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Mortgage Termination at AgChoice Farm Credit

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Mortgage Termination at AgChoice Farm Credit

by

Jonathan B. Dressler and Jeffrey R. Stokes*

Abstract

Mortgage termination is important when considering risk management at financial institutions and can generally be of two types: default and prepayment. Data consisting of 1,060 fixed rate mortgages collateralized by farm real estate to dairy producers made by AgChoice ACA from January 1, 2001 through June 30, 2006 were utilized to estimate survival and hazard functions for the mortgages. These functions are important components of a competing risks modeling approach to estimating the drivers of mortgage termination.

Keywords: Basel Accord, mortgage termination, Survival Analysis, survivor function, hazard rate, competing risks, semi-parametric.

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Introduction

A better understanding of agricultural mortgage termination through prepayment or default has many important practical implications. More precise measurement of prepayment risk and/or credit risk can aid agricultural lending institutions' risk management practices. In addition, the Basel Accord has had many implications for banks' management of economic capital relating to the risks they face (Basel Committee on Banking Supervision 2006). Increasingly, banks are being encouraged to develop models and methods to measure mortgage termination by their regulators.

Mortgage termination is an imperative concern because prepayment and default interrupt anticipated principal and interest payments, which can directly affect banks and secondary markets. When prepayment occurs, the bank is forced to restructure an existing loan or make a new loan at a potentially lower interest rate thereby forgoing part of the originally expected yield (margin). In addition to lowered profits from lost yield, the borrower may proceed to find a different lender. The bank could even be at risk of not retaining the full amount of principle if foreclosure occurs, forcing the bank to take possession of the collateral for resale.

If the loan was sold to a secondary market and prepayment occurs, loan poolers and regulators may be forced to cover the lost interest and principal payments guaranteed to the holders of mortgage-backed securities. In the event of default, loan poolers and regulators may even be forced to tap additional sources beyond those regularly held to cover losses. In order to develop standard measures of risks at banks, the Basel Accords were developed and recommended to banks within the participating nations.

The Basel Accord was established in 1988 (Basel I) by the Basel Committee on Banking Supervision and consists of representatives from central banks and regulatory authorities of the G10 countries. Even though the Basel Committee cannot enforce any of the accords, most member countries still follow their recommendations. The goal of the Basel Committee is to help banks measure and control their risks more accurately and efficiently, which can help increase the profitability, pricing, and term structuring of loans for banks. Currently the Basel Accord, which is named Basel II, consists of three pillars. Pillar I concerns minimal capital requirements and includes recommendations on the measurement of credit risk, market risk, and operational risk. Pillar II concerns the Supervisory Review Process which is intended to ensure that banks have internal processes to assess whether adequate capital is in place considering evaluation of risk. Pillar III concerns Market Discipline which includes the importance of the disclosure of institutional information (Basel Committee on Banking Supervision 2006).

Specifically, the Basel Committee suggests three approaches to measuring credit risk in determining minimum economic capital requirements: a standardized approach, a foundation internal rating-based approach (IRB), and an advanced IRB approach. The standardized approach uses discrete risk weights that are referenced from ratings by external credit agencies, with higher risk weights being applied to lower quality credit and vice versa. Two alternatives to the standardized approach are the foundation and advanced IRB approaches, which use a probability of default (PD), loss given default (LGD), and exposure at default (EAD) to estimate

capital requirements (Barry 2001). In all, banks use the product of these three measures to estimate a loan loss distribution, or an expected loss (EL) over time (Zech and Pederson 2004).

The difference between the foundation and advanced IRB approach is in how the estimates are obtained. With the foundation IRB approach, the bank uses their own estimates of the PD for each borrower and the regulator's inputs for LGD and EAD. With the advanced IRB approach, the bank supplies its own estimates for PD, LGD, and EAD (Barry 2001).

The starting point when considering mortgage termination is an understanding of the embedded call and put options associated with mortgage termination. Prepayment is an embedded call option giving the mortgagor the right to prepay. Default is an embedded put option giving the mortgagor the right to default. Further, these two options are categorized as optimal and suboptimal in the financial literature.

It follows that mortgagors will exercise either of these embedded options whenever they become financially attractive, or "in-the-money", and is also known as optimal prepayment and default. Optimal prepayment occurs when the market interest rate drops below the contractual rate of interest plus any transaction costs associated with prepayment, making it financially attractive to prepay. Optimal default occurs when the market value of the mortgaged asset falls below the current level of outstanding principal. Contemporary option theory attributed to Black and Scholes (1973), Merton (1974), and Cox *et al.* (1985) seeks to price contingent claims on the value of an underlying asset. Several empirical studies have shown that the embedded options are a function of interest rates and the underlying value of the collateralized asset (Dunn and McConnell, 1981, Buser and Hendershott, 1984, Foster and Van Order, 1985, Brennan and Schwartz, 1985, Hendershott and Van Order, 1987, and Kau *et al.*, 1990).

Sub-optimal prepayment and default are considered to be any other event that precipitates either prepayment or default of a loan. Considering agricultural mortgages, it is most common to see optimal prepayments and suboptimal defaults. Optimal prepayments are most common due to movement in market interest rates. Optimal defaults are not common because agricultural lenders typically require loan-to-value ratios that are low relative to home lending. More often, it is the case that low cash flow causes a sub-optimal default.

Estimating mortgage risk is of great importance and much focus for institutions that underwrite, service, purchase, or regulate credit. Few empirical analyses use farm-level data when considering agricultural mortgage termination. Therefore, the objectives of this analysis are as follows:

- To identify the main factors affecting the termination of agricultural loans collateralized by farm real estate.
- To explore the usefulness of Survival Analysis (SA) as a technique for measuring the drivers of termination as well as the timing of termination.
- To suggest appropriate data and modeling approaches for AgChoice to consider in the context of the Basel Accord.

Literature Review

Estimating Agricultural and Commercial Mortgage Termination

While many empirical studies of mortgage termination exist for residential mortgages, a limited number of empirical studies exist concerning commercial and agricultural mortgage termination because the commercial and agricultural mortgage markets are small relative to the residential market. Also, a lack of disaggregate loan-level data exists. It is important to note that caution should be used when comparing commercial and agricultural mortgages to residential mortgages. Commercial mortgages are typically used to finance investment properties with debt payments often being made from the cash flows provided by the underlying or mortgaged asset. Agricultural mortgages are typically used to finance real estate purchases with debt payments often being made from the sale of commodities produced on the collateral. This creates a different set of incentives for the optimal exercise of the embedded put and call options within the mortgage contract (Ciochetti *et al.* 2002).

In the past, much of the focus in assessment of agriculture mortgage risk emphasized only credit risk. Miller and Ladue (1989) used weighted Logit models to calculate loan default probabilities to assess borrower quality within a short- and intermediate-term agricultural loan portfolio from an upstate New York bank. Others such as Barry *et al.* (2002) use migration analysis to assess credit risk. Migration analysis is based on historic movements (transition probabilities) of individual loans over time from one risk rating to another. These historic transition probabilities are then extrapolated into the future to estimate overall portfolio credit risk. Lastly, Zech and Pederson (2004) assess four different types of credit risk models developed by major financial institutions, and suggest one of the models to be used in respect to agriculture to estimate the distribution of loan losses due to credit risk.

More recently, Featherstone *et al.* assessed the probability of default (PD) and risk-rating class from a sample of loans from a Farm Credit bank portfolio. The PD was estimated via Logistic regression, which incorporated three covariates that controlled for repayment capacity, owner equity, and working capital. In all, 1.83% (2,892 loans) of the sample fell under the category of default. Loans were then mapped into a consolidated ten point risk rating class system using Standard & Poor's (S&P) reported probabilities of default. PD was then compared across different loan types.

Much of the literature concerning agricultural mortgage termination is motivated from a cost-based analysis. Sherrick *et al.* (2000) use an option-based approach to develop a credit-risk valuation model that estimates the cost of insuring against credit risks in agricultural mortgage-backed securities (AMBS). Probabilistic information about loss distributions is used to assess insurance valuation and solvency likelihood across differing pool sizes, deductibles, timing alterations, premium loadings, adverse loan selection, and changing underwriting standards. Their results indicate that lower credit risk insurance costs are associated with larger pool sizes.

Brinch and Stokes (2001) analyze the impact of the Federal Agricultural Mortgage Corporation (Farmer Mac) prepayment penalties on the cost of funding loans, prepayment behavior, and AMBS. An analytic AMBS model is estimated based on the annualized yield of 3-month

Treasury Bills from January 5, 1972 to April 19, 1995, volatility of Pennsylvania cropland cash rent (1967-1995), and suboptimal probabilities of default and prepayment. The AMBS model is developed and numerically solved using pathwise simulation and dynamic programming and is used to quantify prepayment and default by valuing the two embedded options associated with mortgages. Their results suggest that prepayment penalties are an imperfect means of shielding investors from prepayment risk, and that a profit-maximizing mortgagor can still find situations where prepayment is advantageous after the cost of prepayment penalties. They also find that yield maintenance generally offers investors more prepayment risk protection.

Similar to Brinch and Stokes (2001), Stokes and Brinch (2001) present an AMBS model that is more consistent with agricultural real estate and mortgages. They analyze prepayment penalties used by Farmer Mac to determine the implications for the cost of capital facing potential mortgagors and the risk protection they provide investors. They also use their model to value the embedded options of optimal default and prepayment and to determine equilibrium interest rates that might potentially induce a borrower to obtain a loan with a prepayment penalty. An empirical analysis is performed to analyze the extent that Farmer Mac prepayment penalties preclude optimal prepayment given a specific term structure of interest rates. Lastly, Monte Carlo simulation is used to determine the probability of optimal prepayment given the specific term structure used to develop the model.

Katchova and Barry (2005) use credit risk models based on Merton's option pricing approach and credit value-at-risk methods to estimate economic capital needed to protect against unexpected losses using farm-level data from the Illinois Farm Business Farm Management Association for 1995-2002. In all, loss-based methods are used to calculate the probability of default, loss given default, expected losses, and unexpected losses. These loss-based measures were then used to estimate the credit value-at-risk, or the sum of the expected and unexpected losses. The analysis is performed on the total portfolio of farms, and then by groupings of farms into different credit quality classes using CreditMetrics and Moody's KMV models. Results indicate that the necessary capital for agricultural lenders varies substantially depending on the risk and granularity of the portfolio.

Adding to the current mortgage termination literature is of much interest to academics and practitioners. Moreover, only a limited number of empirical studies exist when considering agricultural mortgage termination, and apparently none use Survival Analysis (SA). Using SA may provide benefits over other censored response approaches such as Logit in that termination timing is also estimated. Similarly, more drivers of default and prepayment can be modeled than with straight forward application of contingent claims pricing which often assumes a limited or undefined set of state variables affecting mortgage termination.

Methods

Forms of SA techniques originated centuries ago from the use of mortality tables, but now a new era of SA techniques stimulated by interests in reliability of military equipment during World War II is applied (Smith and Smith, 2001). SA is currently known as a set of statistical procedures that accommodate time-to-event censored data. Censoring occurs when the event of interest (prepayment or default) is not observed within the specified time series of interest.

Particularly, mortgage termination concerns random right censoring, indicating that the event of interest occurs sometime after the end of the time window of interest. Associated with SA is both a survivor and hazard function. The survivor function reveals the probability of some entity surviving to time t , while the hazard function, or conditional density, specifies the instantaneous rate of failure at $T=t$, given that the entity has survived up to time t . The hazard rate is more useful when interpreting survival data because it essentially is a measure of risk throughout time, with higher hazard rates coinciding with a higher risk of an event occurring. In all, survival analysis allows for the estimation of both the probability and timing of an event (prepayment or default) simultaneously (Allison 1995).

To model prepayment and default, a strict definition of the event of interest (prepayment and default) must be specified. Prepayment is defined by the termination of a note through a paid in full (PIF) status which includes notes being PIF by frequent/infrequent payments towards principal, note re-pricing, or note modification. A note re-pricing occurs when a borrower wishes to change interest rates, and a note modification occurs when changes are made that reflect changes in the loan contract. Default is often defined by the termination of a note through a non-accrual status (≥ 90 days past due), or when a note is modified to an interest only status.

In the context of mortgage termination, the basic survivor function, $S(t)$ indicates the probability that a loan will survive to at least time t and can be defined as:

$$S(t) = P(T \geq t) = 1 - F(t) = \int_t^{\infty} f(x)dx \quad (1)$$

with $T \geq 0$, and with $F(t)$ denoting the cumulative distribution function with corresponding probability density function (p.d.f.) denoted by $f(x)$, that is

$$F(t) = P(T \leq t) = \int_0^t f(x)dx. \quad (2)$$

The survivor function is simply the cumulative area ($1 - F(t)$) under the survival curve past time t , and is also referred to as the reliability function (Tableman and Kim 2004). Another way to describe the distribution of an event T is to use the hazard function. The hazard function indicates the probability that a loan defaults, or becomes PIF, at time t , conditional on the loan having survived to that time and is defined as:

$$h(t) = \lim_{\delta t \rightarrow 0} \left\{ \frac{P(t \leq T < t + \delta t | T \geq t)}{\delta t} \right\} = \frac{f(t)}{S(t)}, \quad T \geq 0 \quad (3)$$

Nonparametric Methods

The Kaplan-Meier (K-M) or product limit estimator is the approach most often used for nonparametric estimation. This method is best to use when data sets are smaller with precisely measured event times (Allison 1995). The K-M also adjusts the estimate to reflect the presence of right-censored observations. Censored observations occur when the event of interest (either prepayment or default) is not observed within the time period of interest. Therefore, the loan continues to exist past the end of the analysis and is considered censored. This particular type of censoring is called right-censoring (Tableman and Kim 2004).

Kaplan-Meier (KM) or product limit estimator

The nonparametric survival function is defined as,

$$\hat{S}(t) = \prod_{\langle j|t_{(j)} \leq t \rangle} \left(\frac{n_j - d_j}{n_j} \right) = \prod_{\langle j|t_{(j)} \leq t \rangle} \left(1 - \frac{d_j}{n_j} \right) = \hat{S}(t-1) \left(1 - \frac{d_t}{n_t} \right), \quad t_j \geq 0 \quad (4)$$

where $\hat{S}(t) = 1$ if $t < t_1$, and with an estimated cumulative hazard of

$$\hat{H}(t) = -\log \hat{S}(t) = -\log \prod_{\langle j|t_{(j)} \leq t \rangle} \left(1 - \frac{d_j}{n_j} \right), \quad t_j \geq 0 \quad (5)$$

where n_j represents the number of observations at risk at time j , and d_j represents the number of observations that experience the event (prepayment or default) at time j (Hosmer and Lemeshow 1999).

Parametric Methods

Parametric survival analysis methods assume the survivor function $S(t)$ follows some distribution such as exponential, Weibull, log-normal, gamma, etc. Parameter estimates can then be obtained via Maximum Likelihood estimation.

Cox Proportional Hazards model (CPH)

One of the most widely used methods for survival analysis data is the Cox proportional hazards model developed by Cox (1972). The CPH model assumes that the baseline hazard, h_0 , is the same for all observations indicating that the proportional hazard ratio (ratio of hazards) between two observations is constant with respect to t , and is defined as

$$h(t; x_i) = h_0(t) \exp(\beta^T x_i) \quad (6)$$

where β^T represents a vector of coefficients, and x_i represents a vector covariates (Tableman and Kim, 2004). However, this model only incorporates discrete time variables. An extended Cox model which incorporates time-dependent variables is presented in Tableman and Kim (2004).

Another method developed by Cox (1975) allows for estimation without specifying a baseline hazard function, only focusing on the coefficients (Cox Partial Likelihood). It is partial in the sense that only a partial likelihood results with estimates that have larger standard errors that are less efficient (Allison, 1995).

A common competing risk framework treats both the call (prepay) and put (default) options as dependent risks since the borrower forfeits the right to exercise one of the options through the

exercise of the other (Deng *et al.*, 2000). Therefore, modeling just default or prepayment alone or together will either underestimate or overestimate the survival and hazard functions because the cause specific hazard rate for risk i is defined as

$$h_i(t) = \lim_{\Delta t \rightarrow 0} \frac{P\left[t \leq X_i < t + \Delta t, \delta = i \mid X_j \geq t, j = 1, \dots, K\right]}{\Delta t} \quad (7)$$

with the overall hazard rate of

$$h_T(t) = \sum_{i=1}^K h_i(t) \quad (8)$$

If we let $S(t_1, \dots, t_K) = \Pr[X_1 > t_1, \dots, X_k > t_k]$, then the cause specific hazard rate is given by

$$h_i(t) = \frac{-\partial S(t_1, \dots, t_k) / \partial t_i \big|_{t_1 = \dots = t_k = t}}{S(t, \dots, t)} \quad (9)$$

where $X_i = T = \text{Min}(X_1, \dots, X_p)$ (Kline and Moeschberger 2003).

Data

The data used for analysis consists of primary and secondary loan-level data from the Pennsylvania based ACA, AgChoice Farm Credit. In all, AgChoice services approximately 15,000 loans covering 7,000 customers throughout 52 of the 67 counties in Pennsylvania, and 4 in West Virginia. The analysis focuses on a sample of mortgages with a primary SIC code labeled “dairy” from the population of fixed rate mortgages collateralized by real estate originated from January 1, 2001 thru June 30, 2006. The analysis focuses on “dairy” mortgages because these loans represent a substantial percentage (approximately 30%) of all outstanding credit delivered by AgChoice. Also, the ACA felt the “best” aggregate and disaggregate data could be obtained from these mortgages due to the frequency of servicing, or updating of borrower information.

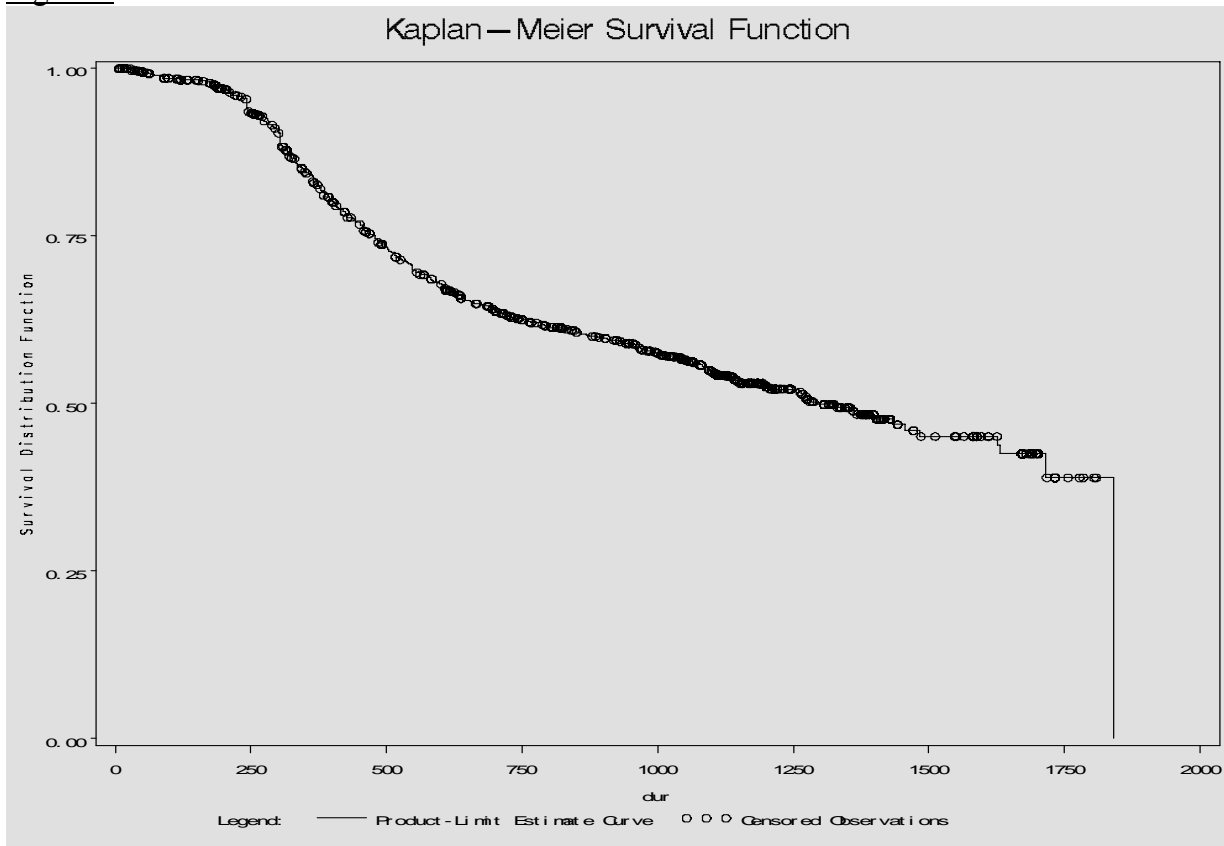
In all, 1,060 fixed-rate loans from 701 customers were reviewed ranging from origination amounts of \$6,859.33 to \$2.6 million representing a significant portion of AgChoice’s portfolio over the 5.5 year period. The average loan amount is \$242,693.10, with an average fixed interest rate of 7.05% (range 3.00% to 9.875%). The total number of loans originated for each year is as follows: 243 in 2001, 259 in 2002, 313 in 2003, 99 in 2004, 90 in 2005, and 56 as of June 30, 2006. Of the 1,060 loans that originated over the 5.5 year period, 462 fell under the definition of prepay, and 14 fell under the definition of default. One reason for the low frequency of defaults throughout the 5.5 year period is that a default (under the definition of ≥ 90 days) may actually masquerade as a prepayment due to the work with, work down, or work out strategies used by the ACA should problems arise. For instance, if payment problems arise, a loan could possibly be restructured (i.e. rewritten as a balloon note) before it reaches the 90 day threshold of default.

Preliminary Results

KM Survivor curve

Figure 1 contains the empirical KM Survivor Curve. This nonparametric estimate contains a total of 918 loans, with 535 being censored, and 383 being terminated via prepayment or default. There are only 918 loans included within the preliminary analysis because complete information was not available for all 1,060 loans. Therefore, the empirical survivor function is understated (actually 476 terminations) and could be improved with the addition of the incomplete information. However, one point to note from figure 1 is the sharp fall of the survivor function within the earlier stages of loan life.

Figure 1

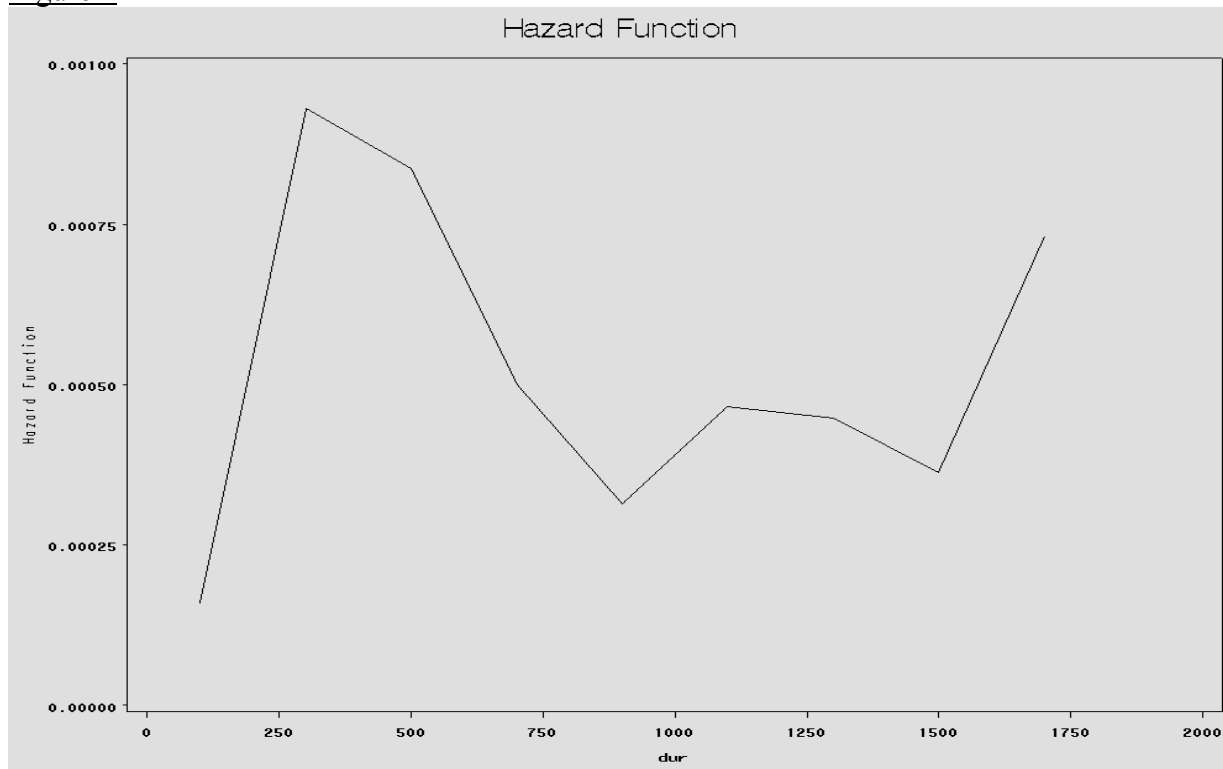


Hazard Function

Figure 2 contains the combined empirical hazard function for prepayment and default with respect to a change in time of fifty days. One important point to note is the connection between figure 1 and figure 2. It is evident that higher hazard rates, or higher chances of termination, coincide with an accelerated decline of the KM Survivor Curve. To further improve the interpretation of the hazard function, future analysis will segregate between prepayment and default. Lastly, caution should be used when interpreting the right tail of the hazard function, as it is exaggerated due to censoring. Therefore, future analysis will need to include intervals of time that are consistent with the data. For example, an interval of time that doesn't exceed the

maximum day of loan observation should be chosen to remove the exaggeration within the right tail due to censoring.

Figure 2



Looking Ahead

Much of the empirical work concerning agricultural mortgage termination uses a contingent claims approach to valuation typically with simulation, but none use SA. Green and Shoven (1986) were likely the first to apply SA to mortgages. Their analysis focused on a proportional hazards approach to estimate the sensitivity of mortgage prepayments to prevailing interest rates from a data set consisting of 3,983 mortgages held by two large California Savings and Loan Associations. Their results indicated that market interest rates are a significant determinant of prepayment probabilities, and that “good” data were not readily available at the time of the study. Later, better methods associated with the proportional hazards model were developed and proven to provide better estimates.

Deng (1997) applied a semi-parametric estimation (SPE) approach with competing risks and time-varying covariates developed by Deng *et al.* (1995) to a set of individual mortgages maintained by the Federal Home Loan Mortgage Corporation (FHLMC or Freddie Mac). Prepayment and default are dependent upon each other and are considered “competing risks” since a borrower forfeits the right to exercise one of the options in the future through the exercise of the other. Therefore, using a SPE approach is beneficial over a parametric approach for the following reasons. First, SPE can model the dependent competing risks straightforward, and can be used to estimate the baseline hazard function using the Kaplan-Meier approach simultaneously with covariates. Also, ties in failure time are not a problem, allowing unobserved

error terms (unobserved heterogeneity) to be incorporated. Lastly, SPE transforms the proportional hazard function into a regression framework (Deng 1997).

Using a parametric approach to estimate the baseline hazard function limits estimation capabilities and can bias results (Allison, 1995). Deng (1997) also argues that a stochastic term structure of interest rates, rather than a deterministic term structure should be used when considering prepayment evaluation. A deterministic term structure of interest rates fails to account for any tangible and/or intangible costs associated with mortgage prepayment such as documentation fees, escrow fees, or time costs. Also, a deterministic term structure of interest rates inappropriately assumes borrowers have perfect information about the interest rate term structure. Specifically, Deng (1997) adopts the simplified binomial process from Tian (1992) to derive the prepayment option value. This path-independent process has been demonstrated to supersede other discrete-time models in numerical accuracy when estimating market interest rate movements (Tian, 1992).

The focus of this particular analysis will be on estimating mortgage termination using SA techniques within a competing risks framework. Particularly, a SPE approach will be implemented with both static and time-varying covariates as regressors to estimate mortgage termination. The variables of interest that will be used for estimation include a variety of static and time varying financial characteristics (income/balance sheet data), borrower characteristics (demographics), and market characteristics (market prices).

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