# Mortgage Meltdown: Default Sensitivity To Declining Home Values And Loan-To-Value Ratios

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**ABSTRACT**

*The current study investigates the recent mortgage crisis to determine whether deteriorating aggregate loan-to-value (LTV) ratios resulted in more acute default responses to depreciating home prices. We find evidence that default rates did not behave erratically or disproportionately to falling housing values during the subprime crisis, but we found some proof that the aggregate LTV ratio was associated with increased foreclosure rate volatility.*

**Keywords:** Declining Home Values; Loan-To-Value Ratios

## INTRODUCTION

The value of a home purchased in Las Vegas, Nevada, at the turn of the century more than doubled over the next six years. Locking into ostensibly lucrative profits, investors and homeowners injected capital into real estate with reckless abandon. Fueled by healthy demand and a seemingly never-ending supply of cheap credit as evidenced by increasing median loan-to-value at origination values (relaxed lending requirements taking the form of lower down payments), property values appreciated at unprecedented rates and everyone, from the first-time home buyer to the investment banker, was ecstatic. With time, charts of property values across the United States began to resemble the exponential growth curves of Tulip bulb prices in Holland during the infamous Tulip Mania of the 1600s. The former Chairman and CEO of Citi Group summarized the rapidly accelerating housing prices succinctly: "When the music stops in terms of liquidity, things will get complicated. But as long as the music is playing, you've got to get up and dance. We're still dancing" [Nakamoto and Wighton, 2007]. Unbeknownst to the chairman, the music had already slowed and was soon to cease. In the first quarter of 2006 property values in the United States reached their zenith, and a mere 36 months later property values across the nation had depreciated by a third, with some economists contending that prices still had a long way to fall.

With approximately eighty percent of all consumer debt outstanding in the United States held in home mortgage notes, any type of inefficiency or instability in mortgage loan markets can easily manifest itself in deleterious effects on the macroeconomic health of the United States as well as global financial markets. The worldwide financial crisis of 2007 is proof of the significant influence toxicity in American mortgage markets can have on the globe's developed economies. Therefore, isolating contributing factors to mortgage market instability constitutes an invaluable pursuit that may provide insight into prospective policy solutions aimed at preventing future disasters in the United States housing market.

The aftermath of the 2007 financial crisis invited commentary from a wide array of critics, ranging from media pundits to housing economists, who quickly made subprime lending the household culprit and favorite harbinger of the financial meltdown. This study critically addresses two salient questions: (1) Did default rates respond disproportionally to decreases in home values during the 2007 subprime crisis, indicating instability and overly aggressive financial leverage by homeowners in the mortgage market, and (2) what underlying characteristics of the United States mortgage lending industry can be discerned as contributing factors to mortgage market

instability? Instability in mortgage markets can be gauged by constructing delinquency-price elasticities and calculating volatilities for different measures of default. A delinquency-price elasticity reflects the degree of responsiveness between default rates and changes in home prices, which can be an indicator of toxicity in the market. This paper hypothesizes that homeowner equity is a contributing factor in default responsiveness to depreciating home values, as negative equity can distort homeowner incentives to honor debt obligations. In essence, low aggregate homeowner equity in the national housing stock represents a scenario in which the homeowner is financially overleveraged, exposing the mortgage and housing markets to high levels of default and consequently systemic macroeconomic risk.

The first section of this study highlights the relevant literature and summarizes existing theory conventionally relied upon to estimate default probabilities. We explain the option-theoretic default model to provide a clear understanding of the mechanics at work in homeowner default decisions. The second section of this paper outlines the methodology of this study, while the third section reviews the results and analysis.

## REVIEW OF THE LITERATURE

Before progress was made on fine-tuning modern option-theoretic default models, housing economists and mortgage originators relied on what is now called the frictionless model of default. These default models were in many cases almost identical to the renowned option pricing equation devised by Fisher Black and Myron Scholes [1973]. The Black-Scholes (BS) equation prices a derivative contract contingent on changing prices in the underlying asset. As mortgage notes exhibit similar characteristics to call and put options used in financial markets, housing economists used the BS model to price mortgage contracts and hypothesized that default probabilities would be conditional on the relationship between the mortgage contract price and the underlying asset (in this case the collateralized real estate). It was believed that a homeowner would default instantaneously whenever the value of the mortgage contract exceeded the value of the home. In such a scenario the homeowner would in effect put the mortgage loan back to the bank by "selling" the home in exchange for the extinguishment of the homeowner's mortgage loan liability. Similarly, a homeowner could prepay the loan at any time during the loan's term and exercise the mortgage as a call option effectively buying the mortgage loan from the lender. This unflinching and dogmatic application of the BS model to estimate default resulted in large error terms and was deemed inadequate to model mortgage loan default probabilities. Dunn and McConnell [1981] as well as Cunningham and Hendershott [1984] explore mortgage and mortgage insurance pricing, relying on contingent claims pricing as pioneered by Black and Scholes.

The foundations for the modern option-theoretic default models used by mortgage originators were laid by Foster and Van Order in 1984. Although the product of Foster and Van Order's research, as well as the default models used in present day studies, still relies on the theoretical underpinnings of the BS equation, these modified models provide a much more reliable estimation of mortgage default. Improvements to the model's predictive ability were made through the inclusion of transaction costs and other considerations unique to mortgage contracts, such as homeowner illiquidity, credit constraints, and homeowner and real estate heterogeneity. Vandell [1995] further develops the frictionless contingent claims models used to price mortgages by accounting for borrower liquidity and lender forbearance strategies. Phillips et al. [1996] concentrate on a variety of other factors unique to mortgage contracts that the traditional contingent claims model does not account for, such as household incomes and mortgage loan term structures.

More recent research has honed in on the significance of negative equity in housing markets, which theoretically provides financial incentive for the homeowner to default on the mortgage loan, relocate to a similar home, and assume a new mortgage loan obligation. Elul [2006] recognizes the important interplay between loan-to value (LTV) ratios on mortgage loans and precipitous drops in real estate values. LTV ratios (calculated by dividing the balance of the outstanding mortgage loan by the value of the home) measure the homeowner's equity stake in the home. Elul notes the dramatic effects home price decreases can have on loan vintages with high LTV ratios, as well as the nonlinear relationship the LTV ratio shares with default probabilities. According to Elul, higher LTV ratios result in disproportionally higher default probabilities for the mortgage loan, suggesting that homeowners will experience a "pain point" beyond the negative equity threshold (a LTV ratio above 1.00) at which default becomes instantaneous.

Foote, Gerardi, and Willen [2008] conduct research on the implications of negative equity in mortgage markets by constructing hazard functions to analyze the effect negative equity may have on overall default rates in the state of Massachusetts. By estimating a duration model for different levels of homeowner equity, the authors conclude that the relationship between LTV and default probability is highly nonlinear, and the default probability of a loan increases rapidly after the LTV ratio of the mortgage note increases past 80 percent. The author's findings indicate that a loan with a LTV ratio of 1.00 is 3.5 more likely to default than a loan with a LTV ratio of .75.

This literature review summarizes the relevant literature on the default and prepayment behavior of mortgage loan contracts, briefly reviewing the maturation of the haphazard application of the BS equation to the now conventionally used adjusted option-theoretic pricing model. This study endeavors to supplement the literature by exploring how default probabilities have behaved in the past in response to changes in home values at the aggregate level. If national default rates respond disproportionally during times of heightened aggregate LTV ratios, then an aggregate LTV statistic can be applied to judge the risk and vulnerability in national mortgage markets.

## METHODOLOGY

To analyze the responsiveness of default rates to home prices, the current study constructs default-price elasticities for each fiscal quarter since 1987. The elasticities are defined as:

$$\frac{\%\Delta\, Default\ Rate}{\%\Delta\, HPI} \qquad [1]$$

Here, the *Default Rate* consists of seriously delinquent and past due rates obtained from the Mortgage Bankers Association, and the home price index (*HPI*) is the national Case-Shiller HPI calculated from a composite of twenty major U.S. metropolitan areas. Seriously delinquent rates are calculated by dividing the number of loans with payments 90 or more days in arrears by the total stock of mortgage loans outstanding at the national level. Past due rates are calculated in a similar fashion but gauge the proportion of loans with payments only 30 days or more past due. Default rate volatilities are obtained by calculating the four-quarter standard deviations in the seriously delinquent and past due rates.

To isolate influences on the responsiveness of aggregate default to changing national home prices, the seriously delinquent/price and past due/price elasticities are regressed using a logged ordinary least squares regression, which takes the general form:

$$Y = \beta_0 + \beta_1 X_{LTV} + \beta_2 X_{DSR} + \beta_3 X_{UNEMP} + \varepsilon \qquad [2]$$

The explanatory variables used in these regressions include an instrumental variable that proxies the aggregate national LTV ratio, because the LTV ratio is the loan characteristic hypothesized by this study to influence mortgage market instability. The aggregate LTV variable is created by dividing outstanding mortgage debt as reported by the Federal Reserve Bank of New York by the overall value of residential homes in the United States obtained from the Lincoln Institute of Land Policy. Figure 1 depicts the trend of this study's constructed national LTV ratio since 1979. Other control variables include the national unemployment rate (obtained from the Bureau of Labor Statistics) as well as a debt-service-ratio (DSR) obtained from the Federal Reserve System of the United States. Unemployment is considered by the literature to be a significant exogenous shock to homeowners that increases default probabilities and is therefore used as a control variable. The debt-service-ratio (the ratio of disposable income allocated to servicing debt allocations for households across the United States) is used to control for homeowner credit constriction, as homeowner illiquidity is another exogenous shock indicated by the literature to have significant positive effects on default probability [Elul, 2006]. Similar logged ordinary least squares regressions are run to discern correlations between the aggregate LTV ratio and the volatilities in both home prices as well as delinquency rates. The results and analysis appear in the following section.

## RESULTS AND ANALYSIS

The resultant default-price elasticities revealed interesting observations regarding the responsiveness of default rates to home price changes during the subprime crisis. Figure 2 shows a bar graph of the seriously delinquent/price elasticities by quarter since 1987 and indicates that elasticities were not dramatically larger during the subprime crisis than they had been at any point in time in the past three decades. Out of the twenty highest elasticities observed over the time period, nine occurred during the 1990s, prior to the subprime crisis. The mean elasticity recorded during the subprime crisis (calculated from the second fiscal quarter of 2006 to the end of 2011) is 4.74, which is insignificant with a population mean and standard deviation of 3.36 and 3.137, respectively.

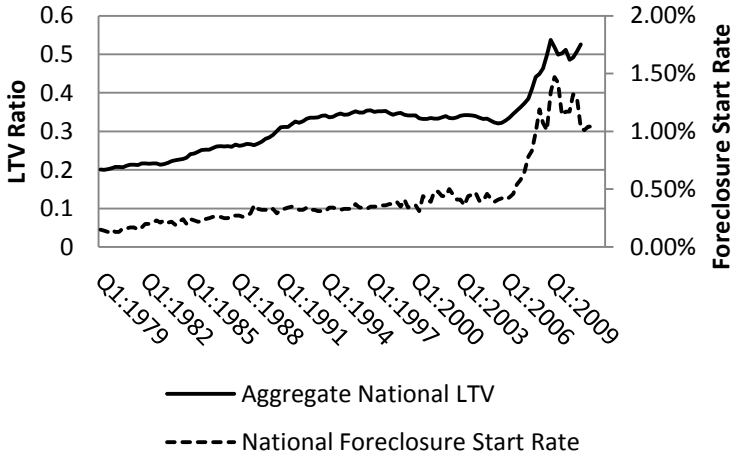


**Figure 1**
**Aggregate LTV in American Housing Market from 1979 – 2011**

Source: "Land and Property Values in the U.S." available from http://www.lincolninst.edu/subcenters/land-values/price-and-quantity.asp ,"Standard & Poor's Case-Shiller Home Prices Indices," available from http://www.standardandpoors.com/indices/sp-case-shiller-home-price-indices/en/us/?indexId=spusa-cashpidff--p-us---- and "Mortgage Bankers Association National Delinquency Survey." available from http://www.mbaa.org/ResearchandForecasts/ProductsandSurveys/NationalDelinquencySurvey.htm; see Morris A. Davis and Michael G. Palumbo, "The Price of Residential Land in Large US Cities," *Journal of Urban Economics*, Vol. 63 (1), 2007: 352-84.

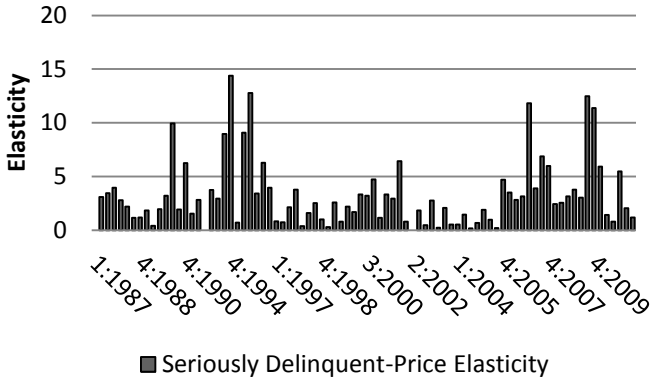


**Figure 2**
**Seriously Delinquent-Price Elasticity since 1987 Q1**

Source: "Mortgage Bankers Association National Delinquency Survey." available from http://www.mbaa.org/ResearchandForecasts/ProductsandSurveys/NationalDelinquencySurvey.htm and "Standard & Poor's Case-Shiller Home Prices Indices," available from http://www.standardandpoors.com/indices/sp-case-shiller-home-price-indices/en/us/?indexId=spusa-cashpidff--p-us----; see Morris A. Davis and Michael G. Palumbo, "The Price of Residential Land in Large US Cities," *Journal of Urban Economics*, Vol. 63 (1), 2007: 352-84.

An even more telling observation can be garnered from parsing out time periods in which home values appreciated. As this study is concerned with instability in mortgage markets and such instability tends to emerge during times of depreciating asset prices, it is worthwhile to analyze only periods of home value down-turns and their respective elasticity. Figure 3 exhibits seriously delinquent-price elasticities since 1987, excluding all quarters in which the HPI advanced. It clearly displays two major downturns in the housing markets since 1987, one during the early 1990s and the other during the subprime crisis. Although the downturn of the 2007 subprime crisis was characterized by a prolonged period of home value depreciation, Figure 3 shows that the responsiveness of default rates to changes in home prices during the subprime crisis was proportional to that experienced during the housing price downturn of the early 1990s. The mean elasticity observed during the 1990s and the subprime crisis are nearly identical at 3.233 and 3.232, respectively. This observation suggests that the relaxed mortgage lending standards unique to the 2007 subprime crisis (mainly evidenced by a rising trend in the aggregate LTV ratio) might not have drastically affected the responsiveness of default to depreciating home prices. Of course the subprime crisis of 2007 was marked by extreme default and foreclosure rates that had never before been experienced in the United States, but these default rates were proportional to the equally detrimental and pronounced depreciation in home values.

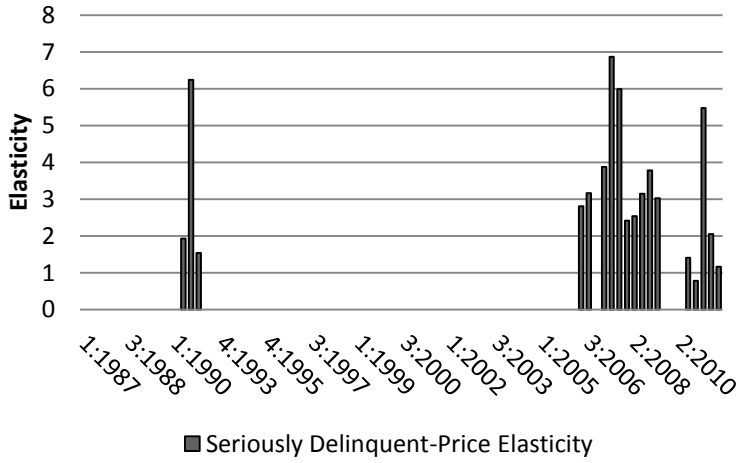


**Figure 3**
**Seriously Delinquent-Price Elasticities (Selected Time Periods)**

Source: "Mortgage Bankers Association National Delinquency Survey." available from http://www.mbaa.org/ResearchandForecasts/ProductsandSurveys/NationalDelinquencySurvey.htm and "Standard & Poor's Case-Shiller Home Prices Indices," available from http://www.standardand poors.com/indices/sp-case-shiller-home-price-indices/en/us/?indexId=spusa-cashpidff--p-us----; see Morris A. Davis and Michael G. Palumbo, "The Price of Residential Land in Large US Cities," *Journal of Urban Economics*, Vol. 63 (1), 2007: 352-84.

The proportionality of sensitivity spikes experienced during the subprime crisis to those experienced during the 1990s suggests that high aggregate LTV might not have been a substantial contributor of unprecedented rates of default and that homeowners were nowhere near the theoretical "pain point" the literature espouses for instantaneous default. Were the true aggregate LTV ratio near 1.00 or near the pain point, the large decreases in home prices would have provided substantial incentive for homeowners to default en masse, resulting in disproportionate default rates to decreases in the HPI. That the elasticities observed during the subprime crisis were similar to those experienced during the 1990s suggests that the U.S. housing stock exhibited an adequate margin of safety between housing value and outstanding mortgage debt; default rates did not respond acutely to changes in home values. Although the subprime crisis decimated the American economy, default rates responded proportionally and predictably to decreases in national home prices.

Regressions run to discern if the aggregate LTV correlated with default-price elasticities since 1987 provided inconclusive results. No statistically significant correlation was found between aggregate LTV and either the seriously delinquent/price or past due/price elasticity. However, the aggregate LTV variable did prove to be highly correlated with volatilities in the seriously delinquent rate, the past due rate, the foreclosure start rate, and the

Case-Shiller HPI. Results are given in Table 1. As the table suggests, a one percent increase in the aggregate LTV ratio was associated with an increase in the volatility in the foreclosure rate of three percent. Thus, the results using volatilities as gauges of instability provided evidence that higher aggregate LTV ratios did correlate strongly with increased volatility in both default rates and home prices.

**Table 1**
**OLS Regression Results for Various Default and HPI Volatilities**

| Explanatory Variable | Foreclosure Start Rate Volatility | Seriously Delinquent Volatility | Past Due Volatility | HPI Volatility |
|---|---|---|---|---|
| Aggregate LTV | 3.24* (6.09) | 3.20* (6.55) | 1.80* (3.78) | 1.57* (3.44) |
| Unemployment | -0.18 (-0.49) | 0.27 (0.80) | -0.04 (-0.12) | -1.19* (-3.45 |
| Debt Service Ratio | 6.07* (5.09) | 6.39* (6.39) | 2.94* (2.96) | 8.977* (9.22) |
| Constant | 7.28 (2.75) | 10.53 (4.41) | 1.37 (0.55) | 17.50 (7.63) |

* Significant at the 99 % confidence level, t-scores given in parentheses, log-log regression.

One major constraint of this study is the limited population size from which inferences were drawn. The Case-Shiller HPI is available back to 1987, and the HPI published by the Federal Housing Authority only has housing price data back to 1991. This data limitation is of grave consequence to inferences drawn about time periods in which the HPI decreased, given that the data analyzed only contained two discernible downturns in housing prices, one of which was the subprime crisis. Therefore, the elasticities experienced during the subprime crisis were only compared to one control time period during the 1990s. A reliable HPI prior to 1987 potentially would have included more downturn periods against which to compare default responsiveness during the subprime crisis. Also, including default statistics from 20 metropolitan areas simultaneously may have concealed potential correlations between default-price elasticity and aggregate LTV, as Midwestern states experienced substantially different default rates than did states on both the Eastern and Western Seaboard.

Finally, the inferences outlined in this paper could be substantiated by similar research conducted at the individual state level. Although the evidence provided by this study suggests that the national LTV was not close to levels that are predicted to result in high default probabilities by option-theoretic pricing models, the dynamic between outstanding mortgage debt and the market value of the housing stock might be significantly different for varying geographies. It would be worthwhile to examine states particularly hard-hit by the subprime crisis and analyze whether or not default responsiveness was higher in these states and if the state-level LTV suggests a local housing market that was insolvent.

## CONCLUSION

The subprime crisis of 2007 and ensuing global recession served as a grave reminder of the frailty of modern financial markets. Many commentators were quick to point to relaxed lending standards and a shift in mortgage lending to extend credit to subprime borrowers as scapegoats for the crisis. Option-theoretic default modeling corroborates these assertions and predicts that deteriorating LTVs at origination and shrinking homeowner equity would result in more acute responses in default rates to negative changes in home prices. The findings in this study contradict the postulation that subprime lending led to increased responsiveness of default, as default-price elasticities during the crisis were observed to have been just as steep as in a prior housing downturn experienced during the 1990s during which subprime lending and rising aggregate LTV ratios were not as prevalent. This observation implies that, although evidence exists indicating an inflationary price bubble in U.S. real estate prior to the subprime crisis, default rates did not behave erratically or disproportionably to falling housing values. However, the strong correlations observed when estimating volatilities of default, foreclosure, and HPI volatilities did provide some evidence that increasing aggregate LTV ratios may contribute to increased capriciousness and uncertainty in mortgage markets. As the housing market plays an instrumental role in the overall health of the U.S. economy, such weaknesses in the mortgage market should not remain unaddressed. Conducting aggregations of the LTV ratio at more detailed geographic levels such as at the city, county, or state level could provide an early indication of housing markets that are becoming overleveraged and face increased risk of insolvency. Such an indicator would be of tremendous assistance in determining the stability and health of mortgage and housing markets across the United States.

 

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**NOTES**

 