The Impact of the Mortgage Credit Expansion on the Performance of Residential Leases

Brent W. Ambrose, Ph.D.
Institute for Real Estate Studies
Smeal College of Business
The Pennsylvania State University
University Park, PA 16802
(814) 867-0066
bwa10@psu.edu

and

Moussa Diop
Department of Insurance and Real Estate
Smeal College of Business
The Pennsylvania State University
University Park, PA 16802
mud173@psu.edu

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ABSTRACT

Did the expansion in subprime mortgage credit during the 2001-2006 housing bubble adversely affect other real estate markets? We empirically answer this question using insights from a simple theoretical model demonstrating how an expansion in subprime lending increased the overall riskiness of rental household population. Using a large database of residential rental lease payment histories, our results confirm that the expansion in subprime lending corresponds with an overall decline in the quality of rental payments. As a result, we confirm that the expansion of higher risk subprime mortgages had a direct impact on the residential rental market.

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PRELIMINARY: PLEASE DO NOT QUOTE

1 Introduction

The severe economic downturn following the bust of the housing bubble has stimulated considerable research focusing on various aspects of the preceding mortgage credit expansion (Chomsisengphet and Pennington-Cross, 2006; Mayer and Pence, 2008; Danis and Pennington-Cross, 2008; Demyanyk and Van Hemert, 2009; Greenspan and Kennedy, 2008). Yet little is known about the possible spillover effects of this housing credit expansion on the other sectors of the real estate market. Were the direct effects of this credit expansion limited to the housing market and residential mortgage-backed securities? Our study partly fills this gap by showing that the residential rental market was adversely affected by the development of subprime lending because lower risk renters migrated into homeownership, leaving behind a riskier renter population.

In economics, the housing tenure choice literature views owning and renting as substitutes, hence individual tenure choice decisions are technically based on the relative attractiveness of these two alternative options. Household characteristics and financial considerations play an important role in housing demand and tenure choice decisions (Henderson and Ioannides, 1983; Ioannides and Rosenthal, 1994). Since most households typically borrow the bulk of the purchase price of their home, the availability of mortgage financing influences these decisions as well. For example, Linneman and Wachter (1989), Duca and Rosenthal (1994), Haurin, Hendershott, and Watcher (1997), and Linneman, Megbolugbe, Watcher, and Cho (1997) among others show that borrowing constraints, both wealth and income related, limit households' propensities to become homeowners. More recently, Calem, Firestone, and Wachter (2010) also emphasize the primary adverse effects of credit impairment and lack of credit history on homeownership.

The sustained growth in mortgage lending from 2001 to 2006, attributed in part to the interaction of looser underwriting standards and the development of innovative mortgage products targeted at underserved populations (Kiff and Mills, 2007; Watcher, Pavlos and Pozar, 2008), enabled numerous households previously excluded from the mortgage market

to achieve, at least temporally, the American dream of homeownership (Bernanke, 2007). For example, the national average homeownership rate grew 2.4% from 67.5% in 2000 to 68.9% in 2006. Furthermore, as shown in Figure 1, the phenomenon was more pronounced in urban areas where average homeownership rates in metropolitan areas and major cities rose by 2.9% and 5.6%, respectively.

Given the remarkable expansion mortgage credit in the previous decade, a natural question then is to what extent the growth in homeownership adversely affected the residential rental market. We address this question by examining the performance of residential leases using a national database of multifamily rental data. We analyze the probability of payment defaults under these leases during the explosive growth in subprime lending. The empirical results document a sustained increase in lease defaults in high subprime MSAs as compared to areas that experienced less subprime activity. A cross-sectional analysis of the data shows that after controlling for the effects of other potential determinants of lease defaults, a significant (both economically and statistically) positive relationship exists between subprime lending and the likelihood of lease defaults. We also show that the increase in lease defaults was caused by the migration of low risk renters into homeowership. This adverse spillover on the residential rental market was largely caused by the surge in subprime lending, but easier access to conventional mortgage financing also contributed. This study provides a more comprehensive understanding of the impacts of the mortgage credit expansion on the real estate market in general. To our knowledge, the possible adverse effect of mortgage expansion on the residential rental market has not yet been explored.

Section 2 presents a simple model of rental risk that motivates the empirical analysis. Section 3 presents the empirical analysis and section 4 contains several robustness checks. Section 5 concludes by summarizing the key points of this study and introduces potential research questions.

2 A Simple Model of Rental Risk

Our goal is to present a simple model illustrating how changes in the mortgage market and underlying economic conditions may impact the rental market risk distribution. Our model captures two stylized facts observed during the previous decade. First, following the 2001 recession overall household credit risk declined as the economy expanded. For example, Figure 2 shows that the U.S. average unemployment rate steadily declined from 2003 through 2007 as the economy recovered from the 2001 recession. Second, as home prices increased mortgage credit supply, and subprime mortgage credit in particular, increased through the relaxation of underwriting standards. For example, recent studies by Glaeser, Gottlieb and Gyourko (2010), Coleman, LaCour-Little and Vandell (2008), and Mian and Sufi (2009), and Anderson, Capozza and Van Order (2008) document a significant expansion in subprime lending in the last decade along with a deterioration in standard underwriting metrics.

In order to isolate the impact of tenant credit risk, we simplify the analysis by assuming that households have a strict preference for ownership over tenancy for housing units that provide identical utility. Hendersen and Ioannides (1983), Ioannides and Rosenthal (1994), Calem et al. (2010), and Duca and Rosenthal (1994) provide evidence showing that tenure choice decisions depend on household characteristics and financial position, as well as capital market conditions, and that some households may find renting optimal. Assuming that the risk distribution of these optimal renters is constant over time, variations in the riskiness of the renter population will be mainly driven by credit availability. Thus, this assumption allows us to study the implications of changes in the mortgage market on the overall credit risk of renter households.

We begin by modeling the distribution of home owners and renters in a spatially defined, local market using the approach of Ferguson and Peters (1995) and Ambrose, Pennington-Cross, and Yezer (2002). We assume that all information about a household's ability to obtain mortgage credit is quantified by an inverse credit risk score (Φ) that is a monotonically increasing function of household's probability of default. Furthermore, we assume that

all lenders set minimum underwriting standards (Φ^*) such that households with credit risk scores above this score are rejected and all households with credit scores below receive mortgages. Thus, households that are rejected by lenders are confined to the rental market. We define $r(\Phi)$ as the marginal probability density function and $R(\Phi)$ as the cumulative density function of the household's credit risk.

In order to show the effects of the expansion in subprime lending, we segment the mortgage market into conventional and subprime lenders with corresponding underwriting standards of Φ^C and Φ^S, respectively. The probability that a household applies for a conventional or subprime mortgage is a function of both the household's credit risk and the prevailing underwriting standards. Following Ambrose, Pennington-Cross, and Yezer (2002), we assume that $\alpha(\Phi; \Phi^C)$ is the share of households with credit risk Φ that apply for subprime mortgages given conventional underwriting standards (Φ^C). We note that $\alpha(\Phi; \Phi^C)$ is an increasing function of Φ, is approximately 0 when $\Phi \ll \Phi^C$ and increases monotonically to 1 at some value of $\Phi > \Phi^C$.

Figure 3 shows the distribution of household tenure status based on the marginal density function of credit risk and underwriting standards. Consistent with the subprime market being less than 20 percent of all mortgage origination activity,[1] we show the conventional underwriting criteria (Φ^C) to the right of the peak of the distribution and the subprime underwriting criteria (Φ^S) to the right of Φ^C. Let $A(\Phi^C)$ denote the fraction of households that apply for a subprime mortgage such that

$$A(\Phi^C) = \int_0^1 r(\Phi)\alpha(\Phi; \Phi^C)d\Phi. \tag{1}$$

Thus, in Figure 3 the value of $A(\Phi^C)$ is given as the region $Y + Z + M$. The fraction of all

[1]See Chomsisengphet and Pennington-Cross (2006) for a description of the development of the subprime market.

households that apply for a subprime mortgage and are accepted is denoted as:

$$E(\Phi^C;\Phi^S) = \int_0^{\Phi^S} r(\Phi)\alpha(\Phi;\Phi^C)d\Phi \tag{2}$$

and is represented as $Y+Z$. Finally, the fraction of households that are rejected by subprime lenders is

$$D(\Phi^C;\Phi^S) = \int_{\Phi^S}^1 r(\Phi)\alpha(\Phi;\Phi^C)d\Phi \tag{3}$$

and is represented by region M. Similar relations can be shown based on the conventional underwriting criteria (Φ^C) with region N in Figure 3 denoting the fraction of households that are rejected from conventional lenders but do not find subprime financing attractive or do not apply for such financing. Thus, the combination of areas N and M represents the rental market. Since households in region N are lower risk than households in region M, the initial overall risk of the rental market will depend on the relative sizes of regions N and M.

As discussed above, we are interested in determining the effect of two changes observed during the recent U.S. housing bubble period: a decrease in overall household credit risk and a decline in subprime mortgage underwriting standards. First, Figure 4 illustrates the effects of a decrease in household credit risk holding mortgage underwriting standards constant. We show the impact on the owner and renter market as the distribution of household credit risk shifts from $r(\Phi)$ to $r'(\Phi)$ such that $R'(\Phi) > R(\Phi)\ \forall\ \Phi$.[2] As Φ^C and Φ^S remain fixed and $r(\Phi)$ shifts to $r'(\Phi)$ where $r(\Phi)$ first order stochastically dominates $r'(\Phi)$, then $r(\Phi)\alpha(\Phi;\Phi^C)$ decreases monotonically (represented by the dashed line in Figure 4). As a result, the number of households originating conventional mortgages increases ($X' > X$) while the fraction of households originating subprime mortgages declines ($Y'+Z' < Y+Z$). Furthermore, as more households now qualify for conventional financing, the fraction of households remaining in the rental market decline ($N'+M' < N+M$). To the extent that the fraction of households

[2]Following Ferguson and Peters (1995), the shift in the credit risk distribution implies that $R(\Phi)$ first order stochastically dominates (FOSD) $R'(\Phi)$.

who remain ineligible for conventional financing but do not select a subprime mortgage is significantly smaller ($N' << N$) than the fraction of households that do not qualify for any mortgage (M'), then the overall riskiness of the rental market increases.

In fact, N' is relatively small and worth little consideration. As noted above, area N shrinks due to the shift in $r(\Phi)$ and then normally slightly expands as a result of the downward rotation in $r(\Phi)\alpha(\Phi;\Phi^C)$ to $r'(\Phi)\alpha(\Phi;\Phi^C)$. However, during the housing bubble $\alpha(\Phi;\Phi^C)$ increased over time as subprime borrowing gained acceptance with the public and subprime premiums over conventional mortgage rates declined[3], pushing $r(\Phi)\alpha(\Phi;\Phi^C)$ in the opposite direction. The effect of this upward shift in $\alpha(\Phi;\Phi^C)$ is likely to be stronger than the shift in $r(\Phi)$, making N' almost insignificant over time.

Second, we note that during the housing bubble period mortgage underwriting standards, and subprime underwriting standards in particular, declined suggesting that Φ^S shifted to the right to $\Phi^{S'}$. Figure 5 shows the effect of these changes combined with the reduction in household credit risk. As noted above, the decrease in household credit risk as the economy expands increases the number of households who qualify for conventional mortgages thereby reducing the number of households who remain in the rental market. In addition, as the subprime underwriting criteria decline, the number of households who qualify for mortgage credit increases further reducing the size of the rental market. To the extent that the number of lower risk renters (N') is unaffected by the shift in Φ^S and remains negligible, while households in region M'' (i.e., the number of households who do not qualify for any mortgage credit) are riskier than the households in M' and M, then the overall observed riskiness of the rental population increases. In other words, if the expansion of the subprime market pulls a greater proportion of lower risk households into homeownership, then the overall risk of the remaining rental population increases. We directly test this hypothesis in the following section by examining cross sectional differences in rental population default rates controlling for changes in subprime mortgage origination activity.

[3]See Chomsisengphet and Pennington-Cross (2006) and Demyanyk and Hemert (2009) for evidence showing an overall decline in subprime interest rate premiums.

3 Empirical Analysis

3.1 Data

We now turn to an empirical analysis of the hypotheses discussed in the previous section. To measure changes in the overall risk in the rental market, we utilize the residential rent data compiled by Experian RentBureau for the period from January 2001 to December 2006.[4] RentBureau maintains a national database consisting of over 875,000 individual lease contracts originated during this period from approximately 2,000 multifamily properties (complexes). The database contains lease characteristics (lease start date, lease termination date, renter move-in date, renter move-out date, last transaction date) and property location (city, state, and zip-code). To maintain privacy, limited information is disclosed on specific property locations and individual renters. The company updates lease records every month, noting whether rent was paid on time or not, the type of payment delinquency, if applicable, the accrued number of late payments, and any write-off on rental or non-rental payments due.[5] Table 1 reports the time-series distribution of lease contracts from the properties surveyed. Over time, as RentBureau expanded its geographic coverage, new properties and locations were added to the database.

Rent payments for each lease in the database, whether active or closed, are recorded in a 24-digit vector representing the renter's payment performance over the previous 24 months from the month of reporting or the month the lease ended. The rent payments are coded in the lease's payment vector as P (on-time payment), L (late payment), N (insufficient funds or a bounced check), O (outstanding balance at lease termination), W (write-off of rent at lease termination), or U (write-off of non-rent amount owed at lease termination). Since RentBureau only maintains a 24-month payment record for each lease, the payments for those leases still active in November 2009, the last month of reporting, with a full payment

[4]RentBureau collects and updates rental information from property management companies nationwide and makes that information available to the multifamily industry.

[5]RentBureau also separately tracks collections on terminated leases.

vector are left censored.[6]

We aggregate the individual lease rental records to the metropolitan (MSA) area to study the effects of subprime activity on rental default rates. MSA numbers are added to leases using the 2009 MSA definitions published by the Office of Management and Budget (OMB).[7] We restrict the analysis to properties located in MSAs that have a minimum of 40 leases per year and to leases with rent payments greater than $100 per month. Thus, as shown in Panel B of Table 1, our sample contains 723,495 leases in 171 MSAs. Appendix A lists the MSAs included in the final sample. We then drew a random sample of 150,000 leases for the empirical analysis.

Table 2 shows the descriptive statistics for the final lease sample and reveals an interesting characteristic of the mortgage credit expansion: none of the MSAs in our sample was unaffected by the surge in subprime lending, even though some MSAs (e.g., Manchester-Nashua, NH) experienced no growth in mortgage lending during that period. However, we do see significant variation across MSAs in terms of both subprime and mortgage credit activities. For example, house prices increased at an average rate of 7.4 percent per annum with some areas, such as Riverside-San Bernardino, CA and Naples-Marco Island, FL experiencing average annual price growths of more than 12 percent during that 6-year period. Meanwhile, the average annual increases in market rent and per-capita gross personal income were 3.6 percent and 3.9 percent, respectively, highlighting the documented disconnect between house prices and these more traditional determinants of mortgage demand (Mian and Sufi, 2009). As expected, housing supply responded positively to the booming housing market.

[6]In some cases, the payment vector contains missing values. If the missing values are between two populated cells indicating on-time payments, then we record the missing values as on-time. Similarly, if the missing values occur at the end of the payment vector, we reclassify them as timely payments as long as they are posterior to the lease signing date. Otherwise, missing payments are treated as missing values, potentially biasing our rent risk measure downward.

[7]The 2009 MSA definitions are published by OMB in Bulletin No. 10-02, dated December 1, 2009. The same MSA designations are kept throughout the study.

3.2 Empirical Model

To test the hypothesis that increases in subprime mortgage activity altered the risk distribution in the rental market, we estimate a Cox proportional hazard model of lease default rate. We assume that a renter exits the rental contract either by completing the contract or by defaulting, where the time to default T is a random variable with a continuous probability distribution $f(t)$, where t is a realization of T. The cumulative probability of default is defined as

$$F(t) = \int_0^t f(s)ds \tag{4}$$

and the corresponding survival function is given as

$$S(t) = 1 - F(t) = Pr(T > t). \tag{5}$$

Thus, the probability (l) that the renter will default in the next short time interval Δ, given that the lease is still open is

$$l(t, \Delta t) = Pr(t \leq T \leq t + \Delta t | T \geq t). \tag{6}$$

The hazard rate is the function that characterizes this distribution and is defined as

$$\lambda(t) = \lim_{\Delta t \to 0} \frac{l(t, \Delta t)}{\Delta t} = \frac{f(t)}{S(t)}. \tag{7}$$

Following Cox (1972), we specify the hazard rate as

$$\lambda(t) = \exp(\beta' X)\lambda_0(t) \tag{8}$$

where λ_0 is the baseline hazard and (8) is estimated via maximum likelihood.

In order to determine whether the rental household population risk shifted in response to expansion in the subprime lending market, we follow Gross and Souleles (2002) and separate

X into components representing the subprime market, macro economic factors, and location specific factors. Specifically, we assume that X includes both time-variant and time-invariant factors:

$$\beta' X = \beta_0 + \beta_1 SUB(t) + \beta_2 Y + \beta_3 Z(t) \tag{9}$$

where *SUB(t)* represents the level of subprime activity at time t, Y represents a set of time-invariant location control factors, and $Z(t)$ is a set a time-varying macroeconomic risk factors.

In (9), we define a proxy for subprime mortgage activity as the lagged percentage of subprime originations relative to the quantity of purchase mortgage originated in the MSA (*L_SUB(t)*). We obtain micro-level mortgage data from the Home Mortgage Disclosure Act (HMDA) mortgage origination data for originated purchase loans on owner-occupied houses.[8] We identify subprime mortgages using the Department of Housing and Urban Development (HUD) lists of subprime lenders.[9] We lag the subprime measure by one year because the HMDA data are published annually and do not contain exact transaction dates. Under the hypothesis that subprime mortgage origination activity increased the risk of the rental population, we expect the marginal effect of *L_SUB(t)* on lease defaults during the 2001-2006 period to be positive.

In order to accurately isolate the effect of subprime lending on lease defaults, we control for the impact of the general growth in mortgage lending by including the lagged percentage change in the quantity of purchase mortgages originations (*LC_MRG_ORIG*). The expected

[8]Enacted by the Congress in 1975, the HMDA legislation requires lending institutions to report the mortgage applications they receive in the metropolitan statistical areas they serve to the Federal Financial Institutions Examination Council. HMDA lists mortgage originations processed by lending institutions in the various metropolitan areas they serve. The data include property locations, applicant information, loan characteristics, and ultimate purchasers of mortgage loans. (www.ffiec.gov/hmda/)

[9]The lists are accessible at http://www.huduser.org/portal/datasets/manu.html. We note that not all loans made by these lenders were subprime and some conventional mortgage lenders also were extensively involved in subprime lending. HMDA also flags high-price mortgages, which are more likely to meet the subprime qualification. But this identifier is not available prior to 2004. Thus, we use the High-price mortgage indicator to test the robustness of the results.

effect of *LC_MRG_ORIG* is ambiguous since an expansion in mortgage credit can result from positive economic shocks (Mian and Sufi, 2009) or as the result of a decline in mortgage underwriting standards (Anderson, Capozza, and Van Order, 2008).

To control for changes in macroeconomic conditions over time, we include in (9) the monthly MSA unemployment rate (*UNEMPOY*) published by Bureau of Labor and Statistics (BLS). Ceteris paribus, an increase in unemployment is expected increase the rate of lease defaults in the area, consistent with a shift in $r(\Phi)$ in Figure 5 to the right. On the other hand, a positive economic shock resulting in higher average personal income, as measured by the lagged change in the MSA's per-capita gross annual personal income (*LC_INCOME*) from Bureau of Economic Analysis (BEA), will reduce the overall household credit risk (corresponding to the leftward shift in $r(\Phi)$ to $r'(\Phi)$ in Figure (5), resulting in an increase in household movement from renter status to home ownership). We also control for the effect of changes in housing prices (*LC_HPRICE*). To the extent that serial correlation exists in the housing market, an environment of rising house prices increases the incentives to purchase a home in order to benefit from future house price increases.[10] However, higher house prices also make it more difficult for households to qualify for mortgage financing, everything else the same. We expect this second effect to dominate. For example, Ioannides and Kan (1996) find house price appreciation to discourage renters from becoming homeowners. We measure the change in house prices by the lagged change in the area's house price index (HPI) produced by the Federal Housing Finance Agency (FHFA). To measure changes in the local rental market, we include the annual change in the MSA's fair market rent (*C_MKT_RENT*).[11]

Although we do not have a direct measure of household credit quality, we do observe an indirect proxy for property quality through the level of rent paid for individual units. To the extent that household income is positively correlated with credit risk and higher

[10]Case and Shiller (1989) provide evidence consistent with the assumption that house prices are serially correlated.

[11]Fair market rent (FMR) estimates for each MSA are produced by HUD. We do not lag FRMs as they are based on the previous year rents.

quality buildings that command higher rents cater to higher income households, then we can construct a proxy of household credit quality (*CREDIT_RISK*) by taking the ratio of individual current gross lease payments to the local fair market rent (FMR). We expect *CREDIT_RISK* to be negatively related to lease defaults.

To control for changes in the demand for rental units, we include the percentage of the state's population in the 20-year to 34-year age group relative to the state's annual population (lagged by one period). We also control for overall growth in the supply of rental housing by including the number of units in multifamily building permits issued during the year in each MSA (lagged two periods to reflect typical time between permitting and construction completion).

Finally, we include in (9) a series of dummy variables to control for state and year fixed effects. The state fixed-effects control for possible systematic differences in regional economic conditions. The year fixed-effects, on the other hand, control for national factors, such as general economic and capital market conditions and changes in mortgage underwriting standards, not captured by the variables outlined above.

3.3 Results

Our analysis begins by comparing the evolution of lease defaults between low and high subprime lending areas. We classify MSAs into quartile groups according to the percentage of purchase subprime mortgage originations from 2001 to 2006. MSAs in the bottom (top) quartile are classified as low (high) subprime areas.

As a preliminary step, we examine the basic rental survival and default hazard curves. We define a lease default event as the first occurrence of a rent payment not made when due. Figure 6 displays the hazard curves of lease defaults over a 24-month observation period from 2002 to 2006 for the low and high subprime groups. As expected, the hazard curves show a steep increase in defaults during the first months, reaching a maximum at around month 5, and a slower downward trend as leases are removed from the sample after the first

default event is observed. The 2002 and 2003 hazard curves shows no major difference in lease defaults between the two groups. This is confirmed by the insignificant coefficient of *SUB_DUMMY*, indicating a high subprime MSA, for those years in Table 3. For the following years on the other hand, both Figure 6 and Table 3 show statistically higher incidences of lease defaults in the high-subprime MSAs. The lease default rates were 31%, 44%, and 28% higher in the high-subprime MSAs compared to the low-subprime MSAs in 2004, 2005, and 2006, respectively. In addition, the evolution of hazard curves in the high subprime MSAs (Figure 7) shows a pattern of increasing lease defaults coinciding with the growth in subprime lending. For example, lease contracts originated in 2002 have the lowest hazard curve while leases originated in 2006, at the peak of the subprime lending market, have the highest hazard curve.[12]

We report the coefficients from the estimation of the Cox proportional hazard model (equation (9)) in Table 4. The primary results are in column 1 and column 2, which controls for the general growth in mortgage credit. Both estimations find the marginal effects of subprime lending (*L_SUB(t)*) on lease defaults to be overwhelmingly positive and both statistically and economically significant. The estimated coefficients indicate that a 1% rise in subprime mortgage originations results in a 2% increase in the hazard rate of lease defaults. Thus, the expansion of subprime lending during that period negatively affected the performance of residential leases. In column 2, we include the growth in the overall mortgage market (*LC_MRG_ORIG*). Although the estimated coefficient is statistically significant at the 5 percent level, the marginal effect is not economically meaningful; a 1% growth in purchase mortgage originations being only associated with a 0.06% decrease in lease defaults. Thus, the results from this model confirm that it was the expansion in subprime lending and not the overall growth in mortgage lending that had the largest effect on the rental dis-

[12]The crossing of hazard curves after month 12 reflects the fact that most residential leases are for 12 months initially and are renewed only if the building manager is satisfied with the renter's performance. Since not all leases are renewed at expiration, the appropriate observation period for this analysis is 12 months. The analysis presented next is based on that observation period, but a 24-month period is used later to test the robustness of the results.

tribution. This finding is intuitive as renters were less likely to have access to conventional mortgage financing prior to the development of subprime products (Bernanke, 2007).

However, Table 4 shows that the most significant drivers of lease defaults during that period remain unemployment (*UNEMPLOY*) and house prices (*LC_HPRICE*). For example, a 1% increase in unemployment, from its average of 5.2% to 6.2%, results in a 7% increase in lease defaults. Also, lease defaults are lower in MSAs that experienced high growth in house prices. For example, a 1% rise in average house price corresponds with a 3.8% decrease in defaults. As noted, this may be due to renters having difficulty qualifying for mortgage financing in high-price growth areas. We also see that tenant credit quality (*CREDIT_RISK*) is inversely associated with rent defaults. Tenants who can afford rents 1% higher than the MSA's FMR are roughly 0.3% less likely to default. On the other hand, the marginal effects of higher market rent (*C_MKT_RENT*) and income (*LC_INCOME*) were positive and statistically significant. The coefficient of the rental supply variable is not statistically significant.

Column 3 in Table 4 restricts the analysis to leases signed in 2006, which coincide with the peak of the subprime lending market. The estimated coefficients from this model confirm the previously discussed findings, except for the larger effect of the subprime variable. As observed in Figure 7, the expansion of subprime lending appears to be associated with a rise in lease defaults in the high subprime areas well.

4 Robustness Checks

This section discusses the outcomes of the various sensitivity tests presented in Table 5. Column 1 simply repeats the model reported in column 2 of Table 4, as this model serves as our baseline for comparison. Columns 2, 3, and 4 in Table 5 test the sensitivity of the previous results to choice of mortgage origination and subprime metrics. *L_SUB_HP(t)* is percentage of subprime mortgages, mortgages flagged as high-price in the HMDA data, relative to

the quantity of purchase mortgages. *L_SUB*(t)*, *L_SUB_HP*(t)*, and *LC_MRG_ORIG*(t)* are identical to *L_SUB(t)*, *L_SUB_HP(t)*, and *LC_MRG_ORIG(t)*, respectively, except that they are based on the dollar volumes rather than the quantities of mortgage originations. The results based on these alternative metrics confirm the documented significant positive relationship between subprime lending and residential lease defaults from 2001 to 2006, hence confirming that our results are not driven by the choice of purchase mortgage or subprime metrics. The coefficients of the general change in mortgage originations, though statistically significant for the most part, remain economically insignificant. Overall, these results provide further evidence in support of the hypothesis that the expansion of subprime lending during the recent housing boom adversely affected the residential rental market. However, caution may be required when interpreting these results since the analysis does not directly control for renter characteristics. In addition, we note that we applied a conservative approach to identifying lease defaults. As noted in the section describing the rent data, missing payment records were almost always systematically reclassified as paid on time. Thus, the number of lease defaults used in the analysis is certainly lower than the actual figures, resulting in a downward bias of this study's findings.

In table 6, we report results based on different lease maturities. Our dataset tracks a 24-month payment history for each renter. However, most residential leases are 12-months. Thus, we expect that households who remain in the same unit for longer than 12-months are less risky than the overall population of renters. To confirm this finding, we estimate the rent default hazard model over the full 24-month window and find that the estimated coefficient for *L_SUB* is lower than over the first 12-months. Finally, in column 3 we estimate the hazard of default over months 13 to 24, given the household did not default or leave during the first 12-months. As expected, we now find the coefficient for *L_SUB* is not statistically significant. This indicates that long-term renter households are less sensitive to growth in the subprime mortgage market.

5 Conclusion

A large and still growing body of research has investigated the various aspects of the past mortgage expansion, particularly its subprime component, and the resulting crisis following the U.S. housing bubble. However, no study has examined the potential spillover on the residential rental market. Yet, the development of exotic mortgage products and the widespread use of risk-based pricing, along with the easing of underwriting standards, allowed households previously excluded from the mortgage market to have access to mortgage financing and achieve their lifetime objective of owning a home, to the detriment of the residential rental market as low risk renters moved into homeownership.

We document a significant positive relationship at the MSA level between residential lease defaults and the level of the subprime originations and a significant deterioration of the renter pool over time in areas with substantial subprime lending activity. Overall, our analysis demonstrates an interconnected real estate market such that an exogenous shock in one part of the market inevitably produces ripple effects on the other sectors.

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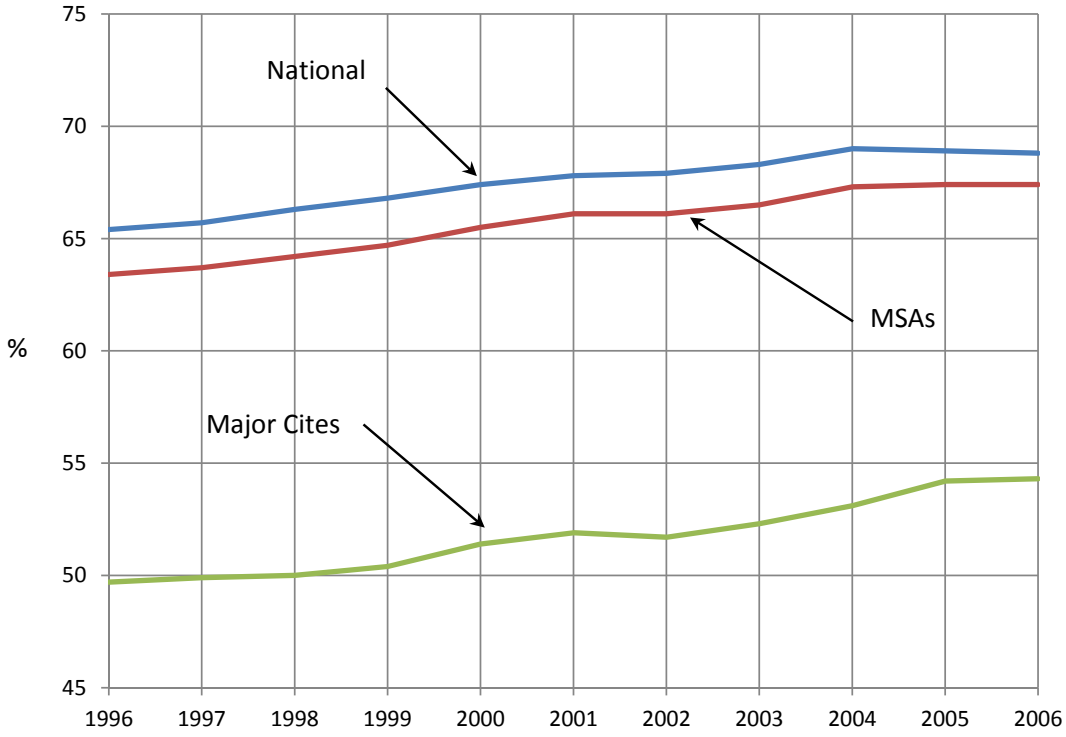

Figure 1: **Homeownership Rates**
(Source: U.S. Census Bureau)

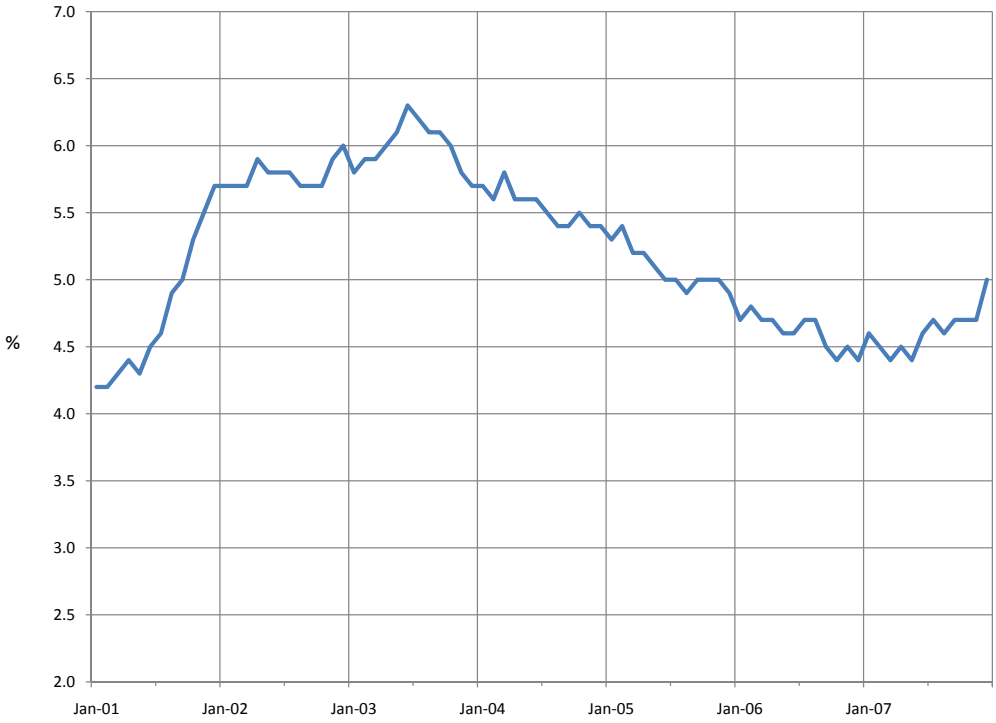

Figure 2: **Seasonally Adjusted Monthly Unemployment Rates**
(Source:Bureau of Labor Statistics)

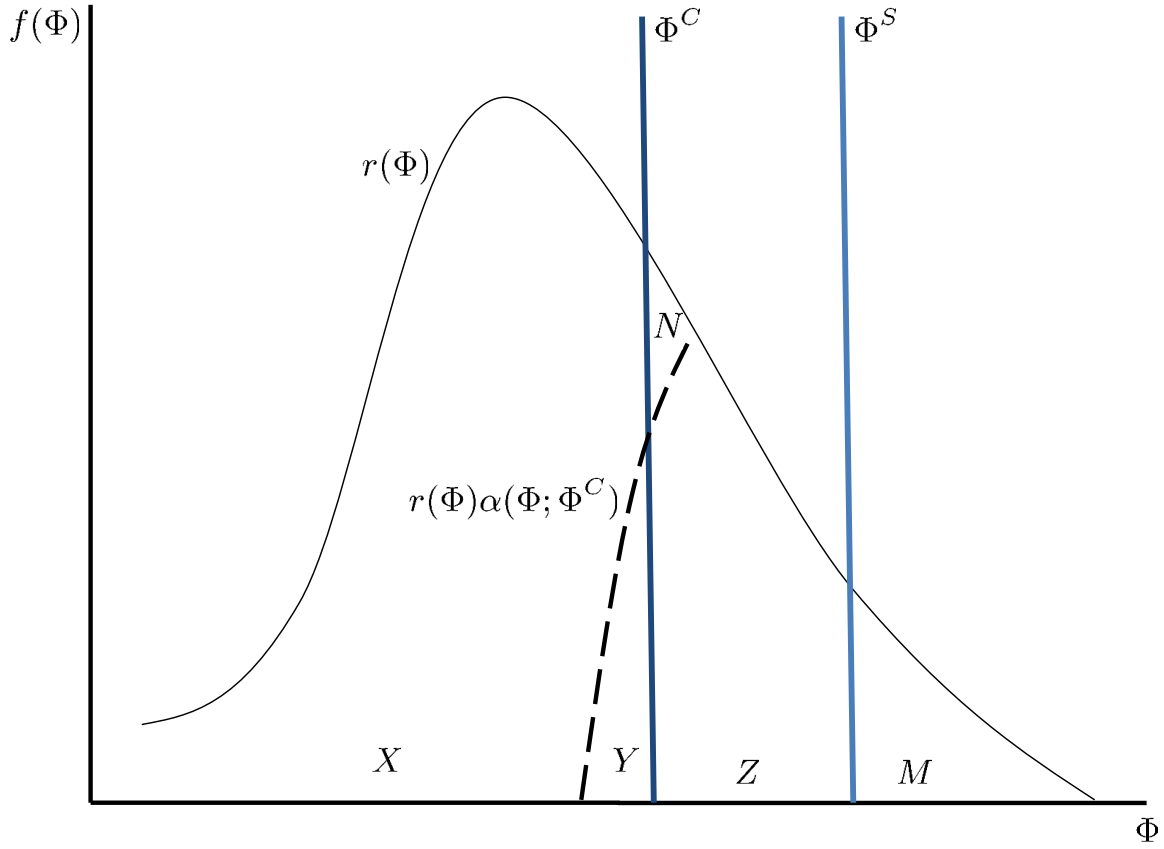

Figure 3: **The Distribution of Conventional, Subprime, and Rental Households** Note: $r(\Phi)$ = marginal probability density function of the household credit risk; $\alpha(\Phi;\Phi^C)$ =share of households with credit risk Φ that apply for subprime mortgages given conventional underwriting standards (Φ^C). Φ^S = the subprime underwriting standards; N = conventional rejections; M = subprime rejections; X = conventional mortgage originations; $Y + Z$ = subprime mortgage originations; $N + M$ = the rental market.

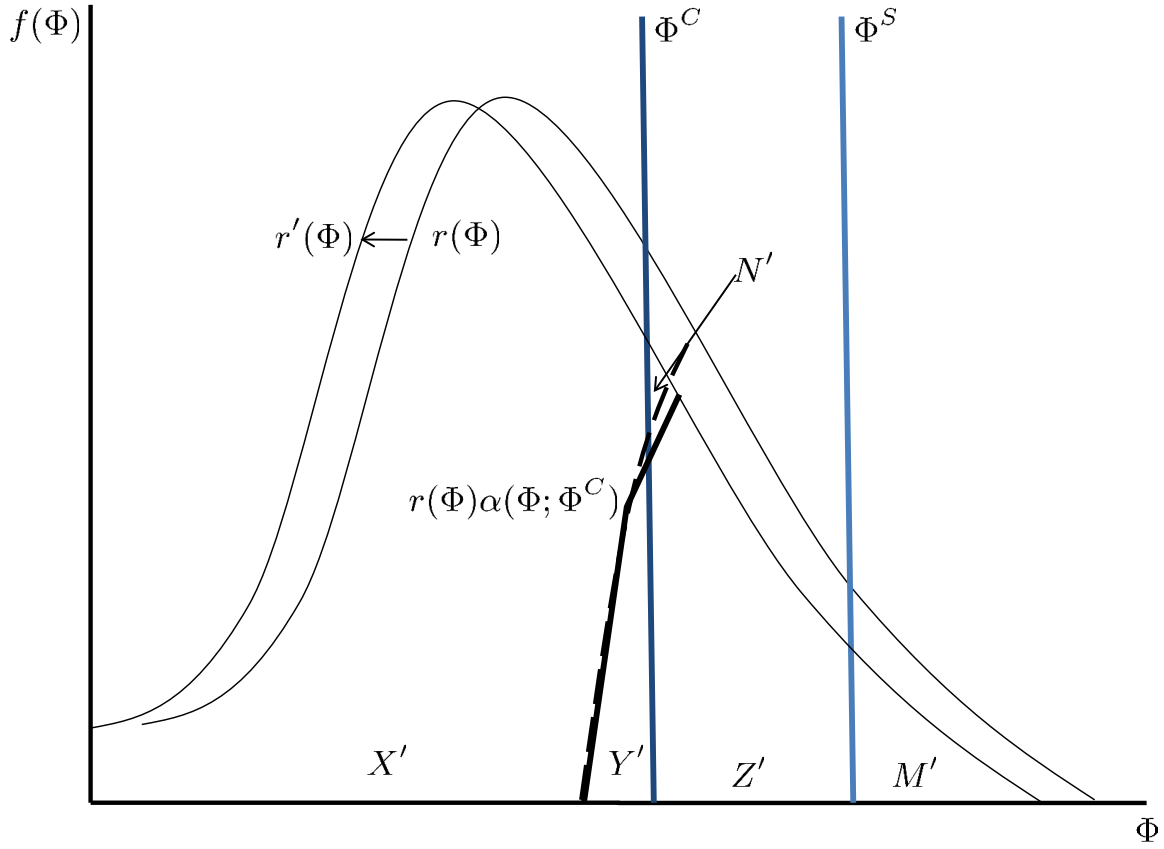

Figure 4: **The Impact of a Decrease in Household Credit Risk**
Note: $r(\Phi)$ = marginal probability density function of the household credit risk; $\alpha(\Phi;\Phi^C)$ =share of households with credit risk Φ that apply for subprime mortgages given conventional underwriting standards (Φ^C). Φ^S = the subprime underwriting standards; N' = conventional rejections; M' = subprime rejections; X' = conventional mortgage originations; $Y' + Z'$ = subprime mortgage originations; $N' + M'$ = the rental market.

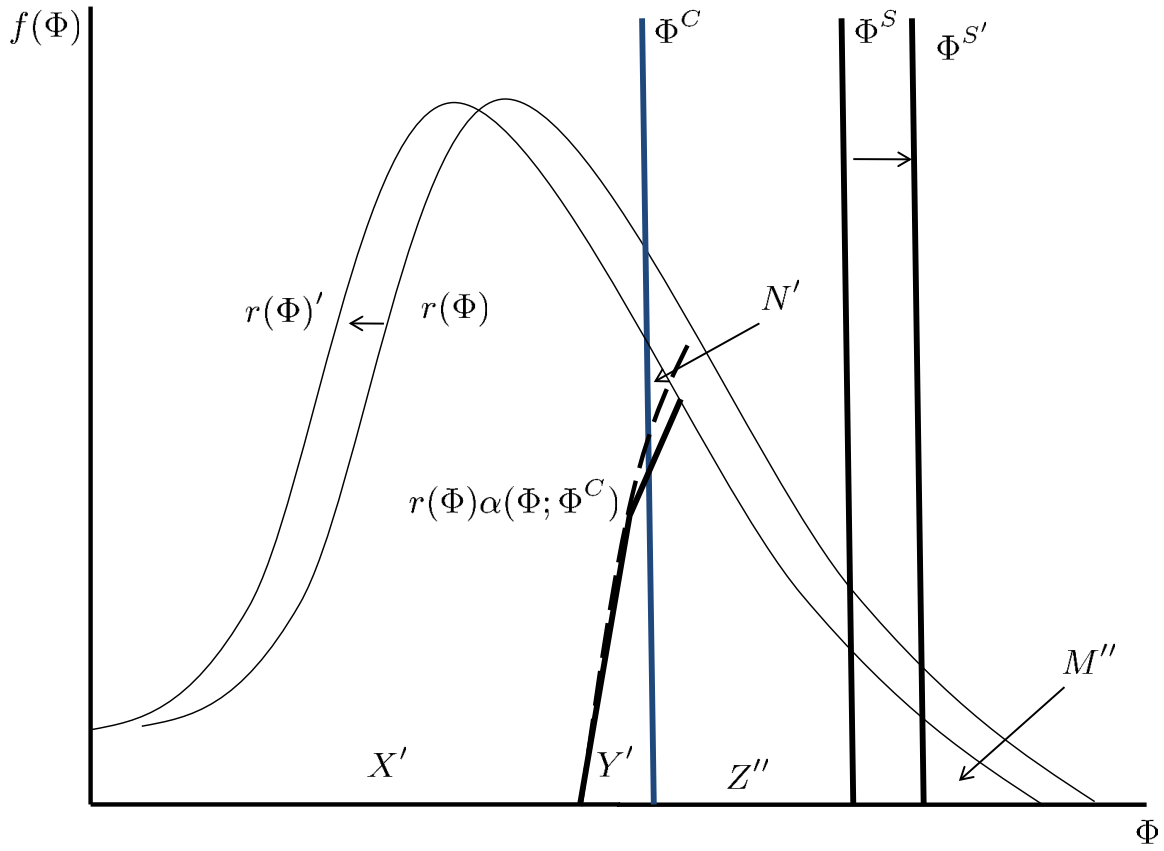

Figure 5: **The Impact of a Decrease in Household Credit Risk and a Relaxation in Subprime Lending Standards**
Note: $r(\Phi)$ = marginal probability density function of the household credit risk; $\alpha(\Phi;\Phi^C)$ =share of households with credit risk Φ that apply for subprime mortgages given conventional underwriting standards (Φ^C). Φ^S = the subprime underwriting standards; N' = conventional rejections; M' = subprime rejections; X' = conventional mortgage originations; $Y' + Z'$ = subprime mortgage originations; $N' + M'$ = the rental market.

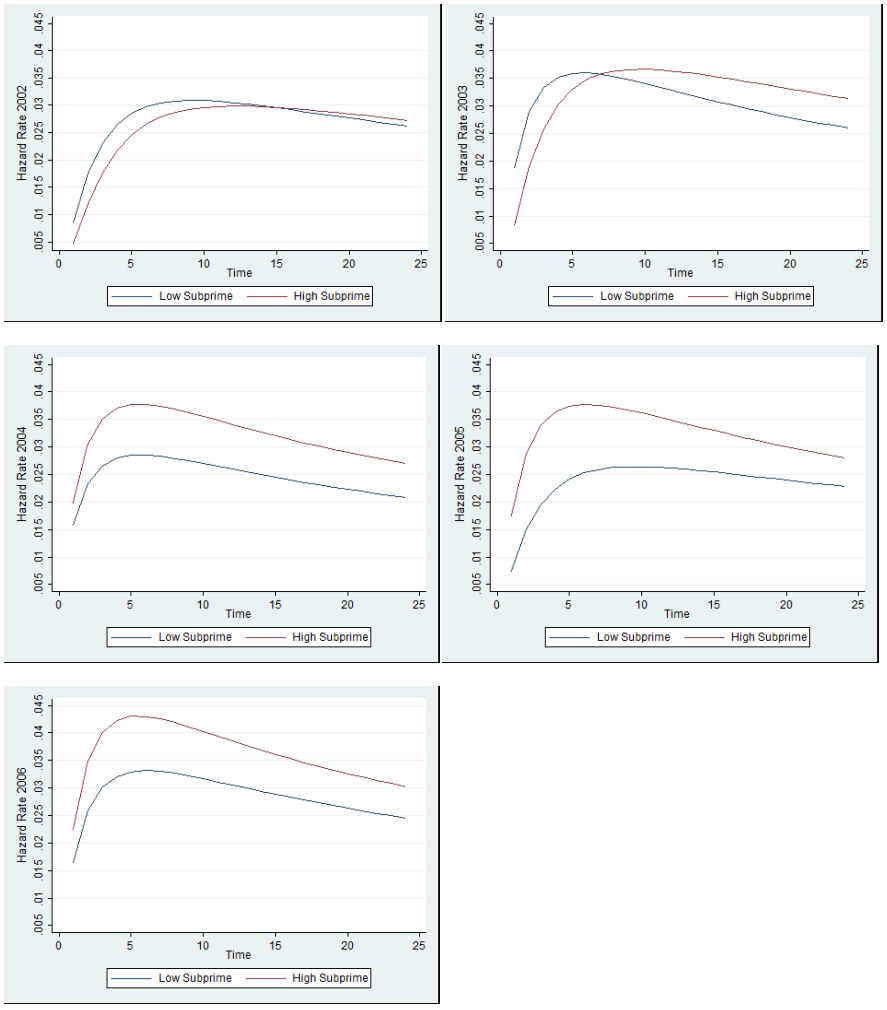

Figure 6: **Lease Hazard Curves in Low and High Subprime MSAs from 2002 to 2006, assuming a lognormal distribution.** (MSAs are classified according to the percentage of purchase subprime mortgages originations from 2001 to 2006. Low subprime MSAs are those in the 1st quartile whereas high subprime MSAs are those in the 4th quartile.)

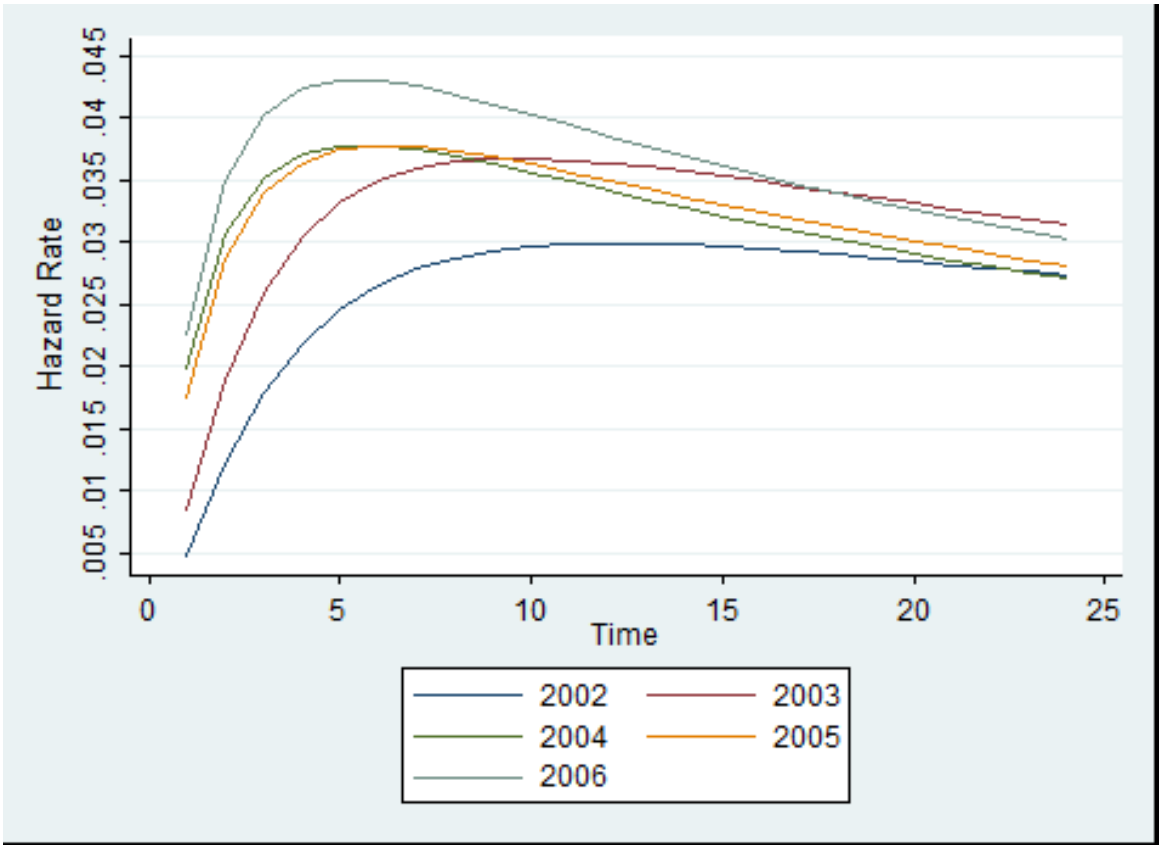

Figure 7: **Evolution of Lease Hazard Curves in High Subprime MSAs, Assuming a Lognormal Distribution.** (MSAs are classified according to the percentage of purchase subprime mortgages originations from 2001 to 2006. Low subprime MSAs are those in the 1st quartile whereas high subprime MSAs are those in the 4th quartile.)

Table 1: Distribution of Leases by Origination Year

	2001	*2002*	*2003*	*2004*	*2005*	*2006*	*Total*
Original Data							
Leases	46,820	57,138	102,926	145,661	216,377	306,894	875,816
Properties	1,110	1,364	1,695	2,103	2,652	2,993	
Final Sample							
MSAs	40	79	98	120	140	150	
Leases							
No. of leases	31,186	48,543	77,176	129,576	187,788	249,226	723,495
Leases Per MSA	780	614	788	1,080	1,341	1,662	
Min No. of Leases	46	40	43	40	40	42	
Max No. of Leases	6,989	9,092	13,624	21,081	27,060	27,174	

Note: Leases are classified by cohort year, the year of the first rental payment reported by RentBureau, which is not necessarily the year of the first payment under the lease. For each cohort year, only MSAs with at least 40 leases are retained, resulting in the final sample containing 171 MSAs, listed in the Appendix (Source: RentBureau)

Table 2: Descriptive Statistics

Variable	Description	Mean	Std. Dev.	Min	Max
L_SUB	Percentage of subprime mortgages relative to the number of purchase mortgages originated in the MSA during the year (lagged 1 period).	17.27%	5.65%	6.31%	35.86%
LC_MRG_ORIG	Percentage change in the number of purchase mortgages originated in the MSA during the year (lagged 1 period).	10.12%	6.86%	-13.49%	28.52%
UNEMPLOY	Monthly unemployment rate in the MSA.	5.19%	1.26%	3.30%	10.59%
LC_INCOME	Percentage change in per-capita annual income in the MSA (lagged 1 period).	3.92%	1.17%	0.56%	8.87%
LC_HPRICE	Percentage change in the MSA's quarterly HPI (lagged 1 period).	1.85%	1.00%	0.57%	4.13%
CREDIT_RISK	Tenant credit risk (Contracted Rent / Fair Market Rent at lease origination).	116.51%	19.27%	74.96%	170.09%
C_MKT_RENT	Percentage change in the MSA's annual Fair Market Rent.	3.61%	1.81%	-1.14%	11.18%
L_SUPPLY_MULT	Number of units in multifamily building permits issued during the year in the MSA (lagged 2 periods and logged).	1741	3183	0	16930
L_RENTER_POP	Percentage of population in the 20- to 34-year age group relative to the state's annual popution (lagged 1 period).	20.48%	1.62%	17.54%	26.72%

Note: These statistics are based on MSA or state averages from January 2001 to December 2006.

Table 3: Simple Hazard Analysis

	2002	*2003*	*2004*	*2005*	*2006*
SUB_DUMMY	0.9281	0.9932	1.3069***	1.4421***	1.2811***
	(-1.17)	*(-0.16)*	*(8.23)*	*(14.13)*	*(12.07)*
N	2,484	4,894	9,350	15,240	22,623
LR Chi2	1.37	0.02	67.7	199.6	145.6

Note: *SUB_DUMMY* is set equal to 1 in high subprime MSAs and 0 otherwise. MSAs are classified according to the percentage of purchase subprime mortgages originations in the area from 2001 to 2006. Low subprime MSAs are those in the 1st quartile whereas high subprime MSAs are areas in the 4th quartile. The reported figures are the marginal effect of *SUB_DUMMY* on the hazard rate with the t-statistics in parentheses ($*$ p < 0.10, $**$ p < 0.05, $***$ p < 0.01).

Table 4: Cox Proportional Hazard Model of Lease Defaults

	(1)	*(2)*	*(3)*
			2006 Cohort
L_SUB	1.0201***	1.0211***	1.0223***
	(16.89)	*(16.78)*	*(10.73)*
LC_MRG_ORIG		0.9994**	0.9920***
		(-2.56)	*(-12.56)*
UNEMPLOY	1.0724***	1.0697***	1.0700***
	(10.76)	*(10.24)*	*(7.28)*
LC_HPRICE	0.9620***	0.9627***	0.9906*
	(-10.64)	*(-10.41)*	*(-1.80)*
CREDIT_RISK	0.9972***	0.9973***	0.9977***
	(-19.41)	*(-19.38)*	*(-13.30)*
C_MKT_RENT	1.0022**	1.0018*	1.0018
	(2.25)	*(1.82)*	*(1.36)*
LC_INCOME	1.0128***	1.0138***	1.0258***
	(4.44)	*(4.74)*	*(5.59)*
L_ SUPPLY_MULT	0.9980	0.9973	0.9998
	(-0.79)	*(-1.06)*	*(-0.06)*
L_RENTER_POP	1.0395	1.0275	0.9892
	(1.27)	*(0.87)*	*(-0.11)*
DUMMY_2002	1.0064	0.9725	
	(0.15)	*(-0.63)*	
DUMMY_2003	1.0879**	1.0599	
	(2.09)	*(1.4)*	
DUMMY_2004	1.4577***	1.4060***	
	(9.75)	*(8.33)*	
DUMMY_2005	1.6436***	1.5700***	
	(12.56)	*(10.5)*	
DUMMY_2006	1.8871***	1.8310***	
	(15.6)	*(14.37)*	
State Dummies	*Yes*	*Yes*	*Yes*
Num. Observations	*149998*	*149998*	*90558*
Wald Chi2	*1452.7*	*1456.3*	*587.2*

Note: These Cox proportional hazard model estimations of lease defaults are based on a 12-month observation period from lease origination. Columns *(1)* and *(2)* use all leases in the sample for the 6-year period from January 2001 to December 2006. Column*(3)* only reflects leases originated in 2006. *L_SUB(t)* is the lagged percentage of quantity of purchase mortgages from HMDA originated in the MSA by HUD subprime lenders. *LC_MRG_ORIG(t)* represents the lagged percentage change in the quantity of purchase mortgages from HMDA originated in the MSA. The above figures are the estimated marginal effects of the explanatory variables. The robust t-statistics are noted below with 1, 2, and 3 stars indicating statistical significance at 10%, 5%, and 1%, respectively.

Table 5: Model Estimations Based on Various Subprime Metrics

	(1)	*(2)*	*(3)*	*(4)*
L_SUB	1.0211***			
	(16.78)			
L_SUB_HP		1.0161***		
		(16.86)		
*L_SUB**			1.0225***	
			(14.64)	
*L_SUB_HP**				1.0159***
				(14.66)
LC_MRG_ORIG	0.9994**	0.9993***		
	(-2.56)	*(-2.79)*		
*LC_MRG_ORIG**			0.9992***	0.9994***
			(-3.24)	*(-2.71)*
UNEMPLOY	1.0697***	1.0694***	1.0676***	1.0702***
	(10.24)	*(10.32)*	*(9.82)*	*(10.4)*
LC_HPRICE	0.9627***	0.9684***	0.9630***	0.9689***
	(-10.41)	*(-8.76)*	*(-10.29)*	*(-8.56)*
CREDIT_RISK	0.9973***	0.9973***	0.9973***	0.9973***
	(-19.38)	*(-19.32)*	*(-19.30)*	*(-19.24)*
C_MKT_RENT	1.0018*	1.0016	1.0004	1.0005
	(1.82)	*(1.61)*	*(0.37)*	*(0.51)*
LC_INCOME	1.0138***	1.0115***	1.0124***	1.0096***
	(4.74)	*(4.00)*	*(4.27)*	*(3.35)*
L_ SUPPLY_MULT	0.9973	0.9997	0.9981	0.9997
	(-1.06)	*(-0.12)*	*(-0.76)*	*(-0.11)*
L_RENTER_POP	1.0275	1.0644**	1.0503	1.0850***
	(0.87)	*(2.07)*	*(1.60)*	*(2.74)*
DUMMY_2002	0.9725	0.9299*	0.9126**	0.8891***
	(-0.63)	*(-1.65)*	*(-2.12)*	*(-2.74)*
DUMMY_2003	1.0599	0.9911	0.9517	0.9138**
	(1.40)	*(-0.22)*	*(-1.25)*	*(-2.32)*
DUMMY_2004	1.4060***	1.2932***	1.2131***	1.1644***
	(8.33)	*(6.48)*	*(5.05)*	*(4.02)*
DUMMY_2005	1.5700***	1.3452***	1.3165***	1.2080***
	(10.50)	*(7.19)*	*(6.87)*	*(4.76)*
DUMMY_2006	1.8310***	1.4334***	1.5397***	1.3010***
	(14.37)	*(8.86)*	*(10.92)*	*(6.57)*
State Dummies	*Yes*	*Yes*	*Yes*	*Yes*
Num. Observations	*149998*	*149998*	*149998*	*149998*
Wald Chi2	*1456.3*	*1431.3*	*1371.5*	*1352.1*

Note: These Cox proportional hazard model estimations of lease defaults are based on a 12-month observation period from lease origination and use all leases in the sample for the 6-year period from January 2001 to December 2006. *L_SUB(t)* is the lagged percentage of quantity of purchase mortgages from HMDA originated in the MSA by HUD subprime lenders, whereas *L_SUB_HP(t)* is the lagged percentage of quantity of purchase mortgage originations in the MSA classified as high-price mortgage in the HMDA data. *LC_MRG_ORIG(t)* represents the lagged percentage change in the quantity of purchase mortgage originations from HMDA in the MSA. *L_SUB*(t)*, *SUB_HP*(t)*, and *LC_MRG_ORIG*(t)* are the corresponding variables based on the volumes, rather than the quantities, of purchase mortgage originations. The above figures are the estimated marginal effects of the explanatory variables. The robust t-statistics are noted below with 1, 2, and 3 stars indicating statistical significance at 10%, 5%, and 1%, respectively.

Table 6: Estimations Based on Various Lease Observation Periods

	(1)	*(2)*	*(3)*
	01-12 mo.	*01-24 mo.*	*13-24 mo.*
L_SUB	1.0211***	1.0202***	1.0274
	(16.78)	*(19.69)*	*(1.32)*
LC_MRG_ORIG	0.9994**	1.0005**	1.0019
	(-2.56)	*(2.43)*	*(0.35)*
UNEMPLOY	1.0697***	1.0376***	1.1955*
	(10.24)	*(6.87)*	*(1.91)*
LC_HPRICE	0.9627***	0.9906***	1.0234
	(-10.41)	*(-3.36)*	*(0.53)*
CREDIT_RISK	0.9973***	0.9968***	0.9958**
	(-19.38)	*(-25.46)*	*(-2.33)*
C_MKT_RENT	1.0018*	1.0036***	0.9953
	(1.82)	*(4.13)*	*(-0.29)*
LC_INCOME	1.0138***	1.0121***	1.0699*
	(4.74)	*(5.00)*	*(1.81)*
L_SUPPLY_MULT	0.9973	0.9995	1.0399
	(-1.06)	*(-0.21)*	*(1.08)*
L_RENTER_POP	1.0275	0.9567*	0.9213
	(0.87)	*(-1.71)*	*(-0.18)*
DUMMY_2002	0.9725	1.2685***	0.3825**
	(-0.63)	*(6.66)*	*(-2.20)*
DUMMY_2003	1.0599	1.3930***	0.5107*
	(1.40)	*(9.82)*	*(-1.85)*
DUMMY_2004	1.4060***	1.7094***	0.6531
	(8.33)	*(15.86)*	*(-0.84)*
DUMMY_2005	1.5700***	1.7676***	0.6076
	(10.5)	*(16.12)*	*(-1.25)*
DUMMY_2006	1.8310***	1.974***	0.7159
	(14.37)	*(18.57)*	*(-0.69)*
State Dummies	*Yes*	*Yes*	*Yes*
Num. Observations	*149998*	*149998*	*3960*
Wald Chi2	*1456.3*	*1529*	*23.9*

Note: The Cox proportional hazard model estimations of lease defaults are for a 12-month period from lease origination date for column *(1)*, a 24-month period for column *(2)*, and for the second 12-month period from lease origination date for column *(3)*. Columns *(1)* and *(2)* are based on all leases originated in the 6-year period from January 2001 to December 2006, whereas column*(3)* only includes leases that have survived the first 12 months. *L_SUB(t)* is the lagged percentage of the quantity of purchase mortgages from HMDA originated in the MSA by HUD subprime lenders. *LC_MRG_ORIG(t)* represents the lagged percentage change in the quantity of purchase mortgage originations in the MSA from HMDA. These above figures are the estimated marginal effects of the explanatory variables. The robust t-statistics are noted below with 1, 2, and 3 stars indicating statistical significance at 10%, 5%, and 1%, respectively.

Appendix:

Table 7: List of MSAs in the Data Sample

No.	FIPS	Name	State	No.	FIPS	Name	State
1	10180	Abilene	TX	72	31420	Macon	GA
2	11100	Amarillo	TX	73	31700	Manchester-Nashua	NH
3	11340	Anderson	SC	74	32820	Memphis	AR
4	11460	Ann Arbor	MI	75	33100	Miami-Fort Lauderdale-Pompano Beach	FL
5	11700	Asheville	NC	76	33260	Midland	TX
6	12020	Athens-Clarke County	GA	77	33460	Minneapolis-St. Paul-Bloomington	MN
7	12060	Atlanta-Sandy Springs-Marietta	GA	78	33660	Mobile	AL
8	12220	Auburn-Opelika	AL	79	33780	Monroe	MI
9	12260	Augusta-Richmond County	GA	80	33860	Montgomery	AL
10	12580	Baltimore-Towson	MD	81	34900	Napa	CA
11	12940	Baton Rouge	LA	82	34940	Naples-Marco Island	FL
12	13140	Beaumont-Port Arthur	TX	83	34980	Nashville-DavidsonMurfreesboro	TN
13	13380	Bellingham	WA	84	36100	Ocala	FL
14	13820	Birmingham-Hoover	AL	85	36220	Odessa	TX
15	14020	Bloomington	IN	86	36540	Omaha-Council Bluffs	NE
16	14260	Boise City-Nampa	ID	87	36740	Orlando-Kissimmee-Sanford	FL
17	14460	Boston-Cambridge-Quincy	MA	88	36980	Owensboro	KY
18	14500	Boulder	CO	89	37100	Oxnard-Thousand Oaks-Ventura	CA
19	14540	Bowling Green	KY	90	37340	Palm Bay-Melbourne-Titusville	FL
20	14860	Bridgeport-Stamford-Norwalk	CT	91	37460	Panama City-Lynn Haven-Panama City Beach	FL
21	15180	Brownsville-Harlingen	TX	92	37700	Pascagoula	MS
22	15260	Brunswick	GA	93	37860	Pensacola-Ferry Pass-Brent	FL
23	16580	Champaign-Urbana	IL	94	37980	Philadelphia-Camden-Wilmington	DE
24	16700	Charleston-North Charleston-Summerville	SC	95	38060	Phoenix-Mesa-Glendale	AZ
25	16740	Charlotte-Gastonia-Rock Hill	NC	96	38860	Portland-South Portland-Biddeford	ME
26	16860	Chattanooga	TN	97	38900	Portland-Vancouver-Hillsboro	OR
27	16980	Chicago-Joliet-Naperville	IL	98	39100	Poughkeepsie-Newburgh-Middletown	NY
28	17140	Cincinnati-Middletown	OH	99	39300	Providence-New Bedford-Fall River	MA
29	17300	Clarksville	TN	100	39580	Raleigh-Cary	NC
30	17460	Cleveland-Elyria-Mentor	OH	101	39900	Reno-Sparks	NV
31	17780	College Station-Bryan	TX	102	40060	Richmond	VA
32	17820	Colorado Springs	CO	103	40140	Riverside-San Bernardino-Ontario	CA
33	17900	Columbia	SC	104	40220	Roanoke	VA
34	17980	Columbus	GA	105	40900	SacramentoArden-ArcadeRoseville	CA
35	18140	Columbus	OH	106	40980	Saginaw-Saginaw Township North	MI

Continued on the next page

No.	FIPS	Name	State	No.	FIPS	Name	State
36	18580	Corpus Christi	TX	107	41500	Salinas	CA
37	19100	Dallas-Fort Worth-Arlington	TX	108	41620	Salt Lake City	UT
38	19140	Dalton	GA	109	41700	San Antonio-New Braunfels	TX
39	19380	Dayton	OH	110	41740	San Diego-Carlsbad-San Marcos	CA
40	19660	Deltona-Daytona Beach-Ormond Beach	FL	111	41860	San Francisco-Oakland-Fremont	CA
41	19780	Des Moines-West Des Moines	IA	112	41940	San Jose-Sunnyvale-Santa Clara	CA
42	19820	Detroit-Warren-Livonia	MI	113	42020	San Luis Obispo-Paso Robles	CA
43	21340	El Paso	TX	114	42220	Santa Rosa-Petaluma	CA
44	21780	Evansville	IN	115	42340	Savannah	GA
45	22180	Fayetteville	NC	116	42660	Seattle-Tacoma-Bellevue	WA
46	22380	Flagstaff	AZ	117	42680	Sebastian-Vero Beach	FL
47	23540	Gainesville	FL	118	43100	Sheboygan	WI
48	23580	Gainesville	GA	119	43340	Shreveport-Bossier City	LA
49	24660	Greensboro-High Point	NC	120	43780	South Bend-Mishawaka	IN
50	24780	Greenville	NC	121	43900	Spartanburg	SC
51	24860	Greenville-Mauldin-Easley	SC	122	44140	Springfield	MA
52	25620	Hattiesburg	MS	123	44700	Stockton	CA
53	26100	Holland-Grand Haven	MI	124	44940	Sumter	SC
54	26420	Houston-Sugar Land-Baytown	TX	125	45220	Tallahassee	FL
55	26620	Huntsville	AL	126	45300	Tampa-St. Petersburg-Clearwater	FL
56	26900	Indianapolis-Carmel	IN	127	45780	Toledo	OH
57	27180	Jackson	TN	128	46060	Tucson	AZ
58	27260	Jacksonville	FL	129	46140	Tulsa	OK
59	28020	Kalamazoo-Portage	MI	130	46340	Tyler	TX
60	28660	Killeen-Temple-Fort Hood	TX	131	46660	Valdosta	GA
61	28700	Kingsport-Bristol-Bristol	TN	132	46700	Vallejo-Fairfield	CA
62	28940	Knoxville	TN	133	47020	Victoria	TX
63	29460	Lakeland-Winter Haven	FL	134	47260	Virginia Beach-Norfolk-Newport News	VA
64	29620	Lansing-East Lansing	MI	135	47580	Warner Robins	GA
65	29820	Las Vegas-Paradise	NV	136	47900	Washington-Arlington-Alexandria	DC
66	30460	Lexington-Fayette	KY	137	47940	Waterloo-Cedar Falls	IA
67	30780	Little Rock-North Little Rock-Conway	AR	138	48620	Wichita	KS
68	31100	Los Angeles-Long Beach-Santa Ana	CA	139	48660	Wichita Falls	TX
69	31140	Louisville/Jefferson County	KY	140	49180	Winston-Salem	NC
70	31180	Lubbock	TX	141	49340	Worcester	MA
71	31340	Lynchburg	VA	142	49700	Yuba City	CA