Panel A: Default

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| FICO (scaled) | 0.68*** | 0.646*** | 0.587*** | 0.511*** | 0.502*** | 0.562*** | 0.569*** |
| LTV | 1.007*** | 1.013*** | 1.014*** | 1.019*** | 1.017*** | 1.03*** | 1.046*** |
| Low_Doc dummy | 1.148*** | 1.242*** | 1.224*** | 1.407*** | 1.385*** | 1.512*** | 1.592*** |
| Prep. Penalty dummy | 1.174*** | 0.73*** | 1.175** | 0.629*** | 0.802*** | 0.993 | 1.017 |
| Fees and Points | 1.142*** | 1.089*** | 1.049*** | 1.086*** | 1.133*** | 1.058*** | 0.956*** |
| Interest Volatility | 1.015*** | 1.022*** | 1.014*** | 1.002*** | 1.028*** | 1.098*** | 1.058*** |
| PVAR | 1.001*** | 1.002*** | 1.021*** | 1.037*** | 1.094*** | 1.117*** | 1.056*** |
| House Price Growth | 0.54*** | 0.6*** | 0.605*** | 0.735*** | 0.758*** | 0.78*** | 0.809*** |
| PosUnempG dummy | 1.237*** | 1.746*** | 1.426*** | 1.212*** | 1.079*** | 1.228*** | 1.16*** |
| LR | 28685 | 23650 | 29732 | 33877 | 51958 | 47428 | 11577 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

Panel B: Prepayment

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| FICO (scaled) | 1.188*** | 1.221*** | 1.158*** | 1.139*** | 1.09*** | 1.174*** | 1.156*** |
| LTV | 0.996*** | 0.995*** | 0.997*** | 0.998*** | 0.995*** | 0.991*** | 0.988*** |
| Low_Doc dummy | 0.974* | 0.95*** | 0.97*** | 0.972*** | 0.975*** | 0.911*** | 0.935*** |
| Prep. Penalty dummy | 0.881*** | 0.894*** | 0.956* | 0.632*** | 0.754*** | 0.79*** | 0.761*** |
| Fees and Points | 1.063*** | 1.021*** | 1.01*** | 1.03*** | 1.039*** | 1.003*** | 0.981*** |
| Interest Volatility | 1.011*** | 1.01*** | 1.003*** | 0.996*** | 1.005*** | 1.02*** | 1.02*** |
| PVAR | 1.003*** | 1.003*** | 1.015*** | 1.026*** | 1.063*** | 1.072*** | 1.042*** |
| House Price Growth | 1.296*** | 1.112*** | 1.107*** | 1.141*** | 1.156*** | 1.154*** | 1.15*** |
| PosUnempG dummy | 0.799*** | 0.833*** | 0.967*** | 0.89*** | 0.884*** | 0.909*** | 1.178*** |
| LR | 25413 | 15590 | 32847 | 85999 | 187254 | 101862 | 12533 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 8C: Default and Prepayment Hazard Ratios by cohort (year of origination) for FRM products**

Panel A: Default

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| FICO (scaled) | 0.527*** | 0.586*** | 0.504*** | 0.519*** | 0.465*** | 0.517*** | 0.45*** |
| LTV | 1.012*** | 1.012*** | 1.017*** | 1.02*** | 1.021*** | 1.027*** | 1.043*** |
| Low_Doc dummy | 1.232*** | 1.181*** | 1.262*** | 1.354*** | 1.349*** | 1.409*** | 1.599*** |
| Prep. Penalty dummy | 1.060* | 0.993 | 1.284*** | 1.203*** | 1.225*** | 1.201*** | 1.694*** |
| Fees and Points | 1.159*** | 1.095*** | 1.046*** | 1.078*** | 1.13*** | 1.051*** | 0.957*** |
| Interest Volatility | 1.018*** | 1.022*** | 1.015*** | 1.005*** | 1.022*** | 1.100*** | 1.06*** |
| PVAR | 1.003*** | 1.003*** | 1.02*** | 1.038*** | 1.079*** | 1.122*** | 1.056*** |
| House Price Growth | 0.855*** | 0.566*** | 0.619*** | 0.721*** | 0.76*** | 0.802*** | 0.791*** |
| PosUnempG dummy | 1.138*** | 1.477*** | 1.468*** | 1.295*** | 0.996 | 1.028 | 1.109*** |
| LR | 33662 | 45171 | 44132 | 60445 | 51548 | 37125 | 11924 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

Panel B: Prepayment

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| FICO (scaled) | 1.41*** | 1.241*** | 1.157*** | 1.126*** | 1.101*** | 1.148*** | 1.129*** |
| LTV | 0.994*** | 0.995*** | 0.998*** | 0.997*** | 0.997*** | 0.993*** | 0.991*** |
| Low_Doc dummy | 0.928*** | 0.955*** | 0.966*** | 0.945*** | 0.97*** | 0.926*** | 0.95*** |
| Prep. Penalty dummy | 0.94*** | 0.923*** | 1.063*** | 0.856*** | 0.834*** | 0.807*** | 0.735*** |
| Fees and Points | 1.041*** | 1.031*** | 1.019*** | 1.032*** | 1.048*** | 1.002*** | 0.975*** |
| Interest Volatility | 1.007*** | 1.01*** | 1.004*** | 0.996*** | 1.004*** | 1.024*** | 1.025*** |
| PVAR | 1.002*** | 1.003*** | 1.016*** | 1.034*** | 1.068*** | 1.077*** | 1.048*** |
| House Price Growth | 1.000*** | 1.05*** | 1.081*** | 1.162*** | 1.161*** | 1.142*** | 1.102*** |
| PosUnempG dummy | 1.000 | 0.976*** | 1.108*** | 0.916*** | 0.902*** | 0.914*** | 1.165*** |
| LR | 33649 | 42129 | 75327 | 220160 | 207246 | 95469 | 14817 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 8A.1: Default and Prepayment Hazard Ratios by cohort (year of origination) for ARM2 products**

Panel A: Default

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| FICO (scaled) | 0.514*** | 0.475*** | 0.477*** | 0.47*** | 0.454*** | 0.527*** | 0.625*** |
| LTV | 1.01*** | 1.016*** | 1.015*** | 1.021*** | 1.019*** | 1.03*** | 1.045*** |
| Low_Doc dummy | 1.182*** | 1.288*** | 1.284*** | 1.405*** | 1.291*** | 1.473*** | 1.554*** |
| Prep. Penalty dummy | 1.238*** | 1.047 | 1.276*** | 0.992 | 1.013 | 0.923*** | 0.777*** |
| Fees and Points | 1.157*** | 1.112*** | 1.044*** | 1.053*** | 1.127*** | 1.041*** | 0.956*** |
| Interest Volatility | 1.013*** | 1.025*** | 1.021*** | 0.99*** | 1.01*** | 1.098*** | 1.05*** |
| PVAR | 1*** | 1.001*** | 1.023*** | 1.045*** | 1.104*** | 1.156*** | 1.072*** |
| House Price Growth | 0.936*** | 0.929*** | 0.945*** | 0.993*** | 1.03*** | 0.998*** | 1.006*** |
| PosUnempG dummy | 1.11*** | 1.084*** | 1.379*** | 1.093*** | 0.954*** | 0.863*** | 1.319*** |
| LR | 50148 | 52069 | 65214 | 110271 | 197705 | 288569 | 75981 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

Panel B: Prepayment

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| FICO (scaled) | 1.351*** | 1.294*** | 1.242*** | 1.245*** | 1.24*** | 1.239*** | 1.173*** |
| LTV | 0.994*** | 0.994*** | 0.996*** | 0.997*** | 0.995*** | 0.989*** | 0.985*** |
| Low_Doc dummy | 0.927*** | 0.933*** | 0.931*** | 0.953*** | 0.943*** | 0.896*** | 0.886*** |
| Prep. Penalty dummy | 0.944*** | 0.754*** | 0.779*** | 0.748*** | 0.785*** | 0.899*** | 0.766*** |
| Fees and Points | 1.036*** | 1.018*** | 1.009*** | 1.016*** | 1.025*** | 1 | 0.987*** |
| Interest Volatility | 1.007*** | 1.008*** | 1.002*** | 0.992*** | 1.001*** | 1.011*** | 1.013*** |
| PVAR | 1.001*** | 1.001*** | 1.01*** | 1.014*** | 1.036*** | 1.03*** | 1.031*** |
| House Price Growth | 1 | 0.983*** | 0.994*** | 1.035*** | 1.065*** | 1.061*** | 1.074*** |
| PosUnempG dummy | 0.991 | 1.113*** | 1.145*** | 1.033*** | 0.919*** | 0.977*** | 1.068*** |
| LR | 41357 | 55826 | 115931 | 268947 | 516422 | 393532 | 64663 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 8B.1: Default and Prepayment Hazard Ratios by cohort (year of origination) for ARM3 products**

Panel A: Default

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| FICO (scaled) | 0.489*** | 0.482*** | 0.435*** | 0.447*** | 0.419*** | 0.489*** | 0.439*** |
| LTV | 1.013*** | 1.017*** | 1.02*** | 1.024*** | 1.021*** | 1.026*** | 1.042*** |
| Low_Doc dummy | 1.254*** | 1.206*** | 1.307*** | 1.411*** | 1.399*** | 1.44*** | 1.629*** |
| Prep. Penalty dummy | 1.074** | 1.05 | 1.24*** | 1.145*** | 1.289*** | 1.231*** | 1.763*** |
| Fees and Points | 1.163*** | 1.118*** | 1.049*** | 1.069*** | 1.118*** | 1.042*** | 0.953*** |
| Interest Volatility | 1.018*** | 1.024*** | 1.017*** | 1.001*** | 1.014*** | 1.094*** | 1.056*** |
| PVAR | 1.003*** | 1.004*** | 1.025*** | 1.05*** | 1.094*** | 1.15*** | 1.066*** |
| House Price Growth | 0.931*** | 0.923*** | 0.959*** | 1.006*** | 1.031*** | 1.011*** | 0.985*** |
| PosUnempG dummy | 1.113*** | 1.109*** | 1.303*** | 1.04** | 0.934*** | 1.024 | 1.275*** |
| LR | 32775 | 28445 | 26169 | 42323 | 38386 | 30736 | 9941 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

Panel B: Prepayment

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| FICO (scaled) | 1.411*** | 1.264*** | 1.189*** | 1.172*** | 1.197*** | 1.213*** | 1.154*** |
| LTV | 0.994*** | 0.995*** | 0.998*** | 0.997*** | 0.997*** | 0.993*** | 0.99*** |
| Low_Doc dummy | 0.929*** | 0.961*** | 0.961*** | 0.938*** | 0.956*** | 0.909*** | 0.938*** |
| Prep. Penalty dummy | 0.94*** | 0.934*** | 1.077*** | 0.872*** | 0.829*** | 0.831*** | 0.722*** |
| Fees and Points | 1.041*** | 1.029*** | 1.018*** | 1.026*** | 1.034*** | 1.004*** | 0.978*** |
| Interest Volatility | 1.007*** | 1.009*** | 1.004*** | 0.996*** | 1.001*** | 1.018*** | 1.02*** |
| PVAR | 1.002*** | 1.002*** | 1.014*** | 1.024*** | 1.049*** | 1.046*** | 1.04*** |
| House Price Growth | 0.996*** | 0.985*** | 1.007*** | 1.047*** | 1.07*** | 1.062*** | 1.072*** |
| PosUnempG dummy | 1.005 | 1.095*** | 1.192*** | 1.04*** | 0.913*** | 0.949*** | 1.134*** |
| LR | 33605 | 38206 | 68300 | 168993 | 156916 | 70879 | 14145 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.

**Table 8C.1: Default and Prepayment Hazard Ratios by cohort (year of origination) for FRM products**

Panel A: Default

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| FICO (scaled) | 0.508*** | 0.537*** | 0.519*** | 0.472*** | 0.463*** | 0.532*** | 0.548*** |
| LTV | 1.012*** | 1.016*** | 1.018*** | 1.023*** | 1.017*** | 1.03*** | 1.047*** |
| Low_Doc dummy | 1.207*** | 1.239*** | 1.334*** | 1.425*** | 1.383*** | 1.541*** | 1.656*** |
| Prep. Penalty dummy | 1.358*** | 0.663*** | 1.198*** | 0.677*** | 0.891* | 1.035 | 0.978 |
| Fees and Points | 1.156*** | 1.111*** | 1.05*** | 1.078*** | 1.121*** | 1.044*** | 0.953*** |
| Interest Volatility | 1.015*** | 1.025*** | 1.016*** | 0.999* | 1.017*** | 1.092*** | 1.051*** |
| PVAR | 1.001*** | 1.002*** | 1.025*** | 1.05*** | 1.107*** | 1.153*** | 1.067*** |
| House Price Growth | 0.934*** | 0.911*** | 0.953*** | 1.007*** | 1.032*** | 1.009*** | 1.004 |
| PosUnempG dummy | 1.059** | 1.132*** | 1.247*** | 1.008 | 0.886*** | 0.973 | 1.362*** |
| LR | 17601 | 14653 | 16316 | 23535 | 35971 | 36698 | 9781 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

Panel B: Prepayment

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| FICO (scaled) | 1.307*** | 1.269*** | 1.19*** | 1.171*** | 1.164*** | 1.24*** | 1.186*** |
| LTV | 0.995*** | 0.996*** | 0.997*** | 0.997*** | 0.995*** | 0.99*** | 0.987*** |
| Low_Doc dummy | 0.946*** | 0.952*** | 0.952*** | 0.965*** | 0.966*** | 0.89*** | 0.909*** |
| Prep. Penalty dummy | 0.842*** | 0.913** | 0.919*** | 0.61*** | 0.786*** | 0.798*** | 0.777*** |
| Fees and Points | 1.035*** | 1.016*** | 1.011*** | 1.022*** | 1.027*** | 1.006*** | 0.986*** |
| Interest Volatility | 1.007*** | 1.007*** | 1.003*** | 0.996*** | 1.002*** | 1.014*** | 1.016*** |
| PVAR | 1.001*** | 1.002*** | 1.011*** | 1.017*** | 1.042*** | 1.039*** | 1.03*** |
| House Price Growth | 0.996*** | 0.981*** | 1.002*** | 1.044*** | 1.062*** | 1.059*** | 1.072*** |
| PosUnempG dummy | 0.998 | 1.165*** | 1.092*** | 1.002 | 0.91*** | 0.96*** | 1.123*** |
| LR | 13783 | 12305 | 26850 | 60734 | 130934 | 66246 | 10715 |
| p-value ($H_0$: $\beta = 0$) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

The symbols ***, ** and * denote statistical significance at 1-percent, 5-percent and 10-percent levels respectively.