

The Hazard Rates of First and Second Default

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Abstract

This paper examines hazards of repeated mortgage default, conditional on reinstating out of an initial default episode. Results indicate that subsequent default risk for borrowers who reinstate out of a first default is significantly greater than the risk of first default, especially during the first two years. In addition economic factors helpful in predicting first defaults are not helpful in predicting additional default episodes. This has important implications for mortgage investors and servicers as foreclosure avoidance efforts intensify.

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1. Introduction

The dynamics of borrower default and the conditions which result in foreclosure are gaining importance as mortgage lenders and services realize that foreclosure avoiding loss mitigation efforts can pay significant dividends.¹ Lenders, responding to growing pressure from mortgage insurers and secondary market agencies, are actively engaging in default forbearance programs in an effort to reduce mortgage credit costs. One key issue not yet addressed is the relative post-default payment performance of mortgages that have successfully avoided foreclosure on an initial default. Understanding the propensity of these mortgages to default again is of critical importance to mortgage servicers and investors and is ultimately necessary to determine the success of any default forbearance program. This paper presents a model of the hazard of second default, given that a borrower has reinstated out of a first default, and compares it to the hazard rates of first default. It is the first known effort at analyzing the risk profile of these borrowers.² Of particular interest is the difference between the hazard of default for borrowers who have reinstated out of an earlier default versus the hazard of initial default. With the increasing emphasis on loss-mitigation, understanding the hazard of second default will be critical for participants in the secondary mortgage market as greater numbers of reinstated loans are securitized out of loss mitigation programs.

Statistical models suited for this type of analysis include “failure time” or “duration” models.³ Duration analysis concerns either the length of time that elapses from the beginning of some event to its end, or else the waiting time before an event

¹ Ambrose and Capone (1996b) discuss lender foreclosure alternatives and provide evidence of the cost savings available to lenders.

² Borrowers are recognized as “in default” after becoming 90-days delinquent on their mortgage payments. At this point, lenders may begin foreclosure proceedings. Foreclosure in the U.S. is governed by State law. It is the legal process for liquidating the property to pay off the mortgage debt of a defaulted borrower. The legal action is called accelerating the terms of the note. In practice, the lender is generally the purchaser of the property at the foreclosure sale and must then liquidate it itself. Dependent upon the property State, foreclosure processes may take from 6 weeks to 18 months (see Durham (1985) or Madway (1974)).

³ See Kiefer (1988) for an overview of duration models applied to economic data.

occurs. In the present case, we examine the length of time between borrower reinstatement and a second default using the traditional Cox proportional hazard model.⁴

In the next section, we present a discussion of the data used in the analysis. Section 3 presents the hazard rates for first and second default. Section 4 follows with the model for the time to second default and the statistical results. We conclude in section 5.

2. Data

Data for this analysis is drawn from 724,666 FHA single-family residential mortgages originated during 1989. We then recreate their default and prepayment experience through the third quarter of 1995. For borrowers who reinstate their mortgage out of default, we also track any subsequent default or prepayment episode. Information known at loan origination is available from loan characteristics files maintained by HUD. Property values are updated over time using an SMSA-level repeat transactions index, covering 49 major metropolitan areas.⁵ After focusing on these SMSAs and eliminating observations with missing values, we have a final sample of 42,764 mortgages. Of these borrowers, 25,324 (59.2 percent) prepaid their mortgage during the sample period and 5,650 (13.2 percent) defaulted at least once. Thus, 11,790 (27.6 percent) mortgages neither defaulted nor prepaid and were still active at the end of the sample period. Given the dramatic decline in interest rates between 1992 and 1994, it is not surprising that more than half of the mortgages paid off during the sample period.

Of the 5,650 initial defaults, 3,345 (59.2 percent) reinstated their mortgages (resumed making payments) while 2,305 (40.8 percent) terminated the loan through foreclosure, property sale, or through entry into the FHA assignment program.⁶ Of the 3,345 reinstated mortgages, 744 (22.2 percent) defaulted again prior to the end of the

⁴ See Cox (1972).

⁵ This series, though not publicly available, was provided for this research by the Office of Federal Housing Enterprise Oversight (OFHEO). It uses the same technology as does OFHEO's publicly available HPI Report. The Report publishes quarterly repeat-transaction price indices based on Fannie Mae and Freddie Mac loan purchases for the nation, 9 Census Divisions, and the 50 States plus District of Columbia.

sample period and none prepaid. The lack of prepayments from the group of repeat defaulters is surprising but consistent with the notion that borrowers who default and then reinstate are very close to the optimal default region where prepayment is either prohibited or not financially viable.⁷

3. Default Hazard Rates

We begin by defining the time to default, T , as a random variable which has a continuous probability distribution, $f(t)$, where t is a realization of T . The cumulative probability is defined as

$$F(t) = \int_0^t f(s)ds = \Pr(T \leq t) \quad (1.)$$

and the survival function is defined as

$$S(t) = 1 - F(t) = \Pr(T \geq t). \quad (2.)$$

The survival function provides an indication of the probability that the time to default will be of length at least t . The probability that a default will occur in the next short interval of time, Δt , given that the borrower has not defaulted prior to time t is characterized as

$$I(t, \Delta t) = \Pr(t \leq T \leq t + \Delta t | T \geq t). \quad (3.)$$

The function which characterizes this aspect of the distribution is the hazard rate and is defined as

$$\mathbf{I}(t) = \lim_{\Delta t \rightarrow 0^+} \frac{\Pr(t \leq T < t + \Delta t | T \geq t)}{\Delta t} = \frac{f(t)}{S(t)}. \quad (4.)$$

The hazard rate provides an indication of the rate at which borrowers default at time t , given the mortgage remains current until t .

⁶ Assignment does not technically terminate a loan, but because the FHA insurance is terminated the loan disappears from our database. We treat assignment as a foreclosure alternative because HUD is saving a loan from imminent foreclosure.

⁷ Prepayments are not technically prohibited on FHA-insured loans where there is negative equity. As long as a borrower has made 6 consecutive mortgage payments, they can streamline refinance a property with negative equity (they simply don't get an appraisal), but they must pay all closing costs in cash.

Figure 1 plots the survival curves for default while Figure 2 shows the hazard rates of default.⁸ In this analysis we are concerned with determining whether borrowers who reinstate their mortgages face the same default hazard rate as borrowers at origination. The survival and hazard rates (Figures 1 and 2) clearly indicate differences in the underlying pattern of default. The survival curve for second default falls dramatically in the months following reinstatement, whereas the survival curve for initial default displays a gradual decline. The graph of the hazard rates shows a sharp rise in the hazard of second default over the first 3 months, to 3.7 percent, followed by a sharp decline to less than 2 percent after month 12. After month 12, the hazard of second default remains less than 1 percent but displays high volatility compared to initial default. The hazard of first default displays the normal pattern of slowly rising over the first 24 months and then remains relatively stable at 0.3 percent. The hazard of second default suggests that once a mortgage has survived 2 years after the initial default experience, the probability of defaulting again is relatively small and similar to the hazard of initial default. The difference appears to be in the increased volatility of the monthly series of second-default hazard rates.

While Figures 1 and 2 clearly indicate a difference in the survival and hazard rates for first and second defaults, as a matter of formality, we present statistics testing the null hypothesis that the hazard rates are the same. Table 1 reports the three test statistics which, not surprisingly, are highly significant supporting the conclusion that the default hazard rates are different.

4. Proportional Hazard Model

We now employ Cox Proportional Hazard model with time-varying covariates to discern the factors influencing the difference between the hazards of first and second default. Unlike accelerated failure time (AFT) models, the proportional hazard model requires minimal assumptions about the underlying distribution of the data.

The proportional hazard model is specified as

$$\mathbf{I}_i(t) = \mathbf{I}_0(t)e^{b'X_i(t)} \quad (5.)$$

⁸ Survival curves and hazard rates are estimated using the life-table method.

where $\mathbf{I}_0(t)$ is the unspecified baseline hazard, and $X_i(t)$ is a matrix of financial/economic, personal, and State-specific legal characteristics. The financial/economic variables are allowed to change over time. The dataset contains multiple defaults at the same time, so the model is estimated using the Efron (1977) likelihood function

$$L(\mathbf{b}) = \prod_{m=1}^n \frac{\exp(\mathbf{b}s_i)}{\prod_{i=1}^{d_k} \left[\sum_{l \in R_k^*} \exp(\mathbf{b}x_l(t)) - \frac{i-1}{d_k} \sum_{l \in D_k} \exp(\mathbf{b}x_l(t)) \right]} \quad (6.)$$

where d_k denote the multiple defaults at time T_k , s_i is the sum of vectors $x_l(t)$ over the borrowers who default at time T_k , and n represents the number of distinct, ordered default times.⁹

The specific set of variables used here is described in Ambrose and Capone (1997). We capture the dynamics of borrower equity and default-option value with the probability that an individual property may have negative equity in each month. The potential for prepayment is estimated each month as the ratio of the present value of the remaining mortgage payments at the current market interest rate to the outstanding loan balance. Borrower personal characteristics include income, race, and first-time homebuyer status. Borrower default may also be dependent on local economic conditions. The influence of “trigger events” on default hazards is measured by the state unemployment rate in each month. We also include a variable for States which place limits on the ability of lenders to collect post-deficiency deficiency judgments, as that affects the put-option value of default.

Appendix A and Table 2 describe the variables in greater detail while Table 3 provides the descriptive statistics for first- and second-time defaulters. From Table 3, we see that the mean time in the sample for mortgages originated in 1989 is 51.7 months. However, for borrowers who reinstate out of first default, the mean time to either a second default or end of sample period is just 16.4 months.

⁹ Since mortgage default and prepayment are substitutes, we estimate the default hazard in a competing risk framework. The likelihood function is estimated via maximum likelihood assuming censoring of the non-default outcomes (prepayments and active status at the end of the sample period). Results for the prepayment hazard model are available from the authors upon request.

Empirical Results

Table 4 presents results of the proportional hazard models of the time to first and second default. The covariate effects for first default are all as expected, however, no similar pattern emerges in the second-default model. There, only two coefficients are statistically significant, and they have the “wrong” sign. The Chi-squared statistic for the second-default equation is very low, and only significant at the 0.05 level. The final column of Table 4 provides Wald-statistics from the test of equivalency of coefficients across equations.

Financial Factors

Our results indicate that financial motivation factors are paramount in determining the hazard of first default. The positive *PREPAY* coefficient indicates that the hazard of default is higher when the market interest rate is greater than the contract rate, indicating negative call-option value. The coefficient in the second-default equation is not significant, and the Wald statistic indicates that the coefficient estimates are significantly different between the two equations. It is interesting that none of the cured defaults in our database subsequently prepaid their mortgages. But mortgage default is likely accompanied by other credit problems, so that borrowers are not eligible to refinance their mortgages for a period of time.

The coefficient for *PNEQ* for the first default model also is positive and highly significant. The risk ratio suggests that a 1 percentage point increase in the probability of negative equity (over the mean) increases the hazard of first default nearly six-fold. In contrast, the coefficient for *PNEQ* in the hazard of second default is significantly negative, indicating that further decreases in borrower equity lower the hazard of second default. The risk ratio implies that a 1 percent increase in the probability of negative equity will reduce the hazard of second default by 62 percent. This suggests that trigger events leading to default in adverse economic circumstances may not be entirely random. Or, at least, the conditional expectation of a negative trigger event is a positive function of time since last trigger event.

To follow this through, let us say a borrower experiences a job loss that precipitates an initial default, but that a new job is found and the borrower recovers and cures the default. Our results suggest that should economic conditions deteriorate again,

this borrower has a smaller chance of incurring a second spell of unemployment, compared with borrowers who did not experience a job loss during the first economic decline. This result would match a waiting-time interpretation: the chance of any one borrower experiencing a negative trigger event is a random variable which is a function of time since the last trigger event.

The inability to predict second defaults based on primary economic motivations—call and put option values—has a very clear implication for mortgage pricing. Namely, that as the percent of reinstatements in a pool increases, default prediction with traditional models becomes less and less accurate.

State-Economic Characteristics

We proxy overall economic conditions by using the monthly State unemployment rate. The significantly negative coefficient confirms the results of the *PNEQ* variable, discussed above. Again, conventional wisdom holds only for initial defaults, where an increase in area unemployment rates presages an increase in mortgage defaults. A one point increase in the unemployment rate results in a 4 percent increase in the hazard of first default. However, our results indicate that the same one point increase in the unemployment rate reduces the hazard of second default by 8 percent.

For the hazard model of first default we find a significantly positive coefficient on *NODEF*. The risk ratio indicates that hazard of first default is 23 percent higher in states which limit deficiency judgments, making it easier for borrowers to capture the full put-option value. This is consistent with the theoretical predictions in Ambrose, Buttimer, and Capone (1997). However, it is interesting to note that anti-deficiency judgment laws do not have a measurable impact on the hazard of second default. It may be that borrowers who successfully avoid foreclosure on a first default have learned that lender threats regarding deficiency judgments are empty, because FHA has a policy of not pursuing deficiency judgments on owner-occupants.

Borrower Characteristics

In analyzing borrower characteristics (Table 3), we see that borrowers who default and reinstate are not very different from the overall sample of borrowers at origination. Then, in Table 4, we see that no borrower characteristics have significant influences on the hazard of second default. In contrast, borrower characteristics do have

a significant impact on the hazard of first default. In particular, minority borrowers have a 50 percent higher hazard of first default than do non-minority borrowers.¹⁰ Coefficients for *FTIME* show some minor evidence that first-time homebuyers may have more difficulty fully recovering from an initial default episode.

A surprising result with respect to borrower income is the highly significant negative coefficients for *INC60*, and *INC80* indicating that middle- and upper-income FHA borrowers have higher hazards of default. These suggest that middle- and upper-income borrowers who turn to FHA do so because they have credit problems that preclude their use of conventional mortgages. Lower income borrowers, on the other hand, may be prone to use FHA insurance because of low down payment requirements and/or high allowances for payment-to-income ratios. These lower-income borrowers may have higher credit ratings than the higher-income FHA borrowers. However, any distinctions that do exist here for first-default hazard disappear for second defaults. If anything, there is some evidence that middle-income borrowers (*INC100*) do best in terms of fully recovering from an initial default episode.

5. Conclusions and Implications

Using a unique dataset of defaults on FHA mortgages, this paper analyzes the differences in the relative hazards of first and second default. Results confirm our theoretical expectations that the hazard of second default is significantly different from the hazard of first default. What is, perhaps, surprising is that second default rates cannot be predicted in the same manner as first defaults. Unemployment rates and negative property equity appear to influence second defaults in an opposite manner to first defaults. Borrower characteristics and call-option values also have much less effect on second default hazards.

Examination of Kaplan-Meier estimates shows that borrowers who cure a first-default have high, but declining hazards of second defaults during the ensuing two years.

¹⁰ This is consistent with the finding of Ambrose and Capone (1996a) who also report that minority borrowers have a higher default rate while being more likely to reinstate out of default than non-minority borrowers.

After that time, their rates of default are, on average, similar to rates of first default for other borrowers, but the volatility of the repeater group rates is much higher.

Our analysis has important implications for investors in mortgage-backed securities. Currently, Fannie Mae and Freddie Mac require that servicers repurchase loans from MBS pools after 120 days delinquency, making the distinction between first and second default immaterial for their MBS investors. Cured defaults remain in the retained portfolios of the agencies, and so the repeat-default risk is significant for them. However, movements in the mortgage industry toward lender repayment plans can keep more of these loans in security pools, changing MBS prepayment speeds and the abilities of current models to accurately capture them.

For Ginnie Mae investors, the issue of second default hazard is already much more significant. Not only do FHA and VA loans have higher default rates than do conventional loans, but FHA and Ginnie Mae do not require repurchase of 90-day delinquent loans from the Ginnie Mae MBS pools. Defaulted loans are repurchased from the pools only at foreclosure. Since foreclosure is equivalent to a prepayment for Ginnie Mae investors, default and reinstatement rates are leading indicators of future MBS payoffs. Thus, understanding the factors which influence the probability of second default can have a significant impact on the predictions of Ginnie Mae prepayment speeds.

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Table 1
Test Statistics for Differences in
Default Hazard Rates

Test	$\chi^2(1)$	p-value
Log-Rank	3018.10	0.0001
Wilcoxon	3529.64	0.0001
-2Log(LR)	1213.71	0.0001

Table 2
VARIABLE DEFINITIONS

Dependent Variable:

TIMETO Either the number of months between mortgage origination and default (in the case of first default) or the number of months between first default reinstatement and second default.

Independent Variables:

Financial Characteristics:

PREPAY One minus ratio of the present value of mortgage payments at the market interest rate to the present value of mortgage payments at the contract rate. Measures whether prepayment option is “in-the-money”.

PNEQ Probability that borrower’s equity ratio is negative. See Deng, Quigley, and Van Order (1994)

Borrower Characteristics:

RACE Borrower’s race (1=minority/0=white)

FTIME First-time homebuyer (1=yes/0=no)

INC60 Borrower income less than or equal to 60 percent of area median income.

INC80 Borrower income greater than 60 and less than or equal to 80 percent of area median income.

INC100 Borrower income greater than 80 and less than or equal to 100 percent of area median income.

INC120 Borrower income greater than 100 and less than or equal to 120 percent of area median income.

INC120+ Borrower income greater than 120 percent of area median income.

ENTRY TIME Time trend variable denoting the month of reinstatement.

State Specific Characteristics:

NODEF State limits on borrower deficiency judgments (1=yes/0=no).

EMPLRATE Monthly state unemployment rate.

Table 3
Descriptive Statistics
Panel A: Mortgages Originated in 1989

Variable	N	Mean	Std. Dev.	Minimum	Maximum
<i>TIMETO</i>	42764	51.723	18.559	1	83
<i>PREPAY</i> ¹	42764	-0.170	0.084	-0.445	0.300
<i>PNEQ</i> ¹	42764	0.025	0.070	0	0.679
<i>RACE</i>	42764	0.211	0.408	0	1
<i>FTIME</i>	42764	0.708	0.455	0	1
<i>INC60</i>	42764	0.121	0.327	0	1
<i>INC80</i>	42764	0.210	0.407	0	1
<i>INC100</i>	42764	0.217	0.412	0	1
<i>INC120</i>	42764	0.164	0.370	0	1
<i>NODEF</i>	42764	0.339	0.474	0	1
<i>EMPLRATE</i> ¹	42764	4.765	0.902	2.8	7.8
<i>ENTRY TIME</i>	42764	8.188	2.767	1	12

Panel B: Mortgages which reinstated out of first default

Variable	N	Mean	Std. Dev.	Minimum	Maximum
<i>TIMETO</i>	3345	16.426	15.988	0	59
<i>PREPAY</i> ¹	3345	-0.128	0.100	-0.392	0.207
<i>PNEQ</i> ¹	3345	0.153	0.115	0	0.679
<i>RACE</i>	3345	0.329	0.470	0	1
<i>FTIME</i>	3345	0.738	0.440	0	1
<i>INC60</i>	3345	0.134	0.340	0	1
<i>INC80</i>	3345	0.211	0.408	0	1
<i>INC100</i>	3345	0.220	0.415	0	1
<i>INC120</i>	3345	0.166	0.372	0	1
<i>NODEF</i>	3345	0.353	0.478	0	1
<i>EMPLRATE</i> ¹	3345	4.820	0.897	2.8	7.8
<i>ENTRY TIME</i>	3345	52.281	19.223	11	84

¹-Time-varying coefficients. Mean reported is the mean at month of default.

Table 4
Proportional Hazard Model of the time to default.

$$I_i(t) = I_0(t)e^{b'X_i}$$

Variable	Hazard of First Default			Hazard of Second Default			Wald Statistic ^a
	Parameter Estimate	χ^2	Risk Ratio	Parameter Estimate	χ^2	Risk Ratio	
<i>PREPAY</i>	3.16 ^{***}	930.9	23.56	0.06	0.0	1.06	7.3 ^{***}
<i>PNEQ</i>	1.75 ^{***}	239.9	5.75	-0.97 ^{***}	7.0	0.38	5.7 ^{***}
<i>UNEMPLOY</i>	0.04 ^{***}	13.0	1.04	-0.08 ^{***}	9.9	0.92	3.3 ^{***}
<i>RACE</i>	0.41 ^{***}	190.4	1.50	0.01	0.0	1.01	3.7 ^{***}
<i>FTIME</i>	-0.02	0.4	0.98	0.06	0.5	1.06	-0.7
<i>INC60</i>	-0.09 ^{**}	3.9	0.91	-0.01	0.0	0.99	-0.4
<i>INC80</i>	-0.15 ^{***}	13.6	0.86	-0.01	0.0	0.99	-0.9
<i>INC100</i>	-0.06	2.4	0.94	0.17	2.5	1.19	-1.6
<i>INC120</i>	-0.03	0.4	0.97	0.07	0.4	1.08	-0.6
<i>NODEF</i>	0.21 ^{***}	50.0	1.23	0.01	0.0	1.01	1.8
<i>ENTRY TIME</i>	-	-	-	-0.01	0.5	0.99	-
Log Likelihood	115698			11251			
Restricted Log L	114693			11228			
$\chi^2(11)$	1105 ^{***}			23.1 ^{**}			

^a - Wald statistic tests the null hypothesis that the parameter estimates for first and second default are equal.

*** - significant at the 1 percent level.

** - significant at the 5 percent level.

* - significant at the 10 percent level.

Appendix: Variable Definitions

Financial Characteristics

$PNEQ$ is the probability that an individual property may have negative equity, given mean expected equity as measured by MSA-level house price growth, and the variance of growth rates around the mean.¹¹ To capture the value of the prepayment option, we add the variable, $PREPAY$, which, following Deng *et al* (1994), is defined as

$$PREPAY = 1 - \frac{pvbalr}{mortbal}, \quad (8.)$$

where $pvbalr$ is the present value of the remaining mortgage payments at the current market interest rate and $mortbal$ is the outstanding balance. Positive values of $PREPAY$ indicate that the market interest rate is greater than the contract rate and, accordingly, the prepayment option is “out of the money”, while negative values of $PREPAY$ indicate that the prepayment option is “in-the-money.”

Personal Characteristics

Borrower personal characteristics are obtained by matching default records with loan origination files. The origination files maintained by HUD provide information on borrower income, race, and first-time homeownership. First-time buyers ($FTIME$) tend to be younger families having less savings and less well established credit histories, thus making them riskier than older borrowers with well established credit histories and greater savings/assets. We test for the presence of a race effect on default by including a minority dummy variable, $RACE$ (minority = 1). As many studies have noted, sub-optimal (trigger-event induced) default may also be a function of the borrower’s ability to weather a financial crisis such as job loss or divorce. One factor which has a direct impact on such abilities is non-housing wealth. We include a proxy variable measuring income at origination, relative to the MSA median income.¹² With this we categorize borrowers by whether their incomes are less than 60 percent of area median income ($INC60$), between 60 and 80 percent ($INC80$), between 80 and 100 percent ($INC100$), between 100 and 120 percent ($INC120$), and

¹¹ Using the variance of the SMSA repeat transaction index (ϵ^2), the probability of negative equity is calculated as

$$pneq = \Phi \left(\frac{\log(pvbal) - \log(mktval)}{\sqrt{\epsilon^2}} \right)$$

where $pvbal$ is the present value of the remaining mortgage payments, $mktval$ is the current market value of the property estimated using the SMSA repeat transaction index, and Φ is the cumulative normal density function. (See Deng (1995) and Deng, Quigley and Van Order (1994)).

¹² The variable $FTIME$ also proxies for wealth effects.

greater than 120 percent (*INC120+*) of area median income.¹³ The variable *ENTRY-TIME* is the month in which the borrower reinstated out of first default and is used to control for differences in entry time across the sample.

State-Specific Factors

Borrower default may also depend on local economic conditions. Borrowers may default due to a “trigger event,” such as a loss in income due to an unexpected job loss. To capture this effect, we include the monthly state unemployment rate as an indicator of general economic conditions (*EMPLRATE*). The unemployment rate may be considered as a proxy for the joint probability of a default “trigger event” and its severity.

Finally, States also have the ability to limit lender response to default by controlling the use of deficiency judgments. We include an indicator variable (*NODEF*) which indicates which States place limits on the ability of lenders to collect post-foreclosure deficiency judgments. FHA has a policy of not pursuing deficiency judgments except in the case of investors, repeat foreclosures, and property abandonment, which makes this variable’s effect rather interesting. Lenders can still *threaten* borrowers with deficiency judgments in order to attempt to leverage reinstatement.

¹³ *INC120+* is dropped from the model specification to prevent singularity.

Figure 1
Default Survival Curves

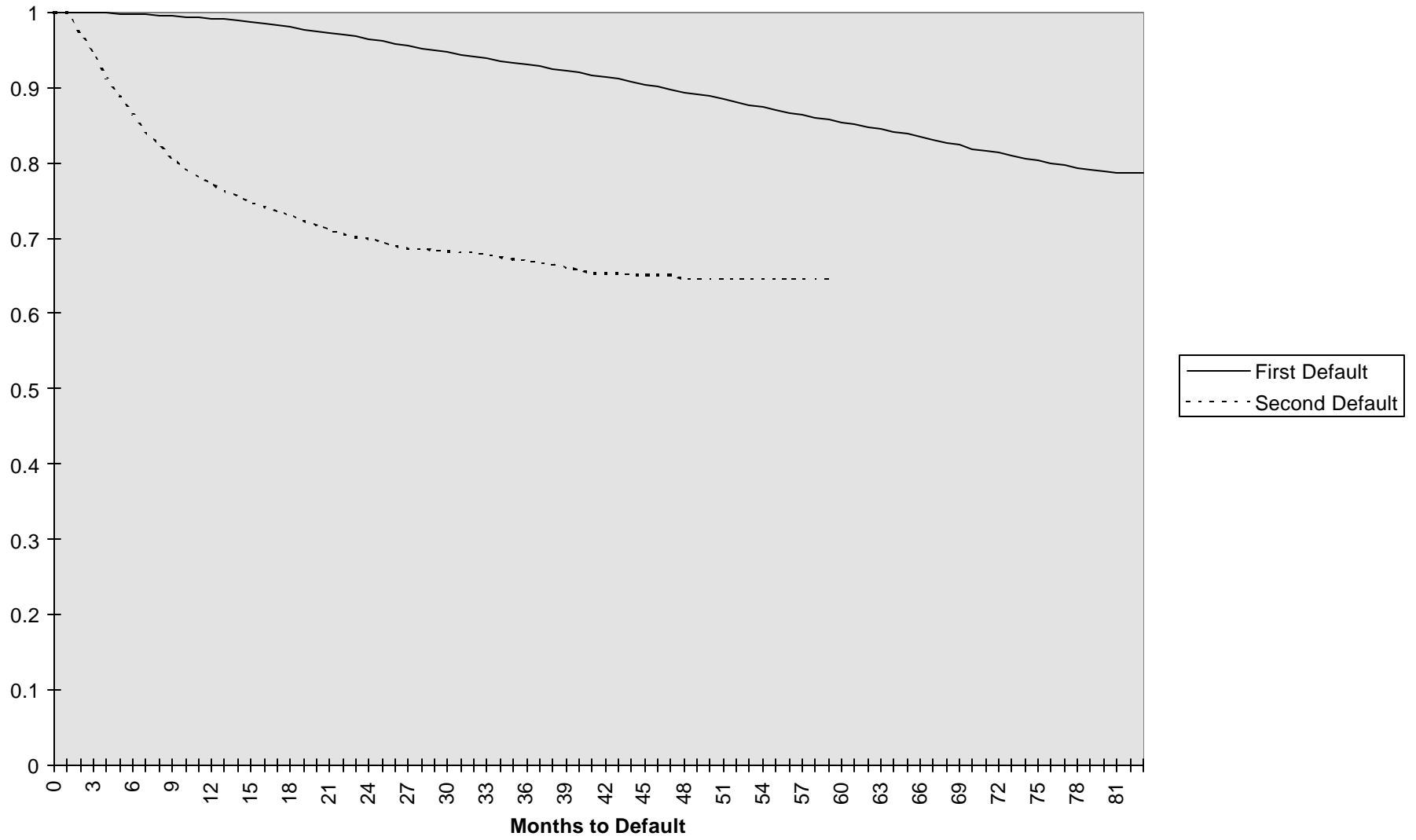


Figure 2
Default Hazard Plots

