House Prices, Home Equity-Based Borrowing, and the U.S. Household Leverage Crisis*

Atif Mian
University of California, Berkeley and NBER

Amir Sufi
University of Chicago Booth School of Business and NBER

April 2010

Abstract

Using individual-level data on homeowner debt and defaults from 1997 to 2008, we show that borrowing against the increase in home equity by *existing* homeowners is responsible for a significant fraction of both the rise in U.S. household leverage from 2002 to 2006 and the increase in defaults from 2006 to 2008. Employing land topology-based housing supply elasticity as an instrument for house price growth, we estimate that the average homeowner extracts 25 cents for every dollar increase in home equity. Home equity-based borrowing is stronger for younger households, households with low credit scores, and households with high initial credit card utilization rates. Money extracted from increased home equity is *not* used to purchase new real estate or pay down high credit card balances, which suggests that borrowed funds may be used for real outlays. Lower credit quality households living in high house price appreciation areas experience a relative decline in default rates from 2002 to 2006 as they borrow heavily against their home equity, but experience very high default rates from 2006 to 2008. Our conservative estimates suggest that home equity-based borrowing added $1.25 trillion in household debt, and accounts for at least 39% of new defaults from 2006 to 2008.

*We thank Neil Bhutta, Erik Hurst, Andreas Lehnert, Sydney Ludvigson, Jeremy Stein, Francesco Trebbi, Robert Vishny, and seminar participants at Boston College, the University of British Columbia, the University of California—Berkeley, the University of Chicago, Harvard Business School, Duke University, Princeton University, New York University, Wharton, London Business School, the London School of Economics, and the NBER Monetary Economics, Risk and Financial Institutions, and Aggregate Implications of Microeconomic Behavior sessions for comments. We are grateful to the National Science Foundation and the Initiative on Global Markets at the University of Chicago Booth School of Business for funding. Mian(773) 965 5214, atif@haas.berkeley.edu; Sufi: (773) 702 6148, amir.sufi@chicagobooth.edu

U.S. household leverage sharply increased in the years preceding the 2007 economic recession. The top panel of Figure 1 shows the steady rise in household debt since 1975, which accelerated beginning in 2002. In just five years, the household sector doubled its debt balance. In comparison, the contemporaneous increase in corporate debt was modest. The middle panel shows that the increase in household debt from 2002 to 2007 translated into a striking rise in household leverage as measured by the debt to income ratio. During the same time period, corporate leverage declined. The dramatic absolute and relative rise in U.S. household leverage from 2002 to 2007 is unprecedented compared to the last 25 years.

One reason for the rapid expansion in household leverage during this period is that mortgage credit became more easily available to new home buyers (Mian and Sufi (2009)). However, strong house price appreciation from 2002 to 2006, which may have been fueled by the availability of mortgage credit to a riskier set of new home buyers, could also have had an important feedback effect on household leverage through *existing homeowners*. Given that 65% of U.S. households already owned their primary residence before the acceleration in house prices, the feedback from house prices to borrowing may be an important source of the rapid rise in household leverage that preceded the economic downturn.

Our central goals in this study are to estimate how homeowner borrowing responded to the increase in house prices and to identify which homeowners respond most aggressively. We examine this *home equity-based borrowing channel* using a data set consisting of anonymous individual credit files of a national consumer credit bureau agency. We follow a random sample of over 74,000 U.S. homeowners (who owned their homes as of 1997) at an annual frequency from the end of 1997 until the end of 2008.

The bottom panel of Figure 1 plots the growth in debt of 1997 homeowners over time and shows that existing homeowners borrow significantly more debt as their house prices appreciate

from 2002 to 2006. While the aggregate trend is suggestive of a link, changes in house prices and homeowner borrowing may be jointly determined by an omitted variable such as a shock to expected income growth (Attanasio and Weber (1994), Muellbauer and Murphy (1997)). As a result, proper identification of the effect of house prices on borrowing requires an exogenous source of variation in house price growth.

We use two different instruments for house price growth, one based on across-MSA variation and another based on within-MSA variation. The across-MSA specification uses housing supply elasticity at the MSA level as an instrument for house prices. MSAs with elastic housing supply should experience only modest increase in house prices in response to large shifts in the demand for housing because housing supply can be expanded relatively easily. In contrast, inelastic housing supply MSAs should experience large house price changes in response to the same housing demand shock (Glaeser, Gyourko, and Saiz (2008)).

We confirm this relationship in our data using the land-topology based measure of housing supply elasticity introduced by Saiz (2010) as an instrument. The across-MSA instrumental variables estimate suggests an elasticity of borrowing with respect to increased home equity of 0.52, or borrowing of 25 cents on for every dollar gain in home equity from 2002 to 2006.[1] Our within-MSA estimates using the fraction of subprime borrowers in a zip code interacted with MSA elasticity as an instrument for house price growth reveals similar estimates.

The home-equity based borrowing channel is not uniform across households. Homeowners with high credit card utilization rates and low initial credit scores have the strongest tendency to borrow against an increase in home equity. In fact, we find no effect of house prices on borrowing for homeowners in the top quartile of credit score distribution. These results suggest the presence of credit constraints at the household level under the assumption that

[1]A concern with our IV specification might be that MSAs with inelastic housing supply received differential non-house price related credit shocks during the boom years (e.g. higher permanent income shocks). However, we show through a number of tests that this does not appear to be the case. See section II for more details.

low credit scores and high credit card utilization rates proxy for borrowing difficulty. However, these same characteristics may also proxy for individuals with self-control problems.[2] Finally, contrary to predictions of a standard life cycle-based borrowing model, we find that the home equity-based borrowing channel is stronger for younger homeowners.

The real effects of the home equity-based borrowing channel depend on what households do with the borrowed money. We find no evidence that borrowing in response to increased house prices is used to purchase new homes or investment properties. In fact, home equity-based borrowing is not used to pay down expensive credit card balances, even for households with a heavy dependence on credit card borrowing. Given the high cost of keeping credit card balances, this result suggests a high marginal private return to borrowed funds.

The increase in leverage due to the home equity-based borrowing channel plays an important role in the ensuing financial crisis. Our data contain information on defaults, and we show that borrowing against rising home equity is accompanied by a relative decline in default rates from 2002 to 2006, especially for low credit score and high credit card utilization homeowners. However, the relative decline in default rate begins to reverse starting in 2006. By the end of 2008, the default rate of homeowners experiencing house price growth from 2002 to 2006 skyrockets past homeowners experiencing no previous house price appreciation.

Our random sample of the entire U.S. population allows us to use our microeconomic estimates to calculate the aggregate impact of the home equity-based borrowing channel. Our conservative estimate is that a total of $1.25 trillion of the rise in household debt from 2002 to 2006 is attributable to existing homeowners borrowing against the increased value of their homes. We also estimate that at least 39% of total new defaults seen between 2006 and 2008 are from 1997 homeowners who borrowed aggressively against the rising value of their houses.

[2] Like much of the previous literature (e.g., Gross and Souleles (2002)), we do not attempt to distinguish liquidity constraints from self-control problems, which we believe is a fruitful avenue for future research.

Our findings are related to research on the effect of house price growth on consumption, refinancing, and borrowing behavior (Hurst and Stafford (2004), Lehnert, Andreas (2004), Case, Quigley, and Shiller (2005), Haurin and Rosenthal (2006), Campbell and Cocco (2007), Greenspan and Kennedy (2007), Cooper (2009), Bostic, Gabriel, and Painter (2009)). Our results complement this research by using a novel data set and a novel empirical strategy to isolate the effect of house prices on borrowing. We believe that the empirical strategy we utilize is of first-order importance given that house prices, borrowing behavior, and consumption are likely jointly driven by unobservable permanent income shocks.

I. Data and Summary Statistics

A. Data

The final data set used in our analysis consists of detailed credit report information from Equifax for 74,149 homeowners in 2,307 zip codes located in 68 MSAs. The initial random sample includes a total of 266,005 individuals that live in 3,079 zip codes located in 95 MSAs covered by the Fiserv Case Shiller Weiss zip code level house price indices as of 1997. We choose to focus on the FCSW zip codes given the importance of zip code level house prices in our empirical tests. As noted in Mian and Sufi (2009), these zip codes represent over 45% of aggregate home debt outstanding. Within these zip codes, we randomly sample individuals at a rate of 0.45% per zip code. Given the importance of housing supply elasticity as an instrument for house price growth, we further limit the sample to zip codes located within an MSA covered by the Saiz (2010) topography-based elasticity measure. This reduces the sample to 208,119 individuals within 2,340 zip codes in 68 MSAs.[3]

The Equifax data do not contain an explicit measure of homeownership. Instead, we measure homeownership by splitting the sample into three groups of individuals based on 1997

[3] In an unreported robustness test, we match the remaining FCSW zip codes to the closest MSA covered by the Saiz (2010) measure. The results are similar.

credit report information. The first group (34%) contains individuals that have mortgage or home equity debt outstanding. The second group (8%) contains individuals that do not currently have mortgage or home equity debt outstanding, but their credit report indicates that they have had a mortgage or home equity account in the past. The third group (58%) contains individuals that do not have either a current or previous mortgage account. We define as "1997 homeowners" individuals in the first two groups.[4]

The rate of homeownership among individuals in the credit report data (42%) is significantly lower than the fraction of households that own their primary residence in census data (65%). We believe that this difference is driven by the fact that our measures are for individuals, not for households. As a result, individuals with no current or previous mortgage debt that live in a home in which some other individual has mortgage debt will not be counted as a homeowner. In addition, any homeowner with no previous or current mortgage debt outstanding will be excluded in our definition of homeownership.

There are 88,769 homeowners in our sample. The final restriction we make is to exclude homeowners that move from their 1997 zip code between 1997 and 1999. Approximately 17% of homeowners move within the first two years of our sample, at which point the fraction that moves levels off significantly. We exclude these "transient" individuals since we want to ensure that when the house price shock hits, the homeowners are living in the zip code we assign them to initially. This leaves 74,149 homeowners in 2,307 zip codes located in 68 MSAs.[5]

Due to restrictions on the dissemination of individual credit report information, Equifax only provides us data on these homeowners in groups of at least five individuals. We are free to sort the data in any way before the groups are formed. The primary data-sort that we utilize sorts

[4] The second group includes two types of individuals that we cannot separate: individuals that own their home but have paid off their mortgage and individuals who previously had a mortgage but are now renters. We include this group as homeowners given that they have a low probability of moving, which suggests that they are homeowners. All results are materially unchanged if we exclude this group from our homeowner classification.

[5] Appendix Tables 1 and 2 show statistics on renters and homeowners that move zip codes between 1997 and 1999.

homeowners by their 1997 zip code and then by their 1997 credit score before groups are formed. This ensures that our unit of observation, a group of 5 homeowners on average, is as homogenous as possible on observed characteristics. In a few tests where we estimate heterogeneity of our main effect, we re-sort the data to maximize available variation along the dimension of interest. For example, we re-sort data by zip code and then age when testing whether young homeowners behave differently than old homeowners.

We augment the individual level data with several additional data sets. We use the following zip code level time-varying sources of data: house price data from FCSW, IRS income data, employment and payroll information from the Census Business Statistics, aggregate consumer credit score data from Equifax. All of these additional data sets are described in detail in the appendix of Mian and Sufi (2009). The IRS data are available only for 1998, 2002, 2003, 2005, and 2006. We add information for missing years by interpolating data prior to 2006 and extrapolating data post 2006 based on observed time trends. We also use 2000 decennial census zip code level information on demographics. Finally, the primary measure of topology-based housing supply elasticity comes from Saiz (2010).

B. Summary Statistics

Table I presents summary statistics for the sample of 74,149 1997 homeowners grouped into units containing 5 to 9 individuals. The median home debt (mortgage plus home equity) outstanding as of 1997 is $88 thousand which is higher than the average amount of $62 thousand reported in the 1998 Survey of Consumer Finances.[6] The discrepancy is likely due to two factors: first, we do not count as homeowners any individual that has never used debt to finance their home purchase. Second, the 1998 SCF separates out debt used for the purchase of second homes or residential investment properties, whereas we cannot separate primary residence versus other

[6] See Kennickell, Starr-McCluer, and Surette (2000).

residential mortgage debt. Mortgage debt makes up 88% of total debt outstanding for homeowners.

After remaining relatively constant from 1998 to 2002, total debt grows by 34% from 2002 to 2006. This growth is driven almost exclusively by home debt. The increase in leverage can also be seen in the sharp increase in the total debt to income ratio, which increases by 0.8 from 2002 to 2006, which is more than ½ a standard deviation of the 1997 level. Default rates are stable from 1998 to 2006, at which point they rise sharply by 3.8 percentage points from 2006 to 2008, which is a doubling of the 1997 level. Table I also includes information on individual 1997 credit score, 1997 credit card utilization, 1997 age, sex, and 2008 income.[7]

The topology-based housing supply elasticity measure in Saiz (2010) varies from 0 to 12 and is increasing in elasticity. Appendix Figure 1 on the online appendix shows the elasticity measure for the 68 MSAs in our sample and plots house price growth from 2002 to 2006 against elasticity. Both the zip code level IRS wage data and the Census business statistics payroll data show growth of about 12% from 2002 to 2006. Employment growth is 8% over the same time period. One measure from Mian and Sufi (2009) that we use is the fraction of all consumers in a zip code with a "subprime" credit score, which is defined to be a score below 660 as of 1997. In our sample, homeowners on average live in a zip code with 31% subprime consumers.

II. The Effect of House Prices on Home Equity-Based Borrowing

A. Theoretical Motivation

How should an individual homeowner respond to an increase in their house price, all else being equal? This is the thought experiment that our empirical specification attempts to implement using instruments for house price growth. The theoretical answer to this question depends on the underlying model of consumer behavior.

[7] Individual income data are only available from Equifax for 2008. This estimate is based on payroll data that Equifax matches with their records.

A useful starting benchmark is *unconstrained long-lived* homeowners. These homeowners plan on using housing consumption in the foreseeable future, perhaps due to bequest motives, and are not credit-constrained when choosing their consumption paths. Sinai and Souleles (2005) and Campbell and Cocco (2007) show that such households are naturally hedged against house price fluctuations in the absence of credit constraints or substitution effects. Any increase in house prices makes future housing consumption more expensive. As a result, the propensity to borrow out of housing gains is zero.[8]

A second possible model is based on *short-lived* homeowners who do not value housing bequests very highly and plan on consuming part of their housing capital before death. Such homeowners would like to borrow against unexpected increases in home equity to finance consumption, with the propensity to borrow being strongest for older homeowners with shorter life horizons.

A third possibility is *credit-constrained* homeowners who want to borrow more today to smooth consumption over time, but are unable to do so due to limited collateral. Such homeowners would borrow more against increases in home equity to relax their budget constraints (Ortalo-Magne´ and Rady (2006), Lustig and Van Nieuwerburgh, (2006)). Finally following Laibson (1997), homeowners with *limited self-control* may aggressively borrow against increased access to housing wealth in order to finance current consumption.

B. Across MSA Empirical Strategy Based on Housing Supply Inelasticity

Our empirical strategy is designed to estimate the effect of house prices on home equity-based borrowing. As the aggregate data in Figure 1 show, there is a strong correlation between house price growth and homeowner debt growth. However, it is possible that omitted time

[8] An important caveat is a situation in which homeowners have short expected tenure or a high probability of moving. In this case, a relative house price shock may be treated as a real wealth shock.

varying factors drive both house prices and borrowing behavior. Perhaps the most worrisome time-varying trend is changes in productivity or permanent income.

Our first empirical test exploits variation across MSAs in housing supply elasticity. The intuition of the tests is straightforward: for an equivalent housing demand shock, the slope of the housing supply curve determines that degree to which housing prices rise in an area. The insight of Glaeser, Gyourko, and Saiz (2008) is that this basic prediction holds under most models of house price evolution. As long as builders respond to house prices, an increase in housing supply puts an upper bound on house price appreciation in elastic housing supply MSAs.

In the top panel of Figure 2, we show evidence consistent with this intuition. The top panel plots the growth in average house prices relative to 2001 for MSAs in the highest and lowest quartile categories based on the Saiz (2010) housing supply elasticity measure. The most elastic housing supply MSAs experience almost no increase in house prices from 1997 to 2008. In contrast, inelastic housing supply MSAs experience strong growth of over 100% from 2001 to 2006. The pattern in the top panel of Figure 2 is also seen in our first stage estimate in column 1 of Table II, which shows a strong effect of housing supply elasticity on house price growth. The magnitude suggests that a one standard deviation decrease in MSA housing supply elasticity leads to a one-half standard deviation increase in house price growth from 2002 to 2006.

The bottom two panels of Figure 2 plot the growth in total debt for all homeowners and the change in the aggregate debt to income ratio, respectively, for inelastic and elastic MSAs. The total debt growth and the change in debt to income are significantly higher in inelastic MSAs from 2002 to 2006. The growth rate is 20 percentage points higher and the debt to income change is 0.6 higher in inelastic MSAs relative to elastic MSAs.

Figure 2 and the estimate in column 1 of Table II motivate the following first-differenced instrumental variables specification:

(1) $$LeverageGrowth0206_{izm} = \theta X_{izm} + \beta \widehat{HousePriceGrowth0206_{zm}} + u_{izm}$$

(2) $$HousePriceGrowth0206_{zm} = \delta X_{izm} + \rho Elasticity_{m,1997} + \varepsilon_{izm}$$

Where $LeverageGrowth0206_{izm}$ represents the change in homeowner leverage from 2002 to 2006 for individual *i* living in zip code *z* within MSA *m*. Equation (2) represents the first stage, where the instrument is MSA level housing supply elasticity (*Elasticity*). All standard errors are clustered at the MSA level.

Column 2 of Table II presents the instrumental variables estimate with no control variables. The estimated elasticity of debt with respect to house prices is 0.52 among homeowners. The estimate increases when including individual level control variables when added linearly (column 3) or when added non-parametrically with 50 indicator variables for 2-percentile bins (column 4). The estimate is reduced slightly when we include a host of zip code level census demographic control variables and zip code level controls for the growth in wages, payroll, and employment (column 5). [9]

An alternative IV specification using the debt to income ratio also shows a positive effect of house prices on leverage. The estimate of 1.5 in column 6 implies that a one standard deviation change in house prices leads to a 1/4 standard deviation increase in the debt to income ratio. The effect of house prices on debt to income ratios is insensitive to individual level controls (columns 7 and 8), and slightly sensitive to zip code level demographics and income patterns (column 9).

In Table III, we present IV estimates of the effect of an increase in home equity on home borrowing in dollar units. The first stage estimate in column 1 implies that a one standard deviation decrease in housing supply elasticity leads to a $32 thousand increase in home equity. The second stage estimates in columns 2 through 5 suggest that 1997 homeowners borrow 25

[9] The IV estimate in Table II assumes a linear relationship between total debt growth from 2002-2006 and predicted house price growth over the same period. A non-parametric plot of the second stage relationship shows that this assumption is reasonable (see Appendix Figure 2 in the online appendix).

cents on every dollar of additional home equity value. As columns 3 to 5 show, the estimate is insensitive to both individual and zip code level control variables.

C. Does the Home Equity-Based Borrowing Channel Vary By Consumer Type?

Exploring the cross-sectional heterogeneity of the effect provides important insights into the underlying model of consumer behavior that is most consistent with the home equity-based borrowing channel. We examine how the propensity to borrow against increased home equity varies by the homeowner's base year credit score and credit card utilization rate. Credit scores play an important role in the availability and pricing of consumer credit, and consumers below critical thresholds are often unable to obtain financing at reasonable interest rates.[10] Credit card utilization rate is measured by the fraction of the total available credit card limit that is used. Credit scores and credit card utilization rates have a correlation coefficient of -0.88 in our sample of homeowners, and an OLS regression of one on the other yields an R^2 of 0.78. The literature on consumer credit often interprets low credit scores and high credit card utilization rates as indicators for liquidity constrained households (see Gross and Souleles (2002)). However, such variables may also be systematically correlated with an underlying behavioral attribute of households such as self-control problems.

The top four panels of Figure 3 examine debt growth patterns for inelastic and elastic MSAs by 1997 homeowner credit score and credit card utilization rate. We define "high" and "low" categories as the top and bottom quartile of the respective distribution. The top panel of Figure 3 shows a very strong home equity-based borrowing effect for low credit quality borrowers. In contrast there is almost no effect for high quality borrowers as both elastic and inelastic debt growth path are similar throughout the sample period. A similar pattern is revealed in the middle panel that uses 1997 credit card utilization to separate borrowers.

[10] See http://www.freddiemac.com/corporate/reports/moseley/chap6.htm and congressional testimony of Staten (2004) at http://financialservices.house.gov/media/pdf/033004ms.pdf#page=3.

In addition to showing cross-sectional heterogeneity, the top four panels of Figure 3 also provide support for the exclusion restriction in our instrumental variables specification. The fact that there is almost no difference in borrowing between inelastic and elastic MSAs for high credit quality and low credit card utilization zip codes is inconsistent with a general non-housing related credit demand shift in inelastic MSAs. An alternative channel for higher borrowing in inelastic MSAs must explain why the effect is absent in high credit score and low credit card utilization individuals.

As we discuss in Section II.A, a standard model without liquidity constraints hypothesizes that older consumers should be more willing to extract cash from the increased value of home equity. The bottom two panels of Figure 3 do not show evidence in favor of this hypothesis. We split the sample into consumers in the lowest and highest quartile of the age distribution; the inelastic-elastic differential in debt growth does not appear to be significantly different for young and old homeowners.

In Table IV, we present estimates of the following specification:

(6) $$LeverageGrowth0206_{izm} = \theta X_{izm} + \beta \widehat{HousePriceGrowth0206_{zm}} + \tau \widehat{HousePriceGrowth0206_{zm}} * InteractionTerm_{izm} + u_{izm}$$

(7) $$HousePriceGrowth0206_{zm} = \delta * X_{izm} + \rho Inelasticity_{m,1997} + \omega Inelasticity_{m,1997} * InteractionTerm_{izm} + \varepsilon_{izm}$$

As equation (7) shows, the instruments in the first stage are housing supply inelasticity and housing supply inelasticity interacted with the relevant interaction variable listed at the top of the column in Table IV. In column 1, the estimated coefficient on the interaction term is negative, which implies that the effect of house price growth on home equity-based borrowing from 2002 to 2006 is lower for individuals with a higher 1997 credit score. The magnitude of the difference is large. For a consumer one standard deviation above the mean 1997 credit score, the elasticity

of debt with respect to house prices is 0.35. For a consumer one standard deviation below the mean 1997 credit score, the elasticity is 0.76.

The positive estimate on the interaction term in column 2 implies that individuals with a high credit card utilization rate have a larger borrowing response to house price growth. The estimate implies that for a consumer one standard deviation below the mean 1997 credit card utilization rate, the elasticity of debt with respect to house prices is 0.36. For a consumer one standard deviation above the mean 1997 credit card utilization rate, the elasticity is 0.78.

An alternative measure of liquidity constraints is the debt to income as of 1997, which we examine in column 3. There is some evidence that households with higher debt to income ratios as of 1997 borrow more aggressively, but the coefficient estimate is not statistically significant at a reasonable confidence level.[11] In addition, the coefficient estimate on the interaction term is not significant for either sex or household income. The coefficient estimate on the age interaction term in column 5 is negative and statistically significant at the five percent level. The evidence suggests that the borrowing of older consumers is less responsive to house price growth than young consumers, which is inconsistent with life-cycle models of consumer financial behavior.

D. Examining the Exclusion Restriction

One concern with the above findings is the validity of the exclusion restriction. It is possible that differential trends in inelastic and elastic MSAs during this time period would lead to differential borrowing patterns even in the absence of differential house price growth. Of course, the robustness of our findings to a series of rigorous control variables partially mitigates this concern, but omitted factors not captured by our control variables could still be a worry.

In Table V, we examine the exclusion restriction directly. Panel A presents evidence on the correlation between housing supply elasticity and zip code level measures of per capita

[11] Debt to income ratios are only slightly negatively correlated to credit scores, which suggests they are not an accurate measure of credit constraints.

payroll, per capita wage, and total employment growth. Our goal in Panel A is to present evidence on differential permanent income or productivity shocks that may drive household borrowing and house price appreciation in inelastic areas. While there is a negative correlation between housing supply elasticity and IRS per capita wage growth over the 2002 to 2006 time period, this correlation is not robust across the different measures of payroll and employment growth (columns 1 and 3).

However, a comparison of the *level* of income growth from 2002 to 2006 is not necessarily the proper empirical test. As permanent income theory would predict, what matters for changes in household borrowing behavior is the *change* in expected income growth. When we examine the *difference* in growth rates between 1998-2002 and 2002-2006, we find no positive correlation with housing supply inelasticity. Instead, column 4 of Table IV presents evidence that elastic MSAs receive a *positive* payroll shock from 2002 to 2006.

In Panel B, we conduct additional tests to examine the exclusion restriction. Columns 1 and 2 show that the positive effect of house prices on borrowing is driven by an increase in home (mortgage plus home equity) debt. In columns 3 and 4, we show that the effect of house price growth on credit card balances is statistically insignificant and very close to 0 for the credit card balances to income ratio.[12] The specifications in columns 2 and 4 include the interaction term of credit score and house price growth and show that lower credit quality homeowners borrow aggressively against their home but do not increase credit card balances. In columns 5 and 6, we examine renters who never buy into the rising housing market during the sample period. As the estimates show, there is no statistically significant differential increase in borrowing among renters in inelastic areas, even for low credit quality renters (column 6).

[12] Ideally, we would want to examine outstanding credit card debt on which interest is being paid. However, the credit bureau only collects outstanding credit card balances. Several tests suggest that balances are strongly correlated with outstanding debt, especially among high credit card utilization individuals. Increases in credit card balances are strongly positively correlated with future default, and outstanding credit card balances are strongly negatively correlated with credit scores. Further, given that all of our tests are done in first-differences, any error in using balances instead of debt that is similar across housing supply elasticity is removed.

While it is impossible to test the exclusion restriction explicitly, there is little evidence to suggest that the increased homeowner borrowing that we find in inelastic housing supply MSAs is driven by something other than house prices. The fact that the increased borrowing is concentrated in home-related debt is consistent with a home equity-based borrowing channel. Further evidence in support of the exclusion restriction comes from our earlier result that there is almost no differential effect for high credit score and low credit card utilization borrowers. If something other than house prices drives borrowing in inelastic MSAs, it would have to uniquely apply to low credit quality homeowners and lead them to only borrow against their homes.

E. Within-MSA Estimation Strategy

As a further robustness check to the across-MSA estimation strategy, we outline an alternative within-MSA estimation technique that exploits variation at the zip code level to identify the effect of house prices on homeowner borrowing. We describe the full details of our within-MSA technique in the online appendix; we provide a brief outline here given space constraints.

The motivation for this test comes from Mian and Sufi (2009), who show that from 2002 to 2005 house price appreciation in subprime zip codes was significantly stronger than prime zip codes in the same MSA. [13] However, this relationship *only* holds true in MSAs with inelastic supply of housing: in elastic MSAs, there is no differential appreciation for subprime zip codes. Mian and Sufi (2009) argue that these trends are driven by an expansion in the supply of credit to subprime zip codes everywhere, but the expansion leads to a relative increase in subprime zip code house prices only where there are natural restrictions to the expansion of housing supply. Based on this evidence, we propose a triple difference-in-differences estimator that utilizes zip code level within MSA variation in house prices. This idea translates into estimating the following reduced form regression equation:

[13] A subprime (prime) zip code is one in which a high (low) fraction of the population have a credit score below 660.

(3) $$y_{izmt} - y_{izm,1998} = \alpha_m + \delta^t * X_{izmt} + \gamma^t * Subprime_{zm,1997} +$$

$$\beta^t * Subprime_{zm,1997} * Inelasticity_{m,1997} + \varepsilon_{izmt} \quad for\ t = 1999, 2000, \ldots, 2008$$

which examines the growth in *y* from the base year 1998 to *t* for individual *i* living in zip code *z* within MSA *m*. We relate the growth in *y* to MSA fixed effects, individual and zip code level control variables (*X*), the fraction of subprime borrowers (*Subprime*) in zip code *z* within MSA *m* in 1997, and the interaction between the zip code fraction of subprime borrowers and the housing supply inelasticity (*inelasticity*) of MSA *m*.[14] The coefficient of interest is β.

Figure 4 presents the estimate of β for years 1999 to 2008. The top panel examines the relative growth in house prices for high subprime share zip codes in highly inelastic MSAs. House price growth is strongest in subprime zip codes of inelastic MSAs. The bottom two graphs show a relative increase in debt growth and debt to income ratios for homeowners living in high subprime share zip codes within highly inelastic MSAs. These graphs are based on a triple-difference estimate which compares homeowner leverage in high subprime share zip codes within inelastic MSAs to both homeowners in high subprime share zip codes in elastic MSAs and homeowners in low subprime share zip codes in the same MSA.

Figure 4 suggests that a potential instrument for house prices is the zip code level share of subprime borrowers as of 1997 interacted with MSA housing supply inelasticity. In the online appendix, we examine how this instrument is correlated with debt and debt to income levels in 2002. Homeowners' debt amounts and debt to income ratios in high subprime share zip codes within inelastic MSAs are not significantly different than homeowners in high subprime share zip codes within elastic MSAs prior to the house price acceleration in 2002. We describe and report the within-MSA instrumental variables specification in the online appendix, and we find estimates that are qualitatively similar to the estimates from the across-MSA analysis presented in the previous sub-section.

[14] To help with interpretation, we use *housing supply inelasticity* which is 4 minus the Saiz elasticity measure.

The within-MSA approach explores a different source of house price variation relative to the across-MSA approach. In econometric terms, both the across and within approaches are local average treatment effect (LATE) estimators with the "local average" computed over mutually exclusive parts of the house price distribution. Yet the two approaches produce similar estimates of the effect of house prices on homeowner borrowing, which demonstrates the robustness of our core estimates.

III. The Macroeconomic Impact of the Home Equity-Based Borrowing Channel

A. What Are Consumers Doing with Borrowed Money?

What do homeowners do with the money borrowed against home equity? The question is important in order to understand the real effects of the home equity-based borrowing channel. For example, if home equity borrowing is used to pay down other more expensive forms of consumer credit such as credit card debt, then home equity borrowing may not have a large aggregate impact. However, if home equity-based borrowing is used primarily for consumption or home improvement, then the real and policy implications are substantial.

We first test whether high house prices lead homeowners to "trade up" by taking a bigger mortgage to move to a bigger home. Our data records the current zip code of each individual borrower. We can therefore construct an indicator variable for whether a homeowner moves from 2002 to 2006. Columns 1 and 2 of Panel A in Table VI show that house price appreciation is not correlated with the probability of moving. This is true when examining the OLS specification or when using MSA housing supply inelasticity as an instrument for house price growth. These estimates are inconsistent with the argument that households are much more likely to move to new homes after realizing an increased value of home equity. In columns 3 and 4, respectively, we split the sample into homeowners that move and do not move zip codes between

2002 and 2006. The elasticity of debt growth with respect to house price growth is similar in both samples, showing that borrowed money is unlikely to finance the purchase of new homes.[15]

In Panel B, we examine whether homeowners use the increased value of home equity to buy investment properties. While we do not have data on the purchase of investment properties, the consumer credit reports contain the number of mortgage accounts. Under the assumption that consumers must obtain a new mortgage to purchase an investment property, we should detect any systematic use of increased home equity to purchase an investment property by examining the number of mortgage accounts.

Column 1 and 2 of Panel B show that the change in the number of mortgage accounts from 2002 to 2006 is *negatively* correlated with house price growth. In other words, our estimates suggest that homeowners in high house price appreciation MSAs are less likely to buy investment properties. In column 3, we control for the change in the number of mortgage accounts and find a similar elasticity of debt growth with respect to house price growth. Finally, in column 4, we exclude any consumer with any change in the number of mortgage accounts and find a similar estimate of the effect of house price growth on debt growth. The evidence in Panel B shows that our effect is not driven by purchase of investment properties by homeowners.[16]

We do not have individual information on financial assets. However, evidence from the Survey of Consumer Finances is inconsistent with the view that homeowners use borrowing to buy additional financial assets.[17] According to the SCF, the fraction of families holding almost

[15] A remaining concern is within-zip code moves, which we cannot measure using our data. In an unreported robustness test, we isolate the sample to zip codes below the median and below the 30th percentile in total households. The underlying assumption is that within-zip code moves are less likely in these smaller zip codes. In these zip codes, homeowners that do not move to a new zip code have even larger increases in debt. While we cannot rule out the argument that within-zip code moves are responsible for the increase in homeowner debt, this test casts doubt on the alternative hypothesis.

[16] Homeowners with low house price appreciation appear more likely to buy a second home instead. One possibility is that this is driven by low house price appreciation home owners buying an investment property in "hot markets" to ride the housing wave that did not affect their city.

[17] See Bucks, Kennickell, Mach, and Moore (2009), Aizcorbe, Kennickell, and Moore (2003), and Bucks, Kennickell, and Moore (2006)

every class of financial security *declined* from 2001 to 2007. This is true of stocks (21.3% to 17.9%), savings bonds (16.7% to 14.9%), and pooled investment vehicles (17.7% to 11.4%). Only retirement accounts increased slightly (52.2% to 52.6%). Conditional on having a financial asset, the SCF reports a decline in the median value of financial assets from $29.8 thousand to $25.3 thousand from 2001 to 2007.

Do consumers use their home equity-based borrowing to pay down expensive credit card balances? Panel C isolates the sample to homeowners in the top quartile of the credit card utilization distribution as of 1997. The mean credit card balance outstanding among this group is almost $10 thousand and the mean credit card utilization rate (amount outstanding divided by the high limit) is 0.7. Column 1 shows an elasticity of home debt borrowing with respect to house price growth of 0.75 among this sample. Despite the large increase in home-equity based borrowing and the large amount of outstanding credit card balances, the estimates in columns 2 and 4 show that these individuals do not pay down credit card balances in response to house price growth. While we cannot see the exact use of borrowed funds in our data, the results in Panel C suggest that the marginal return to the use of borrowed funds is quite high.

While we do not have direct data on real outlays by individuals, we show that consumers do not use home equity-based borrowing to buy real estate or financial assets, and consumers do not use borrowed funds to pay down credit card debt with a high interest rate. While more evidence is needed, our findings are suggestive that a large fraction of home equity-based borrowing is used for consumption or home improvement. This conclusion is consistent with survey evidence by Brady, Canner, and Maki (2000) who find that from 1998 to 1999, 40% of households cite home improvement as a reason for home equity extraction, and 39% cite consumer expenditures. Using similar survey data, Canner, Dynan, and Passmore (2002) find that over 50% of funds liquefied from home equity are used for either home improvement or

consumer expenditures.

B. Home Equity-Based Borrowing and Defaults

What role did the unprecedented increase in leverage for high house price growth homeowners play in the ensuing financial crisis? A unique advantage of our data set is that we can estimate the default rate implications of aggressive home equity-based borrowing.

The top panel in Figure 5 examines total debt default rates for 1997 homeowners in the highest and lowest quartile MSAs based on house price elasticity. During the early period of the sample when house prices grow, there is a relative decline in the default rate for homeowners in inelastic versus elastic MSAs. However, from 2006 to 2008, default rates for homeowners in inelastic MSAs experience a sharp increase in default rates, *surpassing* the default rate in elastic areas. The middle and lower panel examine the lowest and highest quartile of credit quality (credit score) distribution, respectively. The middle panel shows that the aforementioned result is concentrated among low credit quality borrowers – the same homeowners that borrow aggressively against their rising home equity in the early part of the sample.

The magnitudes for low credit quality borrowers are large. From 2001 to 2005, the default rate falls by almost five full percentage points in inelastic MSAs, whereas it falls by only two percentage points in elastic MSAs. When house prices begin to decelerate and fall from 2006 to 2008, the default rate for low credit quality borrowers in inelastic MSAs skyrockets past the corresponding default rate in elastic MSAs (an increase of 12 versus 4 percentage points respectively).[18]

C. The Macroeconomic Impact of the Household Borrowing Channel

How much of the increase in mortgage credit can be attributed to a direct effect of existing homeowners borrowing against the increasing value of their housing equity? Since our estimates of the home equity-based borrowing channel is based on a representative sample of the

[18] In the online appendix, we report regressions that show results similar to those shown in Figure 5.

U.S., we can integrate our estimated effect to compute the economy wide magnitude of home equity-based borrowing due to higher house prices.

Our baseline estimate of column 2 in Table II suggests that homeowners increase their total borrowing by 0.52 percent for every 1.0 percent increase in house prices. Since our estimated effect is based on a difference in differences approach, the *level* impact of house prices on borrowing is not identifiable. Therefore, the appropriate in-sample aggregate effect of our estimate should be computed using relative differences in house price growth.

Let i index an MSA such that the MSAs are ordered by their housing supply inelasticity with i=1 being the most elastic. Let $\Delta\widehat{P}_i$ be the predicted percentage change in house prices for MSA i given its supply inelasticity. Given our borrowing elasticity estimate of 0.52, the average percentage change in total borrowing due to the house price channel for homeowner living in MSA i is given by $[0.52 * (\Delta\widehat{P}_i - \Delta\widehat{P}_1)]$.[19] Since we know each homeowner's level of initial debt, we can convert the percentage change in debt into new debt taken out in dollars. Aggregating this procedure for all MSAs gives us an aggregate borrowing due to house price appreciation effect of $1.25 trillion dollars over four years from 2002 to 2006.[20] This increase represents 53% of the overall increase in debt of homeowners from 2002 to 2006.

We repeat our analysis to examine the effect of house price appreciation on total defaults for the U.S. economy. Using estimates from Appendix Table 5 in the online appendix, we find

[19] We use 0.52 because it is the *average estimated effect*, which is the appropriate weighted average of the underlying heterogeneity in the effects. One concern is that the equal-weighting low and high credit quality individuals is inappropriate given results in Table 4. However, high and low credit score homeowners have on average the same debt amounts, so dollar weighting and equal weighting produce similar results.

[20] The sum of home equity-based borrowing over our regression sample is equal to $2.2 billion. Since our random sample has a sampling rate of 0.494%, and we dropped 18% of homeowners (dollar-weighted) due to early moves, the total effect in our sample of zip codes is: $2.2/(0.00494*(1-0.18))= $543 billion. The zip codes in our regression sample represent 28.6% of U.S. household credit in 2002. To estimate the home-equity borrowing channel effect for remaining zip codes not in our sample, we apply our home equity-based borrowing elasticity estimate of 0.52 to the house price appreciation for these zip codes. House price appreciation is measured using zip code level price estimate from zillow.com wherever possible, and using MSA level OFHEO price index otherwise. For 10.4% of dollar-weighted zip codes, we do not have any house price data and assume a home equity borrowing effect of zero to be conservative. The aggregate home equity borrowing effect comes out to be $1.25 trillion.

that defaults due to the home equity-based borrowing channel represent 39% percent of total new defaults in the U.S. economy. This suggests that the current mortgage default crisis is not entirely driven by individuals buying into a rising housing market. A significant part of the default crisis is driven by existing homeowners borrowing heavily against the rising value of their house.

VI. Conclusion

We provide evidence of a strong link between asset prices and household borrowing. The use of individual level data and an instrumental variables methodology enables us to estimate the magnitude of the home equity-based borrowing channel, and identify the type of borrowers for whom this effect is the strongest. Since our individual level data is representative of U.S. household sector, we also back out the economy-wide magnitude of our findings.

In addition, we show that the effect of house prices on borrowing is not uniform across the population, but concentrates largely among homeowners with low credit scores and a high propensity to borrow on credit cards. Whether such heterogeneity reflects traditional credit constraints at the household level or self-control problems remains an open question for future research. These results support models in which the balance sheet strength of agents has important effects on borrowing and real economic activity (Bernanke and Gertler (1989), Kiyotaki and Moore (1997)).

The link we show between house prices and household borrowing suggests that housing and household leverage play an important role in macroeconomic fluctuations. Such a connection is increasingly being recognized in the literature (e.g., Aoki, Proudman, and Vlieghe (2004), Iacoviello (2005), Jeske and Krueger (2005), Iacoviello and Manetti (2008), Leamer (2008), and Favilukis, Ludvigson, and Van Niewerburgh (2009), Glick and Lansing (2010)). Indeed, Mian and Sufi (2010) show that changes in household leverage at the county level serve as an early and powerful predictor of the onset and severity of the recession of 2007 to 2009.

References

Aizcorbe, Ana, Arthur Kennickell, and Kevin Moore, 2003, "Recent Changes in U.S. Family Finances: Evidence from the 2001 and 2004 Survey of Consumer Finances." Available at: http://www.federalreserve.gov/PUBS/oss/oss2/2001/scf2001home.html

Aoki, Kosuke, James Proudman, and Gertjan Vlieghe, "House Prices, Consumption, and Monetary Policy: A Financial Accelerator Approach," *Journal of Financial Intermediation* 13: 414-435.

Attanasio, O.P., Weber, G., 1994. "The aggregate consumption boom of the late 1980s: aggregate implications of microeconomic evidence". *Economic Journal* 104, 1269–1302.

Bernanke, Ben and Mark Gertler, 1989, "Agency Costs, Net Worth, and Business Fluctuations," *American Economic Review* 79: 14-31.

Bostic R., Stuart Gabriel and Gary Painter, 2009, "Housing Wealth, Financial Wealth, and Consumption: New Evidence from Micro Data", Working Paper.

Bucks, Brian, Arthur Kennickel, Traci Mach, and Kevin Moore, 2009, "Changes in U.S. Family Finances from 2004 to 2007: Evidence from the Survey of Consumer Finances." Available at: http://www.federalreserve.gov/pubs/bulletin/2009/pdf/scf09.pdf

Bucks, Brian, Arthur Kennickel, and Kevin Moore, 2006, "Recent Changes in U.S. Family Finances: Evidence from the 2001 and 2004 Survey of Consumer Finances." Available at: http://www.federalreserve.gov/PUBS/oss/oss2/2004/bull0206.pdf

Campbell, J. and Cocco, J., 2007. "How do house prices affect consumption? Evidence from micro data", *Journal of Monetary Economics*, 54, 591–621.

Canner, Glenn, Peter Brady, and Dean Maki, 2000, "The Effects of Recent Mortgage Refinancing," *Federal Reserve Bulletin*, July: 441-450.

Canner, Glenn, Karen Dynan, and Wayne Passmore, "Mortgage Refinancing in 2001 and early 2002," *Federal Reserve Bulletin*, December: 469-481.

Case, K., Quigley, J. and Shiller, J., 2003. "Comparing wealth effects: the stock market versus the housing market", unpublished paper.

Cooper, Dan, 2009, "Impending Spending Bust? The Role of Housing Wealth as Borrowing Collateral," Working Paper, University of Michigan.

Favilukus, Jack, Sydney Ludvigson, and Stijn Van Niewerburgh, 2009, "The Macroeconomic Effects of Housing Wealth, Housing Finance, and Limited Risk-Sharing in General Equilibrium," Working paper, New York University.

Glaeser, Edward, Joseph Gyourko and Albert Saiz, 2008. "Housing Supply and Housing Bubbles", Harvard University, Working Paper.

Glick, Reuven and Kevin Lansing, 2010. "Global Household Leverage, House Prices, and Consumption," FRBSF Economic Letter, January.

Greenspan, A. and Kennedy, J., 2007. "Sources and uses of equity extracted from homes", Federal Reserve Board Finance and Economics Discussion Series, Working Paper no. 2007–20.

Gross, David and Nicholas S. Souleles, 2002. "Do Liquidity Constraints And Interest Rates Matter For Consumer Behavior? Evidence From Credit Card Data", *The Quarterly Journal of Economics*, MIT Press, vol. 117(1), pages 149-185, February.

Haurin D. and Stuart S. Rosenthal, 2006. "House Price Appreciation, Savings, and Consumer Expenditures", Working Paper.

Hurst, E. and Stafford, F., 2004. "Home is where the equity is: mortgage refinancing and household consumption", *Journal of Money, Credit and Banking*, 36, 985–1014.

Iacoviello, M., 2005. "House prices, borrowing constraints and monetary policy in the business cycle", *American Economic Review*, 95, 739–64.

Iacoviello, Matteo and Raoul Minetti, 2008, "The Credit Channel of Monetary Policy: Evidence from the Housing Market," *Journal of Macroeconomics* 30: 69-96.

Jeske, Karten, and Dirk Krueger, 2005, "Housing and the Macroeconomy: The Role of Implicit Guarantees for Government-Sponsored Enterprises," Working Paper, Federal Reserve Bank of Atlanta.

Kennickell, Starr-McCluer, and Brian Surette, 2000, "Recent changes in U.S. Family Finances: Results from the 1998 Survey of Consumer Finances," Available at: http://www.federalreserve.gov/PUBS/oss/oss2/98/bull0100.pdf

Kiyotaki, Nobuhiro, and John Moore, 1997. "Credit Cycles", *Journal of Political Economy*, 105, 211-248.

Laibson, David, 1997. "Golden Eggs and Hyperbolic Discounting", *Quarterly Journal of Economics*, 443-477.

Leamer, Edward, 2008. "Macroeconomic Patterns and Stories", Springer.

Lehnert, Andreas, 2004, "Housing, Consumption, and Credit Constraints," Working Paper, Federal Reserve Board.

Lustig, H. and Van Nieuwerburgh, S., 2005. "Housing collateral, consumption insurance and risk premia: an empirical perspective", *Journal of Finance*, 60, 1167–1219.

Mian, Atif R. and Sufi, Amir, 2009. "The Consequences of Mortgage Credit Expansion: Evidence from the U.S. Mortgage Default Crisis", *Quarterly Journal of Economics*.

Mian, Atif R. and Sufi, Amir, 2010. "Household Leverage and the Recession of 2007 to 2009", *IMF Economic Review*, June.

Muellbauer, J., Murphy, A., 1997. "Booms and busts in the UK housing market", *Economic Journal* 107, 1701–1727.

Ortalo-Magne´, F., Rady, S., 2006. "Housing market dynamics: on the contribution of income shocks and credit constraints", *Review of Economic Studies* 73, 459–485.

Saiz, Albert, 2010. "The Geographic Determinants of Housing Supply", *Quarterly Journal of Economics*, forthcoming.

Sinai, T. and Souleles, N. S., 2005. "Owner-occupied housing as a hedge against rent risk", *Quarterly Journal of Economics*, 120, 763–89.

Stein, Jeremy, 1995. "Prices and Trading Volume in the Housing Market: A Model with Downpayment Effects", *Quarterly Journal of Economics*, 110, May, pp. 379-406.

Table I
Summary Statistics

This table presents summary statistics for 74,149 individuals who have either an existing mortgage account with positive balance as of 1997 or a previous mortgage account. The sample is further restricted to individuals that do not move zip codes between 1997 and 1999. Individuals are sorted into groups of at least 5 individuals. Each group consists of individuals living in the same zip code as of 1997, and the individuals are sorted by 1997 credit score before groups are formed. The income in the denominator of the debt to income ratio comes from zip level IRS data. The zip code level median home value as of 1997 comes from the 2000 value reported in the decennial Census multiplied by the growth rate from 2000 to 1997 reported in the Fiserv Case Shiller Weiss data. The housing supply elasticity measure we use is from Saiz (2010). The Saiz (2010) measure is increasing in elasticity from 0 to 12. There are 2,307 zip codes and 68 MSAs that are represented in the sample.

	N	Mean	Median	St. Dev.
Equifax individual level data				
Total debt, 1997, $thousands	13337	100	94	72
Home debt, 1997, $thousands	13337	88	82	70
Growth in total debt, 1998-2002	13337	0.086	0.079	0.619
Growth in total debt, 2002-2006	13337	0.344	0.320	0.684
Growth in home debt, 1998-2002	13337	0.094	0.051	0.899
Growth in home debt, 2002-2006	13337	0.394	0.355	0.901
Total debt to income ratio, 1997	13043	2.537	2.515	1.524
Change in debt to income ratio, 1998-2002	13336	-0.002	-0.085	0.903
Change in debt to income ratio, 2002-2006	13336	0.754	0.424	1.381
Total debt default rate, 1997	13337	0.038	0.000	0.111
Change in default rate, 1998-2006	13333	-0.007	0.000	0.132
Change in default rate, 2006-2008	13328	0.038	0.000	0.168
Credit score, 1997	13337	780	789	95
Credit card utilization fraction, 1997	13336	0.332	0.260	0.256
Age, 1997	13336	48	47	7
Male	13323	0.513	0.500	0.257
Income, 1997, $thousands	13336	79	73	35
Fiserv Case Shiller Weiss zip level data				
House price growth, zip level, 1998-2002	13295	0.402	0.423	0.141
House price growth, zip level, 2002-2006	13337	0.465	0.468	0.227
Saiz (2010) MSA level elasticity measure				
Housing supply elasticity	13337	1.228	0.998	0.641
Median home value, 1997, $thousands	13328	129	193	135
IRS zip level income data				
Per capita wage growth, 2002-2006	13336	0.116	0.110	0.061
Census business statistics zip level data				
Per capita payroll growth, 2002-2006	12993	0.118	0.117	0.121
Employment growth, 2002-2006	12993	0.082	0.071	0.189
Equifax zip level aggregate data				
Fraction of zip code with credit score under 659, 1997	13334	0.306	0.292	0.116

Table II
The Effect of House Prices on Household Borrowing for 1997 Homeowners

This table presents estimates of the effect of house prices on household borrowing for individuals who have either an existing mortgage account with positive balance as of 1997 or a previous mortgage account. Individual dummy variables are quintile indicator variables for 2% bins of the 1997 credit score, 2008 income, 1997 debt to income ratio, and 1997 age variables. Census controls are zip code level variables for the vacancy rate, fraction white, fraction black, education indicator variables for less than high school and high school diploma only, the unemployment rate, the poverty rate, and the fraction of households in the zip code living in an urban setting, all measured as of 2000. Income controls are zip code level variables from the IRS and Census business statistics for the logarithm of the 2002 employment, per capita wage, and per capita payroll level, and the growth in wage, payroll and employment from 1997 to 2000, 2000 to 2002, and 2002 to 2006. All standard errors are clustered at the MSA level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Left hand side variable	HP growth 2002-2006	Total debt growth 2002-2006				Change in total debt to income ratio 2002-2006			
Housing supply elasticity	-0.172**								
	(0.038)								
Instrumented HP growth, 2002-2006		0.519**	0.651**	0.587**	0.498**	1.473**	1.511**	1.323**	1.195**
		(0.108)	(0.126)	(0.118)	(0.083)	(0.292)	(0.306)	(0.270)	(0.209)
(Credit score, 1997)/100			-0.020+				-0.115**		
			(0.010)				(0.028)		
Ln(household income, 2008)			0.141**				0.223**		
			(0.019)				(0.036)		
Debt to income ratio, 1997			-0.035**				0.065**		
			(0.006)				(0.015)		
Age, 1997			-0.013**				-0.030**		
			(0.001)				(0.003)		
Male dummy variable			0.031	0.028	0.018		0.131*	0.125*	0.098+
			(0.025)	(0.023)	(0.024)		(0.056)	(0.051)	(0.053)
Additional control variables				Individual dummy variables	Individual dummy, census, income variables			Individual dummy variables	Individual dummy, census, income variables
N	13337	13337	13028	13028	12605	13336	13027	13027	12605
R^2	0.24	0.01	0.01	0.04	0.05	0.01	0.05	0.09	0.12

**,*, + coefficient statistically distinct from 0 at the 1, 5, and 10% level, respectively.

Table III
The Effect of House Prices on Household Borrowing for 1997 Homeowners, Dollar for Dollar Changes

This table presents estimates of the effect of house prices on household borrowing for individuals who have either an existing mortgage account with positive balance as of 1997 or a previous mortgage account. Individual dummy variables are quintile indicator variables for 2% bins of the 1997 credit score, 2008 income, 1997 debt to income ratio, and 1997 age variables. Census controls are zip code level variables for the vacancy rate, fraction white, fraction black, education indicator variables for less than high school and high school diploma only, the unemployment rate, the poverty rate, and the fraction of households in the zip code living in an urban setting, all measured as of 2000. Income controls are zip code level variables from the IRS and Census business statistics for the logarithm of the 2002 employment, per capita wage, and per capita payroll level, and the growth in wage, payroll and employment from 1997 to 2000, 2000 to 2002, and 2002 to 2006. All standard errors are clustered at the MSA level. All standard errors are clustered at the MSA level.

Left hand side variable	(1) Change in home value 2002-2006 $thousands	(2)	(3) Change in total debt 2002-2006 $thousands	(4)	(5)
Housing supply elasticity	-50.736**				
	(11.179)				
Instrumented change in home value, 2002-2006		0.245**	0.271**	0.253**	0.246**
		(0.050)	(0.056)	(0.056)	(0.065)
Median home value, 2002	0.459**	0.020	-0.014	-0.010	-0.076
	(0.103)	(0.039)	(0.044)	(0.037)	(0.079)
(Credit score, 1997)/100			-8.176**		
			(1.260)		
Ln(household income, 2008)			26.960**		
			(3.858)		
Debt to income ratio, 1997			4.537**		
			(1.150)		
Age, 1997			-1.847**		
			(0.216)		
Male dummy variable			7.287+	6.978+	6.253
			(4.234)	(3.996)	(4.259)
Additional control variables				Individual dummy variables	Individual dummy, census, income variables
N	13328	13328	13199	13199	12497
R^2	0.6	0.03	0.07	0.1	0.12

**,*, + coefficient statistically distinct from 0 at the 1, 5, and 10% level, respectively.

Table IV
Cross-Sectional Heterogeneity in Effect of House Prices on Household Borrowing for 1997 Homeowners

This table presents estimates of the cross-sectional heterogeneity of the effect of house prices on household borrowing for individuals that have either positive outstanding mortgage debt as of 1997 or a previous mortgage account. In each column, we interact house price growth with the variable in the top of the column. The instruments in the first stage are MSA level housing supply elasticity and MSA level housing supply elasticity interacted with the interaction variable listed in the top of the column. In all columns, we use the data sorts that maximize variation in the interaction variable. More specifically, in columns 1 and 2 we utilize data sorted by credit score before groups are formed. In columns 4 to 6, we utilize data sorted by each interaction variable before groups are formed. All standard errors are clustered at the MSA level.

	(1)	(2)	(3)	(4)	(5)	(6)
Interaction variable	(Credit score, 1997)/100	CC utilization, 1997	Debt to income, 1997	Ln(household income, 2008)	Age, 1997	Male
Left hand side variable	Total debt growth 2002-2006					
Instrumented house price growth, 2002-2006	2.282**	0.361**	0.356*	0.789+	1.416**	0.684**
	(0.497)	(0.108)	(0.177)	(0.400)	(0.362)	(0.142)
Instrumented house price growth, 2002-2006	-0.213**	0.825**	0.130	-0.032	-0.017*	0.016
*Interaction term (listed at top of column)	(0.059)	(0.241)	(0.099)	(0.085)	(0.007)	(0.128)
(Credit score, 1997)/100	0.054+	-0.044*	-0.036*	0.002	0.004	-0.055*
	(0.032)	(0.018)	(0.018)	(0.031)	(0.030)	(0.024)
Credit cart utilization, 1997	-0.096+	-0.479**	-0.043	0.048	0.135*	-0.097+
	(0.056)	(0.106)	(0.055)	(0.054)	(0.051)	(0.057)
Ln(household income, 2008)	0.146**	0.147**	0.162**	0.202**	0.148**	0.148**
	(0.019)	(0.019)	(0.020)	(0.042)	(0.018)	(0.021)
Debt to income ratio, 1997	-0.032**	-0.032**	-0.104*	-0.044**	-0.041**	-0.037**
	(0.006)	(0.006)	(0.046)	(0.007)	(0.005)	(0.007)
Age, 1997	-0.012**	-0.012**	-0.014**	-0.015**	-0.008**	-0.012**
	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.002)
Male dummy variable	0.031	0.031	0.017	0.003	-0.002	0.006
	(0.026)	(0.026)	(0.022)	(0.025)	(0.029)	(0.054)
N	13198	13198	13198	12598	12889	11690
R^2	0.02	0.02	0.01	0.04	0.07	0.01

**,*, + coefficient statistically distinct from 0 at the 1, 5, and 10% level, respectively.

Table V
Examining Exclusion Restriction

This table presents evidence on the exclusion restriction for the MSA-level analysis in Tables II and III. Panel A examines the correlation between economic activity and housing supply elasticity in the sample of homeowners. "Growth shocks" represent the differences in 1998 to 2002 and 2002 to 2006 growth rates for each respective variable. Panel B examines the home debt and credit card balances for homeowners and debt patterns for renters. Renters are defined as individuals that have no housing related debt from 1997 to 2006. All standard errors are clustered at the MSA level.

Panel A: Income and employment measures

	(1)	(2)	(3)	(4)	(5)	(6)
Left hand side variable	Business payroll growth 2002-2006	IRS wage growth 2002-2006	Employment growth 2002-2006	Payroll growth shock	Wage growth shock	Employment growth shock
Housing supply elasticity	-0.003	-0.020**	-0.006	0.016*	-0.006	-0.002
	(0.006)	(0.003)	(0.013)	(0.007)	(0.005)	(0.014)
N	2241	2306	2241	2220	2306	2220
R^2	0.00	0.04	0.00	0.00	0.00	0.00

Panel B: Home, credit card, and renters' debt

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	Homeowners		Homeowners		Renters	
Left hand side variable	Home debt growth 2002-2006		Credit card balances growth 2002-2006		Total debt growth 2002-2006	
Instrumented HP growth, 2002-2006	0.535**	2.718**	0.080	-0.139	-0.029	0.260
	(0.120)	(0.617)	(0.110)	(0.426)	(0.161)	(1.280)
Instrumented HP growth, 2002-2006		-0.283**		0.023		-0.041
*(Credit score, 1997)/100		(0.073)		(0.058)		(0.160)
(Credit score, 1997)/100		0.093**		0.069**		-0.007
		(0.033)		(0.026)		(0.081)
N	13337	13337	13337	13337	5058	5058
R^2	0.00	0.00	0.01	0.00	0.00	0.00

**,*, + coefficient statistically distinct from 0 at the 1, 5, and 10% level, respectively.

Table VI
What Do Homeowners Do with Borrowed Money?

Panel A examines whether households in high house price growth areas are more likely to move to a new zip code and whether movers and non-movers experience differential growth rates in debt from 2002 to 2006. Panel B examines whether households in high house price growth areas are more likely to increase their number of mortgages, which is a proxy for the purchase of an investment property. Panel C isolates the sample to individuals in the top quartile of the 1997 credit card utilization distribution and examines whether households in high house price appreciation areas are more likely to pay down credit card balances. All specifications include controls for 1997 credit score, 2008 income, 1997 debt to income, age, and sex. Standard errors are clustered at the MSA level.

Panel A: Purchase of new homes?

	(1)	(2)	(3)	(4)
Sample	MSA averages	Full	Movers	Non-movers
Left hand side variable	Probability of moving	Probability of moving	Total debt growth 2002-2006	
HP Growth, 2002-2006	0.046			
	(0.036)			
Instrumented HP Growth, 2002-2006		0.010	0.668**	0.662**
		(0.076)	(0.140)	(0.134)
N	68	13196	6673	6523
R^2	0.40	0.02	0.01	0.01

Panel B: Purchase of investment properties?

	(1)	(2)	(3)	(4)
Sample	Full	Full	Full	No change in # of mortgages
Left hand side variable	Change in # of mortgages 2001-2005		Total debt growth 2002-2006	
HP Growth, 2002-2006	-0.011			
	(0.021)			
Instrumented HP Growth, 2002-2006		-0.109*	0.624**	0.642**
		(0.047)	(0.097)	(0.138)
Change in # of mortgages, 2001-2005			0.633**	
			(0.030)	
N	12772	12772	12772	3827
R^2	0.02	0.02	0.10	0.02

Panel C: Paying down credit card balances?

	(1)	(2)	(3)	(4)
Sample	Top quartile credit card utilization as of 1997			
Left hand side variable	Home debt growth 2002-2006	Credit card balance growth 2002-2006	Change in home debt to income 2002-2006	Change in credit card balance to income 2002-2006
Instrumented HP Growth, 2002-2006	0.750**	0.084	1.875**	0.017
	(0.153)	(0.143)	(0.394)	(0.022)
N	3233	3233	3233	3233
R^2	0.02	0.01	0.06	0.01

**,*, + coefficient statistically distinct from 0 at the 1, 5, and 10% level, respectively.

Figure 1
Aggregate U.S. Leverage and House Price Patterns

This figure presents aggregate U.S. leverage and house price patterns. Aggregate debt information come from the Federal Reserve flow of funds data, aggregate income comes from NIPA, and aggregate house price index data come from OFHEO. In the bottom right panel, aggregate debt for 1997 homeowners comes from Equifax data where homeowners are defined to be individuals who have either an existing mortgage account with positive balance as of 1997 or a previous mortgage account.

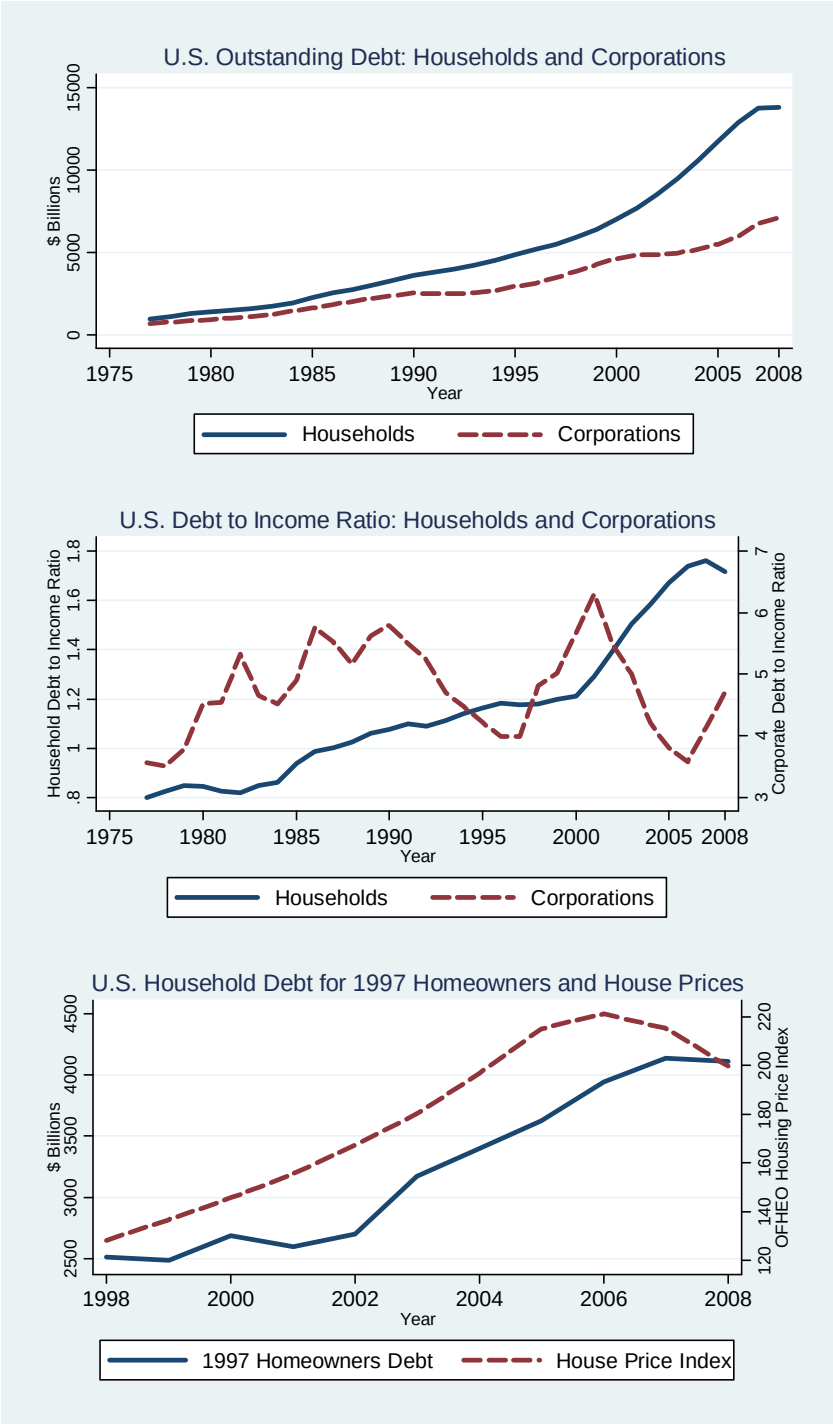

Figure 2
House Price and Leverage Patterns, Inelastic versus Elastic Housing Supply MSAs

This figure presents house price, total debt, and total debt to income patterns for the top and bottom quartile MSAs based on housing supply elasticity from Saiz (2010). The sample includes individuals with mortgage debt outstanding as of 1997 or with a previous mortgage account.

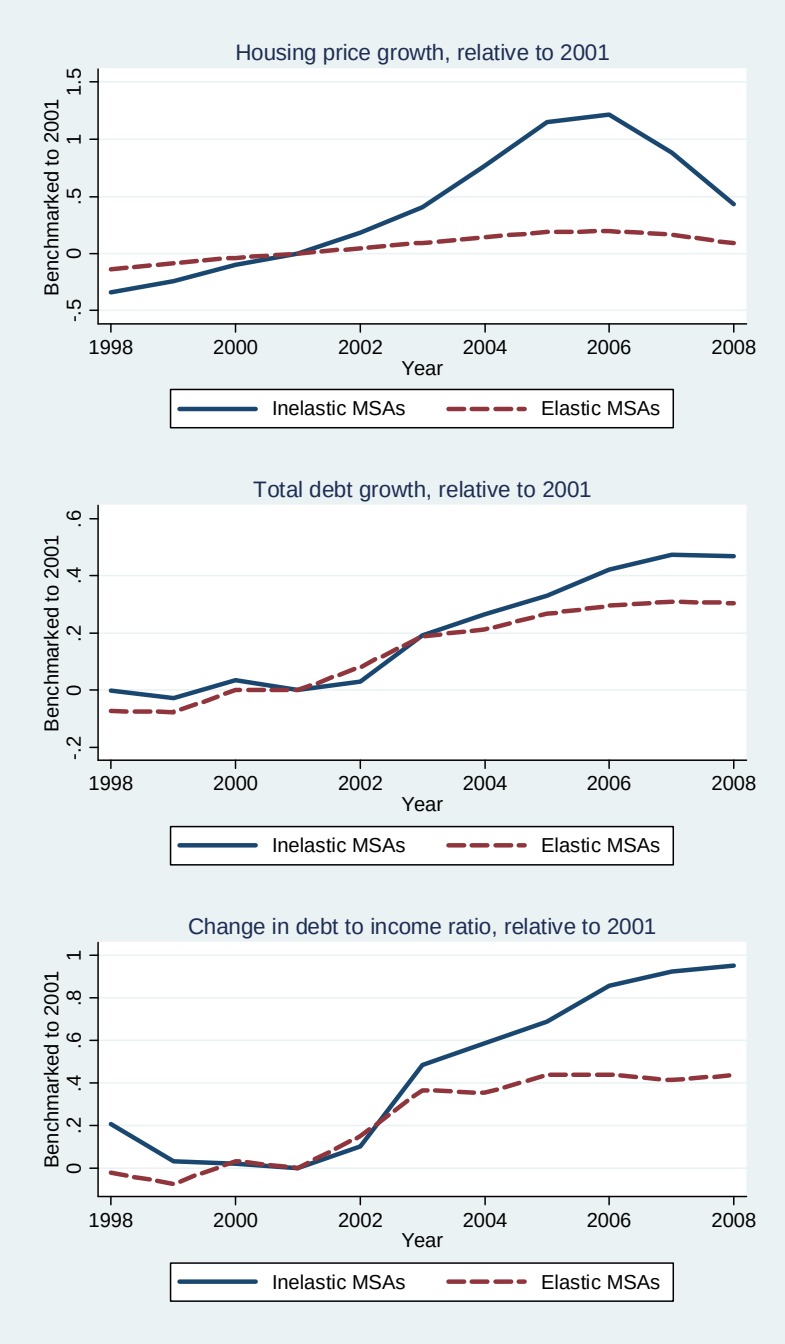

Figure 3
Cross-Sectional Heterogeneity in Leverage Patterns for 1997 Homeowners
By Housing Supply Elasticity

This figure presents household leverage patterns for the highest and lowest quartile of housing supply elasticity MSAs, by the credit quality of borrowers as of 1997 (top two panels), the credit card utilization rate of borrowers as of 1997 (middle two panels), and the age of borrowers (bottom two panels). The sample includes individuals with mortgage debt outstanding as of 1997 or with a previous mortgage account.

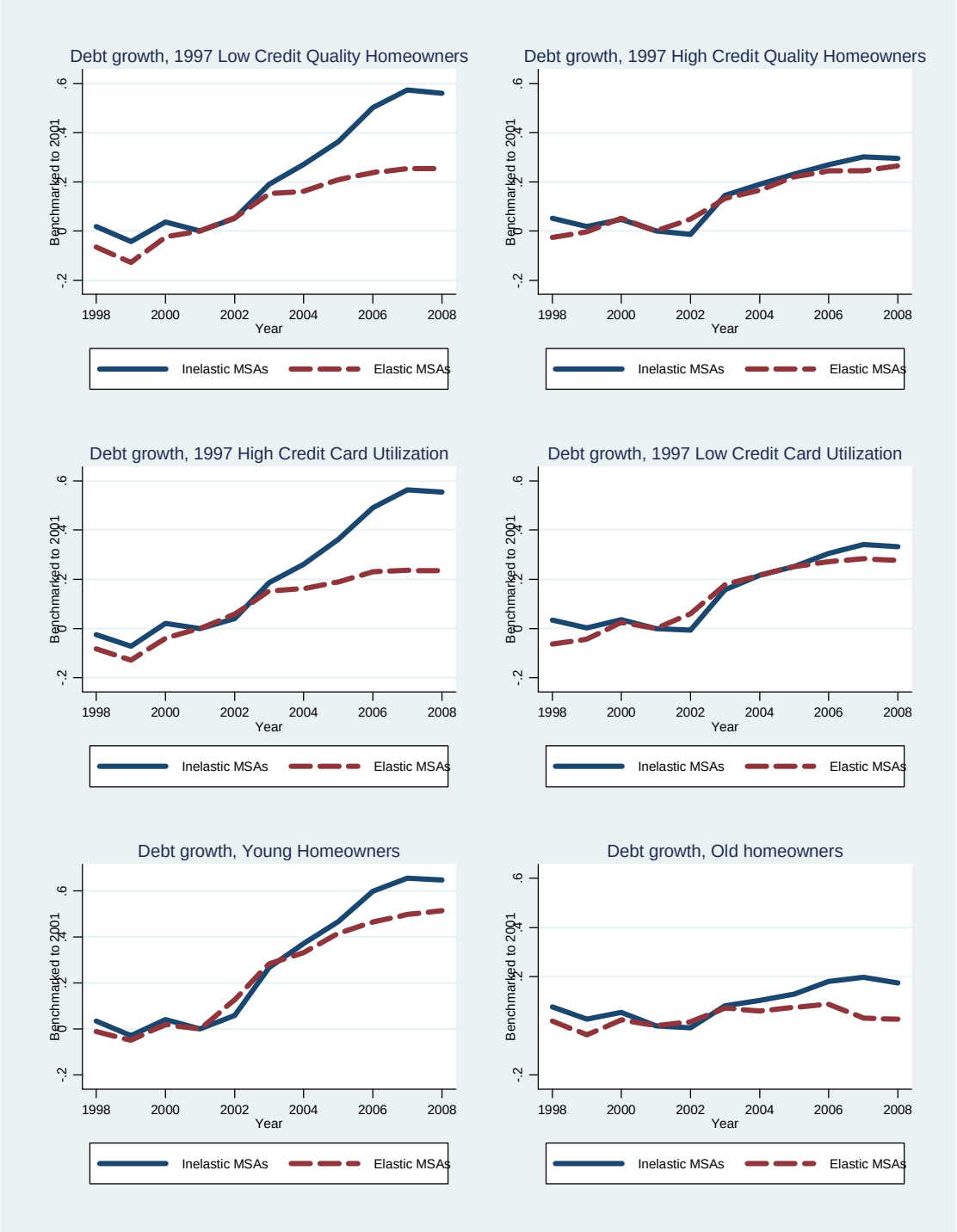

Figure 4
House Price and Leverage Patterns for
Homeowners Living in High Subprime Share Zip Codes in Inelastic Housing Supply MSAs

This figure plots the coefficient estimates for β^t for the following specification for each year *t*:

$$\boldsymbol{y_{ict} - y_{ic,1998} = \delta^t * Subprime_{ic,1998} + \beta^t * Subprime_{ic,1998} * Inelastic_{c,1998} + \alpha_c + \varepsilon_{ict}}$$

where *y* is the natural logarithm of house prices in the top graph, the natural logarithm of total debt in the middle graph, and the debt to income ratio in the bottom graph. The graphs show differential patterns for homeowners living in high subprime share zip codes in inelastic housing supply MSAs relative to both homeowners living in low subprime share zip codes in the same MSA and homeowners in high subprime share zip codes in elastic housing supply MSAs.

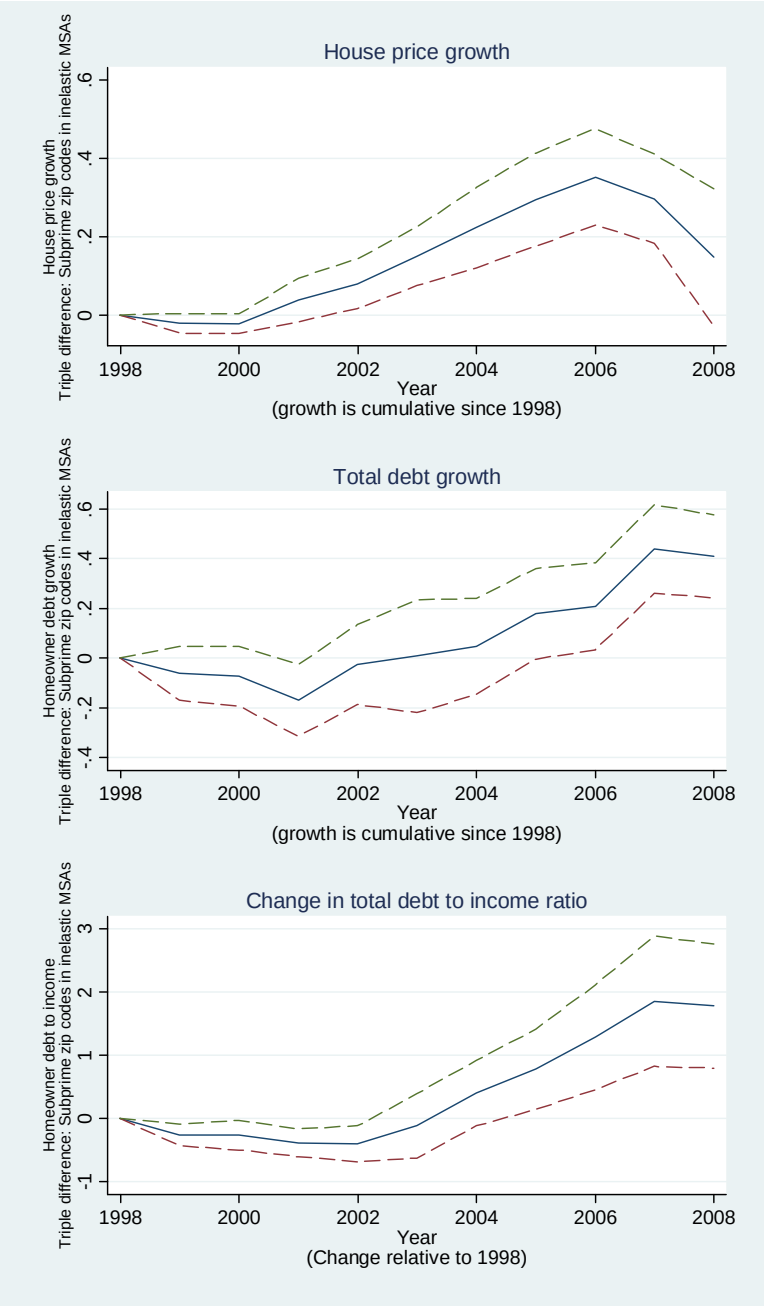

Figure 5
Default Patterns for Homeowners, By Housing Supply Elasticity and 1997 Credit Quality

This figure presents default patterns for the highest and lowest quartile of housing supply elasticity MSAs, by the credit quality of borrowers as of 1997. The top graph examines the full sample. The middle graph examines borrowers in the lowest quartile of the 1997 credit score distribution, and the bottom graph examines borrowers in the highest quartile of the 1997 credit score distribution. The sample includes individuals with mortgage debt outstanding as of 1997 or with a previous mortgage account.