A Confidence Interval for Default and Prepayment Predictions of Manufactured Housing Seasoned Loans[1]

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Abstract

Competing risk hazard functions are estimated to predict prepayment and default probabilities for Manufactured Housing (MH) seasoned loans using proprietary loan-level data composed of MH loans booked between January 1996 and September 2004. Results show that variables used to capture option price theory in the literature on mortgage termination affect MH borrowers differently. Land-home borrowers are more likely to behave in a way consistent with the predictions of the theory, while chattel borrowers are more likely to put their mortgage even when it is in the money not to do so. Then, the study uses bootstrapping to estimate a confidence interval to the predicted conditional default (CDR) and prepayment rates (CPR). Validations' results not only confirm stability of the parameter estimates but also show that actual CDR and CPR lie within the estimated confidence intervals.

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[1] This paper is an extract of my dissertation on Manufactured Housing Seasoned Loans: Default and Prepayment Predictions, and Racial Discrimination. I thank Samuel Myers, Paul Glewwe, Glen Pederson and Elisabeth Davis for their valuable comments during the conception of this project. I am also grateful for comments from participants at the Applied Economics Workshop at the University of Minnesota. All remaining errors are those of the author.

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The growth of mortgage and asset-backed securities in the 1990s has given rise to a body of literature on mortgage defaults and prepayments focused on either commercial mortgage or conventional residential mortgage markets[2]. This paper addresses two challenges left in the dark of this literature. First, it focuses on manufactured housing (MH) loans' default and prepayment probabilities. Second, it estimates a confidence interval to minimize the hedge taken by investors financing these types of loans. The accuracy of the forecasted conditional default and prepayment rates are crucial given that they are used as key assumptions in financial processes used to value and determine underwriting standards for loan originations, portfolio acquisitions, and pool securitizations.

Even though manufactured housing loans are similar to residential mortgages by their characteristics, they differ from them in the following ways. First, the collateral often depreciates over time, not only making it harder to apply option price theory to prepayment/refinance behavior, but also creating incentives to default. Moreover, the economic variables susceptible to capture consumer behavior seem not to have the same impact on the loan termination than on the conventional mortgage, raising the need for a confidence interval for an efficient implementation of the estimated parameters.

This work is divided into 5 sections. The first contains a brief introduction to MH. Section 2 reviews the literature on mortgage prepayment and default models and sets up the theoretical and empirical models. Section 3 provides a description of the data. Section 4 discusses the parameter estimates and validation of the models. Section 5 provides a confidence interval for the models.

[2] Recent studies were consecrated to subprime mortgage markets given the increase of subprime lending in the last ten years (Gjaja and al., 2004 & 2005; Danis and Pennington-Cross, 2005a; Danis and Pennington-Cross, 2005b).

1. Manufactured Housing: Definition and Facts

Manufactured housing is a term used to define housing units that are assembled in factories and then transported to their sites of use. Even though the term's general use includes both mobile homes and modular homes, its technical use is restricted to mobile homes, i.e. a class of homes regulated by the Federal National Manufactured Housing Construction and Safety Standards Act of 1974. This Act directed the Department of Housing and Urban Development to create a national building code that would make mobile homes safer by reducing their vulnerability to high winds and fire (Hart et al., 2002). The 1980 Housing Act changed the official legal name of mobile homes to manufactured housing. The technical difference between modular and mobile homes is that modular homes are usually hauled to their use locations on flat-bed trucks rather than being towed, and they lack the axles and an automotive-type frame typical of mobile homes. Both are properly referred to as manufactured housing.

The type of manufactured housing this paper will be focusing on is mobile homes. They are defined as movable dwellings, 8 feet or more wide and 40 feet or more long, designed to be towed on their own chassis, with transportation gear integral to the units when they leave the factory. They are housing units built in factories, rather than on site, and are taken to the place where they will be occupied, usually carried by tractor-trailers over public highways. They are built in a controlled factory environment on a permanent chassis to be used with or without a permanent foundation when connected to the required utilities.

The two major types of mobile homes are “single-wide” and “double-wide.” "Single-wide" are sixteen feet or less in width and are towed to their site as a single unit, whereas "double-wide" are twenty-four feet or more wide and are towed to their site in two separate units, which are then joined together.

Mobile homes are usually much less expensive than site-built homes, and are often associated with rural areas and high-density developments sometimes referred to as trailer parks. For many low and moderate-income families, adequate site-built housing is out of reach. Because of their lower cost manufactured housing is traditionally, although certainly not always, used by lower-income people. Moreover, the fact that they are perceived to depreciate in value much more quickly than site-built homes has led to prejudice and negative zoning restrictions, built around the stereotypical concept of a trailer park. Early mobile homes, even well-maintained ones, tended to depreciate in value over time like motor vehicles rather than appreciate in value, as is typically the case with site-built homes. The arrival of mobile homes in an area tended to be regarded with alarm, particularly by the owners of more valuable real estate who often feared that their property values would become depressed (See Munneke and Carlos Slawson, 1999).

This combination of factors led most jurisdictions to enact restrictive zoning regulations concerning the areas in which mobile homes can be placed, as well as the number and density of mobile homes permissible on any given site. Often other restrictions, particularly minimum size requirements, limitations on exterior colors and finishes, and mandatory specifications regarding foundations were enacted as well. Many jurisdictions will not allow any additional mobile homes, and others have strongly limited or forbidden entirely all single-wide models, which tend to depreciate more rapidly in value than modern double-wide models.

Despite the stigma associated with life in mobile homes, studies have shown that there are nevertheless many reasons people live in mobile homes (Wallis, 1991; Hart et al., 2002). These studies also show that mobile home owners are not necessarily low-income people with challenged credit, limited skills and limited education. The category of people who buy mobile homes has been widening over time.

Wallis (1991) shows that two processes have shaped the use, form, and meaning of mobile homes. The first process is one of invention, or innovation, carried out by mobile home manufacturers, park developers, and the people who live in mobile homes. These people, driven by necessity and entrepreneurship, have created a new form of housing, figured out how to relate it to land and community, how to finance, insure, and otherwise protect and market it (Wallis, 1991). Mobile home manufacturers have improved standards of construction over time and present their products as alternatives to conventional site-built homes. According to Hart et al. (2002), one of every five new single-family housing units purchased in the United States is a mobile home, sited anywhere from the conventional trailer park to custom-designed “estates” aimed at young couples and retirees.

The second process affecting the mobile home sector has been one of regulation or categorization carried out primarily by institutions: zoning and building agencies, mortgage bankers, and insurance companies. These two processes together – one pushing at the boundaries of affordability and the other increasing standards of acceptability - have given rise to a differentiated market of manufactured housing. The quality and features of new MH models leads to greater acceptance by a growing segment of the marketplace. Additionally, insurers and lenders are now more likely to treat the higher-end double-wide as they would a traditional home with regard to coverage and lending practices (Jewell, 2003). Notwithstanding there is still a market for the traditional mobile home, as the demand for housing continues to grow and the price of site-built housing will more likely continue to increase.

Two factors are determinant in the segmentation of MH products in this study: the *site* and the *width* of the home. Based on the site where the home will be placed, there are two types of MH loans. One type funds both the home and the land on which the home is placed. This type of loan will be designated as a land-home (LH) loan. A financial institution could as well finance only a mobile home, which will be placed either on a rented spot in a trailer park (park loans) or on privately owned land (non park loans). This second type of product is known as chattels (CH). LH loans are usually a larger amount than chattels, and LH collateral tends to hold value better than chattels. Also, the empirical hazards graphed in section 3 show that LH loans tend to perform better than chattels in the sense that will be made explicit in the empirical part of the paper. The width of mobile homes is the second factor explaining loan amounts and performances. Double-wide homes are more expensive than single-wide ones. They tend to hold value better and outperform single-wide homes in terms of default and prepayment rates.

2. Determinant of Mortgage Termination

This paper builds on three kinds of models in the literature on mortgage termination. The first are the econometric valuation models, which rely heavily on data mining techniques involving statistical analysis of historical prepayment and default data. The major characteristic of this trend is that statistical significance determines the retention criteria of factors driving mortgage termination and, therefore, behavioral theory plays a minor role when selecting predictors of mortgage termination.

This trend characterizes the first generation of mortgage termination models developed in the mortgage industry where the availability of data permitted statistical inference to be used to mine business decisions. The modeling techniques used in this first generation of mortgage termination models are a transfer of consumer score card techniques commonly used for revolving accounts. The focus on credit risk obliterate the importance of simultaneously modeling market risk which became a big component of mortgage cash flow management, particularly in the interest rate and house price environments of the 1990's. The emphasis on data mining constitutes the main drawback for this type of modeling work as their results are vulnerable to changes in economic factors affecting borrowers' choices to prepay or default. This paper departs from this trend by relying on behavioral theory and doing more than a simple stepwise estimation of default and prepayment.

The second approach is the option-theoretic approach (Black and Scholes, 1973; Merton, 1973; Dunn and McConnell, 1981; Deng, 1997). Option theory has been the dominant paradigm for research on residential mortgage prepayment and default. An option is a contract, or a provision of a contract, that gives the holder the right, but not the obligation, to buy (or, alternatively, to sell) a set quantity of a particular asset at a set price on, or up to, a given future date. If the contract is an option to buy, it is a "call" option; if it is an option to sell, it is a "put" option. Similarly, a mortgage is considered as a contract that gives the homeowner the right to call, i.e. buy the mortgage back from the lender, or to put, i.e. sell (give up) to the lender the property right on the asset backing the contract. A mortgage can be seen as an “American option,” as opposed to a “European option,” given that it can be exercised at any time up to the date the option expires (Black and Scholes, 1973). The decision to exercise a call or put option is driven by the extent to which the embedded options to prepay or default are “in the money.” The theory holds that mortgage borrowers will exercise embedded call (prepayment) or put (default) options when either of these options are “in the money” (Deng et al., 2000; and Calhoun and Deng, 2002).

The assumption driving the option-theoretic approach to mortgages is that even though mortgages depend on the real economy through the process describing changes in the term structure and the house price, the valuation of mortgages does not necessarily depend on the variables determining the underlying economy (Kau and Keenan, 1995). These variables can be considered as exogenously determined by the prevailing state of the nature and then factored into the borrower’s valuation of the mortgage. A mortgage’s valuation is entirely explained by arbitrage reasoning as put forth by Arrow-Debreu’s (AD) seminal work on assets valuations in markets with uncertainty (1954). Indeed, the key idea behind the theoretical approach to mortgage termination is the no arbitrage opportunity condition; i.e. the absence of a position in the marketplace with a positive probability of realizing a profit without taking a risk. This idea constitutes the building block of the results in the contingent claims models by Black and Scholes (1973) hereafter BS, Merton (1973), and Cox, Ingersoll, and Ross (1985).

BS is indeed the basis of the literature on mortgage termination. According to BS, the current value of the option is approximately equal to the price of the underlying asset minus the price of a pure discount bond that matures at the same date as the option, with a face value equal to the striking price of the option. Formally, a call option with strike price K at maturity date t+H is a function of the current price of the underlying asset S_t and of the short-term interest r_t:

$$P_t(K, H) = p_{BS}(S_t, r_t, K, H; \sigma)$$

where σ is the volatility parameter. Given observed asset prices S_t, interest rates r_t, and derivative price $P_t(K_j, H)$, the no arbitrage condition and the completeness of markets imply that BS volatility, defined as the solution of

$$P_t(K_j, H) = p_{BS}(S_t, r_t, Kj, H; \sigma(Kj))$$

is an infinitely accurate estimator of $\hat{\sigma}$. Such a conclusion is the shortcoming of the BS model, as different strike prices K_j can lead to different estimates of $\hat{\sigma}$ (See Clement et al., 2000).

On one hand, the present study expands upon the contingent claims models, as these models emphasize the fact that the value of the mortgage is correlated with underlying state variables (interest rate and house price) whose values are derived from the process determining the economic environment[3]. The apparent difficulty of linking

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[3] As shown in the summary by Kau and Keenan (1995), the values of the term structure and the house price are derived from the process describing the true economic environment relevant to the mortgage as follows:

$$dr = \mu_r(r, H, t)dt + \sigma_r(r, H, t)dz_r \qquad (1)$$

$$dH = \mu_H(r, H, t)dt + \sigma_H(r, H, t)dz_H \qquad (2)$$

with

$$dz_r, dz_H = \sigma\ (r, H, t)dt \qquad (3)$$

where H is the house price, r the spot rate, dz_r and dz_H are standard Wiener process with $E[dz] = 0$ and $E[dz^2] = dt$, and σ capturing the correlation between the disturbances to the house price and those of the term structure. The Wiener process term z assures that the actual changes in the interest rate and house price differ from the expected changes in an unbiased way because of normally distributed, serially uncorrelated disturbances to the economy.

the deterministic conclusion of BS with uncertainty characterizing asset valuation in this market gave rise to literature trying to reconcile risk neutral valuation and stochasticity. The major feature of the mortgage contract is indeed uncertainty about its future due to its lengthy maturity term in a stochastic economic environment. Hendershott and Van Order (1987[4]) and Kau and Keenan (1995) provide a thorough review of the way authors have strived in the literature to solve this problem. Still, these applications of the contingent claim models to mortgage termination have limitations, making it difficult to apply to the topic at hand.

The first limitation concerns the disputed approach of the default and prepayment decision as competing risk decisions. Common applications of contingent claims to

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In the case where the house is a traded asset with a rental rate $s(r, H, t)$, the principle that the economy appears to be risk neutral after adjustment means that the adjusted expected return to the house must simply be the risk-free rate r; that is,

$$(\mu_H - \lambda_H \sigma_H)/H + s = r \qquad (4)$$

This, together with the LEH that $\lambda_r = 0$, gives us the final forms

$$dr = \mu_r(r, H)dt + \sigma_r(r, H)dz_r \qquad (5)$$

and

$$dH = [r - s(r, H)]Hdt + \sigma_H(r, H)dz_H \qquad (6)$$

Under the perfect capital market assumption together with the local expectations hypothesis, it has been shown (see au et al., 1995) that the value of the mortgage M satisfies

$$\frac{1}{2} r\sigma_r^2 \frac{\partial^2 M}{\partial r^2} + \rho\sqrt{r}H\sigma_r\sigma_H \frac{\partial^2 M}{\partial r \partial H} + \frac{1}{2} H\sigma_H^2 \frac{\partial^2 M}{\partial H^2} + \gamma(\theta - r)\frac{\partial M}{\partial r} + (r-d)H\frac{\partial M}{\partial H} + \frac{\partial M}{\partial t} - rM = 0$$

This follows almost directly from the model of Black and Scholes (1973). From the above equation together with the appropriate boundary conditions, we can solve for the optimal values of the state variables r* and H*. This is the relevant argument explaining why the major form of prepayment in the MH finance industry is refinance. This leads to an optimal rule about mortgage termination: Default when the house value falls to H; prepay when interest rates decline to r* or when the house price is much greater than H*. Thus the difference between the outstanding mortgage balance and H* defines the extent to which the put option must be in the money for optimal default, and the difference between the mortgage coupon rate and r* defines the extent to which the call option must be in the money at exercise. In this setting, when the value of the house drops to below the level that would fully collateralize the outstanding debt, a homeowner may rationally choose to default on the mortgage. The broader literature on the relationship between house prices and mortgage market activity suggests that declines in house prices also restrict mobility and refinancing. In weak house price environments, mobility is reduced because homeowners have less equity to use to trade up to larger houses, and refinancing is held down because loan-to-value constraints tend to bind.

[4] Hendershott, P. H., and R. Van Order (1987). "Pricing Mortgages: An Interpretation of the Models and Results," Journal of Financial Services Research, 1, 77-111.

mortgage termination have focused on either default or prepayment only. Most of the papers in this literature have overlooked the fact that default and prepayments are conditional on each other. The present study takes the option, as in Deng et al. (2000), to model default and prepayment together. But, opposite to Deng, the present study uses a discrete time hazard model to account for the fact that prepayment and default are usually reported on a monthly basis.

Moreover, this study incorporates the results of works in contract theory using discrete time stochastic growth models, as in Eaton and Gersovitz (1981) and, even more, in the seminal work on debt-constraint asset markets by Kehoe and Levine (1993) and its refinement by Alvarez and Jermann (2000). These models bring two important perspectives to the present study. First, they set up a discrete time sequential framework in which the agent has to make an optimal choice given his utility function and the constraints he faces. Translated to the MH default and prepayment decision, the borrower has to choose every month, when his payment is due, either to make the monthly payment and continue with his mortgage contract, default on the mortgage payment, or pay the outstanding balance in full. Second, this framework has the advantage of making explicit the participation constraint implying that the borrower is assumed to have a clear understanding of the fact that a default decision today will prevent him from exercising his prepayment option, as this will exclude him from future contingent claim markets. Therefore, this participation constraint makes more relevant the competing risk characteristics of prepayment and default and supports the choice made in this paper to model the two events together.

Eaton and Gersovitz (1981) have the merit of laying down, in a general equilibrium setting, conditions under which a decision to default can be optimal for a borrower and lead to an inefficient outcome for the economy as a whole. However, their paper cannot be applied to the problem at hand for two reasons. First, there is no intertemporal transfer given that the output in the economy is not storable and there is no asset in the economy defined in their paper. Second, the model focuses on the international private market, in which borrowing is restricted to short-term consumption smoothing.

Kehoe and Levine (1993) – and their extension by Alvarez and Jermann (2000) – bring new dimensions to the debt-constraint asset market by specifying a bidding participation constraint for borrowers and introducing the possibility of being excluded from future contingent claims markets and having the assets backing the claim seized. The participation constraint individually rationalizes the decision to default in a way that, for Kehoe and Levine, guarantees that agents at no time would be better off reverting permanently to autarchy. At the same time, such a result represents a limitation to the application of this model to the default decision, unless we adopt a more practical participation constraint, introduced in Alvarez and Jermann (2000), in which continuation implies that the corresponding utility is at least as high as the utility level corresponding to reverting to autarchy. This refinement opens up the possibility of a default outcome (reversion to autarchy) as an optimal choice.

Applied to the exercise of the “call” or “put” options of the mortgage contract, mortgage continuation should imply that the continuation utility - mortgage valuation - should be at least as high as the reward of either of the options to call or to put the mortgage at any time and any history. This set up allows for a timing consistent with the empirical part of this paper that uses a discrete time hazard model to predict default and prepayment. The choice of a discrete time specification is driven by the fact that mortgagors service loans on a month-by-month basis. They usually report default or prepayment on a month-end basis. Depending on the mortgage's closing date, billing cycles can be different from one borrower to the next, but mortgagors usually consolidate monthly events for reporting purpose. The reporting purpose seems to be the most important way to count delinquencies and prepayments as they are used in the periodic financial statements of the company.

Formally, we consider an economy with a finite number of consumers choosing between three discrete choices over T discrete periods. At each period t, the consumer has to choose between continuing his mortgage, put or call it. Specifically, at each time t, the borrower chooses either to continue, to call or to put his mortgage with corresponding probability $\pi_i(t)$, i.e.

$$\pi_i(t) = \begin{cases} 1 if alternative 1 is chosen; \\ 0 otherwise. \end{cases} \quad \text{for i=1,2,3 and t=0, 1, … T.} \tag{1}$$

Alternatives are mutually exclusive, i.e. $\sum_{i=1}^{3} \pi_i(t) = 1$ at each t in T.

We assume that all information is publicly held and common knowledge. The agent's preferences are assumed to be rational and continuous, therefore representable by a utility function. At each period t, the borrower maximizes the following utility function:

$$U_j = R_i(j)\pi_i(j) + \varepsilon(j) \tag{2}$$

where $R_i(j) = \Phi(r(j), H(j), j, \phi(j))$ (3) is the deterministic part of the utility function representing the cash flow at time j if alternative i is chosen and $\varepsilon(j)$ is the random error term representing measurement errors, omitted variables and unaccounted information about all past and current realizations of the variables that directly or indirectly affect the value of (2).

The reward $R_i(j)$ is a function of the prevailing economic environment characterized by the idiosyncratic interest rate $r(j)$ [5] and the borrower's relative position with regard to local area house price appreciation $H(j)$. For simplicity, the processes generating the structure rate and house prices are exogenous to the borrower and depend on the state of nature. At time j, the borrower makes his decision to put, call or continue his mortgage based on his knowledge of the current realizations of these variables, not their entire history.

This assumption is realistic given the fact that the majority of MH borrowers are in the lower income bracket of the society, with challenged access to information about past and future interest rates and limited tracking record of house prices appreciation. These two factors become relevant when borrowers find themselves in a position to decide about whether to put or call their mortgages. Consequently, only the prevailing interest rate and house prices are available information when they want to make their choice.

The borrower's choice to call or put his mortgage will depend on the information he has concerning his relative positions with respect to the market interest rates and house price appreciation. These relative positions are a function of the prevailing market

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[5] This has to be thought as a spot interest rate for this specific borrower which is function of both the prevailing market rates and both borrower and collateral specific characteristics.

interest rate, the house price appreciation and idiosyncratic differences across borrowers represented by the history strings of individual past payment choices summarized by their current FICO score. The borrower's position with regard to the prevailing market rates is captured by the borrower refinance incentive; i.e. the change in gap between the coupon rate on his mortgage and the market interest rate evaluated at each time he faces the decision to call or put his mortgage. House price appreciation depends on the status of the housing market in general, the characteristics of the home and the area in which it is located. Its movement determines change in loan-to-value ratio and the borrower's equity position. High house price appreciation leads to a decrease in the proportion of the value of the collateral needed to extinguish the debt and to an increase in the investment equity. Under these circumstances, borrowers are supposed to hold onto their asset. The opposite situation is more conducive to default.

The last element in the reward function is $\phi_j(z^j)$, a vector of other collateral characteristics determined in part by the borrower's creditworthiness and in part by the property characteristics; i.e. type (land-home or chattel), age (new or used), width (single or double-wide), and geographic location[6].

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[6] Given that the lender has already funded the loan, his problem is a Stackelberg-like problem whose optimal solution depends on his ability to foresee borrowers' choices to put or call the mortgage. The lender's problem is therefore to maximize the following profit function:

$$\pi_i(t) = \begin{cases} \sum_{t=0}^{t} \frac{1}{(1+r)^t}(P(t) - VP(t) - IP(t) if the loan stay open; \\ \sum_{t=0}^{t} \frac{1}{(1+r)^t}(P(t) - NCP(t) otherwise. \end{cases}$$

where P(t) is the loan repayment amount at time t, VP(t) is the voluntary prepayment by the borrower, IP(t) is any cost due to involuntary prepayment (default), and NCP(t) is the net cost of prepayment if the loan closes at time t by either prepaying or defaulting. Therefore good predictions of voluntary and involuntary prepayment are crucial to the determination of a loan's cash flow and therefore its pricing.

To estimate the parameter of the reward function, the present study uses survival analysis (See Lancaster, 1990; Hosmer, D. W. and Stanley Lemeshow, 1999) to estimate the probability of an event occurring next period, conditional on the event not having occurred up to the current period. At each point of time, the model is estimating the probability for a loan to prepay (default) next period, conditional on it surviving on the books up to now and not having defaulted (prepaid) yet.

Survival methods have been extensively used in econometric studies having the following three characteristics. First, the empirical model estimates the expected time before a well-defined event occurs. Second, observations are right censored. Right censoring occurs because the event time and type are unknown for individuals for which the event has not yet occurred at the outcome period. In this case, the event outcome is set equal to non event. Third, there are explanatory variables that affect the probability of the occurrence of the studied event. In summarizing survival analysis, two functions are of central interest: the survival function and the hazard function. Survival function is concerned with the expected time T until the event occurs.

Let T be a non-negative random variable representing the waiting time until the occurrence of an event. Assume T is a continuous random variable with probability density function (p.d.f.) f(t) and cumulative distribution function (c.d.f) given by F(t) = Pr{T = t}, giving the probability that the event has occurred by duration t. The survivor function is the probability that the survival time, i.e. the period of time from the time origin to the occurrence of the event at time t, is greater than or equal to t, i.e.

$$S(t) = \Pr(T = t) = 1 - F(t) \qquad (4)$$

For example, the survivor function represents the probability that a loan stays open in books from its origination to some time beyond t. The hazard function is the probability that a loan closes at time t, conditional on it staying open up to t. Formally, the hazard function can be represented as follows:

$$\lambda(t) = \lim_{h\to 0} \Pr(t \le T < t + h \mid T \ge t)/h$$

$$= \frac{f(t)}{S(t)} \qquad (5)$$

The hazard function represents the instantaneous termination rate of a loan at time t, given that they stayed open until t (Kiefer, 1988). This study will not be looking at the survival function. It will instead focus on the hazard function. Still, expression (5) shows clearly that they are closely related.

The reward function $R_i(j)$ is actually determined by unobserved latent variables that are function of variables in expression (3) here represented by the vector z such that $R_i*(j) = z'\beta_i + e$.

The following multinomial logit (MNL) model gives the estimated probability to default (or prepay) for an MH loan during the **j^th^** quarter, given the corresponding reward function represented by the covariates' vector Z and the fact that no prepayment (or default) has occurred prior to quarter j:

$$\text{Prob}\,(default(orprepayment) = 1 \mid z_{it}) = \frac{e^{z_{it}'\beta_1}}{1 + \sum_{i=1}^{2} e^{z_{it}'\beta_i}} \qquad (6)$$

The choice for multinomial specification for the hazard function was guided by theoretical and empirical reasons. The choice set in the case of the MH prepayment and default satisfies the property of irrelevant of independent alternatives. The Independence of Irrelevant Alternatives (IIA) assumption states that the relative odds between any two outcomes are independent of the number and nature of other outcomes being simultaneously considered (McFadden, 1974; Luce, 1959). The clearest case of a violation of this property is when certain outcomes serve as substitutes for others. Multinomial logistic regression assumes that none of the categories can serve as substitutes. If they can serve as substitutes, then the results of multinomial logistic regression might not be very realistic. In the case of MH loans, most borrowers have basically a choice between refinancing the existing loan to a different lender to prepay the existing one or default on the loan. Any other types of transfer of property right conducted as part of loss mitigation have been excluded from the modeling data. Moreover, multinomial logit is best suited for predicting events that occur at regular, discrete points in time, and with large data sets and time-dependent covariates (Allison, 2005).

The hazard model is estimated using the maximum likelihood estimation method with the caveat that a special accommodation is needed given that the study is using a mixed sample composed of seasoned and newly originated loans. As in Berger and Black (1998), newly originated loans permits to recover the parameters associated with new loans, with an associated disadvantage that this approach limits the observable survival time to the duration of the panel data (here up to a maximum of twenty one quarters). By using a mixture of new and seasoned loans, this problem can be avoided. Such a sample is informative about the hazard function in excess of the twenty one quarters spanning from September 1999 to January 2005. While a mixed sample of flow- and stock-sampled observations allows the identification of the hazard function for both long and short spells, the use of a mixed sample requires us to adjust the likelihood function to reflect the presence of stock-sample observations.

This adjustment can be difficult when the origination date of the stock-sampled loans is unknown[7]. Fortunately, we know the beginning date of the stock-sampled loans in our data, which as in Berger and Black (1998) makes the problem more tractable. Following Berger and Black (1998) let the density function of durations given by

$$f(t, z, \beta) \qquad (7)$$

where t is the duration of the spell, z is a vector of (time-invariant) covariates, and β is a vector of parameters. Importantly, we assume that $f(t, z, \beta)$ does not vary over time. If we have a sample of n observations, $\{t_1, t_2, \ldots, t_n\}$, the likelihood function of the sample is

$$L(\beta) = \prod_{i=1}^{n} f(t_i, z_i, \beta) \qquad (8).$$

To introduce stock sampling, let the set C be the set of loans that were in progress at the truncation date. For these observations, we know that the loan has stayed open for r quarters before the panel begins so that the probability that the total survivor time will be t, given that the spell has lasted until time r, is simply given by

$$\frac{f(t, z, \beta)}{S(r, z, \beta)} \qquad (9),$$

[7] Klerman (1992) and Swartz, Marcotte, and McBride (1993b) use mixed samples from the SIPP to estimate spells without health insurance when the date the spell began is unknown. Also see Lancaster (1991) for a discussion of the estimation of duration models when the date the spell begins is unknown.

adjusting these observations by the conditional probability of the loan having stayed open for r quarters at the beginning of the observation period. Therefore the likelihood function for the stock- and flow-sample observations combined may be written as

$$L(\beta)=\prod_{i\in A} h(t_i,z_i,\beta)\times\prod_{i\in A\cup B} S(t_i,z_i,\beta)\times\prod_{i\in C}\frac{f(t_i,z_i,\beta)}{S(r_i,z_i,\beta)} \qquad (10).$$

Convert the last term in equation (10) to a hazard function, the likelihood function becomes

$$L(\beta)=\prod_{i\in A\cup C} h(t_i,z_i,\beta)\times\prod_{i\in A\cup B\cup C} S(t_i,z_i,\beta)\times\prod_{i\in C}\frac{1}{S(r_i,z_i,\beta)} \qquad (11).$$

As explained in Berger and Black (1998), the third term of the right-hand side of equation (11) reflects the adjustment necessary for the stock sample. It is an artifact of the sampling strategy, allowing estimating the underlying parameters of $f(t,z,\beta)$ while conditioning on r. The likelihood function for a sample of n independent observations and two competing risks is given by:

$$L(B)=\sum_{i\in AUC}^{n} h(t_i,x_i,\beta)+\sum_{i\in AUBUCUD}^{n} S(t_i,x_i,\beta)+\sum_{i\in CUD}^{n}\frac{1}{S(r_i,x_i,\beta)} \qquad (12)$$

which can be interpreted as three types of contributions to the probability that a loan terminates at quarter t or later by either defaulting or prepaying, conditional on that same loan having survived t quarters in the books (t + r quarters for the stock sample observation) and not having prepaid or defaulted yet.

3. Data

The development sample is composed of MH proprietary loan-level data from a servicing company. It includes loans funded between July 1995 and December 2003. Two types of censoring and a truncation are applied to the data. First, loans with an open date prior to July 1995 are left-censored from the development sample due to reliability issues. July 1995 corresponds indeed to the implementation of an in-house data warehouse system under which loans were better tracked and serviced. Second, the outcome period is set to January 31, 2005. Data are therefore right censored at that date, meaning that accounts still open on January 31, 2005 are set to non-event even if they happen to close in the following months.

Finally, the dataset is truncated as of January 1, 1999 due to the availability of refreshed FICO[8] scores. The FICO score is considered in the loan industry as a summary of the overall credit worthiness of a consumer. The score is a summation of points given to a customer based on where the consumer stands in regards to key factors correlated with delinquency such as status of existing trades with other creditors, ratio of the balance of trade to credit limit, number of trades, income, assets, etc. Points are determined based on corresponding factors' estimated odds ratios. This score can change from one period to the other depending on the way it is affected by the customer's debt payment history and overall credit profile. Therefore, updating the FICO score as time goes is crucial to improving the predictability of this variable in the model. This is why

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[8] A FICO score is a credit score developed by Fair Isaac & Co. Credit scoring is a method of determining the likelihood that credit users will be ninety days or more past due twenty-four months into the contract. Fair, Isaac began its pioneering work with credit scoring in the late 1950s and, since then, scoring has become widely accepted by lenders as a reliable means of credit evaluation. A credit score attempts to condense a borrower's credit history into a single number.

FICO score enter the model as a time-varying factor, meaning that its value is updated at each point of time.

The truncation date corresponds to the date at which the considered company adopted the policy of updating FICO scores on a regular basis. Starting in January 1999, customers' credit bureau information is refreshed every month. About a third of the accounts on the books get refreshed each month such that every single account gets refreshed at least once every quarter. The left truncation of the data set is the major difference between a model for newly originated loans and a model for seasoned accounts. In the first model, every account at the observation date is a newly originated loan. Default and prepayment are predicted from age zero onwards. Subsequently, loans still open at each point of time are of the same age. By left truncating the development sample on September 1, 1999, loans with an open date prior to September 1999 enter the development sample at their age as of the truncation date, provided that they are still open at this date. Loans open between October 1999 and December 2003 enter the development sample at zero months on books whenever they are funded. The development sample contains both seasoned loans that are not left-censored and newly originated loans during the observation period. This is an analysis using flow and stock samples requiring a special specification for the likelihood function as will be made explicit in section 4 below.

Figure 3-1 Loan Transition States[9]

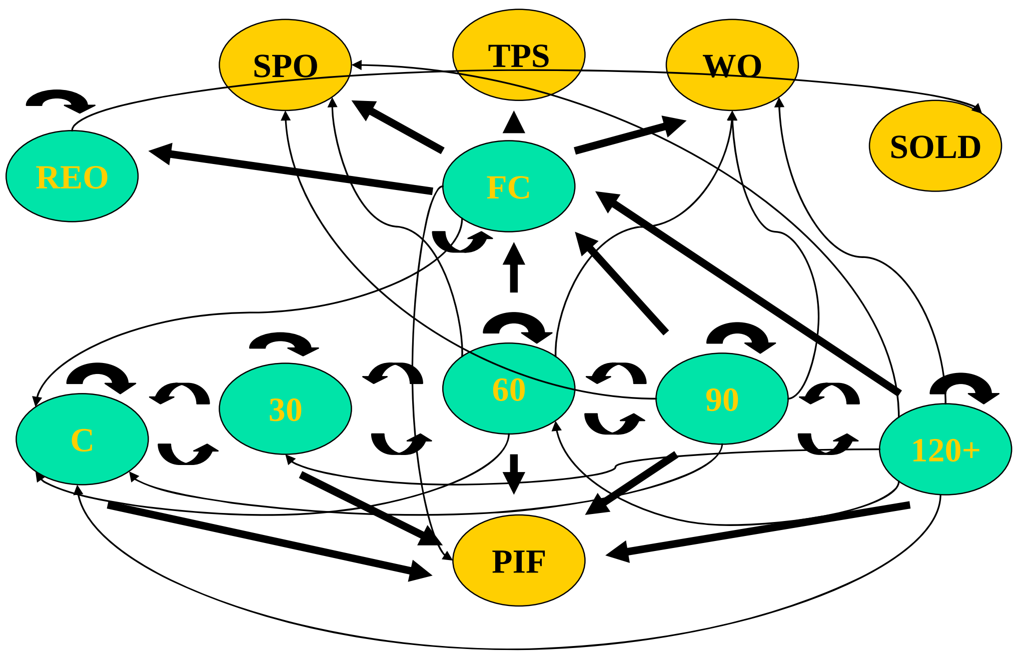


Figure 3-1 above shows different states in which an account can transit before closing by either defaulting or prepaying. When funded, a loan is current until the borrower does not send a payment within thirty days after his payment is due. If this happens to be the case, the account becomes thirty days past due and can transition back to current if the borrower sends in two payments in the following month. If only one payment is received, the account stays in the 30 days bucket. If no payment is sent in the following month, the account rolls into 60 days past due. If still no payment is sent in the following months, the account will roll further into delinquency until the servicer decides to proceed to foreclosure. When the loan is in foreclosure, four things can happen. The mortgagor can repossess the real estate backing the mortgage (REO), ask the borrower to

[9] PIF means that the outstanding balance is Paid in full; C means that the account is current; 30, 60, 90 and 120+ stand for 30, 60, 90 and 120+ days past due; FC stands for foreclosure; REO means repossession; SPO, TPS, WO, and SOLD are different types of resolution out of foreclosure decided by the servicer who can agree to let the borrower sale the property himself and pay back

come up with the outstanding balance to short payoff the loan (SPO), work out a time for the borrower to sell the house and payoff the loan from the proceeds of the sale (TPS), or just write off the loan as a complete loss (WO). If the lender decides to repossess the home, he can either sell the house or, as a loss mitigation strategy for the specific asset class in consideration, work with the defaulted borrower to find another person to transfer the contract to. The latest strategy is called detrimental transfer of equity. Under this mechanism, the new person takes the contract where the first borrower left it by compensating the first borrower for any equity earned in the house and commit himself vis-à-vis the lender to honor the mortgage for the rest of the term.

The present study does not model resolutions out of foreclosure because these decisions are not borrower's choices. They are loan servicing decisions. This study focuses on borrower's behavior by predicting the borrower's decision to either default or prepay, conditional on him/her not having prepaid (or defaulted) yet up to this time. The predicted events are default or prepayment defined as follows. Default means foreclosure subsequent to default. Prepayment is the borrower's choice to pay the outstanding balance in full before the scheduled maturity date. In the specific case of manufactured homes, prepayments are mostly refinances, i.e. cases where borrowers open a new loan with another lender with better conditions to payoff the existing loan and reduce the monthly repayment of the loan.

The following accounts have been excluded from the development sample. First, loans that have been sold to other financial companies are excluded from the development sample. These loans are shown in the books as prepayments even though they are not. Also, loans with terms greater than 360 months have been excluded from the development sample, the reason being that such a term is faulty. The company has never disbursed a loan with a term greater than 360 months.

Given that manufactured homes are of two types, the development sample is first divided by product type into chattel and land-home loans. Land-home loans fund the purchase of both the manufactured home and the land on which the house will be placed. This type of loan is close to the conventional residential mortgage by its terms, collateral value and performance, as will be shown later. Chattel loans fund only the home, which can be placed either on privately owned land (non park) or in a trailer park (park). Chattels, especially park homes, are the most widely known type of manufactured homes that people have in mind when they refer to manufactured housing. They are supposed to depreciate over time, leading to poor credit performance and slow prepayment speed. The empirical part of this paper will compare estimates from these two populations and test for differences between them. For model validation, each of the two populations is split 2/3 for model development and 1/3 for model validation.

Table 3.1 below provides a snapshot of the modeling data by age (quarters on books) and origination year as of the truncation date of September 30, 1999. Loans with negative numbers are loans that are not yet open as of September 30, 1999. They enter the modeling data at the given number of months after the truncation date. Even though the population size between chattel and land-home loans is different, the proportion of loans falling in each quarter bucket is very similar. However, the default and prepayment distributions are different.

Table 3-1 Population Age (in quarters) as of September 30, 1999

	Landhome		***Chattel***	
Qtrs on Books	Count	Pct	Count	Pct
-13	29	0.04%	4	0.00%
-12	271	0.39%	317	0.24%
-11	352	0.51%	329	0.25%
-10	246	0.36%	815	0.62%
-9	623	0.90%	1445	1.10%
-8	1377	2.00%	2642	2.02%
-7	1571	2.28%	2957	2.26%
-6	1375	2.00%	2767	2.11%
-5	925	1.34%	2364	1.80%
-4	1308	1.90%	2566	1.96%
-3	2500	3.63%	4665	3.56%
-2	3533	5.13%	6212	4.74%
-1	2615	3.80%	5525	4.22%
0	3196	4.64%	6180	4.72%
1	3904	5.67%	7509	5.73%
2	3789	5.50%	7611	5.81%
3	2638	3.83%	6318	4.82%
4	3626	5.26%	6254	4.77%
5	4009	5.82%	6731	5.14%
6	3827	5.55%	6675	5.09%
7	2238	3.25%	4994	3.81%
8	3104	4.50%	5078	3.88%
9	3507	5.09%	5996	4.58%
10	3192	4.63%	5669	4.33%
11	1749	2.54%	4028	3.07%
12	2500	3.63%	4310	3.29%
13	2806	4.07%	4941	3.77%
14	2533	3.68%	4792	3.66%
15	1471	2.13%	3508	2.68%
16	2044	2.97%	3599	2.75%
17	2048	2.97%	4228	3.23%
Total	68906	100.00%	131029	100.00%

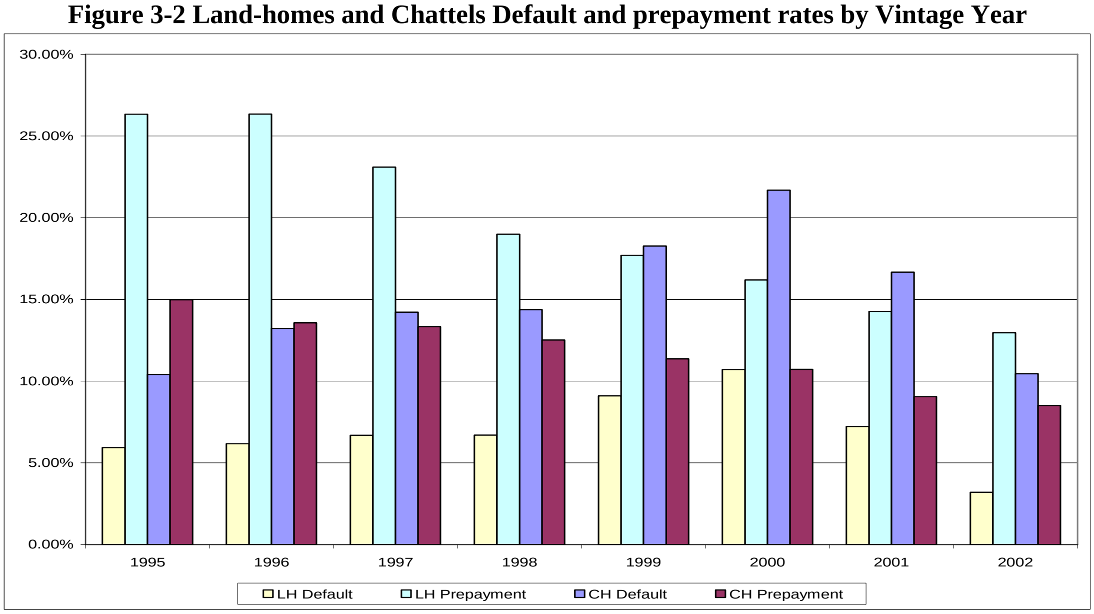
Table 3.2 below shows the proportion of event types at the outcome period of January 31, 2005. Chattel loans have a higher proportion of default compared to land-home loans. Indeed, 23.47 % of chattels went bad, while only 10.03 % of land-homes defaulted.

Table 3-2 Events Distribution as of January 31, 2005

	Land-home		***Chattel***	
Event	Count	Pct	Count	Pct
Censored (0)	42,270	61.34%	74,253	56.67%
Default (1)	6,910	10.03%	30,748	23.47%
Prepayment (2)	19,726	28.63%	26,028	19.86%
Total	68,906	100.00%	131,029	100.00%

Contrariwise, land-homes have a higher prepayment speed (28.63%) compared to chattels (19.86%). Figure 3.1 below stresses even further the same contrast by showing two things. First, for any given vintage year,[10] chattels have a higher default rate than land-homes while land-homes prepay at a higher speed. Second, vintages 1999 and 2000 seem to be riskier than both earlier and later vintages. Overall, they have a higher default rate than other vintages. A combination of factors explains this empirical fact. First, these corresponds to refinancing boom in the mortgage industry during which fierce competition among lenders lowered underwriting requirements leading to an increase in volume. This fact combined with the slowdown of the US economy in 2000 and

Figure 3-2 Land-homes and Chattels Default and prepayment rates by Vintage Year



[10] Loans funded and disbursed during the same calendar year are grouped into a vintage, borrowing the expression to the wine industry. The idea behind is that these loans will reach maturity the same year.

2001 led to higher default rate in the 1999 and 2000 cohort of MH loans, especially for chattel loans.

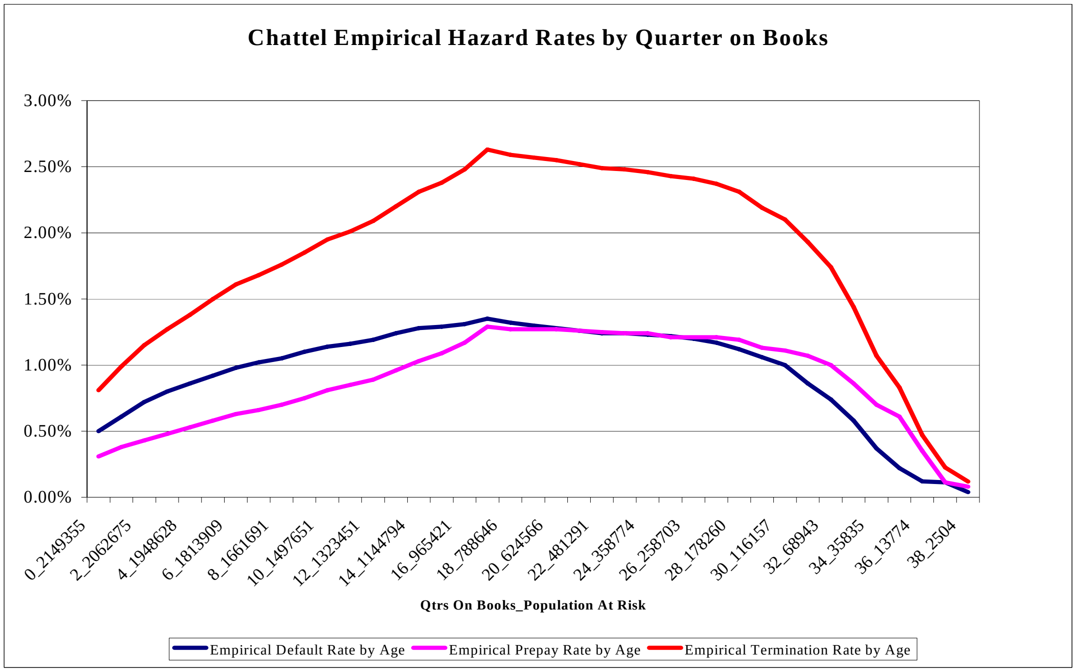
Table 3.3 below provides the summary statistics of the borrowers and collateral characteristics for land-home and chattel loans. On average, chattel borrowers have a lower FICO score (632) than land-home borrowers (638). They have higher loan-to-value ratio (90%) compared to land-homes (86%). Consequently, they carry a higher coupon rate (11.58%) than land-home borrowers (8.73%), with a higher interest-coupon rates spread at origination (3.71 versus 0.83).

Table 3-3 Development Samples Summary Statistics for Land-home and Chattel Populations

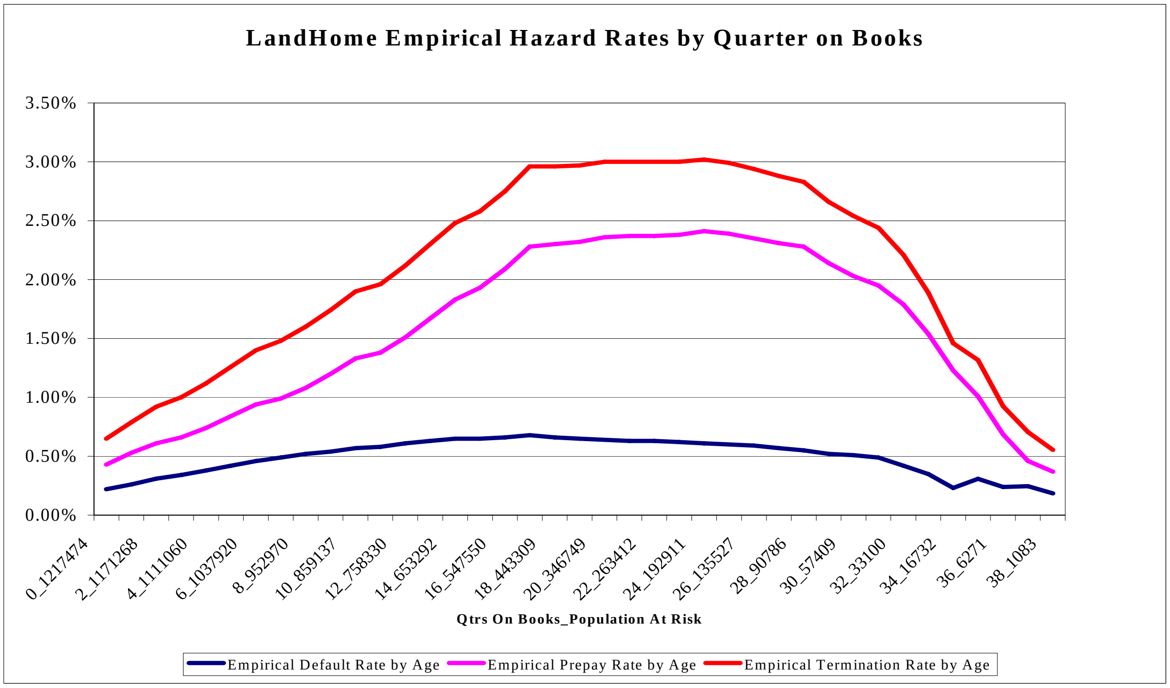
Group	*Loan Count*	*Variable*	*Definition*	*Mean*	*Std Dev*	*Minimum*	*Maximum*
Land-Home	68,906	CFICO	Customer's current FICO score	638	64.5120088	450	836
		ORIG_LTV	Original loan-to-value ratio	85.70	10.4836132	50	100
		LOANAMT	Loan's original balance	$ 79,234	26798.17	7666.32	309668.65
		INTRAT	Loan's coupon rate	8.73	1.5074509	1	17.75
		TERM	Loan's term in months	347	39.5884991	60	360
		QONBOOKS	Loan's age in quarters	24	7.2471385	0	38
		ADJSAL	Customer's adjusted monthly salary	$ 3,429	1423	1000	10000
		SATO	Interest-coupon spread based on 30-yr Freddie rate	0.83	1.6054855	-5.47	10.78
		LOSSMIT	Indicator for accounts ever loss mitigated	23.50%	0.4240303	0	1
		DOUBLE	Indicator for double-wide home	87.54%	0.330298	0	1
		NEW	Indicator for newly built home	87.28%	0.3332125	0	1
		CALI	Indicator for home located in California	1.74%	0.1308679	0	1
Chattel	131,029	CFICO	Customer's current FICO score	632	72.0345968	418	840
		ORIG_LTV	Original loan-to-value ratio	89.62	7.7771992	50	100
		LOANAMT	Loan's original balance	$ 35,525	16036.47	5149	248101
		INTRAT	Loan's coupon rate	11.58	2.1156049	0	18
		TERM	Loan's term in months	278	84.8886185	36	360
		QONBOOKS	Loan's age in quarters	23	7.798516	0	38
		ADJSAL	Customer's adjusted monthly salary	$ 3,026	1469.55	1000	10000
		SATO	Interest-coupon spread based on 30-yr Freddie rate	3.71	2.2361225	-8.01	12.26
		LOSSMIT	Indicator for accounts ever loss mitigated	21.45%	0.4104501	0	1
		DOUBLE	Indicator for double-wide home	48.02%	0.499609	0	1
		NEW	Indicator for newly built home	58.50%	0.4927275	0	1
		CALI	Indicator for home located in California	5.92%	0.2359489	0	1

Land-home loans on average have a higher balance ($79,234 compared to $35,525); they have longer terms (347 versus 278 months); they are in larger proportion double-wide (88% compared to 48%) and new (87% versus 59%). Finally, land-home borrowers have a higher monthly income ($3,429) than chattel borrowers ($3,026).

Based on the statistics above, chattel loans can be assumed to be riskier than land-home loans, while the latter can be assumed to prepay faster than chattel loans. Figures 3.2 and 3.3 below show the empirical hazards by age for land-home and chattel loans



respectively. The empirical hazard is the termination rate of the loans when the only control factor is time on books. It is computed using the life-table method (see Allison, 2005) grouping event time into intervals starting from 0 to 38 quarters on books (the longest survival time of a loan in the data set) by an increment of two. The graph in figure 3.2 and 3.3 shows the conditional probability that a loan will terminate by prepaying or defaulting, given that it has survived up to the beginning of that quarter. For each age (quarter on book) the point in the graph is the ratio of loans of that age that actually close that quarter divided by the population of the same age still at risk of terminating. The x-axis displays a concatenation of the age (quarter on books) and the population at risk, while the y-axis displays the exit rate. The top curve is just a combination of the two sub-hazard rates, each of them providing the rates of accounts closing by defaulting and those closing by prepaying.



Comparing the empirical hazards for the two product-types, we can see that at comparable age land-home loans have a lower default rate than chattels while chattels have a lower prepayment rate than land-homes. This confirms the finding documented previously, i.e. chattel loans are riskier on the credit side while land-home loans are faster on the prepayment side.

4. Estimation Results

Hazard functions have been used to estimate the probability for a manufactured housing loan to close in the next quarter by prepaying (or defaulting), conditional on it having survived up to this quarter and not having defaulted (or prepaid) yet. The hazard function is specified as a discrete-time logistic function, controlling for the age of the loan, the borrower's credit quality given by the FICO score and interest rate spread at loan's origination[11] (SATO), the loan amount, the borrower's monthly income, his idiosyncratic position with respect to market interest rates and local house price appreciation. The borrower's refinance incentive measures his relative position with respect to interest rate and is computed as the change in spread between the loan's coupon and market interest rate from origination to the current quarter. Local area house price indices are used to compute market-to-market values for loan-to-value ratio and borrowers' equity positions. The interest rate environment is also modeled by adding the yield curve to the model. The yield curve is defined as the difference between long-term interest rate (30-year Freddie mortgage rate) and short-term interest rate (1-year Freddie mortgage rate). Indicators for new homes, doublewide homes, 1999 and 2000 vintage years, and a California indicator are added to the model.

Tables 4-1 and 4-2 below provide side by side estimates for land-home and chattel default and prepayment predictions. On the credit side (table 4-1), borrowers with relatively poor credit are more likely to default. Indeed, the lower the FICO score the more likely the borrower will default. Also, the higher the spread between the loan's coupon and the prevailing interest rate at origination the more likely the loan will close by default. Moreover, loans on which any type of loss mitigation[12] policy has been applied are more likely to default.

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[11] As lenders use risk-based pricing when originating loans. The spread between the prevailing mortgage rates in the market and the loan's coupon is indicative of the way the lender perceives the borrower's risk profile. This spread is added on top of other margin that lenders impose to reflect the fact that mortgages require a lot of servicing, the handling of the monthly payment of principal, interest, and escrow amounts.

[12]

Table 4-1 Parameter Estimates for Land-home and Chattel Default Prediction

		Land-home		***Chattel***	
Variable	Description	Mean	Estimates	Mean	Estimates
INTERCEPT			-12.0055** (0.9425)		-6.9656** (0.0575)
CFICO	Refreshed FICO Score	638	-0.00061* (0.000294)	632	-0.00154** (0.000036)
SATO	Interest Spread at Origination based on 30-Yr Fixed Rate	0.83	0.1471** (0.0126)	3.71	0.1251** (0.0014)
LOSSMIT	Indicator for loans ever loss mitigated	0.24	1.3313** (0.0373)	0.21	1.1576** (0.00526)
MTMLTV	Market-to-Market Loan-to-value Ratio	0.68	1.1654** (0.4521)	0.68	-0.0269** (0.00118)
SCALED_EQUITY	Market-to-Market Equity / 1000	$24.912	-0.0122* (0.00565)	$10.719	0.0207** (0.000457)
SCALED_LOANAMT	Loan Amount / 1000	$79.234	0.0101** (0.00193)	$35.525	-0.0922** (0.00203)
SCALED_MTHLY_SAL	Monthly Salary / 1000	$3.429	-0.09** (0.0143)	$3.026	-0.5467** (0.0406)
REFI_INCENT	Interest Rate Spread today minus Interest Rate Spread at Origination	1.27	0.3406** (0.0381)	1.20	-0.077** (0.00598)
AGE1	Loan's age less or equal to 1 year	0.19	1.183** (0.2339)	0.24	0.5614** (0.0125)
AGE2	1 year < Loan's age <= 2 years	0.11	5.0686** (0.8684)	0.13	2.3119** (0.0432)
AGE3	2 year < loan's age <= 3 years	0.15	5.1158** (0.8684)	0.16	2.4697** (0.0434)
AGE4	3 year < Loan's age <= 4 years	0.17	5.2178** (0.8692)	0.16	2.6584** (0.0438)
AGE5	4 year < Loan's age <= 5 years	0.17	4.8966** (0.8705)	0.15	2.5197** (0.0444)
AGE6	Loan's age > 5 years	0.32	4.5384** (0.8725)	0.29	2.4648** (0.045)
DOUBLE	Indicator for double-wide home	0.88	-0.0383 (0.0556)	0.48	-0.2129** (0.00656)
NEW	Indicator for new home	0.87	-0.0122* (0.0585)	0.58	-0.0877** (0.0063)
CALI	Indicator for homes in California	0.02	0.2805 (0.1456)	0.06	-0.5887** (0.0168)
YIELDCURVE_LAG2	Yield Curve	1.90	0.3285* (0.0243)	1.89	0.5444** (0.00412)
VINT_1999	Loan originated in 1999	0.21	0.02* (0.0498)	0.22	0.1351** (0.0074)
VINT_2000	Loan originated in 2000	0.14	-0.126 (0.0627)	0.16	0.2285** (0.00882)

This relationship between credit quality factors and default probability is stable across products; i.e. it is significant and has the same sign in both land-home and chattel models. MH borrowers are differently affected by changes in house price and interest rates when compared to findings in the conventional prime mortgage market. Land-home borrowers are less likely to put their mortgages when they are in the money, while chattel borrowers are more likely to default when they are in the money as shown by the signs of equity and loan-to-value ratio in the models.

The loan amount variables have different signs in the two models. Loan amount has a positive sign in the land-home default model, meaning that big size loans are riskier than smaller size loans. The opposite holds for chattel models. Big size loans are less risky than small size loans. This sign for chattel should be interpreted carefully, as expensive chattel homes are more likely to be located in California or some type of retirement resort, where borrowers are less likely to default. Concerning interest rates, the existence of a refinance incentive doesn’t seem to deter chattel borrowers from putting their mortgage contrary to the conventional prime mortgage borrowers.

The models also show evidence of seasoning, as defaults do ramp up in the first few years the loans are on books before leveling off after the fourth year. This is the case for both chattel and land-home loans. New and double-wide homes are likely to default compared to used and single homes. As for loan amount, California loans are riskier for land-home, but less risky for chattels. Also, chattel loans funded in 1999 and 2000 are more likely to go bad. Finally, MH borrowers are more likely to both default and prepay in a downslopping yield curve. The interpretation of the sign here depends on the one of the long-term or short-term interest rates determining the change in the yield curve. The observed downslopping of the yield curve during the observation period here was due to decrease in short-term interest rates that made it attractive to refinance fixed rate mortgages into adjustable rate ones.

Table 4-2 Parameter Estimates for Land-home and Chattel Prepayment Prediction

		Land-home		***Chattel***	
Variable	Description	Mean	Estimates	Mean	Estimates
INTERCEPT			-7.2029**		-6.3165**
			(0.2446)		(0.0503)
CFICO	Refreshed FICO Score	638	0.00297**	632	0.00303**
			(0.000182)		(0.000043)
SATO	Interest Spread at Origination	0.83	0.2483**	3.71	0.0731**
	based on 30-Yr Fixed Rate		(0.00884)		(0.00181)
LOSSMIT	Indicator for loans ever loss mitigated	0.24	-0.823**	0.21	-1.0912**
			(0.0338)		(0.0111)
MTMLTV	Market-to-Market Loan-to-value Ratio	0.68	-2.0477**	10.72	-0.0298**
			(0.25)		(0.00114)
SCALED_EQUITY	Market-to-Market Equity / 1000	$24.912	-0.00077	$35.525	0.0104**
			(0.00313)		(0.000508)
SCALED_LOANAMT	Loan Amount / 1000	$79.234	0.00416**	$3.026	0.1021**
			(0.00125)		(0.00187)
SCALED_MTHLY_SAL	Monthly Salary / 1000	$3.429	0.0363**	$0.680	-3.3957**
			(0.00829)		(0.0388)
REFI_INCENT	Interest Rate Spread today minus	1.27	0.1404**	1.20	-0.4384**
	Interest Rate Spread at Origination		(0.0241)		(0.00692)
AGE1	Loan's age less or equal to 1 year	0.19	0.2105**	0.24	0.2556**
			(0.0423)		(0.00938)
AGE2	1 year < Loan's age <= 2 years	0.11	0.9383**	0.13	1.3967**
			(0.1299)		(0.0293)
AGE3	2 year < loan's age <= 3 years	0.15	1.1598**	0.16	1.4942**
			(0.1296)		(0.0298)
AGE4	3 year < Loan's age <= 4 years	0.17	1.3067**	0.16	1.7153**
			(0.1311)		(0.0305)
AGE5	4 year < Loan's age <= 5 years	0.17	1.4463**	0.15	1.9365**
			(0.1333)		(0.0313)
AGE6	Loan's age > 5 years	0.32	1.5089**	0.29	2.2192**
			(0.1372)		(0.0324)
DOUBLE	Indicator for double-wide home	0.88	0.6587**	0.48	0.2084**
			(0.044)		(0.00738)
NEW	Indicator for new home	0.87	0.1689**	0.58	-0.0683**
			(0.0402)		(0.0076)
CALI	Indicator for homes in California	0.02	0.0538	0.06	-0.0709**
			(0.0717)		(0.0112)
YIELDCURVE_LAG2	Yield Curve	1.90	0.0441**	1.89	0.3057**
			(0.0138)		(0.00413)
VINT_1999	Loan originated in 1999	0.21	-0.128**	0.22	0.114**
			(0.0343)		(0.00886)
VINT_2000	Loan originated in 2000	0.14	-0.2097**	0.16	0.2533**
			(0.0453)		(0.0116)

On the speed side, borrowers with better credit prepay faster compared to those with constrained credit. The FICO score is positively correlated with prepayment. Moreover, loans on which any type of loss mitigation action was taken are less likely to close by prepaying. At the same time, some MH borrowers are curing following the funding of their mortgage. This is indicated by a positive sign for SATO in the prepayment models.

SATO reflects lenders' risk-based pricing of loans at origination. Therefore, the higher the SATO the riskier the borrower's profile appears to the lender when originating the loan. A positive sign for SATO in the prepayment models means that the higher the SATO the more likely the loan is going to prepay. Given that most of the prepayment activities for MH loans are streamline refinances, a positive sign for SATO means that borrowers with high SATO are able to find another lender who can give them a better deal than the one they currently have. This can happen under two circumstances. The first likely scenario is that interest rates have been decreasing and the borrower's credit profile hasn't deteriorated. He can therefore go to a different lender and get a lower rate based only on the change in the interest rate environment[13]. The second scenario is that interest rates have not changed but the borrower has significantly improved his debt repayment behavior. This will increase his/her FICO score, strengthen his/her overall credit profile, and give him/her access to refinancing options susceptible of reducing his monthly repayment of the loan. In both scenarios, credit curing, or at least credit not deteriorating, is the minimal condition to open up new refinancing perspectives to a borrower with high SATO.

House price appreciation affects prepayment decisions as expected, as borrowers with low current loan-to-value ratio and built equity[14] in their homes are more likely to prepay. As on the credit side, the refinance incentive does not trigger prepayment for chattel borrowers. Still, MH borrowers are more likely to prepay under a flattening yield

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[13] Given that the model controls for changing rate environment with the yield curve and refinance incentive, this first scenario is less plausible.

[14] However, equity variable is not significant for land-home borrowers.

curve, implying that borrowers are swapping short-term interest rates with long-term ones by refinancing into adjustable rate mortgages.[15] Prepayments are likely to increase as loans season, as shown by the signs and the magnitudes of the age bins in the model. Double-wide and new MH loans are more likely to prepay; so are land-home loans booked in 1999 and 2000.

Figure 4-0-1 Land-home & Chattel Actual vs. Expected Default and Prepayment Probabilities by Age

Figures 4-1 to 4-3 plot actual versus predicted default and prepayment rates by a number of variable cuts. The cut by age shows that on average default (Figure 4-1 (a) and (b)) ramps up steeply from the first quarter and reaches a peak at fourteen quarters on

[15] This is a conjecture based on the prepayment behavior observed in the mortgage industry (see …) from the late 90's until mid-2005, a period during which falling interest rates and the media effect related to it, have led borrowers to refinance their mortgages into new adjustable rates products that have been expanding during these years.

books. It then decreases a little bit before leveling off. The same figure 4-1 (c and d) shows that there seems not to be a turning point of prepayment for seasoning MH loans. In these graphs, average prepayment rates continuously increase as loans season for both chattel and land-homes.

Figure 4-2 shows actual versus predicted prepayment probabilities by refinance incentive. It depicts an unconventional result in the literature on mortgage termination, in the sense that this plot of prepayment probability with respect to refinance incentive is not s-shaped[16] and that borrowers in the highest tier of refinance incentive are less likely to prepay compared to borrowers in the second tier. This observation combined with

Figure 4-0-2 Land-home & Chattel Actual vs. Expected Prepayment Rates by Refinance Incentive

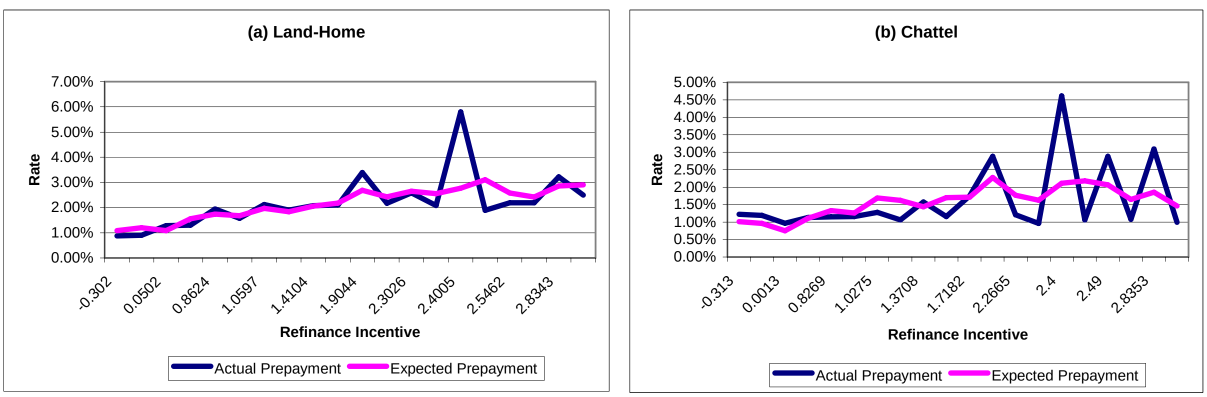
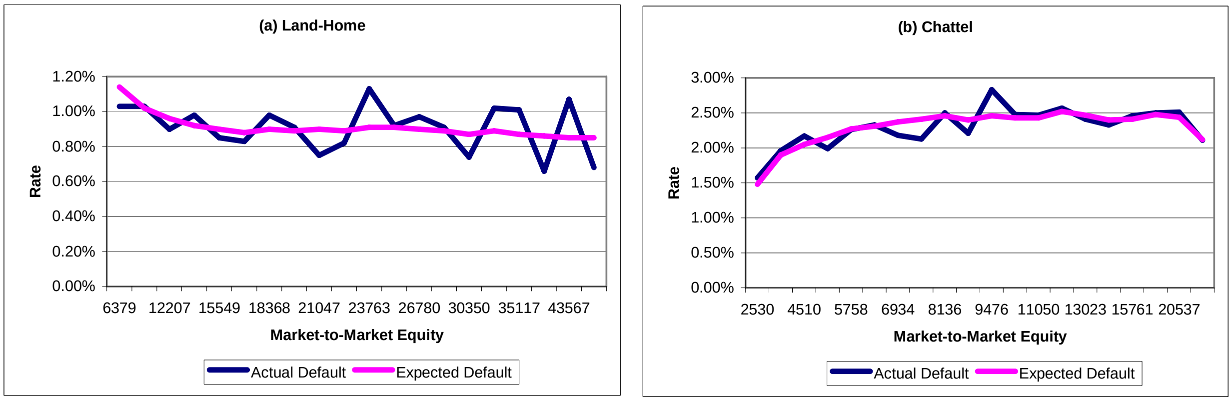


figure 4-3 provide evidence that MH borrowers tend to put their mortgage even when they are in the money. Figure 4-3 (a) shows that borrowers supposedly in the higher end of the equity position are more likely to default. This implies that either these borrowers have idiosyncratic characteristics preventing them from tapping into their built equity to avoid foreclosure on their property, or they don't have any actual equity.

Figure 4-4 depicts actual versus expected events grouped by date of the event. The graphs are very noisy in the tail. This is due to the fact that the data become so thin at

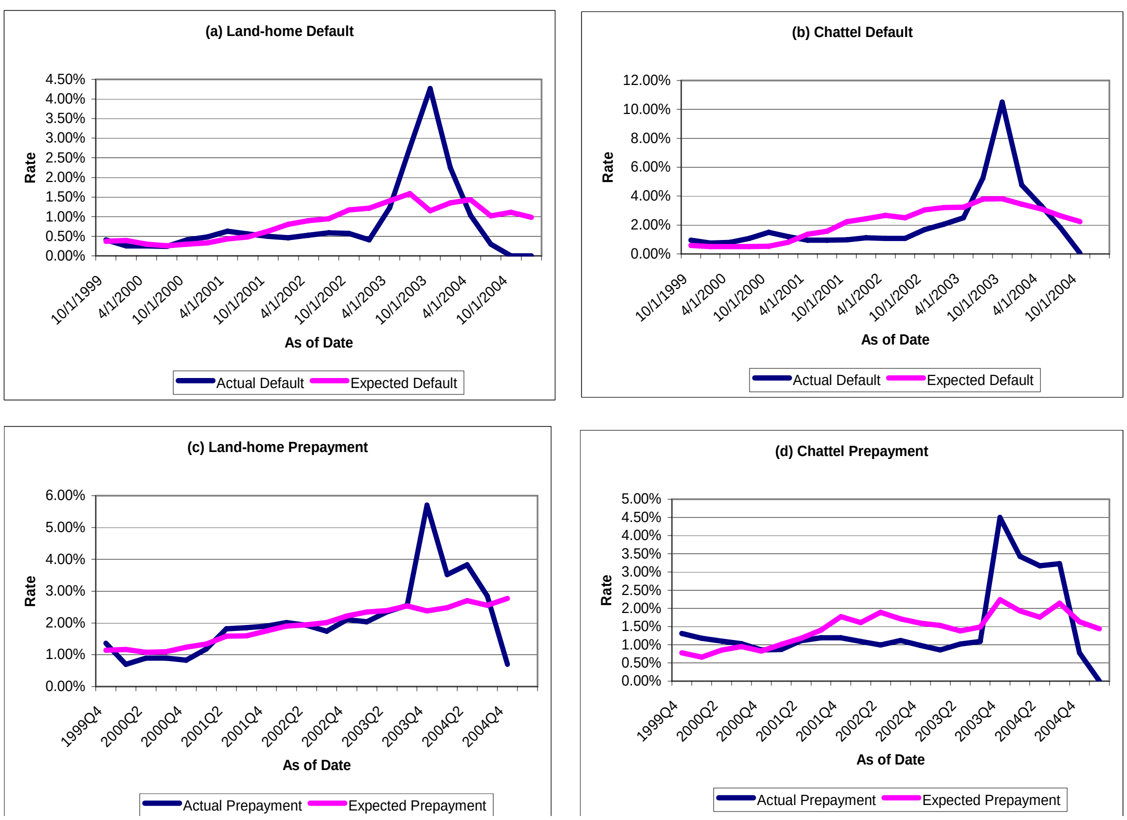
16

Figure 4-0-3 Land-home & Chattel Actual vs. Expected Default and Prepayment Rates by Equity



these later date that any event get a relatively higher importance. Moreover, the company providing the data went through a dramatic change in management that led to picks in foreclosure and prepayments around the takeover period.

Figure 4-0-4 Actual vs. Expected Default and Prepayment Rates by Quarter



Land home loans behave closer to the conventional mortgage with regard to house price appreciation and interest rates. The models validation on the development and holdout sample show an overall better fit of the default predictions than that of the prepayment one. The accuracy of prepayment prediction is challenged by the fact that MH borrowers' prepayment behavior is not always consistent with the theory backing the choice and definition of mortgages' prepayments. The difficulty of accurately predicting

Table 4-3 Models Lift and K-S Statistics

		Default		Prepayment	
Group	**Sample**	**Lift**	**KS**	**Lift**	**KS**
Land-home	**Development**	**5.09**	***41.09***	**4.82**	***38.41***
	Holdout	**4.32**	***37.58***	**4.09**	***29.52***
Chattel	**Development**	**2.33**	***26.71***	**3.34**	***28.81***
	Holdout	**2.04**	***22.82***	**3.08**	***28.10***

default and prepayment for these products requires the estimation of a confidence interval given the importance of borrowers' prepayment behavior (Spahr and Sunderman, 1998) and default for mortgage and mortgage-backed securities cash flow valuation.

5. A Confidence Interval for Default and Prepayment Predictions

Confidence intervals to default and prepayment predictions were estimated using confidence interval bootstrapping. Bootstrapping entails random resampling to obtain the desired empirical distribution of the parameters of interest. One advantage of bootstrapping is that it usually provides more accurate confidence intervals than the conventional asymptotic distribution approaches (Mooney and Duval, 1993). Generally, the 95% confidence interval is computed by adding or subtracting the standard error multiplied by a critical value (e.g. q ± 1.96sq). This computation assumes that the confidence interval is symmetric around q and that the estimate of sq is correct. There are many situations in which the parametric assumptions may be incorrect, and it is useful in such situations to compute bootstrap confidence intervals that do not rely on those assumptions.

Tables 5-1 and 5-2 provide the 2.5th and 97.5th percentiles of the bootstrap samples that form a good approximation of the 95% confidence interval. The median values obtained through resampling is very close to the models estimates given in tables 4-1 and 4-2. Looking at estimates stability through resampling, age bins are very stable. They are not switching signs, confirming the seasoning effects of prepayment and default. Market-to-market loan-to-value ratio, SATO, loss mitigation indicator and monthly salary all stay stable across resampling. The refinance incentive variable, although stable in the models, consistently has an unexpected sign in the default models.

Table 5-1 Estimates for Bootstrapped Land-home Default and Prepayment Models

	Default			***Prepayment***		
Variable	Median	2.5 Pctl	97.5 Pctl	Median	2.5 Pctl	97.5 Pctl
INTERCEPT	-12.0664	-14.6802	-10.7326	-7.1522	-7.8475	-6.5155
AGE1	1.1711	0.9299	1.7913	0.2104	0.1263	0.2957
AGE2	5.0702	4.0966	7.1804	0.9605	0.6669	1.1917
AGE3	5.1052	4.1858	7.3033	1.1498	0.8835	1.4075
AGE4	5.2711	4.2776	7.3561	1.304	1.0494	1.5866
AGE5	4.9117	3.9289	6.9926	1.4469	1.1964	1.679
AGE6	4.5593	3.6019	6.6876	1.5085	1.2245	1.8057
MTMLTV	1.1891	0.1416	2.1131	-2.0686	-2.5718	-1.3258
REFI_INCENT	0.3433	0.2477	0.4242	0.1447	0.0881	0.2068
SATO	0.1503	0.1127	0.1767	0.2462	0.2238	0.2649
SCALED_EQUITY	-0.0124	-0.0248	0.0008	-0.0004	-0.0087	0.0079
SCALED_LOANAMT	0.01	0.0061	0.0144	0.0039	0.0007	0.0078
SCALED_MTHLY_SAL	-0.0884	-0.1248	-0.0585	0.0368	0.0161	0.054
YIELDCURVE_LAG2	0.326	0.2703	0.3971	0.0453	-0.0009	0.0728
CALI	0.292	-0.0883	0.6333	0.0468	-0.1484	0.2037
CFICO	-0.0005	-0.0012	0	0.0029	0.0025	0.0034
DOUBLE	-0.0491	-0.1497	0.0738	0.6573	0.5658	0.7806
LOSSMIT	1.3272	1.2441	1.4277	-0.8245	-0.9216	-0.7598
NEW	0.0035	-0.1199	0.1651	0.1639	0.0743	0.2422
VINT_1999	0.0329	-0.0779	0.1374	-0.1347	-0.2162	-0.0542
VINT_2000	-0.1127	-0.2663	0.0239	-0.2219	-0.3183	-0.1251

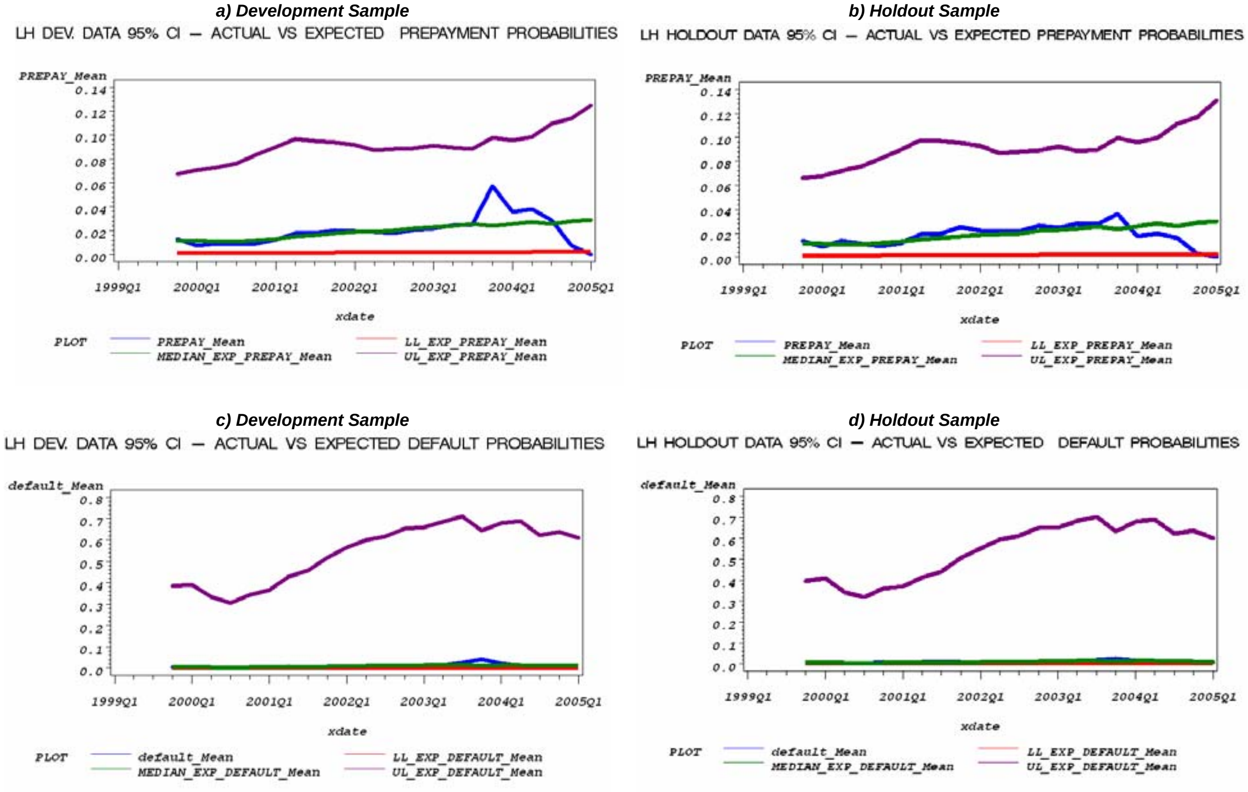
This, combined with the negative signs for equity in the prepayment model and a positive sign for the same variable in the default model, confirm that MH borrowers are more likely to put a mortgage even when this option is not in the money.

Table 5-2 Estimates for Bootstrapped Chattel Default and Prepayment Models

	Default			***Prepayment***		
Variable	Median	2.5 Pctl	97.5 Pctl	Median	2.5 Pctl	97.5 Pctl
INTERCEPT	-6.95607	-7.08747	-6.81044	-6.32149	-6.43316	-6.17746
AGE1	0.56312	0.54082	0.5815	0.25537	0.23659	0.2759
AGE2	2.31094	2.24608	2.3922	1.39817	1.32936	1.45645
AGE3	2.4689	2.3953	2.54421	1.49318	1.4171	1.56314
AGE4	2.65891	2.58421	2.73675	1.71662	1.63771	1.77832
AGE5	2.51877	2.43864	2.59708	1.93479	1.85443	2.00832
AGE6	2.46531	2.38455	2.53901	2.21979	2.12895	2.29429
MTMLTV	-0.56068	-0.65074	-0.44979	-3.39319	-3.52932	-3.29344
REFI_INCENT	-0.07904	-0.09443	-0.06088	-0.43904	-0.453	-0.4207
SATO	-0.02695	-0.0299	-0.02432	-0.02962	-0.03387	-0.02708
SCALED_EQUITY	0.02084	0.01967	0.02197	0.01041	0.00908	0.01183
SCALED_LOANAMT	-0.09274	-0.09774	-0.08738	0.10187	0.09724	0.10523
SCALED_MTHLY_SAL	0.54431	0.53191	0.555	0.3064	0.29671	0.3152
YIELDCURVE_LAG2	-0.59311	-0.62904	-0.55533	-0.06974	-0.09663	-0.0461
CALI	-0.00155	-0.00166	-0.00144	0.00303	0.00294	0.00315
CFICO	-0.21309	-0.23006	-0.19451	0.20837	0.19023	0.2243
DOUBLE	1.15774	1.14415	1.17168	-1.0929	-1.11345	-1.07358
LOSSMIT	-0.08909	-0.1041	-0.07176	-0.06828	-0.08549	-0.05312
NEW	0.12516	0.12132	0.12839	0.07293	0.06921	0.07765
VINT_1999	0.13506	0.11747	0.15607	0.11414	0.0973	0.13692
VINT_2000	0.22849	0.20449	0.25555	0.25313	0.22565	0.27759

Models' estimated obtained by bootstrapping were used to score the modeling and validation data. Figure 5-1 below graphs the 95% confidence interval for prepayment (graphs a and b) and default (graphs c and d) estimated using bootstrapping against actual default and prepayment rates. The purple line is the represents the 97.5 percentile for the considered events while the red line graphs the 2.5 percentile of the same events. The green line represents the median estimates and the blue line shows actual events. The left graphs provide actual versus expected for the development sample while the graphs on the right are plotted after scoring the holdout data sets.

Figure 5-1 Estimated Median and 95% Confidence Interval for Prepayment and Default Events vs. Actual Events



Two facts are worth noticing. First, expected prepayment and default rates derived from the median estimates of the bootstrapped estimates seem to track actual default and prepayment rates better than the models estimated in section 4. Second, even though the derived confidence interval is wide, actual default and prepayment probabilities in both the modeling sample and the holdout data lie with the estimated confidence interval. Therefore the estimated confidence interval defines a comfort zone within which to contain prepayment and default assumptions when valuing mortgages or mortgage-backed securities.

5. Conclusion

This study used loan-level data of MH loans. It estimated competing risk hazard functions to predict MH loans' default and prepayment probabilities. Results show that variables used to capture option price theory in the literature on mortgage termination affect MH borrowers differently. Land-home borrowers are more likely to behave in a way consistent with the predictions of the theory, while chattel borrowers are more likely to put their mortgage even when it is in the money not to do so. The difficulty of accurately predicting default and prepayment for these products required the estimation of a confidence interval given the importance of prepayment and default assumption when forecasting the risk associated to mortgage termination. Interval bootstrapping was used to estimate robust parameters to the model and derive a 95% confidence interval for the estimators. Validations' results not only confirm stability of the parameter estimates but also show that actual CDR and CPR lie within the estimated confidence intervals. The next task still to be completed is to validate these results on an out-of-sample data.

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