Neighborhood Subprime Lending and the Performance of Community Reinvestment Mortgages

Authors

Lei Ding, Roberto G. Quercia, and Janneke Ratcliffe

Abstract

This study analyzes the spillover effect of the spatial concentration of subprime lending on the performance of recently originated community reinvestment mortgages targeting low- to moderate-income borrowers. The level of subprime lending in a census tract is found to be a significant predictor of the default and prepayment probability of the community reinvestment loans in the same neighborhoods. The results suggest that the concentration of subprime lending and the resulting clusters of foreclosed properties reduce neighborhood property values and increase price volatility. The lowered property values and the increased volatility increase the default probability of borrowers holding any loan product, including community reinvestment mortgages. This study provides new evidence concerning the negative impacts of the concentration of subprime lending in certain neighborhoods.

There have been an unprecedented number of defaults by subprime mortgages, with even more subprime foreclosures likely.[1] However, the issues around how to keep borrowers in their homes affect all market segments, not just subprime loans. One major concern is the spillover effect from the subprime crisis where the subprime foreclosures are usually concentrated in certain markets and neighborhoods (Calem, Gillen, and Wachter, 2004). Because of the concentration of subprime mortgage loans in certain areas, there is a potential for negative externalities from the subprime lending because of the reduced access to prime lending, concentration of foreclosures, and the resulting reduced property values. In fact, the performance of other mortgage products, such as FHA loans and some prime loan products, has become worse, as indicated by recent evidence of sharp increases in delinquencies and foreclosures.[2] What caused the defaults of other mortgage products, especially the Community Reinvestment Act (CRA) loans serving low- and moderate-income (LMI) borrowers during the housing crisis? In particular, what is the spillover effect of the meltdown of the subprime market on the default risk of CRA-type loan products, especially considering the concentration of subprime loans in particular places?

Research has identified that subprime loans typically have higher delinquency and default rates (Gerardi, Shapiro, and Willen, 2007). Immergluck (2008) indicates that subprime loans foreclose at rates 10 to 20 times the rate of prime loans, when different measures of foreclosures and different definitions of subprime loans are used. Research has also documented some evidence of the negative effects of foreclosures on property values, the community, the municipal government, and the local economy (Apgar, Duda, and Gorey, 2005; Pennington-Cross and Ho, 2006a; Immergluck and Smith, 2006; Shlay and Whitman, 2006; Lin, Rosenblatt, and Yao, 2008). However, the interplay between the concentration of subprime lending and the performance of other loan products in a neighborhood has received little attention. Only a few studies have investigated the impact of certain neighborhood characteristics on the performance of residential mortgages, but the impact of subprime lending in a neighborhood has not been considered (e.g., Cotterman, 2001). This is in part because subprime lending has grown significantly only since the early 2000s and the meltdown of the subprime market happened very recently.

To fill the gap in the literature, this study focuses on the relationship between the concentration of subprime lending and the performance of a sample of CRA-type mortgages serving low- and moderate-income borrowers in the same neighborhoods. Instead of using data at the aggregate level, this study uses micro-data to analyze how subprime lending impacts the performance of a sample of CRA-type mortgage within the same neighborhood. The particular dataset comes from the Community Advantage Program (CAP) developed by a nonprofit community development financial institution, Self-Help Ventures Fund (Self-Help), in partnership with a group of lenders, Fannie Mae, and the Ford Foundation (Ding, Quercia, and Ratcliffe, 2008). Though borrowers in this program usually have greater credit risk than traditional prime borrowers, the vast majority of loans originated under this program features terms associated with the prime market: 30-year fixed-rate amortizing loans with prime-level interest rates, no prepayment penalties, no balloons, escrows for taxes and insurance, documented income, and standard prime-level fees. CAP borrowers are LMI homebuyers, with high shares of minority households, households headed by single females, and first-time homebuyers. This program reflects a number of affordable lending programs stimulated by CRA, which target LMI and minority borrowers across the country.

This study examined a sample of CAP loans originated from 2001 to 2006 for their performance during the January 2004 through March 2008 period. The findings reveal that the level of subprime activities, measured by the share of subprime originations in a census tract, is a significant predictor of the performance of this sample of CRA-type loans. A higher level of subprime lending in a neighborhood increases the probability of delinquency and default for borrowers holding affordable mortgages in the same neighborhoods. Other things equal, the predicted conditional probability of default for an affordable loan in a tract with a high level of subprime lending (assumed 50% in 2005) would be over

34% higher than that for a loan with similar characteristics but in a tract with the national average level of subprime activities. There is also some evidence that the prepayment probability would be lower for borrowers living in neighborhoods with a higher level of subprime refinance lending. A two-stage probit least squares (2SPLS) analysis shows that a higher level of subprime activities causes a decline in neighborhood property values and increases the price volatility. Because of the declined property value, the default risk of CAP loans in the same neighborhoods increases significantly. Overall, this study provides new evidence concerning the negative impacts of the concentration of subprime lending in certain neighborhoods, and offers some insight into the possible mechanisms through which the concentration of subprime lending impacts the default risk of other loan products.

The next section reviews recent literature on residential mortgage default studies, especially the default risk of prime and subprime borrowers and the spillover effect of foreclosures on the neighborhood and community. The third section describes data and methodology. Empirical results are given in the fourth section, followed by conclusions.

Literature Review

Mortgage Borrowers' Behavior

There has been extensive literature on residential mortgage foreclosure since the 1960s. Borrowers' options usually include the choices of losing the home (*foreclosure*, or *put option*), paying off the mortgage (*prepayment*, or *call option*), and remaining active (Deng, Quigley, and Van Order, 2000). The main driver of whether the borrower exercises the put option is negative equity in the property, but usually a trigger, such as a sudden drop or loss of income or increase in expenses, is also required (Vandell, 1995). If there is sufficient equity in the home, a trigger event is usually insufficient to cause default severe enough to lead to foreclosure, because borrowers can simply sell the property or refinance it when they experience negative trigger events. In addition, some environmental factors, such as local economic conditions and changes in underwriting standards, also influence borrowers' decision to default (Cutts and Merrill, 2008). A downturn in the local economy will slow home sales, depress prices, and increase unemployment, thus increasing the default risk relative to stronger economic conditions.

Default Risk of Subprime Mortgages

In general, research has documented that subprime loans typically have higher delinquency and default rates than prime loans and government-insured products (Gerardi, Shapiro, and Willen, 2007). As summarized by Immergluck (2008),

subprime loans of all types generally foreclose at rates over 10 times that of prime loans. The high default rate reflects the high-risk characteristics of subprime borrowers, such as impaired borrower credit scores, lower levels of household income and assets,[3] or other attributes that increase the credit risk to lenders. More important, some features and loan terms prevalent in subprime products are associated with higher default risk. For example, loans with prepayment penalties and balloon payments, which are common among subprime products, are found to have higher default risk (Danis and Pennington-Cross, 2005; Quercia, Stegman, and Davis, 2007). Another feature common among subprime loans but not so among prime loans is the adjustable rate mortgage (ARM), which periodically adjusts the interest rate on the note based on a variety of indices. There is some evidence that subprime ARMs have a higher risk of foreclosure likely because of the interest-rate risk they carry (Calhoun and Deng, 2002). At the aggregate level, the share of ARMs appears to be positively associated with market risk as measured by the probability of a property declining within two years (Immergluck, 2008). Hybrid ARMs, which have fixed rates for the first few years before the mortgage converts to annual ARMs and usually also carry a prepayment penalty, have been found to bear a particularly high risk of default when the interest rate resets (Ambrose, LaCour-Little, and Huszar, 2005; Pennington-Cross and Ho, 2006b). A recent paper provides evidence that much of the poor performance of subprime loans can be attributed to mortgage types not borrower types (Ding, Quercia, Li, and Ratcliffe, 2008).

Foreclosure studies at the market or neighborhood level have also found a strong association between foreclosure and subprime lending shares. In their analysis of tract-level foreclosure levels in Chicago, Immergluck and Smith (2004) find that the best predictor of future foreclosure levels was the number of subprime loans originated over the previous five years. Mian and Sufi (2008) show that places with high mortgage rejection rates in the mid-1990s had higher than average price increases in the first half of this decade because the development of the nonprime[4] sector enabled those who were previously shut out of the housing market to purchase a home. This suggests that the rapid development of nonprime loans because of looser underwriting was an important factor in the price bubble and the subsequent high foreclosure rate. Immergluck (2008) indicates that recent changes in mortgage markets have resulted in spatially concentrated patterns of foreclosures, particularly in neighborhoods where high-risk products—subprime mortgages, exotic mortgages (such as interest-only, payment-option loans, negative amortization loans, piggy-back loans, and Alt-A loans), and zero-down-payment mortgages—are more prevalent.

However, until very recently, subprime loans were a much smaller part of the overall market and consequently their influence on overall loan performance was negligible. For many years, the subprime sector focused on serving credit-blemished borrowers in need of refinancing and was a minor part of the overall mortgage market. When subprime loans first hit a peak in serious delinquency rates in 2003, they constituted only 4% of the outstanding loans (Cutts and Merrill,

2008). The sizable activity in subprime lending in more recent years should have a greater influence in the mortgage market. The volume of subprime lending peaked in 2005, representing about 20% of the dollars of all new loans originated that year. In 2007, however, the subprime market dropped sharply, to less than 8% of all loan dollars (Inside Mortgage Finance, 2008). As of the fourth quarter of 2007, subprime loans constituted about one eighth of all outstanding loans but 54% of the foreclosures started that quarter (Mortgage Bankers Association, 2008).

Spillover Effects of Foreclosures on Neighborhood Property Values

While the causal relationship between home prices and foreclosures may be two-directional, there is strong evidence of the negative effects of foreclosures on property values. Forgey, Rutherford, and VanBuskirk (1994) and Hardin and Wolverton (1996) find that foreclosures are usually sold at a discount of price (about 23%) because of moral risk, deteriorated housing conditions, and other negative features associated with foreclosure. Similarly, Pennington-Cross and Ho (2006a) find that foreclosed property appreciates on average 22% less than the area average appreciation rate.

Foreclosures, particularly in lower-income neighborhoods, may lead to lower property values because of abandoned foreclosed properties and the resulting physical disorder and even crime in the community. One related study, focusing on the impact of delinquency on property values by Simons, Quercia, and Maric (1998), suggests that average sales prices of a given residence fell by $788 per 1% increase in tax delinquencies within a one-to-two block area of a residence. Immergluck and Smith (2006) find that foreclosures of conventional single-family (one- to four-unit) loans have a significant impact on nearby property values. They estimate that each conventional foreclosure within an eighth of a mile of a single-family home results in a decline of 0.9% in property value, and may be as high as 1.5% in low- to moderate-income communities. Shlay and Whitman's (2006) study on housing values in Philadelphia finds that an abandoned property lowered values on homes within a 150-foot radius by an average of 10% and lowered values on homes within a 450-foot radius by an average of 5%. A recent study based on a 2006 sample in Chicago shows that one foreclosure may lower the value of neighboring properties by as much as 8.7% and that the negative spillover effect on neighboring properties is significant within 0.9 km (about 10 blocks) of the property and within five years from the liquidation (Lin, Rosenblatt, and Yao, 2009).

In many markets, large numbers of foreclosed properties or properties in the foreclosure process depress the price of all homes and increase the time it takes to dispose of any one property. As of late 2007, in some parts of California, nearly 50% of home sales were foreclosed houses, and the share of foreclosed properties in Nevada, Colorado, Tennessee, and Michigan ranged from 9.3% in Tennessee

to 17.5% in Nevada (Zibel, 2008). Faced with the high costs of holding properties, sellers of foreclosed homes are cutting prices rather than holding their property for any extended time. As more foreclosed homes go on sale at prices usually lower than market values, both the competition and the sale time increases for all sellers.

Broader Spillover Effect from Concentrated Foreclosures

The concentration of foreclosures imposes significant costs not only on individual borrowers and properties, but also on communities, municipal governments, and the local economy. Based on operational data from local agencies that handled foreclosures, an early study by Moreno (1995) estimates that a foreclosure, on average, costs the study city $27,000 and the neighborhood $10,000. Apgar, Duda, and Gorey (2005, p. 2) find within one single block in the Auburn/Gresham neighborhood of Chicago that ''accounting for both the foreclosure costs paid for by City and County agencies, and the impact of foreclosure on area property values, a foreclosure on this block could impose direct costs on local government agencies totaling more than $34,000 and indirect effects on nearby property owners (in the form of reduced property values and home equity) of as much as an additional $220,000.''

Ultimately, the spillover effects of concentrated foreclosures will likely impact the economic and social wellbeing of a community, as rising foreclosures and falling house prices can easily squelch economic activities. The possible consequences may include lower consumption and production, increased unemployment, and ultimately recession, and may eventually influence the behavior of borrowers holding outstanding mortgages. As a result, the economic conditions of neighboring homeowners may also be negatively impacted, which could adversely affect their ability to make mortgage payments—another possible impact of the concentration of subprime lending on the performance of other loan products.

In addition, the concentration of subprime lending in certain neighborhoods reflects the lack of access to prime lending in these neighborhoods. Borrowers in riskier markets dominated by subprime lenders undoubtedly would find it difficult to refinance existing mortgages through the prime market. Immergluck and Wiles (1999) provide evidence that the failure of prime lenders to seek out credit-worthy borrowers in lower-income and minority communities leaves those communities vulnerable to subprime lenders.

Overall, the literature review confirms that subprime loans generally carry higher default risk and that the proportion of subprime lending in an area is the best predictor of future foreclosure levels. A concentration of subprime lending would result in more foreclosures in certain neighborhoods, which very likely leads to reduced values of neighboring properties. If the current value of their property falls below their outstanding loan balance (i.e., their home equity is zero or less), mortgagors are much more likely to default on their loans, no matter what kind

of mortgage products they hold. So the literature suggests that a concentration of subprime loans in a neighborhood greatly impacts the overall performance of all outstanding mortgages. This study links the level of subprime lending to the performance of a sample of CRA-type loans.

Data and Methodology

Data

Data for this study comes primarily from a subset of home purchase loans originated by a group of lenders under the Self-Help Ventures Fund's Community Advantage Program (CAP). Stimulated by the Community Reinvestment Act, CAP loans were originated under lender-crafted affordable mortgage programs. These programs feature customized loan guidelines tailored to meet lenders' CRA goals, as well as local market needs. Many of these loans are held in lenders' portfolios because most of them meet neither the underwriting guidelines used by secondary mortgage market institutions nor the underwriting guidelines for FHA loans. However, under the CAP program, participating lenders are able to sell these nonconforming mortgages to Self-Help, which then securitizes and sells them to Fannie Mae or other investors. Participating lenders originate and service the loans under contract with Self-Help. It should be emphasized that, while many of the borrowers are somewhat credit impaired, the program cannot be characterized as subprime. The CAP portfolio, which is made up of retail (i.e., not broker) originations, features loans with prime terms and conditions, such as no prepayment penalties and no balloons.

A subset of 17,080 CAP loans originated from 2001 to 2006 was used in this analysis (Exhibit 1). Loans that had a delinquency or were terminated (either foreclosed or prepaid) before 2004 were dropped from the sample. In other words, for loans originated before 2004, only those that were still active and had not experienced a delinquency before 2004 were included in the sample. All the loans in this sample are home purchase loans with fixed interest rates, without prepayment penalties or balloons; over 98% of them have a 30-year amortization period. Loans in this sample are characterized by high original loan-to-value (LTV) ratios: over 79% of loans have an original LTV of 95% or higher, and with over 73% at 97% LTV or higher. This sample of borrowers also has relatively low credit scores (average score of 680) and low household income (mean household income at origination of about $35,700). The mean back-end ratio—that portion of a person's monthly income that goes toward debt—was 36%. About 39% of borrowers are minorities, including are African Americans (14.4%) and Hispanics (14.7%). National in scope, this sample of 17,080 CAP loans were originated in 44 states and 8,108 census tracts (Exhibit 2). As Exhibit 2 shows, most tracts (62%) have only one CAP loan; less than 9% of tracts have five or more CAP loans. Because the number of CAP loans in each tract is very small,

Exhibit 1 | Descriptive Statistics of Origination Information for CAP Loans

Variable	Percent	Mean
Credit Score		
No Credit Score or missing	3.6%	
CScore < 620	11.9%	
CScore 620–659	21.1%	
CScore 660–719	32.3%	
CScore ≥720		
Credit Score		679.8
Loan Characteristics		
LTV		94.4%
Backend Ratio		36.3%
Frontend Ratio		27.7%
Origination Amount		$96,808
Note Rate		6.70%
Borrower Characteristics		
Female Borrower	40.4%	
Minority Borrower	39.5%	
African-American Borrower	14.4%	
Hispanic Borrower	14.7%	
Income at Origination		$34,589
Neighborhood Characteristics		
Tract MI <80% AMI	30.0%	
Tract MI 80–100% AMI	30.2%	
Tract MI 100–120% AMI	22.9%	
Tract MI ≥120% AMI	16.9%	
<10% Black	56.9%	
10–15% Black	9.2%	
15–30% Black	14.2%	
≥30% Black	19.7%	
Geography		
NC	15.9%	
OH	13.5%	
GA	10.4%	
OK	9.7%	
IL	7.2%	
CA	7.2%	
Other States	36.2%	
Origination Year (# of loans)		
2001	3,506	
2002	3,573	
2003	3,015	
2004	2,954	
2005	2,301	
2006	1,731	
Total	17,080	

Exhibit 1 | (continued)
Descriptive Statistics of Origination Information for CAP Loans

Note: Originated between January 1, 2001, and December 31, 2006. Loans that had experienced delinquency or terminated before January 2004 were not included; a few loans with adjusted rates and a number of other loans with missing data were dropped.

Exhibit 2 | Number of Loans in Census Tract

Number of Loans	Frequency	Percent
1	5,015	61.9%
2	1,439	17.8%
3	631	7.8%
4	327	4.0%
≥5	696	8.6%
Total	8,108	100.0%

Note: The total number of loans is 17,080.

it is safe to assume the performance of CAP loans will not significantly impact the neighborhood.

This study focuses on the impact of subprime activities in recent years and the study period is from January 2004 to March 2008. It is generally accepted that recent subprime vintages are riskier than earlier ones: subprime loans that originated in 2005 and 2006, especially subprime ARMs, have performed the worst because of a relaxed underwriting criteria to credit score, lax documentation and verification of income, higher combined loan-to-value ratios, and the popularity of risky loan terms (Bernanke, 2008). So a concentration of 2005–2006 subprime originations would seem to have greater negative externalities. In addition, beginning in late 2006, economic conditions significantly worsened, with a sharp deceleration—and outright decline in some markets—of house prices, rising interest rates, and in more recent years a weakening economy. All these factors impacted the underwriting and performance of different mortgage products.

Further, sizable subprime lending activities after 2004 at the neighborhood level allow a meaningful analysis. After being a minor part of the overall mortgage

market for many years, the subprime share of all mortgage originations by volume peaked in 2005. That year subprime loans made up over 20% of the dollars of all mortgages originated (Inside Mortgage Finance, 2008). While the subprime share of refinance loans decreased and flowed with interest rate fluctuations, the subprime share of purchase loans grew steadily through 2006 (Immergluck, 2008). The level of subprime lending in 2005–2006 is hypothesized to have greater impact on communities because of its relatively larger market share.

HMDA data were used to construct different measures of subprime lending at the census tract level, including the share of subprime purchase loans and the share of subprime refinance loans in census tracts. The term *subprime* in this analysis refers to those rate-reported ''higher-price'' loans in HMDA. Subprime purchase and refinance loans have different risk characteristics and this study tests the possible differences empirically. Because changes in the shape of the yield curve can affect the proportion of loans reported as higher priced in a given year, different measures based on both 2005 and 2006 HMDA data were examined.

As suggested in Mian and Sufi (2008), the subprime share may pick up the loose underwriting in certain neighborhoods if the impact of recent subprime originations on the performance of CAP loans originated in the same period is examined. To test the robustness of the results, the sample was divided into two cohorts, with one focusing on 2001–2003 originations and the other on 2004–2006 originations. Using two cohorts supports the analysis of whether neighborhood subprime lending impacts only loans originated in the softening market or those seasoned loans as well.

Methodology

Payment history data are used to identify when a loan was delinquent, foreclosed, or prepaid. This study follows the option theory, and views mortgage borrowers as having three options in each month:

- **Default**: Different measures of default (90-day delinquency or foreclosure/returned loans[5]) are used in different models.
- **Prepaid**: If a loan was prepaid before it defaults, it is considered a prepayment.
- **Active**: Active and not default (not seriously delinquent in some models).

A multinomial logit (MNL) is used to model outcomes with multiple possible states. In each month the loan can be in only one state or outcome (active, delinquent, or prepaid). Since the sum of the probabilities of each outcome must equal one, the increase in the probability of one outcome necessitates a decrease in the probability of at least one competing outcome. Thus the multinomial logit model is a competing risk model. The probability of observing a particular loan outcome is given by:

$$\Pr(y_{it} = j) = \frac{e^{\beta_j Z_{it} + \gamma_j S_{it}}}{1 + \sum_{k=1}^{2} e^{\beta_k Z_{it} + \gamma_k S_{it}}} \quad for\ j = 1,2$$

$$\Pr(y_{it} = j) = \frac{1}{1 + \sum_{k=1}^{2} e^{\beta_k Z_{it} + \gamma_k S_{it}}} \quad for\ j = 0 \qquad (1)$$

$$\ln L = \sum_{t=1}^{T} \sum_{i=1}^{N} \sum_{j=0}^{2} d_{ijt} \ln(\Pr(y_{it} = j))$$

where $j = 0,1,2$ represents the three possible outcomes of a loan and the omitted category ($j = 0$) is remaining active and not delinquent (ACTIVE). d_{ijt} is an indicator variable taking on the value 1 if outcome j occurs to loan i at time t, and zero otherwise. Z contains a set of explanatory variables and β is the coefficient. S contains the measures of the level of subprime lending in the neighborhood. To control for the potential statistical problems associated with repeated events, the model is estimated using Stata's *mlogit* procedure with an adjustment to the standard errors for clustering by loan.

Many factors besides subprime lending influence the performance of residential mortgages. Based on the literature, following variables are controlled in the MNL model (Exhibit 5 provides summary statistics):

- **Value of the Put Option** (*put*): According to the option-based theory, home equity plays a central role in determining the probability of foreclosure. The value of the put option of a loan for each month is calculated using the unpaid mortgage balance, and the estimated house price is calculated using the house price index (HPI) of the Office of Federal Housing Enterprise Oversight (OFHEO).[6] The value of the put option indicates the ratio of negative equity (unpaid balance minus estimated house price) to the original house price.
- **Value of the Call Option** (*call*): To determine whether the call option is ''in the money,'' the present discounted value of the current mortgage is compared with the present discounted value of a prevailing market-rate mortgage.[7] Falling interest rates will lead to faster prepayments and drive down delinquency rates as borrowers refinance their way out of potential problems. Rising interest rates cause payment shocks at the reset date for adjustable-rate mortgages and reduce the ability of borrowers to afford a fixed-rate refinance. Saving from refinancing is reported as a ratio, which indicates the fraction of saving by considering a refinancing mortgage with the prevailing market rate.
- **Credit History**: Borrower credit scores at origination are controlled, and lower FICO scores are assumed to be associated with higher credit risk.

- **Debt-to-Income Ratio** (DTI): DTI variables are controlled in the model, and higher DTIs are also assumed to be associated with higher credit risk.
- **Loan Size** (*lupb*): Loan size is measured by the amount of unpaid balance in the log.
- **Loan Age** (*loanage*): Since some early studies indicate that the relationship between loan age and default is not linear, this variable is measured by the log value of the number of months after origination.
- **Borrower Race**: As suggested in the literature, African-American borrowers may have higher default rates on conventional residential mortgages than other borrowers, so dummy variables are included to identify African-American borrowers and Hispanic borrowers.
- **Neighborhood Controls**: The following neighborhood controls are included to capture neighborhood demographic and economic characteristics include: the share of African Americans in a census tract and census tract median income relative to area median income. All the tract-level variables are from the 2000 Census and represent a single point-in-time snapshot of the tract.
- **Area Economic Indicators**: The monthly unemployment rates at the county level from the Bureau of Labor Statistics (BLS) are controlled.
- **Time Dummies**: Dummies of 2001, 2002, 2004, and 2005 originations are considered in different models

Causality Issue

The MNL model is able to test the association between neighborhood subprime lending and the performance of CAP loans. However, the actual transmission mechanisms through which subprime activities influence the CAP loan performance still need to be identified. Since subprime activities seem to influence the CAP loan performance indirectly, failure to address this problem will result in biased and inconsistent estimates. As suggested in the literature, the hypothesis in this study is that subprime lending negatively influences neighborhood property values: a higher level of subprime activities and the resulting high default rates will lead to deterioration in the property values of the neighborhood. Due to the declined property values, the delinquency and foreclosure risk of borrowers in these neighborhoods holding any type of mortgages, including CAP loans, will increase significantly. For simplicity, the study focuses on the default behavior of the sample of CAP loans originated during 2004–2006 in the period from origination to the first quarter of 2008 so there is a cross-sectional dataset.

To control for this endogenous relationship of neighborhood house price dynamics and CAP borrower default behavior, this study employs a simultaneous equations model with an endogenous continuous variable for neighborhood house price appreciation and a endogenous binary variable for CAP loan default ($y_1 = 1$ for

90+day delinquency or foreclosure after origination, 0 otherwise). The model is characterized by the structural equations:

$$y_1^* = \gamma_1 y_2 + \beta_{12} X_{12} + \beta_{11} X_{11} + u_1 \quad (2)$$

$$y_2 = \gamma_1 y_1 + \beta'_{12} X_{12} + \beta_{22} X_{22} + u_2 \quad (3)$$

Where y_1^* is the binary variable for CAP loan default, X_{12} is a vector of exogenous variables used in both equations, X_{11} and X_{22} are vectors of exogenous variables used exclusively in (2) and (3), respectively. y_2 represents neighborhood house price changes and two different measures are tried: the absolute change and the price volatility. The rational for the volatility variables is that consumers usually do not observe home value in static terms and recent movement (trends and volatility) matters as much as absolute changes. Borrower default is hypothesized as a function of neighborhood house price change and the neighborhood house price dynamics is a function of MSA house price change, neighborhood subprime activities, and local economic conditions. Of course, the CAP default behavior is hypothesized to further depress neighborhood house property values.

Both a continuous and a dichotomous variable are hypothesized to simultaneously determine each other and this can be estimated by the two-stage probit least squares (2SPLS), which has been discussed by Maddala (1983). The *cdsimeq* command in STATA was used to obtain consistent estimates for the coefficients, as well as their corrected standard errors (Keshk, 2003).

In the first stage of the analysis, the neighborhood housing price change is regressed on MSA house price change, neighborhood subprime activities, local economic conditions, and other explanatory variables in the model. It is assumed that area house price change, subprime activities, and other neighborhood controls are uncorrelated with unobserved determinants of the CAP loan default behavior and that these instruments only influence the troublesome neighborhood house price change, controlling for the other covariates.[8]

In the second stage of the analysis, the CAP loan default is regressed on the predicted value of neighborhood house price change, as well as other controls of individual borrower credit risk. The instruments, such as neighborhood subprime activities, are not included as regressors in the second stage, assuming they do not influence the default behavior directly.

It is difficult to observe the house price change at the neighborhood level. Fortunately, the neighborhood house price change can be proxied based on one quarterly data series that relate to the valuation of the CAP portfolio provided by Fannie Mae. The data comprises redrawn mark-to-market loan-to-value ratios (MTMs) and property values can also be derived from the MTMs by means of the last observed principal balance on each loan. The full series of data extend from the first quarter of 2003 to the second quarter of 2008. Though Fannie Mae

did not provide the details of the methodology, the MTM data has been used for evaluating acquisitions, internal risk modeling, and fair value computations by Fannie Mae. But the MTM property value data generally does not consider property-specific characteristics.[9] So although the MTM data are assumed to provide house price information for individual properties, housing price changes derived from the proprietary MTM data are assumed to be a better proxy of the neighborhood housing price dynamics than that based on other house price indexes. Unfortunately, the MTM data are not available for all CAP loans and 4,379 out of the 6,986 CAP loans originated during the 2004–2006 period are used in this analysis. The absolute change and volatility (standard deviation of house price changes) measures of neighborhood house price are constructed for each loan during the period of the first quarter of 2006 to the first quarter of 2008.

For the default model, except for the endogenous house price change variable, the important borrower and loan characteristics are controlled including borrower credit score, LTV ratios, DTI ratios, race, and loan size. For the neighborhood housing price change model, the level of subprime activities is measured by the share of home purchase/refinance subprime originations at the tract level. Differences in underlying economic conditions across local markets have important implications for both the level and changes of housing price. Local economic conditions are measured by county unemployment rates and yearly changes, as well as levels of per-capita income and its annual changes. The 2006 county unemployment data and the yearly changes in unemployment rate from 2004 through 2008 were collected from the Bureau of Labor Statistics. Levels of per-capita income in 2006 and yearly changes for 2005 and 2006 were taken from the Bureau of Economic Analysis.[10] Higher unemployment or lower income growth (or income declines) are hypothesized to be negatively associated with house price appreciation.

Results and Discussion

Descriptive statistics suggest that loans in neighborhoods (tracts) with greater subprime activities have higher delinquency rates and lower prepayment rates. Exhibit 3 shows the worst delinquencies for the CAP loans in this study. More than half (52%) were still active and had never experienced any delinquencies as of March 2008. About 32% of borrowers prepaid their mortgages. A total of 20% of the sample experienced different levels of delinquencies, and over 6.3% had at least one 90+day delinquency. Exhibit 4 shows a crosstab of 90-day delinquency rates and the level of subprime lending in census tracts. The 90-day delinquency rate for loans in tracts with extensive subprime purchase lending (with $>50\%$ subprime purchase loans in 2005) is about 7%, about 1.5 times that of loans in neighborhoods with less subprime purchase lending ($<15\%$ subprime purchase loans). When the level of subprime lending is measured by the share of subprime refinance loans in census tracts, this pattern is consistent and more obvious.

Exhibits 6–8 list the results of the multinomial logit models using different dependent variables, different study samples, and different measures of subprime

Exhibit 3 | Loan Performance: Worse Delinquency From January 2004 to March 2008

	Number of Loans	Percent
Current	8,796	51.5%
30-Days	1,831	10.7%
60-Days	457	2.7%
90+ Days Delinquent	1,071	6.3%
Returned	186	1.1%
Foreclosure	239	1.4%
Prepayment	5,540	32.4%
Total	17,080	

Note: The percentages do not sum to 100 because some loans may experience a delinquency first and then prepay the loan.

Exhibit 4 | CAP Loan Performance and Neighborhood Subprime Lending in 2005

Share of Subprime Lending		Delinquency (90+Days)	Foreclosure	# of Loans
Purchase	0%–14.9%	4.7%	1.4%	2,633
	15%–19.9%	5.3%	2.2%	2,114
	20%–29.9%	6.9%	2.7%	4,216
	30%–49.9%	7.7%	2.8%	5,304
	≥50%	7.0%	2.7%	2,813
Refinance	0–14.9%	3.1%	0.7%	1,271
	15–19.9%	3.7%	1.5%	1,505
	20–29.9%	5.9%	2.0%	5,442
	30–49.9%	7.5%	3.2%	7,095
	≥50%	10.4%	3.3%	1,767

Note: Based on a sample of 17,080 CAP loans originated from 2001 to 2006 in 8,108 census tracts. If a loan experienced 90-day delinquency first and prepaid later, it was counted as a 90-day delinquency only. The share of subprime lending is based on 2005 HMDA data.

lending at the neighborhood level. Model 1 to Model 4 in Exhibit 6 focus on the impact of neighborhood subprime purchase activities on default and prepayment of CAP loans, while Model 5 to Model 8 in Exhibit 7 focus on the impact of subprime refinancing activities on the performance of CAP loans. In Models 1, 3, 5, and 7, default is measured by 90-day delinquency, while in Models 2, 4, 6, and 8 default is measured by whether a loan ends up in foreclosure or is returned. The

Exhibit 5 | Variable Description and Means

	2001–2003 Sample		2004–2006 Sample		
Variable	Mean	Std. rr.	Mean	Std. rr.	Description
refi	5.358	6.833	3.931	6.841	Call option, saving from refinancing in the prime market (percentage)
put	−29.201	18.917	−11.887	11.843	Put option: (unpaid balance-house price)/original price (percentage)
cred620	0.102	0.303	0.136	0.343	Borrower credit score less than 620
cred660	0.198	0.398	0.234	0.424	Borrower credit score 620–659
cred720	0.330	0.470	0.322	0.467	Borrower credit score 660–719
dti_miss	0.072	0.259	0.065	0.247	Debt-to-income data missing
dti36	0.292	0.454	0.252	0.434	Debt-to-income ratio 28%–36%
dti42	0.284	0.451	0.296	0.456	Debt-to-income ratio 36%–42%
dti100	0.171	0.376	0.271	0.444	Debt-to-income ratio greater than 42%
af_american	0.159	0.366	0.143	0.350	African-American borrower
hispanic	0.173	0.378	0.078	0.268	Hispanic borrower
lupb	11.237	0.472	11.395	0.445	Unpaid balance (in log)
loanage	3.636	0.516	2.730	0.812	Loan age in months (in log) from origination
tra_inc80	0.305	0.460	0.278	0.448	Tract median income less than 80% AMI
tra_inc120	0.529	0.499	0.548	0.498	Tract median income 80–120% AMI
tra_black15	0.136	0.342	0.144	0.352	Af_american resident share of 15%–30% in tract
tra_black30	0.212	0.408	0.179	0.383	Af_american resident share greater than 30% in tract
u_rate	4.887	1.313	5.132	1.296	County unemployment rate
p_sub_2005	0.325	0.172	0.301	0.162	Tract share of subprime purchase lending in 2005
r_sub_2005	0.325	0.137	0.360	0.131	Tract share of subprime refinance lending in 2005
y2001	0.325	0.468			Dummy for 2001 originations
y2002	0.349	0.477			Dummy for 2002 originations
y2004			0.506	0.500	Dummy for 2004 originations
y2005			0.318	0.466	Dummy for 2005 originations
Sample size	314,833 loan months of 10,094 loans		189,462 loan months of 6,986 loans		

Exhibit 6 | MNL Regression Results of the Impact of Neighborhood Subprime Lending (Home Purchase in 2005)

		2001–2003 Sample				2004–2006			
		Model 1		Model 2		Model 3		Model 4	
		90-day		Foreclosure		90-day		Foreclosure	
Risk	Variable	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value
Delinquent	*refi*	0.069	0.000	0.094	0.000	0.029	0.001	0.017	0.238
	put	0.033	0.000	0.076	0.000	0.028	0.000	0.070	0.000
	cred620	0.939	0.000	0.144	0.532	1.989	0.000	1.679	0.000
	cred660	0.717	0.000	0.004	0.983	1.339	0.000	1.141	0.000
	cred720	0.339	0.007	−0.196	0.246	0.629	0.000	0.449	0.074
	dti_miss	1.193	0.000	1.762	0.000	0.444	0.081	0.470	0.319
	dti36	0.444	0.004	0.477	0.041	0.375	0.023	0.434	0.142
	dti42	0.402	0.010	0.264	0.271	0.351	0.033	0.385	0.194
	dti100	0.272	0.131	0.204	0.467	0.517	0.002	0.683	0.019
	af_american	−0.026	0.852	−0.734	0.005	0.125	0.308	−0.606	0.016
	hispanic	0.227	0.085	0.275	0.132	0.193	0.202	0.296	0.211
	lupb	−0.479	0.000	−0.517	0.005	−0.227	0.020	−0.043	0.821
	loanage	1.284	0.000	2.233	0.000	0.972	0.000	1.599	0.000
	tra_inc80	0.100	0.558	0.009	0.972	0.125	0.437	0.426	0.144
	tra_inc120	0.050	0.727	−0.057	0.783	0.208	0.124	0.608	0.019
	tra_black15	0.100	0.443	0.057	0.779	−0.262	0.066	−0.418	0.112
	tra_black30	0.057	0.681	0.239	0.238	−0.178	0.185	0.011	0.964
	u_rate	−0.097	0.021	−0.160	0.015	0.073	0.037	0.046	0.472
	p_sub_2005	**0.725**	**0.020**	**1.432**	**0.005**	**0.738**	**0.012**	**1.174**	**0.018**
	y2001(y2004)	−1.440	0.000	−2.045	0.000	−0.617	0.000	−0.211	0.375
	y2002(y2005)	−0.887	0.000	−1.163	0.000	−0.352	0.003	−0.027	0.900
	_cons	−5.341	0.000	−7.750	0.001	−7.534	0.000	−12.624	0.000

Exhibit 6 | (continued)

MNL Regression Results of the Impact of Neighborhood Subprime Lending (Home Purchase in 2005)

		2001–2003 Sample				2004–2006			
		Model 1		Model 2		Model 3		Model 4	
		90-day		Foreclosure		90-day		Foreclosure	
Risk	Variable	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value
Prepayment	*refi*	0.055	0.000	0.055	0.000	0.055	0.000	0.052	0.000
	put	−0.015	0.000	−0.015	0.000	−0.021	0.000	−0.022	0.000
	cred620	−0.183	0.004	−0.185	0.003	−0.152	0.193	−0.178	0.118
	cred660	0.124	0.006	0.133	0.003	−0.038	0.661	−0.041	0.630
	cred720	0.106	0.006	0.108	0.005	−0.004	0.961	−0.008	0.914
	dti_miss	−0.251	0.003	−0.258	0.002	0.078	0.587	0.080	0.574
	dti36	0.048	0.338	0.055	0.272	−0.325	0.003	−0.310	0.004
	dti42	0.139	0.006	0.140	0.006	−0.260	0.015	−0.250	0.019
	dti100	0.080	0.160	0.083	0.143	−0.169	0.128	−0.146	0.185
	af_american	−0.482	0.000	−0.481	0.000	−0.516	0.000	−0.512	0.000
	hispanic	0.071	0.090	0.071	0.090	−0.155	0.211	−0.166	0.179
	lupb	0.509	0.000	0.514	0.000	0.194	0.036	0.167	0.065
	loanage	−0.422	0.000	−0.435	0.000	0.271	0.000	0.245	0.000
	tra_inc80	−0.004	0.935	0.002	0.968	−0.143	0.177	−0.180	0.089
	tra_inc120	0.042	0.358	0.050	0.276	−0.029	0.723	−0.039	0.636
	tra_black15	0.044	0.363	0.038	0.430	−0.243	0.016	−0.255	0.011
	tra_black30	−0.050	0.332	−0.045	0.376	0.122	0.228	0.123	0.222

Exhibit 6 | (continued)

MNL Regression Results of the Impact of Neighborhood Subprime Lending (Home Purchase in 2005)

		2001–2003 Sample				2004–2006			
		Model 1		Model 2		Model 3		Model 4	
		90-day		Foreclosure		90-day		Foreclosure	
Risk	Variable	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value
	u_rate	−0.069	0.000	−0.071	0.000	−0.172	0.000	−0.160	0.000
	p_sub_2005	**0.232**	**0.035**	**0.224**	**0.041**	**−0.210**	**0.365**	**−0.205**	**0.373**
	y2001(y2004)	0.516	0.000	0.518	0.000	0.756	0.000	0.740	0.000
	y2002(y2005)	0.371	0.000	0.366	0.000	0.565	0.000	0.544	0.000
	_cons	−9.420	0.000	−9.443	0.000	−7.963	0.000	−7.624	0.000

Note: N = 314,833 loan months of 10,094 loans for the 2001–2003 sample and 189,462 loan months of 6,986 loans for the 2004–2006 sample. The reference group is "active and not default."

Exhibit 7 | MNL Regression Results of the Impact of Neighborhood Subprime Lending (Refinance in 2005)

		2001–2003 Sample				2004–2006			
		Model 5		Model 6		Model 7		Model 8	
		90-day		Foreclosure		90-day		Foreclosure	
Risk	Variable	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value
Delinquent	*refi*	0.070	0.000	0.097	0.000	0.030	0.001	0.017	0.236
	put	0.032	0.000	0.074	0.000	0.028	0.000	0.072	0.000
	cred620	0.936	0.000	0.152	0.502	1.987	0.000	1.681	0.000
	cred660	0.709	0.000	−0.009	0.961	1.339	0.000	1.145	0.000
	cred720	0.340	0.007	−0.193	0.254	0.626	0.000	0.447	0.076
	dti_miss	1.180	0.000	1.765	0.000	0.472	0.064	0.530	0.257
	dti36	0.443	0.004	0.483	0.040	0.379	0.021	0.445	0.132
	dti42	0.391	0.012	0.243	0.311	0.355	0.032	0.389	0.189
	dti100	0.258	0.151	0.173	0.536	0.523	0.002	0.696	0.017
	af_american	−0.007	0.961	−0.714	0.006	0.152	0.214	−0.547	0.030
	hispanic	0.253	0.049	0.308	0.079	0.204	0.180	0.320	0.177
	lupb	−0.406	0.001	−0.354	0.064	−0.189	0.066	−0.004	0.984
	loanage	1.274	0.000	2.235	0.000	0.972	0.000	1.604	0.000
	tra_inc80	0.050	0.780	−0.141	0.589	0.155	0.338	0.496	0.096
	tra_inc120	0.031	0.827	−0.109	0.600	0.225	0.097	0.647	0.013
	tra_black15	0.118	0.363	0.099	0.627	−0.260	0.069	−0.394	0.134
	tra_black30	0.079	0.567	0.284	0.162	−0.146	0.278	0.099	0.675
	u_rate	−0.081	0.042	−0.134	0.033	0.083	0.018	0.064	0.300
	r_sub_2005	**0.852**	**0.027**	**1.931**	**0.001**	**0.617**	**0.114**	**0.771**	**0.250**
	y2001(y2004)	−1.446	0.000	−2.072	0.000	−0.604	0.000	−0.187	0.430
	y2002(y2005)	−0.904	0.000	−1.191	0.000	−0.343	0.004	−0.015	0.946
	_cons	−6.284	0.000	−9.925	0.000	−8.027	0.000	−13.150	0.000

Exhibit 7 | (continued)

MNL Regression Results of the Impact of Neighborhood Subprime Lending (Refinance in 2005)

		2001–2003 Sample				2004–2006			
		Model 5		Model 6		Model 7		Model 8	
		90-day		Foreclosure		90-day		Foreclosure	
Risk	Variable	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value
Prepayment	*refi*	0.056	0.000	0.055	0.000	0.055	0.000	0.052	0.000
	put	−0.015	0.000	−0.015	0.000	−0.021	0.000	−0.022	0.000
	cred620	−0.183	0.004	−0.185	0.003	−0.147	0.210	−0.172	0.133
	cred660	0.131	0.004	0.140	0.002	−0.036	0.680	−0.038	0.655
	cred720	0.109	0.005	0.111	0.004	0.000	0.998	−0.004	0.959
	dti_miss	−0.279	0.001	−0.286	0.001	0.078	0.584	0.082	0.561
	dti36	0.043	0.389	0.050	0.317	−0.325	0.003	−0.310	0.004
	dti42	0.136	0.007	0.137	0.007	−0.258	0.016	−0.247	0.020
	dti100	0.077	0.174	0.080	0.156	−0.168	0.132	−0.144	0.190
	af_american	−0.459	0.000	−0.458	0.000	−0.510	0.000	−0.504	0.000
	hispanic	0.113	0.006	0.112	0.006	−0.152	0.221	−0.162	0.192
	lupb	0.494	0.000	0.499	0.000	0.169	0.076	0.140	0.130
	loanage	−0.415	0.000	−0.428	0.000	0.274	0.000	0.249	0.000
	tra_inc80	0.055	0.330	0.060	0.278	−0.122	0.253	−0.153	0.149
	tra_inc120	0.069	0.132	0.077	0.096	−0.018	0.830	−0.025	0.764
	tra_black15	0.057	0.230	0.051	0.281	−0.237	0.019	−0.247	0.013
	tra_black30	0.003	0.958	0.007	0.891	0.141	0.169	0.145	0.152

Exhibit 7 | (continued)

MNL Regression Results of the Impact of Neighborhood Subprime Lending (Refinance in 2005)

		2001–2003 Sample				2004–2006			
		Model 5		Model 6		Model 7		Model 8	
		90-day		Foreclosure		90-day		Foreclosure	
Risk	Variable	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value
	u_rate	−0.063	0.000	−0.065	0.000	−0.172	0.000	−0.160	0.000
	r_sub_2005	**−0.315**	**0.035**	**−0.315**	**0.033**	**−0.432**	**0.154**	**−0.468**	**0.119**
	y2001(y2004)	0.518	0.000	0.520	0.000	0.754	0.000	0.738	0.000
	y2002(y2005)	0.375	0.000	0.370	0.000	0.564	0.000	0.544	0.000
	_cons	−9.192	0.000	−9.210	0.000	−7.614	0.000	−7.254	0.000

Note: N = 314,833 loan months of 10,094 loans for the 2001–2003 sample and 189,462 loan months of 6,986 loans for the 2004–2006 sample. The reference group is "active and not default."

Exhibit 8 | MNL Regression Results of the Impact of Neighborhood Subprime Lending (2006)

		2001–2003				2004–2006			
		90-day		Foreclosure		90-day		Foreclosure	
Risk	Variable	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value	Coeff.	*P*-value
Default	*p_sub_2006*	1.001	0.002	1.783	0.000	0.649	0.025	1.020	0.050
Prepay	*p_sub_2006*	0.448	0.000	0.430	0.000	−0.199	0.369	−0.220	0.330
Default	*r_sub_2006*	0.877	0.020	1.651	0.002	0.979	0.011	0.719	0.275
Prepay	*r_sub_2006*	−0.393	0.008	−0.401	0.006	−0.523	0.064	−0.528	0.060

Note: The results of other variables are similar to those in Exhibit 6 and Exhibit 7 so they are omitted in this table.

same regression models are run for both the 2001–2003 (old originations) and the 2004–2006 (recent originations) cohorts. Since the qualitative results for all other variables do not change when the 2006 subprime lending measures are used, Exhibit 8 only lists the results for the subprime lending variables. A positive coefficient means that the odds of the particular outcome rather than the reference group (Active) increase as the independent variable increases; a negative coefficient means the odds decrease. Exhibits 9 and 10 provide the results of the two-stage model using the MTM data.

The results from the MNL model indicate that subprime purchase lending is significantly (at the 0.05 level) and positively associated with the default risk (Exhibit 6). This result is consistent when different measures of default (either measured by 90-day delinquency or default) are used and when data of old and recent originations are employed. A higher level of subprime purchase lending in a neighborhood increases the probability of serious delinquency and default for CAP loans. As Exhibit 11 shows, for an average borrower holding a CAP loan originated in 2003, the conditional probability of default increases with the share of subprime purchase loans in tracts where the property is located. Other things being equal, if the borrower lives in a tract with 25% subprime purchase loans in 2005 (the national average share), the predicted probability of default is 0.11% at 48 months after origination. However, if the person lives in a tract with a higher level of subprime purchase activities, for example, 50% in 2005, the predicted probability of default would be 0.16%. In other words, other things equal, the predicted probability of default for a borrower living in a tract with relatively higher level of subprime purchase lending (50% in 2005) would be 42% higher than for the borrower living in an average tract. For more recent originations, the predicted probability of default for a borrower living in a tract with a higher level of subprime purchase lending would be 34% higher than for a similar borrower living in an average tract (Exhibit 12).

There is also consistent evidence that the share of subprime refinancing mortgages is negatively associated with the probability of default for old originations (Exhibit 6). For recent originations, the share of subprime refinancing mortgages is generally insignificant (only significant in Exhibit 8), but the signs of the coefficients are consistent. As Exhibit 11 shows, the predicted probability of default for a CAP loan originated in 2003 in a tract with a higher level of subprime refinance activities would be 62% higher than for the borrower living in an average tract. One possible explanation for the significant and larger negative impact of subprime refinance lending on old originations is that subprime lenders have directed their attention at borrowers with some equity in their houses in more well-established neighborhoods.

Generally, the share of subprime refinance mortgages is significantly and negatively associated with the risk of prepayment (except the insignificant coefficients for Models 7 and 8 in Exhibit 7). One possible explanation is that the higher level of subprime refinancing activities may reflect a lack of access to prime or FHA activities. In some neighborhoods with previous concentrated subprime

Exhibit 9 | Estimates of Two-Stage Probit Model
(Volatility of Neighborhood House Price Change)

		Home Purchase			Refinance	
		Coeff.	*P*-value		Coeff.	*P*-value
default	*cred620*	1.125	0.000	*cred620*	1.124	0.000
	cred660	0.864	0.000	*cred660*	0.863	0.000
	cred720	0.421	0.000	*cred720*	0.421	0.000
	dti_miss	−0.010	0.947	*dti_miss*	−0.004	0.976
	dti36	−0.015	0.850	*dti36*	−0.015	0.849
	dti42	0.049	0.502	*dti42*	0.049	0.497
	ltv95	0.441	0.047	*ltv95*	0.441	0.049
	ltv97	0.235	0.346	*ltv97*	0.235	0.350
	ltv100	0.571	0.005	*ltv100*	0.570	0.005
	ltv120	0.682	0.001	*ltv120*	0.682	0.001
	af_american	0.165	0.081	*af_american*	0.167	0.077
	hispanic	0.037	0.778	*hispanic*	0.038	0.771
	lupb	−0.198	0.007	*lupb*	−0.197	0.007
	tra_inc80	0.205	0.083	*tra_inc80*	0.211	0.076
	tra_inc120	0.248	0.012	*tra_inc120*	0.252	0.011
	tra_black15	−0.258	0.012	*tra_black15*	−0.259	0.012
	tra_black30	−0.061	0.528	*tra_black30*	−0.059	0.538
	y2004	−0.013	0.937	*y2004*	−0.010	0.952
	y2005	0.073	0.668	*y2005*	0.076	0.654
	I_volatility	0.119	0.002	*I_volitality*	0.113	0.005
	_cons	−0.865	0.313	_cons	−0.867	0.312
volatility	*p_sub_2005*	2.195	0.000	*r_sub_2005*	2.299	0.000
	vol_msa	0.445	0.000	*vol_msa*	0.455	0.000
	pi_2004	0.008	0.046	*pi_2004*	0.017	0.000
	pi_0405	3.973	0.003	*pi_0405*	4.734	0.000
	pi_0506	5.959	0.000	*pi_0506*	4.112	0.002
	unemp_2006	0.232	0.000	*unemp_2006*	0.257	0.000
	unemp_0506	0.332	0.000	*unemp_0506*	0.283	0.000
	unemp_0607	0.982	0.000	*unemp_0607*	0.953	0.000
	unemp_0708	0.281	0.000	*unemp_0708*	0.295	0.000
	I_default	−0.087	0.122	*I_default*	−0.111	0.053
	_cons	−0.489	0.076	*_cons*	−1.024	0.000

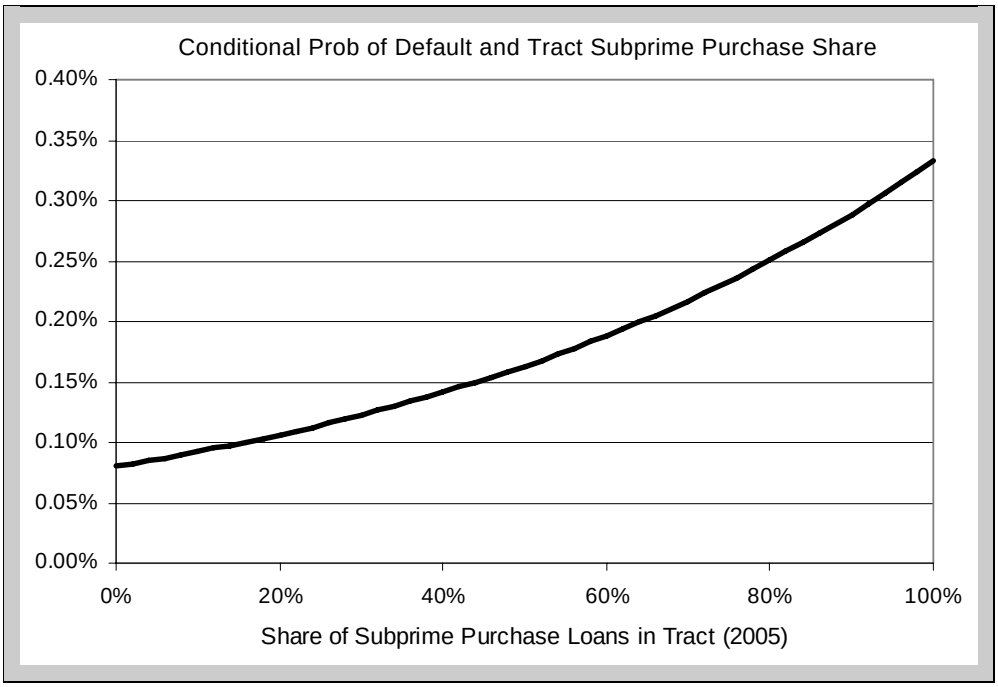
Notes: $N = 4{,}379$. *volitality* represents the price volatility (the standard deviation) during the first quarter 2006 to the first quarter 2008. *I_default* and *I_volatility* are estimated values from the first-stage regressions. Results for the first-stage regression not listed here.

Exhibit 10 | Estimates of Two-Stage Probit Model
(Neighborhood House Price Change)

		Home Purchase			Refinance	
		Coeff.	*P*-value		Coeff.	*P*-value
default	*cred620*	1.144	0.000	*cred620*	1.143	0.000
	cred660	0.815	0.000	*cred660*	0.815	0.000
	cred720	0.400	0.000	*cred720*	0.400	0.000
	dti_miss	−0.003	0.984	*dti_miss*	−0.001	0.993
	dti36	0.012	0.867	*dti36*	0.011	0.881
	dti42	0.054	0.438	*dti42*	0.053	0.440
	ltv95	0.356	0.097	*ltv95*	0.361	0.095
	ltv97	0.321	0.175	*ltv97*	0.326	0.173
	ltv100	0.545	0.005	*ltv100*	0.550	0.005
	ltv120	0.652	0.001	*ltv120*	0.658	0.001
	af_american	0.142	0.119	*af_american*	0.146	0.109
	hispanic	−0.074	0.556	*hispanic*	−0.072	0.565
	lupb	−0.264	0.000	*lupb*	−0.263	0.000
	tra_inc80	0.196	0.065	*tra_inc80*	0.198	0.062
	tra_inc120	0.192	0.034	*tra_inc120*	0.195	0.032
	tra_black15	−0.143	0.153	*tra_black15*	−0.145	0.150
	tra_black30	0.025	0.786	*tra_black30*	0.026	0.782
	y2004	−0.002	0.986	*y2004*	−0.002	0.984
	y2005	0.066	0.483	*y2005*	0.067	0.478
	l_appre_mtm	−3.105	0.000	*l_appre_mtm*	−3.047	0.000
	_cons	3.317	0.005	*_cons*	3.236	0.007
appre_mtm	*p_sub_2005*	−0.082	0.000	*r_sub_2005*	−0.042	0.000
	vol_msa	0.012	0.000	*vol_msa*	0.012	0.000
	pi_2004	−0.003	0.000	*pi_2004*	−0.004	0.000
	pi_0405	−0.340	0.000	*pi_0405*	−0.406	0.000
	pi_0506	0.624	0.000	*pi_0506*	0.700	0.000
	unemp_2006	−0.014	0.000	*unemp_2006*	−0.016	0.000
	unemp_0506	−0.025	0.000	*unemp_0506*	−0.022	0.000
	unemp_0607	−0.053	0.000	*unemp_0607*	−0.051	0.000
	unemp_0708	−0.028	0.000	*unemp_0708*	−0.028	0.000
	l_default	0.017	0.076	*l_default*	0.015	0.020
	_cons	1.152	0.000	*_cons*	1.154	0.000

Notes: $N = 4{,}379$. *appre_mtm* represents the neighborhood house price change during the first quarter 2006 to the first quarter 2008. *l_default* and *l_appre_mtm* are estimated values from the first-stage regressions. Results for the first-stage regression not listed here.

Exhibit 11 | Conditional Probability of Default Old Originations by Tract Subprime Purchase Lending (2005)



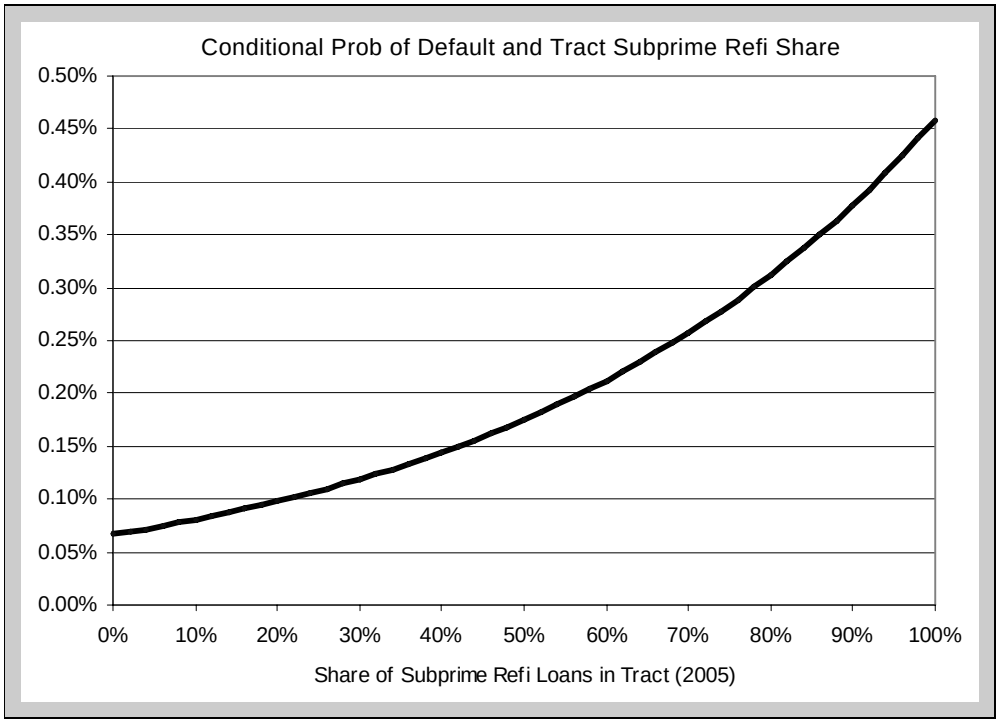
Note: Based on Model 2 in Exhibit 6 for the 2001–2003 sample. The predicted conditional probability is as of 48 months after origination for a borrower holding a CAP loan originated in 2003, with the mean value of other regressors.

activities, borrowers may find themselves without access to credit with favorable terms. The results are consistent for both old originations: the level of subprime lending not only impacts the performance of recent originations but also that of old outstanding CAP mortgages.

Results of the Two-stage Model

Parameter estimates of the default and housing price change equation with the endogenous variables using the MTM property value data are presented in Exhibit 9 (volatility) and Exhibit 10 (neighborhood housing price appreciation). Results suggest the endogenous housing price change variable is a significant predictor of the default behavior of CAP loans but the endogenous default variable is generally insignificant and the only one significant one has a sign different from the hypothesis. It is likely that many of these defaulted CAP (90+days) loans did not end up in foreclosure so their impact on housing price change had been insignificant. It is also possible that the impact of the default of CAP loans on

Exhibit 12 | Conditional Probability of Default for Old Originations by Tract Subprime Refinance Lending (2005)



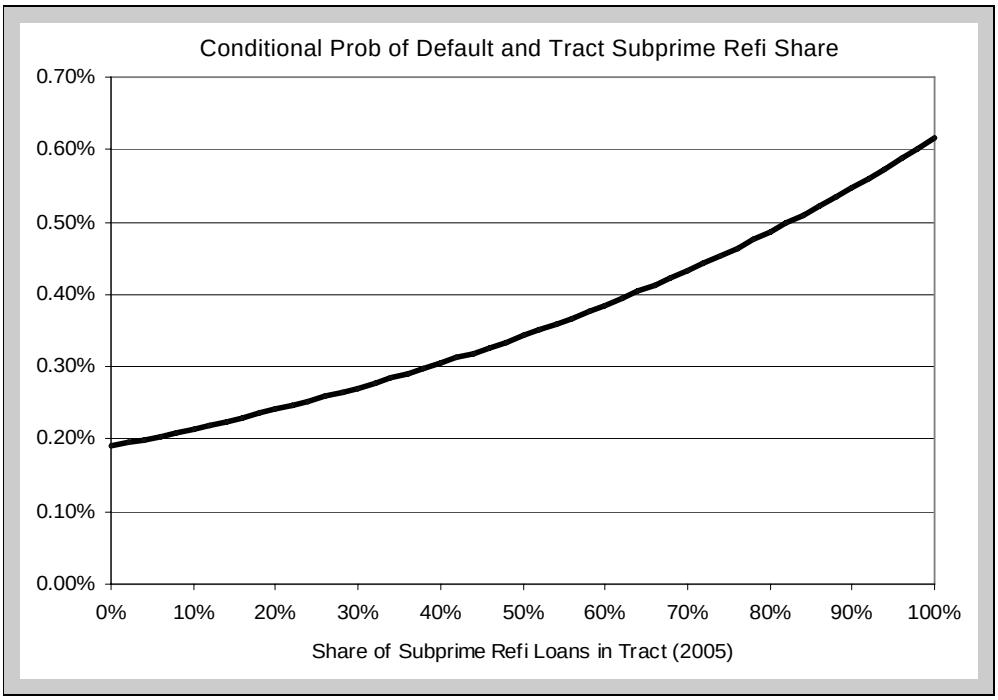
Note: Based on Model 2 in Exhibit 7 for the 2001–2003 sample. The predicted conditional probability is as of 48 months after origination for a borrower holding a CAP loan originated in 2003, with the mean value of other regressors.

neighborhood house price has been marginal since there has been no significant concentration of CAP loans.

The results suggest that subprime purchase lending activities significantly reduce the neighborhood house price appreciation and increase the house price volatility. For a 1% increase in the share of subprime home purchase originations in the neighborhood in 2005, the house price declines by 0.08% and the price volatility measured by the standard deviation of the housing price index during the study period increases by 2.2%. Considering the fact that most CAP loans are very sensitive to house price changes because of their very high loan-to-values, the house price changes due to the concentration of subprime lending will inevitably influence the performance of CAP loans.

The CAP loan default model confirms that the deterioration in neighborhood property values significantly increases the default risk of CAP loans. Based on the results in the second stage of regression, the house price appreciation

Exhibit 13 | Conditional Probability of Default for Recent Originations by Tract Subprime Refinance Lending (2005)



Note: Based on Model 2 in Exhibit 6 for the 2004–2006 sample. The predicted conditional probability is as of 48 months after origination for a borrower holding a CAP loan originated in 2004, with the mean value of other regressors.

significantly reduced the default risk of CAP loans (with an odds ratio of 0.04). The house price volatility also significantly increases the default risk of CAP loans (with an odds ratio of 1.13). The results are robust when different house price measures and different measures of subprime activities at the tract level are used including the share of purchase subprime originations in 2005.[11] The only exception is that the share of subprime refinance lending in 2005 has an insignificant impact on the neighborhood house price appreciation but it does increases the house price volatility. This is somewhat consistent with the results from the MNL regression that the refinance subprime activities only have a marginal impact on the performance of recently originated CAP loans.

Several of the variables that reflect local economic conditions were also associated with the change in property values between 2006 and 2008. As expected, the unemployment rate in 2006 and the subsequent increase in unemployment rate significantly increase the house price volatility and are also significantly and negatively associated with the house price appreciation. The per capital personal income in 2004 and the subsequent change cause a higher level of house price

volatility but are negatively associated with the house price appreciation. It seems both the unemployment and income level and shocks increases volatility. But the most recent changes in the level of income per-capita (from 2005 to 2006, *pi_0506*) is positively associated with the house price appreciation. The results are generally consistent with Mian and Sufi's (2008) finding that the rapid development of nonprime loans in areas with very high denial rates previously was an important factor in the price bubble and the subsequent concentration of foreclosures. Very likely these previously underserved neighborhoods had a lower income and a high unemployment rate before the housing boom.

The results from the 2SPLS model confirm the negative relationship between subprime lending and CAP loan performance from the MNL model. Furthermore, it supports the hypothesis that one mechanism of the impact of the concentrated subprime lending is by lowering the neighborhood property value or increasing the house price volatility. The empirical results are consistent with the increasing evidence in the literature that subprime loans have a much higher foreclosure rate and that foreclosures lower the value of neighboring properties and impose significant costs on communities. Therefore, the negative spillover effects from the concentrated subprime lending contribute to the increased default risk of CAP loans and one important mechanism is its negative spillover effect on neighborhood property values.

Results of Other Controls

As noted previously, many variables other than subprime lending may influence the performance of residential mortgages. Here are some interpretations of some important variables based primarily on results in Exhibit 6 and Exhibit 7, since the qualitative results of these variables do not change when different subprime measures are used.

- **Value of the Put Option**: Borrowers with less or negative equity in their homes (larger value of *put*) are more likely to default and less likely to prepay. The results confirm the common wisdom that the level of equity in a home is a strong predictor for prepayment and default.
- **Value of the Call Option**: The call option (*call*), which measures the saving from refinancing in the prime market, has a significant effect on the outcome of both prepayment and default. The results confirm that if the call option is ''in the money,'' borrowers are more likely to prepay their mortgages. The value of the call option is also positively associated with the probability of default. This may be explained by the fact that many borrowers have greater values of the call option primarily because mortgage note rates are higher. Since a higher note rate may be regarded as a measure of credit risk, so borrowers whose mortgages have higher note rates may be more likely to default on their mortgages.
- **Credit History**: Generally, borrowers with lower credit scores are more likely to experience serious delinquency and default and less likely to prepay.

- **DTI**: Borrowers with higher debt ratios are more likely to experience serious delinquencies and less likely to prepay. But borrowers with higher DTI ratios are not necessarily more likely to end up in default.
- **Borrower Race**: African Americans are significantly less likely to prepay but not significantly different in their delinquency probability and even less likely to end up with foreclosure. For Hispanics, the coefficients for both default and prepayment are insignificant.
- **Neighborhood Controls**: Greater black representation in neighborhoods (tracts) appears to have no statistically significant impact on both default and prepayment. Neighborhood median income level does not have significant impact on prepayment. Income level of neighborhood is generally insignificant (with one exception of borrowers in the median-income neighborhoods for the outcome of default). Generally, the results suggest there is no consistent evidence that racial composition and income of the neighborhood matter in individual default behavior.[12]
- **Unemployment Rate**: County unemployment rate is negatively associated with probability of prepayment in all models and positively associated with the probability of delinquency for recent originations. But for old originations, county unemployment rate is negatively associated with the probability of delinquency and default, which may be explained by some locational information not fully captured by the model.
- **Time Dummies**: Older originations are less likely to experience default and more likely to prepay according to the MNL model.

Conclusions and Implications

The subprime crisis has significant consequences on the entire housing market and the overall economy. The impact of the subprime crisis was examined by focusing on its spillover effect on a segment of community reinvestment mortgages serving LMI borrowers. This study finds that the neighborhood subprime lending level, as measured by the share of subprime purchase or refinance loans, is positively associated with the probability of default for the borrowers holding CRA-type CAP loans in the same neighborhoods. The level of subprime refinance lending is also found to be negatively associated with the probability of prepayment. While this study sample has some particular features, this study shows how CRA-type borrowers suffer from the subprime mortgage crisis.

There are some possible explanations for these relationships. One of the possible transmission mechanisms through which the concentration of subprime lending impacted the performance of CAP loans was identified. By employing a 2SPLS model, the concentration of subprime lending and the resulting clusters of foreclosed properties in certain neighborhoods was found to reduce property values and increases volatility. The lowered neighborhood property values increase

the default probability of borrowers holding any loan products, including CAP loans. The results suggest that the negative spillover effect from the spatial concentration of subprime lending contributes, at least partially, to the increased default risk of CAP mortgages. By showing that previous subprime activities have affected the behavior of other homeowners, the results suggest that in weaker neighborhoods where subprime loans and foreclosures are concentrated, borrowers, no matter what kind of products they have, may have fewer resources and opportunities and may be more vulnerable to default.

The results also suggest that the level of subprime activities can serve as a measure of neighborhood risk in the current housing market and can point to previous loose underwriting, rising subprime foreclosures, or falling neighborhood house prices. Using the share of subprime purchase or refinance loans in each census tract, based on readily available HMDA data, researchers and policymakers can roughly track local lending activities, identify potential hot spots, and better target intervention efforts, such as foreclosure prevention counseling or other services. Although private lenders are originating few subprime loans at any terms now, the spatial concentration of risky loan products should be monitored more closely. Future research would also benefit from identifying threshold effects of the impact of subprime lending and other risky loan products; this could have important policy implications.

Endnotes

[1] The Mortgage Banker Association reports that subprime loans in the second quarter of 2008 had a serious delinquency rate 7.6 times higher than that for prime loans (17.9 vs. 2.35). In addition, subprime mortgages represent 48% of the newly started foreclosures while they only represent 12% of the loans outstanding (MBA, 2008).

[2] Since the first quarter of 2005, the foreclosure start rates for prime ARMs increased from 0.17% to 1.06% in the fourth quarter of 2007 and the foreclosure starts rate for prime fixed loans increased from 0.15% to 0.22% (MBA, 2008).

[3] Based on data from the Loan Performance, Cutts and Merrill (2008) estimate that the share of loans in the subprime segment with limited or no income or asset documentation grew from less than 30% in 2001 to over 50% by 2006 while in the Alt-A segment these loans increased to over 80%.

[4] The term ''Nonprime'' includes both loans to borrowers with weak credit histories, as well as what have come to be called ''A-,'' ''Alt-A,'' and other loan types that fail to be eligible for GSE purchase due to factors other than credit.

[5] Some seriously delinquency loans were returned to original lenders based on the ''limited indemnity'' rule, which usually requires lenders to retain the main recourse on loans until 12 consecutive on-time payments are made. For this study sample, the 186 returned loans are treated as defaults, although Self-Help could not track their performance after they were returned to original lenders. This treatment may overestimate the incidence of foreclosure, but all these loans had experienced serious delinquencies (90+day) and many of them should have ended up in foreclosure in the

current softening housing market although they would not cause further credit losses for Self-Help.

[6] Since the OFHEO house price index (HPI) at metropolitan statistical area (MSA) level is available quarterly, it is assumed that each month in the same quarter has the same appreciation rate. If the property is located in an area outside an MSA, state-level HPI are used. Given the MSA house price index HPI_{i0} at origination and HPI_{it} in month t, the value of the put option for house i with an original purchase price P_{i0} can be calculated for each month, t:

$$put_{it} = \frac{(upb_{it} - P_{i0} * (HPI_{it}/HPI_{i0}))}{P_{i0}}. \quad (2)$$

[7] Given the original balance (OB_i), the term of the mortgage (TM_i), and the interest rate on the mortgage (R_i) for a fixed rate mortgage i, the monthly payments can be calculated:

$$PAY_i = R_i * OB_i \left[\frac{(1 + R_i)^{TM_i}}{(1 + R_i)^{TM_i} - 1} \right]. \quad (3)$$

The future monthly payments (PAY_i) are then discounted by the interest rate (R_i) and prevailing interest rate (PR_i) separately. The Freddie Mac Primary Mortgage Market Survey (PMMS) is used to proxy for prevailing interest rates on prime, conventional, and fixed-rate mortgages:

$$PDC_{cit} = \sum_{m=t}^{TM_i} \frac{PAY_i}{(1 + R_i)^m} \quad PDC_{rit} = \sum_{m=t}^{TM_i} \frac{PAY_i}{(1 + PR_i)^m}. \quad (4)$$

The call option is defined as the difference in the present values of the payment stream at the mortgage note rate and the prevailing interest rate:

$$call_{it} = \frac{PDC_{rit} - PDC_{cit}}{PDC_{rit}}. \quad (5)$$

[8] The variables selected should meet two requirements. First, conditional on the troublesome regressor, the instruments must be uncorrelated with the outcome of interest. The second requirement is that the instruments be correlated with the troublesome regressors.

[9] Except the MTM data, Fannie Mae also provides the RPS housing price data, which incorporates information concerning property transaction, property characteristics, and property tax. Because this additional information arrives sporadically, it has more volatility in individual RPS house price than in individual MTM records.

[10] Since the per capita income data is still unavailable for the years after 2006, the 2004 data at the county level are used as a proxy for the neighborhood income level.

[11] The same regressions were tried using RPS data and the 2006 subprime lending variables. The results are quite consistent with those in Exhibit 9 and 10. The results are available upon request.

[12] Of course, there is a potential multicollinearity among the neighborhood subprime lending variable and other neighborhood characteristics measure. However, even after the subprime lending variables were dropped, the neighborhood characteristics measures are still insignificant.

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Lei Ding, Wayne State University, Detroit, MI 48202 or lei_ding@wayne.edu.

Roberto G. Quercia, University of North Carolina, Chapel Hill, NC 27599 or Quercia@email.unc.edu.

Janneke Ratcliffe, University of North Carolina, Chapel Hill, NC 27599 or Janneke_Ratcliffe@unc.edu.