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Residential Mortgage Delinquency Rates: The Determinants of Default

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Residential mortgages continue to serve as the medium in which mortgage borrowers are able to finance the purchase of their home. In fact, the mortgage itself represents much more than an avenue to home ownership. Mortgages residually connect most individuals with the largest investment of their life. Therefore, one might expect the association of unwavering qualifications with the conditional approval of a mortgage borrower. However, the recent financial crisis of 2008 and its catalyst, the failure of the subprime mortgage market, provided evidence that, financial innovation and relaxed lending standards aided in the complexity of the mortgage framework. As a result, mortgage delinquency rates increased dramatically across the nation in the years that immediately followed the financial crisis. As such, this research will provide answers to why and where mortgage delinquencies occurred in the United States between the years 1999 and 2011.

The economics of purchasing a home include many important financial institutions and their associated financial products. The process begins with potential homebuyers and their mortgage broker. The broker evaluates the financial position of the individual and determines what type of mortgage is appropriate. Through excellent documentation of reliable income, assets and creditworthiness, the potential homebuyer will qualify for a prime mortgage. Conversely, if the potential homebuyer is unable to prove financial independence, a less desirable subprime mortgage, with higher interest rates and greater volatility, will be provided. The middle ground is composed of Alt-A residential mortgages where borrowers may be very creditworthy yet fail to provide documentation of reliable income or assets.

Once the mortgage type is determined, the broker sells the mortgage to a lender for a decent profit. The lender in turn sells the mortgage to an investment banker who packages it with thousands of other mortgages into a collateralized debt obligation (CDO). The investment banker tiers the CDO into three tranches. The top tranche is rated AAA and considered investment grade due to the high creditworthiness of the underlying mortgage borrowers. The second and third tranches gradually become more risky and are rated accordingly. In most cases, the third tranche which offers the highest return, is sold mainly to hedge funds and other risk-seeking investors.

This complex system of financial players and institutions functions well when there is a consistent flow of cash from homeowners. During the years that preceded the financial crisis, home prices increased at an alarming pace which created an irrational exuberance among investors and potential homebuyers. Accordingly, under-qualified mortgage borrowers received mortgages without any documentation of income or assets. Investment bankers pounced on the opportunity to make additional profits by adding a slew of risky residential mortgages to their CDOs which were compounded numerous times. In fact, the true value of any CDO during the years that preceded the financial crisis was unknown and remains unknown today.

When mortgages are originated on unsound fundamentals, the seemingly robust mortgage framework begins to collapse under its own weight. Thus, the drastic increase in mortgage delinquency rates during the run-up to the financial crisis has created the need for greater awareness among investors and potential homebuyers. By developing a thorough understanding

of the residential mortgage framework and the impact that it has on the individual, potential homebuyers can better equip themselves with the knowledge necessary to avoid delinquency. Through empirical research and econometric modeling, this paper examines the leading determinants of mortgage delinquencies between the years 1999 to 2011 and will better educate investors and potential homebuyers of their role in the mortgage market framework.

I. Literature Review

Previous research will be organized into four subsections. The first will entail the overall economic environment, the securitization process and its role during the years that preceded the financial crisis. The second will address the liquidity and credit crunch that developed as a result of the subprime mortgage market failure. The third will analyze mortgage delinquency models and the factors that have proven to be statistically significant predictors of default while the final subsection will address the knowledge of mortgage borrowers and the associated effects of being uninformed.

In predicting mortgage delinquency rates among borrowers, Sarmiento (2012) considered not only the characteristics of the borrower, but of the macroeconomic environment as well. The multivariate regression model includes the following explanatory variables: FICO scores, market-to-market loan-to-values (MTMLTVs), outstanding loan balances, estimated property values, changes in the unemployment rate and changes in home prices. Sarmiento's research as published in *Applied Financial Economics* suggests that there is a significant link between the unemployment rate and mortgage delinquencies. Specifically, the results suggest that an increase in the unemployment rate of 50 percent explains 80 percent of the resulting increase in mortgage delinquencies. Furthermore, Sarmiento finds that an increase in the unemployment rate of only 10 percent increases the probability of default by 15 percent. Conversely, a reduction in the unemployment rate of 10 percent decreases the probability of default by only 3 percent. Accordingly, Sarmiento concludes that the upside is limited when considering unemployment rate shocks and the associated effects on the probability of default.

The increased presence of subprime mortgages attracted risk-seeking financial institutions such as hedge funds, in search of higher returns. The securitization process allowed investment banks to bundle residential mortgages into tranches with different risk levels. The increase in subprime originations only magnified their desire to manufacture CDOs. In fact, Nadauld and Sherlund (2009) suggest that on average, investment banks purchased more residential mortgages with high loan-to-value (LTV) ratios when compared to industry rivals. Additionally, Nadauld and Sherlund conclude that a 10 percent increase in the total amount of subprime loans sold on the secondary market produces the origination of four additional subprime loans per 100 households. This suggests that as more subprime loans were being sold on the secondary market and thought to be a reliable source of income, more subprime loans were originated. This false sense of stability associated with subprime loans was a leading catalyst for the demise of the housing market in late 2006.

With an increased presence of subprime mortgages there existed greater uncertainty throughout the housing market and a greater probability of default among residential mortgage borrowers. Authors Demyanyk and Hemert of the Federal Reserve Bank of St. Louis suggest in their 2008 publication that the market for residential mortgages should theoretically be formed on a risk-

based pricing model. Borrowers that are deemed under-qualified in terms of creditworthiness should provide the largest down payments, whereas well-qualified borrowers should only have to put down a small portion of the home's value. However, the inherent contradiction is that well-qualified borrowers are the ones providing the largest down payments. As a result, the under-qualified borrowers often finance the total cost of their home and quickly find themselves suffering from repayment paralysis.

When the subprime mortgage market failed in mid-2007, investors of all types were affected by the fallout that resulted. The CDOs that were packaged with risky subprime mortgages in their lower tranches became illiquid as home prices plummeted. As a result, there existed a massive liquidity crunch throughout the markets beginning in 2007. Brunnermeier (2009), in the *Journal of Economic Perspectives,* examines the events that resulted from the irrational exuberance fostered among investors.

In May of 2007, the rating agency Moody's looked to downgrade over 60 tranches of subprime mortgage pools which triggered a price reduction of mortgage-related products. Consequently, three months later the French bank BNP Paribas froze redemptions due to its holding of structured mortgage-related products. To avoid the eminent collapse of global financial markets, the European Central Bank injected €95 billion into the interbank market. Fearing the same future collapse, the Federal Reserve injected $24 billion. The Federal Reserve incrementally lowered the discount rate to lower the cost of borrowing and combat the looming credit crunch.

In addition to its discount rate reductions, the Federal Reserve created the Term Auction Facility (TAF) in December of 2007 with an aim to allow commercial banks to bid anonymously for short-term loans. Providing this option enabled commercial banks to avoid the discount window, allowing their financial hardship to be masked. The Federal Reserve also created the Term Securities Lending Facility (TSLF) in March of 2008 which surprisingly allowed investment banks to swap mortgage-related products for Treasury bonds for no more than 28 days. This action was followed by the creation of the Primary Dealer Credit Facility (PDCF) which opened the discount window to investment banks. Never before had the Federal Reserve taken such drastic measures to try and prevent an eminent collapse of the entire global financial system.

The culmination of the subprime mortgage market failure occurred when the investment bank Lehman Brothers was allowed to fail after senior bank executives found themselves unable to administer a takeover on September 15, 2008. The next day AIG, the massive insurance company responsible for the issuance of credit default swaps (CDSs), required assistance from the Federal Reserve after its stock price fell more than 90 percent. Accordingly, the Federal Reserve issued an $85 billion bailout in exchange for an 80 percent stake in the company. All of the events that led to this point were associated with subprime mortgage related products. Their once attractive nature quickly reversed and were soon disregarded as a reliable high-yielding investment.

Recent empirical research has attempted to quantify the determinants of mortgage delinquencies and provide explanations as to how delinquency rates can be minimized. Authors Elul, Souleles, Chomsisengphet, Glennon and Hunt (2010), in the *American Economic Review* examine mortgage data from the LPS database which includes 364,000 fixed-rate mortgages with

maturities of 15, 30 and 40 years originated between the years 2005 and 2006. They utilize a multivariate logistic regression model to help capture the determinants of a homeowner becoming 60+ days delinquent on his/her mortgage payments. When an LTV of below 50 increases to above 120, the chances of default increase by almost percentage 11 points per quarter. The results suggest that both negative equity (as measured by LTV ratios) and illiquidity (as measured by the mortgage borrower's bank card utilization rate) are statistically significant predictors of mortgage delinquencies.

Bajari, Chu and Park (2008) of the *National Bureau of Economic Research* find that the main drivers of mortgage delinquencies to be a reduction in home prices, deteriorating loan quality, high payments relative to income and flaws in the securitization process. The authors mention that much of the growth in the subprime mortgage market can be attributed to the expansion of privately-issued mortgage-backed securities (MBSs) which were not required to conform to standards set forth by Fannie Mae and Freddie Mac, the main securitizers of prime mortgages. Their research concludes that a 20 percent decline in home prices increases the probability of default by 16 percent when considering 30-year fixed-rate mortgages (FRMs) with an initial LTV of 100.

Prior to 2009, most research on mortgage delinquency rates singled out the complexity of the mortgages themselves as the main culprit of default. However, research completed by Mayer, Pence and Sherlund (2009), in the *Journal of Economic Perspectives* suggest that the attributes of the borrowers play a more prominent role. As such, high delinquency rates among subprime mortgage borrowers were caused mainly by low credit scores and high LTV ratios.

The authors note that the median combined loan-to-value (CLTV) among subprime mortgages increased from 90 in 2003 to 100 just two years later, suggesting that the average subprime borrower provided no down payment when purchasing their home. Not surprisingly, subprime loans that were originated between the years 2005 and 2007 had the highest CLTVs and default rates. Intuition suggests that the complexity of the mortgages themselves should be the most significant predictor of default, but research counters such an argument and points towards the borrower's attributes instead.

In addition to the main drivers of mortgage default, authors Bucks and Pence (2008), in the *Journal of Urban Economics* suggest that cognition and financial literacy also play a vital role. Borrowers who find it difficult to obtain a loan are also more likely to have less financial knowledge than their counterparts. In addition, the attractiveness of adjustable-rate mortgages (ARMs) is that any decrease in interest rates will result in the reduction of one's mortgage payments, allowing mortgage holders to sidestep refinancing. Financially illiterate individuals often fail to recognize that if interest rates were to increase, their mortgage payments would skyrocket.

Ultimately, the increased presence of subprime loans, ARMs and CDOs decreased transparency in the mortgage market. When loans are bundled and assigned to tranches in CDOs, they become difficult to value, especially when they are repackaged several times over as they were during the years that preceded the financial crisis. Authors Keys, Mukherjee, Seru and Vig (2010) suggest that once the loan creation process extends past the initial bank or lender, there exists an inherent

transparency problem. Accordingly, as the screening of borrowers became more relaxed, the originate-to-distribute problem permeated the market. Banks no longer needed to rigorously screen potential borrowers since their profit was made from selling the loan upon origination.

II. Methodology

The catalysts of mortgage delinquencies include the characteristics of the homebuyer and of the mortgage itself, along with macro-level variables that quantify the robustness of the economic environment. The mortgage market, which has been recently scrutinized due to the presence and failure of subprime mortgages, operates in a manner consistent with the movements of the business cycle. In other words, when the macro economy is doing well and the country experiences positive economic shocks, the housing market usually performs well. Conversely, economic downturns and subsequent recessions negatively affect the housing market and the ability of homeowners to make timely mortgage payments. As such, mortgage delinquency rates will be the variable of concern for this analysis.

The dependent variable, which measures whether a homeowner was delinquent once during the entire length of his/her mortgage, is binary in nature. This model will attempt to utilize loan characteristics, which include the original CLTV and interest rate, along with characteristics of the homebuyer, which include one's credit score, first-time homebuyer status and original DTI ratio to predict a relationship with mortgage delinquencies. In addition, this model will incorporate year dummy variables that will attempt to identify the years that had the most profound effect on one's ability to make timely mortgage payments. Similarly, region dummy variables were incorporated and will function the same way. Finally, the statewide unemployment rate will be incorporated as an additional explanatory variable. The combination of loan and homebuyer characteristics along with macro-level variables will attempt to better explain the rise in mortgage delinquency rates.

Regression analysis will help with the identification of each explanatory variable's marginal effect on the dependent variable, mortgage delinquency rates. Due to the binary nature of the dependent variable, both linear and non-linear regression estimation techniques will be utilized. The linear probability model (LPM) and the binomial logit/probit models will serve as the main estimation techniques. Complementing them will be semi-log and polynomial models that will attempt to further explain vital relationships between the data. The LPM will take the following functional form:

$$(1)\quad \widehat{DELINQUENCYRATE}_{it} = \hat{\beta}_0 + \hat{\beta}_1 CREDITSCORE_i + \hat{\beta}_2 FIRSTHOME_i + \hat{\beta}_3 ORIGINALCLTV_i + \hat{\beta}_4 ORIGINALDTIRATIO_i + \hat{\beta}_5 ORIGINALINTERESTRATE_i + \hat{\beta}_6 UNEMPLOYMENTRATE_{it} + \hat{\beta}_7 REGION_i + \hat{\beta}_8 YEAR_t + \varepsilon_{it}$$

The data come from the Freddie Mac Single Family Loan-Level Data Set, which is composed of origination and performance data beginning in the year 1999. It is structured as a living data set such that Freddie Mac will continually add and update data as new data become available. The origination data measures the annual originations of 30-year FRMs and tracks them via performance data which is measured by monthly payments made by the homeowner. For the purposes of this research, the data will span from 1999 to 2011 in an effort to gain a

representative analysis of mortgage delinquencies during expansionary and recessionary economic times.

The mortgage data is structured in a time-series, cross-sectional format where the unit of time is measured in years and where the cross-sections are quantified by each individual loan. The time series aspect is identified by the subscript "t" whereas the cross-sectional aspect is identified with theubscript "i" in the above regression model. The data include 492,361 mortgages originated between the years 1999 and 2011. Table 1 of the Appendix presents the descriptive statistics of the data with important years highlighted. The beginning and ending years which bind the data set are included along with the year that held the greatest amount of delinquencies (2007) and the year with the highest unemployment rate (2009). Excluded from the descriptive statistics table is the year 2006 in which the greatest amount of originations took place. Likewise, states in the South originated the greatest number of mortgages between the years 1999 and 2011. For the purposes of this analysis, both "2006" and "South" will be excluded to ensure that the complementary dummy variables are able to be interpreted against a proper base.

Due to the time-series and cross-sectional nature of the data, several statistical tests were conducted to ensure the integrity of the end model. Frequently, time-series data are found suspect of serial correlation where, if identified as positive serial correlation, the unexplained error terms from period one are linked to those from a previous time period. As a result, the estimated coefficients appear to be more statistically significant than they actually are, creating a bias in the standard error terms. To detect the presence of positive serial correlation, the Breusch-Godfrey Serial Correlation LM Test was conducted. As outlined in Table 2 of the Appendix, a statistically significant Obs*R-squared term suggests that the null hypothesis of no positive serial correlation should be rejected, thus requiring a remedy. The autoregressive AR(1) model estimates coefficients, t-statistics and standard errors while considering the impact of past error terms. As a result, the statistically significant AR(1) term in Model 6 of Table 5 in the Appendix suggests that the serial correlation present in the original parameter estimates has been adjusted and accounted for, ultimately yielding interpretable and robust parameter estimates.

In addition to detecting and implementing remedies for the presence of serial correlation, the cross-sectional nature of the data lends itself well to being a potential suspect of heteroskedasticity, where the error terms are non-homogeneous across varying input values. The consequences of heteroskedasticity include non-minimum variance estimates of the coefficients where the standard error estimates are biased. By way of the White test, as seen in Table 3 of the Appendix, and the statistical significance of the Obs*R-squared term, there is sufficient evidence to reject the null hypothesis of no heteroskedasticity. In this scenario, the original model did not serve as a homogeneous predictor of mortgage delinquency rates. Therefore, the Newey-West estimation technique as outlined in Model 7 of Table 5 of the Appendix is employed to correct for such bias in the standard error terms. In addition to estimating robust standard errors in an attempt to rid the model of the effects of heteroskedasticity, the Newey-West estimation technique also considers the presence of serial correlation, suggesting that it is the superior remedy over the Durbin Watson test.
Finally, multicollinearity was tested for to ensure that the explanatory variables moved idiosyncratically throughout time. Fortunately, the relatively low correlation coefficients between explanatory variables eliminated the potential problem of multicollinearity. After the

detection of and adjusting for serial correlation, heteroskedasticity and multicollinearity within the data, robust and accurate parameter estimates were estimated. Table 5 in the Appendix outlines the regression models that include such robust parameter estimates. Therefore, the odds of a homeowner becoming delinquent on his/her mortgage payments can be predicted by the specific loan characteristics (original CLTV and original interest rate), characteristics of the homeowner (credit score, first-time homebuyer status and original DTI ratio) and macro-level variables (region, year and state unemployment rate), all of which will be presented in the Data Analysis section below.

III. Data Analysis

Table 4 and 5 in the Appendix outline the models that were used to quantify the effects of the noted regressors on mortgage delinquency rates. Model 1 is a linear probability model (LPM), Model 2 is a binomial logit model, Model 3 is a binomial probit model, Model 4 is an LPM semi-log right model, and Model 5 is a polynomial model where credit score is squared.

The use of the binomial logit/probit models considers the presence of the binary nature of the dependent variable, mortgage delinquency rates. In the absence of such estimation techniques, the dependent variable is unbound by a set of parameters. In this case, the 0, 1 nature of the dependent variable calls for a nonlinear estimation technique which requires that the coefficients be interpreted as either increasing or decreasing the odds of predicting a mortgage delinquency. Table 6 and 7 in the Appendix outline the process of interpreting the odds ratios. By taking the anti-log of the estimated coefficient, the resulting value can be compared to a value of one, where a value less than one would suggest a decrease in the odds of obtaining a delinquent mortgage payment, and a value greater than one would suggest an increase in the odds. The non-linear nature of the estimation techniques therefore require that the coefficients not be interpreted as unit or percent changes.

In every regression model the results suggest that all regressors, except for the year 2005, are statistically significant at the 1 percent level. Aligned with theory, Model 1 in Table 4 of the Appendix shows that as a homeowner's credit score increases by 10 points, the odds of a delinquent mortgage payment decrease by 2 percent, suggesting that the one's creditworthiness directly relates to his/her ability to make timely mortgage payments. Model 2, the binomial logit model, places even more significance on credit score, suggesting that for a given 10 point increase, a subsequent 26 percent reduction in the odds of a delinquent mortgage payment will result. Thus, in accordance with both Model 1 and 2, there is a significant negative relationship between a homeowner's credit score and the likelihood of a delinquent mortgage payment.

Another statistically significant predictor of mortgage delinquency rates is whether the homeowner is a first-time homebuyer. All models support the claim that first-time homebuyers are better equipped for making timely mortgage payments. Additionally, first-time homebuyers are often held to higher lending standards. As such, Model 1 predicts that first-time homebuyers can expect to experience a 2.8 percent reduction in the odds of a delinquent mortgage payment relative to a non-first-time homebuyer, while Model 2 suggests that a first-time homebuyer can expect to experience a 40 percent reduction in the odds of a delinquent mortgage payment. As a qualitative measure of homebuyers, there exists a statistically significant negative relationship

between whether a person is a first-time homebuyer and the odds of a delinquent mortgage payment.

In accordance with all regression models, loan attributes (original CLTV and original interest rate) are also statistically significant predictors. Models 4 and 5 in table 4 of the Appendix suggest that if the original CLTV increases by a value of 10, the likelihood of a delinquent mortgage payment increases by 1 percent. Model 2 places the greatest emphasis on original CLTV, where a 10 point increase would result in a 15.9 percent increase in the odds of a delinquent mortgage payment. Model 3, the binomial probit model, suggests that a 1 point increase in the original interest rate increases the odds of delinquency by 23.77 percent. Interestingly, the results so far support the theory that the attributes of the homeowner play a more significant role in determining delinquency relative to the attributes of the mortgages themselves.

In terms of the macroeconomic regressor, statewide annual unemployment rate, all regression models support the claim that an increase in the unemployment rate results in a greater likelihood of delinquency. Model 2 predicts that a 1 point increase in the unemployment rate will increase the odds of a delinquent mortgage payment by 4.45 percent. Additionally, the general consensus among every model is that the South not only originated the greatest amount of residential mortgages between the years 1999 and 2011, but also yielded the greatest amount of delinquencies. The Midwest, Northeast, Pacific and West were all less likely to have higher delinquency rates during the same year span, suggesting that the South was hit the hardest with foreclosures during the subprime mortgage failure and subsequent financial crisis that began in late 2007.

In regards to the year dummy variables, all regression models support the claim that between the years 1999 and 2004, and between 2008 and 2011, homeowners were less likely to be classified as delinquent relative to homeowners with mortgages originated in 2006. Accordingly, 2006 was the year that home prices began to drop quickly. There is a discrepancy with the year 2005; some regression models suggest that originations in that year were more likely to become delinquent whereas others suggest the opposite. What is clear is that 2006 was a turning point that linked the height of the housing market failure and the beginning of the financial crisis. Not surprisingly, Model 2 suggests that homeowners who originated a mortgage in 2011 experienced a reduction in the odds of being classified as delinquent by 99 percent relative to homeowners who originated a mortgage in 2006.

Overall, the results suggest that there are many statistically significant predictors of mortgage delinquencies. Among the most robust are the characteristics of the individual homebuyer, which include one's credit score, first-time homebuyer status and DTI ratio. Also of importance is the impact that the macroeconomic environment played in the housing market. Finally, the loan characteristics themselves played a significant role in that as interest rates increased along with the use of debt financing, homeowners quickly became delinquency candidates.

IV. Conclusion

Recent economic events have led to a better understanding of subprime mortgages and their potential adverse effects on homeowners. Mortgages in general represent one of the largest

investments that a person can partake in. Likewise, whether the mortgage is subprime, Alt-A or prime in nature, the effects of delinquency have the potential to be felt on a nation-wide scale. By utilizing several regression models to explain the variation in mortgage delinquency rates, future homeowners and investors can better educate themselves on the very real potential adverse effects of residential mortgage delinquencies. With statistical significance, the qualities of the loan and of the homeowner, along with region, year and other macro-level variables help to quantify the marginal effects on the odds of delinquency. This analysis can and should be utilized to improve one's ability to better predict and understand residential mortgage delinquency rates.

V. References

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VI. Appendix

Table 1: Descriptive Statistics on Mortgage Delinquency Rates

	Mean[1]	Mean[2]	Mean[3]	Mean[4]	Minimum	Maximum	Sum
Delinquent	0.17	0.27	0.06	0.02	0	1	80,881
Credit Score	713	739	762	761	360	850	359,430,809
Original CLTV	78	74	70	79	6	160	37,039,366
Original DTI Ratio	33	37	33	33	0	65	17,183,430
Original Interest Rate	7.33	6.10	5.01	4.62	3.13	11.25	3,052,652
West	0.29	0.27	0.26	0.25	0	1	124,109
Midwest	0.25	0.23	0.26	0.25	0	1	129,372
Northeast	0.14	0.15	0.17	0.17	0	1	75,613
South	0.31	0.34	0.30	0.32	0	1	160,449
Pacific	0.00	0.01	0.01	0.01	0	1	2,818
First Home	0.17	0.14	0.11	0.36	0	1	69,721
Unemployment Rate	4.18	4.60	9.27	8.87	2.3	13.8	2,852,652

Mean[1] = 1999 averages; Mean[2] = 2007 averages; Mean[3] = 2009 averages; Mean[4] = 2011 averages. Minimum, Maximum and Sum values are were calculated using the entire data range (1999-2011). For all independent variables, N = 492,361. The dependent variable measures whether a homeowner was delinquent once (one late payment) over the course of his/her homeownership. Region variables are dummies where 1 represents each particular region in question and Year variables (not shown) function the same way. The year 2006 held the most mortgage originations (44,572) while 2011 held the least amount of originations (19,236).

Table 2: Breusch-Godfrey Serial Correlation LM Test

	Breusch-Godfrey Test		Probability
F-statistic	186.902	Prob. F(1,492337)	0.000
Obs*R-squared	186.8402	Prob. Chi-Square(1)	0.000

Table 3: Heteroskedasticity Test: White

	White Test		Probability
F-statistic	339.667	Prob. F(186,492174)	0.000
Obs*R-squared	56,012.060	Prob. Chi-Square(186)	0.000
Scaled explained SS	84,857.230	Prob. Chi-Square(186)	0.000

Table 4: Regression Results on Mortgage Delinquency Rates

	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	1.190*** (0.012)	5.102*** (0.094)	2.889*** (0.053)	7.663*** (0.049)	4.287*** (0.074)
Credit Score	-0.002*** (0.000)	-0.011*** (0.000)	-0.006*** (0.000)	-	-0.010*** (0.000)
LN Credit Score	-	-	-	-1.162*** (0.007)	-
Credit Score^2	-	-	-	-	0.000*** (0.000)
First Home	0.028*** (0.001)	0.223*** (0.013)	0.123*** (0.007)	0.028*** (0.001)	0.028*** (0.001)
Original CLTV	0.001*** (0.000)	0.007*** (0.000)	0.004*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
Original DTI Ratio	0.001*** (0.000)	0.008*** (0.000)	0.004*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
Original Interest Rate	0.024*** (0.001)	0.161*** (0.009)	0.093*** (0.005)	0.024*** (0.001)	0.022*** (0.001)
Unemployment Rate	0.002*** (0.000)	0.019*** (0.004)	0.011*** (0.002)	0.002*** (0.000)	0.002*** (0.000)
Midwest	-0.026*** (0.001)	-0.206*** (0.011)	-0.118*** (0.006)	-0.026*** (0.001)	-0.026*** (0.001)
Northeast	-0.013*** (0.002)	-0.089*** (0.013)	-0.050*** (0.007)	-0.013*** (0.002)	-0.012*** (0.002)
Pacific	-0.031*** (0.007)	-0.258*** (0.058)	-0.139*** (0.032)	-0.031*** (0.007)	-0.031*** (0.007)
West	-0.017*** (0.001)	-0.123*** (0.011)	-0.071*** (0.006)	-0.017*** (0.001)	-0.017*** (0.001)
1999	0.106*** (0.003)	0.669*** (0.020)	0.382*** (0.011)	0.104*** (0.003)	0.098*** (0.003)
2000	0.164*** (0.003)	1.136*** (0.025)	0.644*** (0.040)	0.162*** (0.003)	0.157*** (0.003)
2001	0.124*** (0.003)	0.845*** (0.021)	0.478*** (0.011)	0.123*** (0.003)	0.120*** (0.003)
2002	-	-	-	-	-

	0.111***	0.769***	0.433***	0.110***	0.108***
	(0.003)	(0.020)	(0.011)	(0.003)	(0.003)
	-	-	-	-	-
2003	0.063***	0.397***	0.225***	0.062***	0.060***
	(0.003)	(0.021)	(0.012)	(0.003)	(0.003)
	-	-	-	-	-
2004	0.045***	0.278***	0.157***	0.046***	0.044***
	(0.003)	(0.018)	(0.011)	(0.003)	(0.003)
2005	-0.002	0.002	0.002	-0.002	-0.002
	(0.002)	(0.017)	(0.010)	(0.002)	(0.002)
2007	0.058***	0.394***	0.249***	0.058***	0.057***
	(0.002)	(0.017)	(0.010)	(0.002)	(0.002)
	-	-	-	-	-
2008	0.027***	0.143***	0.090***	0.027***	0.027***
	(0.002)	(0.018)	(0.011)	(0.002)	(0.002)
	-	-	-	-	-
2009	0.089***	0.965***	0.506***	0.090***	0.094***
	(0.004)	(0.035)	(0.018)	(0.004)	(0.004)
	-	-	-	-	-
2010	0.109***	1.451***	0.729***	0.110***	0.115***
	(0.004)	(0.040)	(0.020)	(0.004)	(0.004)
	-	-	-	-	-
2011	0.120***	2.040***	0.980***	0.121***	0.128***
	(0.004)	(0.058)	(0.026)	(0.004)	(0.004)
Adjusted R^2	0.098	-	-	0.099	0.101
McFadden R^2	-	0.113	0.114	-	-
SE of Regression	0.352	0.352	0.351	0.352	0.351
F-statistic	2,419.077	-	-	2,449.213	2,400.106
Prob (F-stat)	0.000	-	-	0.000	0.000
LR statistic	-	49,902.49	50,332.40	-	-
Prob (LR statistic)	-	0.000	0.000	-	-
Pseudo R^2	0.835	0.834	0.834	0.835	0.835

Model 1: Linear Probability Model (LPM); Model 2: Binomial Logit Model; Model 3: Binomial Probit Model; Model 4: LPM Semi-log Right; Model 5: Polynomial Model Squared Right.

Table 5: Regression Results (Corrected) for Mortgage Delinquency Rates

	Model 6	Model 7	Model 8
Constant	1.187***	1.190***	1.190***
	(0.012)	(0.014)	(0.053)
Credit Score	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)
First Home	-0.028***	-0.029***	-0.028***
	(0.001)	(0.001)	(0.007)
Original CLTV	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
Original DTI Ratio	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
Original Interest Rate	0.025***	0.024***	0.024***
	(0.001)	(0.001)	(0.005)
Unemployment Rate	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.002)
Midwest	-0.026***	-0.026***	-0.026***
	(0.001)	(0.001)	(0.006)
Northeast	-0.013***	-0.013***	-0.013***
	(0.002)	(0.002)	(0.007)
Pacific	-0.031***	-0.031***	-0.031***
	(0.007)	(0.006)	(0.032)
West	-0.017***	-0.017***	-0.017***
	(0.001)	(0.001)	(0.006)
1999	0.106***	0.106***	0.106***
	(0.003)	(0.003)	(0.011)
2000	0.164***	0.164***	0.164***
	(0.003)	(0.004)	(0.004)
2001	0.124***	0.124***	0.124***
	(0.003)	(0.003)	(0.003)
2002	0.111***	0.111***	0.111***
	(0.003)	(0.003)	(0.003)
2003	0.063***	0.063***	0.063***
	(0.003)	(0.003)	(0.003)

	-	-	-
2004	0.045***	0.045***	0.045***
	(0.003)	(0.003)	(0.003)
2005	-0.00	-0.002	-0.002
	(0.003)	(0.003)	(0.003)
2007	0.058***	0.058***	0.058***
	(0.002)	(0.004)	(0.003)
	-	-	-
2008	0.027***	0.027***	0.027***
	(0.003)	(0.003)	(0.003)
	-	-	-
2009	0.089***	0.089***	0.089***
	(0.004)	(0.004)	(0.004)
	-	-	-
2010	0.109***	0.109***	0.109***
	(0.004)	(0.004)	(0.004)
	-	-	-
2011	0.120***	0.120***	0.120***
	(0.004)	(0.004)	(0.004)
AR(1)	0.019***	-	-
	(0.001)	-	-
Adjusted R^2	0.098	0.098	0.098
McFadden R^2	-	-	-
SE of Regression	0.352	0.352	0.352
F-statistic	2,322.890	-	2,419.077
Prob (F-stat)	0.000	-	0.000
LR statistic	-	-	-
Prob (LR statistic)	-	-	-
Pseudo R^2	0.835	0.834	0.834

Model 6: AR(1) Model; Model 7: Newey-West Model; Model 8: White Corrected Standard Errors Model.

Table 6: Binomial Logit Model Coefficient Interpretations

Independent Variable	Coefficient	Antilog	Odds ↑ or ↓	Magnitude
Constant	5.102059	-	-	-
Credit Score	-0.011281	0.974	↓	2.56%
First Home	-0.223389	0.597	↓	40.21%
Original CLTV	0.006872	1.015	↑	1.59%
Original DTI Ratio	0.008129	1.018	↑	1.89%
Original Interest Rate	0.16062	1.447	↑	44.75%
Unemployment Rate	0.018894	1.044	↑	4.45%
Midwest	-0.205753	0.622	↓	37.73%
Northeast	-0.088963	0.814	↓	18.52%
Pacific	-0.258171	0.551	↓	44.81%
West	-0.122804	0.753	↓	24.63%
1999	-0.669317	0.214	↓	78.59%
2000	-1.13645	0.073	↓	92.70%
2001	-0.845138	0.142	↓	85.72%
2002	-0.768871	0.170	↓	82.97%
2003	-0.397235	0.400	↓	59.94%
2004	-0.278233	0.526	↓	47.31%
2005	0.002103	1.004	↑	0.49%
2007	0.393869	2.476	↑	147.67%
2008	-0.142663	0.720	↓	28.00%
2009	-0.965424	0.108	↓	89.17%
2010	-1.450977	0.035	↓	96.46%
2011	-2.039909	0.009	↓	99.09%

Due to the nonlinear nature of the Binomial Logit Model, the anti-logs of the coefficients are calculated to determine the magnitude of the increase or decrease in the odds of predicting mortgage delinquencies. The green up arrow suggests an increase in the odds of predicting a mortgage delinquency, whereas the down arrow suggests a decrease in the odds of predicting a mortgage delinquency.

Table 7: Binomial Probit Model Coefficient Interpretations

Independent Variable	Coefficient	Antilog	Odds ↑ or ↓	Magnitude
Constant	2.88935			
Credit Score	-0.006426	0.985	↓	1.47%
First Home	-0.12325	0.752	↓	24.71%
Original CLTV	0.003583	1.008	↑	0.83%
Original DTI Ratio	0.004496	1.010	↑	1.04%
Original Interest Rate	0.092601	1.237	↑	23.77%
Unemployment Rate	0.010811	1.025	↑	2.52%
Midwest	-0.118386	0.761	↓	23.86%
Northeast	-0.04973	0.891	↓	10.82%
Pacific	-0.138806	0.726	↓	27.36%
West	-0.070566	0.850	↓	15.00%
1999	-0.381739	0.415	↓	58.48%
2000	-0.643538	0.227	↓	77.28%
2001	-0.478347	0.332	↓	66.76%
2002	-0.433304	0.368	↓	63.13%
2003	-0.225173	0.595	↓	40.46%
2004	-0.157457	0.695	↓	30.41%
2005	0.001589	1.003	↑	0.37%
2007	0.248918	1.773	↑	77.39%
2008	-0.089596	0.813	↓	18.64%
2009	-0.505995	0.311	↓	68.81%
2010	-0.728755	0.186	↓	81.33%
2011	-0.980184	0.104	↓	89.53%

Due to the nonlinear nature of the Binomial Probit Model, the anti-logs of the coefficients are calculated to determine the magnitude of the increase or decrease in the odds of predicting mortgage delinquencies. The green up arrow suggests an increase in the odds of predicting a mortgage delinquency, whereas the down arrow suggests a decrease in the odds of predicting a mortgage delinquency.