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HOUSE PRICES, HOME EQUITY-BASED BORROWING, AND THE U.S. HOUSEHOLD LEVERAGE CRISIS

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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 sharp 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 to 30 cents for every dollar increase in home equity. 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 (i.e., consumption or home improvement). Home equity-based borrowing is stronger for younger households, households with low credit scores, and households with high initial credit card utilization rates. Homeowners 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 estimates suggest that home equity-based borrowing is equal to 2.8% of GDP every year from 2002 to 2006, and accounts for at least 34% of new defaults from 2006 to 2008.

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U.S. household leverage sharply increased in the years preceding the current economic recession. The top panel of Figure 1 shows the steady rise in household debt since 1975, which sharply 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 was 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*.

Our central goal in this study is to investigate how existing homeowners respond to the rising value of their home equity, a channel we refer to as the *home equity-based borrowing channel*. This is an important question for several reasons. First, given that 65% of U.S. households already owned their primary residence before the acceleration in house prices beginning in the late 1990s, a strong home equity-based borrowing channel may be an important cause of the rapid rise in household leverage preceding the economic downturn.

Second, the quantitative strength of the home equity-based borrowing channel is theoretically ambiguous. House price appreciation may have no effect on homeowner borrowing because the increase in home equity wealth is counter-balanced with a higher cost of future housing consumption (Sinai and Souleles (2005), Campbell and Cocco (2007)). On the other hand, if homeowners are credit-constrained or subject to self-control issues, then house price

appreciation may induce households to borrow more (Stein (1995), Ortalo-Magne´ and Rady (2006), Lustig and Van Nieuwerburgh (2006), and Laibson (1997)).

Third, to the extent that homeowners use home equity-based borrowing to finance real outlays such as consumption or home improvement, a large home equity-based borrowing channel could provide a quantitative explanation for the decline in the U.S. savings rate in the decade preceding the financial crisis. More broadly, if house prices strongly affect existing homeowners' borrowing behavior, then dramatic swings in the housing market may have real effects on the economy through consumption and mortgage defaults.

We examine the home equity-based borrowing channel using a data set consisting of anonymous individual credit files of a national consumer credit bureau agency. The agency has provided us a random sample of almost 70,000 homeowners living in every major metropolitan statistical area in the United States. We track these individuals at an annual frequency from the end of 1997 until the end of 2008. This data set allows us to separate homeowners borrowing against the rising value of their home equity from renters buying into a hot housing market.

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 (King (1990), 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 (2008). Using this instrument, the across-MSA instrumental variables estimate uncovers a large home equity-based borrowing channel. Our preferred estimate suggests an elasticity of borrowing with respect to increased home equity of 0.60. Alternatively, we find that households borrow 25 to 30 cents on each additional dollar of home equity from 2002 to 2006.

An obvious concern with the IV estimates is that MSAs with an inelastic supply of housing could also experience differential non-house price-related credit demand shocks. A number of tests mitigate this concern however. First, the borrowing patterns in elastic and inelastic MSAs closely track each other until 2002 when housing prices accelerated. Second, there is almost no difference in measures of non-house price credit demand shocks such as income, payroll, and employment growth between inelastic and elastic MSAs during this period.

Third, our results are insensitive to non-parametric controls for changes in credit demand driven by individual income, credit score, age, and sex. Fourth, we find no statistically significant difference in the growth of credit card balances for homeowners living in inelastic versus elastic MSAs. This finding suggests that the home equity borrowing channel, and not a general shift in credit demand, is driving our basic result. Finally, there is no difference in the borrowing behavior of renters between elastic and inelastic MSAs.

Our second instrument for house price growth exploits within-MSA variation and uses the *interaction* of the 1997 fraction of subprime borrowers in a zip code with MSA level housing supply inelasticity as an instrument for house price growth. The instrument is motivated by Mian and Sufi (2009) who show that an expansion of mortgage credit from 2002 to 2005 is associated

with stronger house price appreciation in subprime zip codes compared to prime zip codes, despite relatively declining income opportunities for subprime areas. Furthermore, as theory would suggest, the differential house price appreciation in subprime zip codes is present only in inelastic housing supply MSAs. The interaction of the 1997 share of subprime population in a zip code with MSA level housing supply inelasticity therefore serves as an instrument for within-MSA house price growth.[1] Our within-MSA estimates are similar to the across-MSA estimates.

The real effects of the home equity-based borrowing channel depend on what households do with the borrowed money. We find little evidence that borrowing in response to increased house prices is used to purchase new homes or investment properties. We also find no evidence that home equity-based borrowing is used to pay down credit card balances, even for households in the highest quartile of the 1997 credit card utilization distribution. This finding suggests that the marginal return to the use of borrowed funds is higher to households than the high interest rate on credit card debt. While we do not have data on real outlays, these findings suggest that consumption and home improvement are possible uses of the increased borrowing.

We use our microeconomic estimates to calculate the aggregate impact of the home equity-based borrowing channel. We find that a total of $1.45 trillion of the rise in household debt from 2002 to 2006 is attributable to existing homeowners borrowing against the increased value of their homes. This translates to 2.8% of GDP per year. This is a conservative lower-bound estimate given that it is based on a difference-in-differences estimator that ignores any *level* effect of house prices on borrowing.

Given the large effect of house prices on homeowner borrowing, which model of household behavior is consistent with our estimates? We explore cross-sectional heterogeneity in the effect to explore this question. We find that homeowners with high credit card utilization rates and low credit scores at the beginning of the sample have the strongest tendency to borrow

[1] See Section II.C for more on the within-MSA triple-difference identification strategy.

against increases in home equity. In fact, we find no effect of house prices on borrowing for homeowners in the top quartile of credit score distribution as of 1997. We also find that the home-equity based borrowing channel is stronger for younger homeowners. We find no evidence of a differential effect based on either income or gender.

These results are consistent with a model of credit constraints under the assumption that low credit scores and high credit card utilization rates serve as indicators for borrowing difficulty. However, these characteristics may also proxy for individuals with self-control problems. Our finding that older individuals have a smaller home equity-based borrowing channel is inconsistent with standard life cycle-based models.

The increase in homeowner leverage due to the home equity-based borrowing channel plays an important role in the ensuing financial crisis. Using homeowner default rate data, 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 appreciation from 2002 to 2006 skyrockets past homeowners experiencing no previous house price appreciation.

The reversal is especially strong among low credit score and high credit card utilization homeowners who most aggressively borrow against rising home equity during the housing boom. These same households also see a sharp relative reduction in auto loans from 2006 to 2008, highlighting the link between homeowner leverage and the drop in durable consumption at the beginning of the current recession.

Our findings are related to research on the effect of house price growth on consumption, refinancing, and borrowing behavior (Case, Quigley, and Shiller (2005), Bostic, Gabriel, and Painter (2009), Lehnert (2004), Haurin and Rosenthal (2006), Hurst and Stafford (2004), Campbell and Cocco (2007), Greenspan and Kennedy (2007), Cooper (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. In addition, we are the first in this literature to examine default behavior as it relates to home equity-based borrowing.

These issues are important given that declines in housing and durable consumption often precede economic recessions. Leamer (2008) points out that eight of the ten post-World War II recessions were preceded by a decline in housing and durable consumption. The current recession is no different. Understanding the links between housing and the real economy necessitates a better understanding of the way homeowners respond to fluctuating asset prices. Our analysis provides microeconomic estimates on homeowners' response to increased house values and the macroeconomic effect of the home equity-based borrowing channel. Our findings are therefore related to models in which housing plays a crucial role in the macroeconomy (Aoki, Proudman, and Vlieghe (2004), Iacoviello (2005), Jeske and Krueger (2005), Iacoviello and Manetti (2008), and Favilukis, Ludvigson, and Van Niewerburgh (2009)).

The rest of our study proceeds as follows. The next section describes the data and summary statistics. Sections II through V present results, and Section VI concludes.

I. Data and Summary Statistics

A. Data

The final data set used in our analysis consists of detailed credit report information from Equifax for 67,489 homeowners in 2,046 zip codes located in 45 MSAs. The initial random sample includes a total of 266,058 individuals that live in 3,072 zip codes located in 84 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 (2008) topography-based elasticity measure. This reduces the sample to 189,305 individuals within 2,076 zip codes in 45 MSAs.[2]

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 credit report information. The first group (34%) contains individuals that have mortgage or home equity debt outstanding. The second group (9%) 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 (57%) contains individuals that do not have either a current or previous mortgage account. We define as "1997 homeowners" individuals in the first two groups.[3]

The rate of homeownership among individuals in the credit report data (43%) 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.

[2] In an unreported robustness test, we match the remaining FCSW zip codes to the closest MSA covered by the Saiz (2008) measure. The correlation between housing supply inelasticity and house price growth is slightly weakened, but all other results are similar.

[3] 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 choose to count this group as homeowners given that they have a low probability of moving, which suggests that they are homeowners who have paid off their previous mortgage. Nonetheless, all results are materially unchanged if we exclude this group from our homeowner classification.

There are 81,264 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 15% 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 a final sample of 67,489 individuals in 2,046 zip codes located in 45 MSAs.[4]

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 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

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

zip code level information on demographics. Finally, the primary measure of topology-based housing supply elasticity comes from Saiz (2008).

B. Summary Statistics

Table I presents summary statistics for the sample of 67,489 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.[5] 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 residential mortgage debt. Mortgage debt makes up over 85% 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 0.7 from 2002 to 2006, which is almost 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.[6]

The housing supply elasticity measure in Saiz (2008) varies from 0 to 3 and is increasing in elasticity. Our measure is 3 minus the Saiz (2008) measure so that our measure increases in housing supply inelasticity. Appendix Table 3 shows the inelasticity measure for the 45 MSAs in our sample. Both the zip code level IRS wage data and the Census business statistics payroll data

[5] See Kennickell, Starr-McCluer, and Surette (2000).
[6] Individual income data are only available from Equifax for 2008. This estimate is based on payroll data that Equifax matches with their records.

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.

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.[7]

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.

[7] 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.

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 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. We compare MSAs in the highest and lowest quartile categories based on the Saiz (2008) 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 inelasticity on house price growth. The magnitude suggests that a one standard deviation increase

in MSA housing supply inelasticity leads to a one-half standard deviation increase in house price growth from 2002 to 2006.

The bottom two panels of Figure 2 show a graphical version of the reduced form specification estimates from our empirical model; they show that total debt growth and the change in debt to income is significantly higher in inelastic MSAs from 2002 to 2006. The growth rate is 20 percentage points higher and the debt to income change is 0.5 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) $$HousePriceGrowth0206_{zm} = \delta X_{izm} + \rho Inelasticity_{m,1997} + \varepsilon_{izm}$$

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 inelasticity (*Inelasticity*). 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 0.6 among homeowners. The estimate is completely insensitive to 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 only 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).

An alternative IV specification using the debt to income ratio also shows a positive effect of house prices on leverage. The estimate of 1.6 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. As with the elasticity measures, the effect of house prices on debt to income ratios is completely insensitive to individual level controls (columns 7 and 8), and only slightly sensitive to zip code level demographics and income patterns (column 9).

Figure 3 presents the non-parametric plot of the effect of house price growth on debt growth across the full distribution. It shows the second stage of the IV estimate in column 2 of Table II by plotting total debt growth from 2002-2006 against predicted house price growth over the same period. As Figure 3 shows, the effect is close to linear with a slight convexity near the middle of the distribution. The pattern is also robust across almost the entire distribution, although the statistical precision is lower at the low end of the house price growth distribution.

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 increase in housing supply inelasticity leads to a $30 thousand increase in home equity. The second stage estimates in columns 2 through 5 suggest that 1997 homeowners borrow 25 to 30 cents on every dollar of additional home equity value. As columns 3 to 5 show, the estimate is completely insensitive to both individual and zip code level control variables.

One concern with the findings in Table II, Figure 3, and Table III is the validity of the exclusion restriction. In other words, 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 IV, we further examine the exclusion restriction. Panel A presents evidence on the correlation between housing supply inelasticity and zip code level measures of per capita 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. There is no evidence of differentially stronger growth in per capita payroll or employment growth. While there is a positive correlation between housing supply inelasticity 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 inelastic MSAs receive a *negative* payroll shock from 2002 to 2006.

In Panel B, we conduct additional tests to examine the exclusion restriction. Columns 1 and 4 of Panel B show that the positive effect of house prices on borrowing is driven by an increase in home (mortgage plus home equity) debt. 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. These findings suggest that the channel through which consumers in inelastic MSAs increase debt outstanding is home-equity related and not a general increase in the demand for credit. 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.

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 validity of the exclusion restriction is presented in Section V

where we focus on cross-sectional heterogeneity in the effect of house prices on consumer borrowing. As we show there, there is almost no differential effect for high credit score and low credit card utilization borrowers, which suggests the absence of non-housing related factors driving our results.

C. Within-MSA Empirical Strategy Based on 1997 Fraction of Subprime Borrowers

This section presents an alternative IV strategy that exploits within- MSA variation at the level of zip codes to identify the effect of house prices on homeowner borrowing. The motivation for this test comes from Mian and Sufi (2009). They present evidence of a securitization-driven shift in the supply of mortgages for new home purchase from 2002 to 2005 toward zip codes that have a high fraction of subprime borrowers. Column 1 of Panel A in Table V replicates the basic finding, which shows a strong positive correlation between new home purchase mortgage growth from 2002 to 2006 and the fraction of borrowers with a credit score below 660 as of 1997.

Mian and Sufi (2009) show that higher credit growth for home-purchase mortgages occurs in subprime zip codes despite declining relative, and in some cases absolute, income growth in these areas. Furthermore, 2002 to 2005 is the only period in the last 18 years in which mortgage origination for home purchase is higher in areas with lower income growth.

In columns 2 to 5 of Table V, Panel A, we replicate another finding of Mian and Sufi (2009): the relative shift in the supply of mortgage credit for home purchase toward high subprime share zip codes occurs even in the most elastic MSAs where there is no significant house price growth. However, the shift in the supply of mortgage credit is stronger in more inelastic housing supply MSAs that experience strong house price growth. Based on these findings, Mian and Sufi (2009) argue that house price appreciation cannot fully explain the shift in the supply of mortgage credit to high subprime areas, but house price growth strengthens the effect through a collateral feedback mechanism (as in Kiyotaki and Moore (1997)).

Column 1 of Table V, Panel B presents evidence that the shift in the supply of credit toward subprime share zip codes leads to higher house price growth in subprime zip codes relative to prime zip codes within the same MSA. Columns 2 through 5 show that this effect is only present in inelastic MSAs, as we would expect given the intuition on house prices and supply elasticity in Glaeser, Gyourko, and Saiz (2008). Mian and Sufi (2009) present evidence that the relative house price appreciation in high subprime share zip codes within inelastic MSAs is *credit-induced*: they find that house price growth and income growth are negatively correlated from 2002 to 2006 and that high subprime share zip codes experience relative house price growth despite relatively negative income growth.

Our instrumental variable strategy is designed to exploit credit-induced house price appreciation in high subprime share zip codes within inelastic MSAs to estimate the effect of house price appreciation on homeowner borrowing. The exact thought experiment is as follows. Take two homeowners *IP* and *IS* with the same credit score as of 1997. The homeowners live in the same inelastic MSA, but differ in the neighborhood of residence. Homeowner *IP* lives in a prime neighborhood, while *IS* lives in a subprime neighborhood. We know from Mian and Sufi (2009) that *IS* experiences a larger house price increase than *IP* as a result of the aggregate credit supply expansion. Let ΔB_{IS} and ΔB_{IP} be the change in household borrowing for *IS* and *IP* respectively during the price boom period. Then the double difference (ΔB_{IS} - ΔB_{IP}) provides one possible reduced form measure of the effect of house prices on homeowner borrowing.

However, a concern with this estimate is that despite IS and IP having the same initial credit score, the fact that they live in different neighborhoods potentially makes them different on unobserved dimensions. The unobserved dimensions could also affect the borrowing decisions in a way that makes (ΔB_{IS} - ΔB_{IP}) a biased estimate of the direct house price effect.

How does one control for the unobserved neighborhood effect of subprime versus prime neighborhoods? The triple-difference strategy exploits the additional variation in housing supply elasticity. In particular, as mentioned earlier, the difference in house prices of subprime versus prime neighborhood disappears in elastic MSAs due to easily adjustable housing supply. However, the unobserved dimension of neighborhood effects is still operating on homeowners living in elastic MSAs. Let *ES* and *EP* be two homeowners with the same initial credit scores as *IS* and *IP*. *ES* and *EP* live in subprime and prime neighborhoods of an elastic MSA respectively. Then we can control for the unobserved neighborhood effect of homeowners living in subprime areas by computing the triple difference: [$(\Delta B_{IS} - \Delta B_{IP}) - (\Delta B_{ES} - \Delta B_{EP})$].

This idea translates into estimating the following reduced form regression equation:

(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*. 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. Consistent with the estimates in Panel B of Table V, house price growth is strongest in subprime zip codes of inelastic MSAs. In terms of magnitudes, the coefficient estimate for 2006 implies that in the most inelastic MSA, a one standard deviation increase in the 1997 subprime share of the zip code leads to a 15% increase in house prices from 2002 to 2006.

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. Once

again, 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. In terms of magnitudes, the coefficient estimate for 2006 implies that in the most inelastic MSA, a one standard deviation increase in the 1998 subprime share of the zip code leads to a 9% increase in debt and a 1/2 standard deviation increase in the homeowner debt to income ratio from 2002 to 2006.

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 Panel C of Table V, we examine how this instrument is correlated with debt and debt to income levels in 2002. As Panel C shows, 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.

The results in Table V and Figure 4 together with the results in Mian and Sufi (2009) motivate the following within-MSA instrumental variables specification:

(4) $$LeverageGrowth0206_{izm} = \alpha_m + \theta X_{izm} + \mu Subprime_{zm,1997} + \beta \widehat{HousePriceGrowth0206_{zm}} + u_{izmt}$$

(5) $$HousePriceGrowth0206_{zm} = \alpha_m + \delta * X_{izmt} + \gamma Subprime_{zm,1997} + \rho Subprime_{zm,1997} * Inelasticity_{m,1997} + \varepsilon_{izmt}$$

Equation (5) represents the first stage in which house price growth from 2002 to 2006 is instrumented with the interaction of zip code level subprime share as of 1997 and MSA level housing supply inelasticity. Equation (4) represents the second stage in which we examine the growth in leverage for homeowners as a function of predicted house price growth. The control variables in *X* include median home value in the zip code and individual credit score, income, sex, and age. The control variables imply that we are comparing two homeowners with the same

age, same credit score, same sex, and same income, but one resides in a high subprime share zip code within an inelastic housing supply MSA.

The second stage estimates for both debt growth and the change in debt to income are presented in Table VI. The estimates from the within-MSA specification are slightly higher than the estimates from the across-MSA analysis presented in the previous sub-section. The inclusion of control variables does not change the debt growth specification estimate. However, the effect of house price growth on the change in debt to income is more sensitive to the inclusion of control variables.

The within-MSA approach in Table VI explores a different source of house price variation relative to the across-MSA approach of Table II. 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 quite consistent estimates of the effect of house prices on homeowner borrowing. It should be kept in mind that the majority of the overall house price variation is across MSAs.[8] For this reason, the across-MSA estimate is economically more meaningful, while the within-MSA estimate serves as a useful robustness check.

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

[8] Variance decomposition of house price growth from 2002 to 2006 at the zip code level reveals a between-MSA standard deviation of 0.22 and a within-MSA standard deviation of 0.06. See Table I in Mian and Sufi (2009).

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 VII 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. Taken together, the estimates in Panel A are inconsistent with the argument that homeowners use borrowed money primarily to finance the purchase of new homes.

In Panel B, we examine whether homeowners use the increased value of home equity to buy investment properties. This may be a concern given that the percentage of households in the Survey of Consumer Finances that have outstanding debt on a residential property other than their primary residence increased from 4.6% in 2001 to 5.5% in 2007 (Bucks, Kennickell, Mach, and Moore (2009), Aizcorbe, Kennickell, and Moore (2003)). 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. Taken together, the evidence in Panel B is inconsistent with the hypothesis that households use increased home equity to buy investment properties.

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.[9] According to the SCF, the fraction of families holding almost 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.

One additional fact is also inconsistent with the hypothesis that consumers use home equity-based borrowing to purchase financial assets. As we show in the next section, the home equity borrowing channel is stronger among low credit quality and high credit card utilization individuals. Evidence from the SCF suggests that participation among lower income and lower net worth individuals dropped even more dramatically than the average from 2001 to 2007.

The evidence is inconsistent with the argument that consumers borrowed against increased home equity to purchase real estate or financial assets. In Panel C, we explore whether consumers use increased home equity-based borrowing to pay down outstanding credit card

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

balances. This is a useful exercise given that the mean interest rate on outstanding credit card debt is 12.5% according to the SCF (Bucks, Kennickell, Mach, and Moore (2009)). If consumers do not pay down credit card balances, then it suggests that homeowners derive considerable marginal utility from the use of home-equity based borrowing.

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 0.71. Column 1 shows an elasticity of home debt borrowing with respect to house price growth of 0.8 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.[10] 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 are able to demonstrate 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

[10] 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.

home improvement or consumer expenditures.

B. The Macroeconomic Impact of the Household Borrowing Channel

Since our estimates of the home equity-based borrowing channel is based on a representative sample of the U.S., we can integrate our estimated effect to compute the economy wide magnitude of home equity-based borrowing due to higher house prices.

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? We start with our baseline estimate of column 2 in Table II that suggests that homeowners increase their total borrowing by 0.6 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 home equity-based borrowing elasticity estimate of 0.6, the average percentage change in total borrowing due to the house price channel for homeowner living in MSA i is given by $[0.6 * (\Delta\widehat{P_i} - \Delta\widehat{P_1})]$. 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 $1.45 trillion dollars over four years from 2002 to 2006.[11] This increase represents 59.2% of the overall increase in debt of homeowners from 2002 to 2006.

[11] The sum of home equity-based borrowing over our regression sample is equal to $2.21 billion. Since our random sample has a sampling rate of 0.494%, and we dropped 18.3% of homeowners (dollar-weighted) due to early moves, the total effect in our sample of zip codes is: $2.21/(0.00494*(1-0.183))= $548 billion. The zip codes in our regression sample represent 26.5% 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 0.6 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.

The aggregate increase in debt due to house price appreciation represents 2.8% of GDP per year over the four years. While we do not have data on real outlays, our previous evidence suggests that it is likely that some of the borrowings are used for consumption and home improvement. If we take the extreme view that all of borrowed money is used for real outlays, then our estimate helps explain the drop in the savings rate during this time period.

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

Our estimates above suggest a large response of homeowner borrowing to increases in the value of home equity. In this section, we explore cross-sectional heterogeneity of the effect. Our goal is to provide insight into the underlying model of consumer behavior that is most consistent with the home equity-based borrowing channel.

We first 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.[12] 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.

For 16.6% of dollar-weighted zip codes, we do not have any house price data and assume a home equity borrowing effect of 0 to be conservative. The aggregate home equity borrowing effect comes out to be $1.45 trillion.

[12] 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.

The top four panels of Figure 5 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 5 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.

The top four panels of Figure 5 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 5 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, and we find that inelastic-elastic differential in debt growth is not significantly different for young and old homeowners.

Table VIII presents regression equivalent results for Figure 5 by estimating the following specification:

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

(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 VIII. 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 0.83.

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 0.37. For a consumer one standard deviation above the mean 1997 credit card utilization rate, the elasticity is 0.85.

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 4 is negative and marginally statistically significant with a p-value of 0.11. In column 5, we create an independent interaction term for homeowners over the age of 65. As the interaction term coefficient estimate shows, individuals over 65 have a *lower* sensitivity of borrowing to house price growth. The evidence suggests that the borrowing of older consumers is less responsive to house price growth than young consumers, which is inconsistent with standard life-cycle models of consumer financial behavior.[13]

V. Home Equity-Based Borrowing and the Financial Crisis

[13] In unreported results, we find similar results for cross-sectional heterogeneity of the home equity-based borrowing effect using the within-MSA specification outlined in Section II.C.

The evidence above shows the importance of the home equity-based borrowing channel during the U.S. housing boom. 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 when house price growth decelerates and turns negative. Moreover, since the purchase of autos (a key durable good) is often financed through auto loans, we can estimate the effect of household leverage in explaining the plummet of auto sales during the downturn.

The top panel in Figure 6 examines total debt default rates for 1997 homeowners in the highest and lowest quartile MSAs based on house price inelasticity. As previous results show, homeowners in inelastic MSAs experience both a sharp rise in house price growth and home equity-based borrowing from 2002 to 2006 relative to homeowners in elastic MSAs. As the top panel shows, there is a contemporaneous relative decline in the default rate for homeowners in inelastic versus elastic MSAs. From 2006 to 2008, default rates for homeowners in inelastic MSAs experience a sharp increase in default rates, surpassing the default rate in inelastic areas.

We also split the sample into borrowers in the lowest and highest quartile of the credit quality distribution. As the middle panel shows, low credit quality borrowers in inelastic MSAs experience a very sharp relative decline in default rates. 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. Recall that it is precisely low credit quality borrowers in inelastic MSAs that experience the largest increase in home equity-based borrowing during this time period.

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 default rate for high credit quality borrowers. The magnitude is very large. The default rate for low credit quality homeowners increases by more than 12 percentage points from 2005 to 2008 in inelastic MSAs. The corresponding increase in elastic MSAs is less than 4 percentage points.

Table IX presents estimates of the effect of house price growth on the change in default rates from 2002 to 2006. The instrumental variables specification in columns 1 and 2 is similar to the specification outlined in equations (1) and (2) above, except we examine default rates as the outcome variable. Consistent with Figure 6, we find a negative correlation between default rates and house price growth from 2002 to 2006. The estimate in column 2 implies that a one standard deviation increase in house prices leads to a 1 percentage point decrease in default rates.

In columns 3 through 7, we examine how house price growth differentially affects the decline in default rates from 2002 to 2006 for different homeowners. The instrumental variables specification is similar to the specification outlined in equations (6) and (7) above. The estimates in columns 3 and 4 show that lower credit quality and higher credit card utilization rate homeowners experience an even stronger decline in default rates from 2002 to 2006. In other words, the exact same borrowers experiencing the largest effect of house prices on home equity-based borrowing also experience the largest declines in default rates from 2002 to 2006.

Table X presents the analogous specifications that examine the increase in default rates from 2006 to 2008. The coefficient estimate on house price growth in column 2 is positive and statistically distinct from zero at a high confidence level. In other words, lagged house price growth strongly predicts future default rates. As the specifications with interaction terms show, the effect of lagged house price growth on future defaults is strongest among low credit quality and high credit card utilization households. The magnitude of the difference is very large. Among homeowners one standard deviation below the mean 1997 credit score, a one standard deviation increase in house prices from 2002 to 2006 leads to a full standard deviation increase in default rates from 2006 to 2008. In contrast, among homeowners one standard deviation above the mean 1997 credit score, a one standard deviation increase in house prices from 2002 to 2006 leads to 1/6 standard deviation increase in default rates from 2006 to 2008.

To obtain the macroeconomic magnitudes, we can repeat our analysis from Section III.B to examine the effect of house price appreciation on total defaults for the U.S. economy. Taking the estimate of 0.085 from column 1 of Table X, we find that defaults due to the home equity-based borrowing channel represent 34.8% 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.

Figure 7 provides suggestive evidence on the effect of increased household leverage on the consumption contraction during the recent recession. The top panel compares the evolution of auto loans for elastic and inelastic MSAs for homeowners in the top and bottom quartile of credit score distribution as of 1997. The top-left panel shows a sharp (relative) reduction in auto loans starting in 2006 for low credit quality homeowners living in inelastic MSAs. The magnitude of this drop is also large at almost 20%. There is no such relative drop for high credit quality homeowners living in inelastic MSAs.

The bottom panel repeats this exercise for homeowners in the top and bottom quartile of credit card utilization distribution in 1997. Consistent with the top panel, homeowners with a high credit card utilization rate as of 1997 significantly cut back their purchase of autos with financing, while there is no such effect for homeowners with low credit card utilization. In unreported regression results, we find that the differential drop in auto loans over 2006 to 2008 for homeowners in inelastic MSAs is statistically significant at the 1% level.

From 2002 to 2006, high credit card utilization rate and low credit score homeowners in high house price growth MSAs borrow heavily against the increased value of home equity and experience a sharp relative decline in default rates. These same individuals experience a very large relative increase in default rates and sharp reduction in auto loans when house prices

decelerate and fall from 2006 to 2008. These results highlight the important role that increased homeowner leverage played in the financial and economic downturn of recent years.

VI. Conclusion

We provide evidence of a strong link between asset prices and household borrowing decisions. The use of individual level data and an instrumental variables methodology enables us to precisely estimate the magnitude of the home equity-based borrowing channel. Since our individual level data is representative of U.S. household sector, we can provide an estimate of the economy-wide effect of the rise in house prices on household borrowing during the period of strong house price growth from 2002 to 2006.

The macroeconomic estimate of the effect of house price on household borrowing is large. We also show evidence that the increase in homeowner borrowing is not used to buy new houses, buy investment properties, or pay down costly consumer debt. Taken together, these findings lend support to the view that home equity-based borrowing is used for real outlays. While the effect of collateral on macroeconomic fluctuations has typically focused on business investment (Bernanke and Gertler (1989), Kiyotaki and Moore (1997)), our evidence suggests that fluctuations in house prices and household credit availability may play an important role in the evolution of business cycles. Exploring this link is an important question moving forward.

Our results also highlight the importance of understanding the microeconomic foundations of household behavior. We find that the home equity-based borrowing channel is driven primarily by homeowners with low credit scores and high credit card utilization rates. This may suggest that house price appreciation allows previously credit-constrained homeowners to move toward their optimal level of borrowing and consumption. However, it may also imply house price appreciation provides greater access to borrowing for homeowners that suffer from behavioral biases such as adaptive house price expectations (Agarwal (2007)), dynamically inconsistent preferences, or self-control problems.

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Table I
Summary Statistics

This table presents summary statistics for 67,489 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 2002 comes from the 2000 value reported in the decennial Census multiplied by the growth rate from 2000 to 2002 reported in the Fiserv Case Shiller Weiss data. The housing supply inelasticity measure we use is three – the Saiz (2008) measure. The Saiz (2008) measure is increasing in elasticity from 0 to 3. There are 2,046 zip codes and 45 MSAs that are represented in the sample.

	N	Mean	Median	St. Dev.
Equifax individual level data				
Total debt, 1997, $thousands	12161	101	95	72
Home debt, 1997, $thousands	12161	88	83	71
Growth in total debt, 1998-2002	12161	0.089	0.080	0.620
Growth in total debt, 2002-2006	12161	0.339	0.313	0.681
Growth in home debt, 1998-2002	12161	0.099	0.052	0.901
Growth in home debt, 2002-2006	12161	0.389	0.350	0.899
Total debt to income ratio, 1997	11872	2.507	2.494	1.504
Change in debt to income ratio, 1998-2002	12160	0.007	-0.071	0.900
Change in debt to income ratio, 2002-2006	12160	0.736	0.413	1.364
Total debt default rate, 1997	12161	0.039	0.000	0.112
Change in default rate, 1998-2006	12158	-0.006	0.000	0.133
Change in default rate, 2006-2008	12153	0.038	0.000	0.168
Credit score, 1997	12161	779	788	95
Credit card utilization fraction, 1997	12160	0.333	0.261	0.256
Age, 1997	12160	58	57	7
Male	12148	0.513	0.500	0.257
Income, 1997, $thousands	12160	79	74	35
Fiserv Case Shiller Weiss zip level data				
House price growth, zip level, 1998-2002	12122	0.394	0.415	0.140
House price growth, zip level, 2002-2006	12161	0.463	0.466	0.232
Saiz (2008) MSA level elasticity measure				
Housing supply inelasticity	12161	1.978	2.080	0.473
Median home value, 2002, $thousands	12152	228	193	135
IRS zip level income data				
Per capita wage growth, 2002-2006	12160	0.116	0.110	0.063
Census business statistics zip level data				
Per capita payroll growth, 2002-2006	11850	0.118	0.118	0.122
Employment growth, 2002-2006	11850	0.083	0.073	0.190
Equifax zip level aggregate data				
Fraction of zip code with credit score under 659, 1997	12161	0.307	0.293	0.119

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, 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.

Left hand side variable	(1) HP growth 2002-2006	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Total debt growth 2002-2006				Change in total debt to income ratio 2002-2006			
Housing supply inelasticity	0.213**								
	(0.060)								
Instrumented HP growth, 2002-2006		0.602**	0.614**	0.619**	0.539**	1.599**	1.722**	1.742**	1.313**
		(0.157)	(0.150)	(0.148)	(0.113)	(0.344)	(0.362)	(0.365)	(0.254)
(Credit score, 1997)/100			-0.026*				-0.100**		
			(0.012)				(0.029)		
Ln(household income, 2008)			0.142**				0.214**		
			(0.020)				(0.044)		
Age, 1997			-0.011**				-0.034**		
			(0.001)				(0.003)		
Male dummy variable			0.022	0.024	0.013		0.182**	0.181**	0.117*
			(0.026)	(0.024)	(0.025)		(0.062)	(0.058)	(0.054)
Additional control variables				Individual dummy variables	Individual dummy, census, income variables			Individual dummy variables	Individual dummy, census, income variables
N	12161	12161	12146	12146	11473	12160	12145	12145	11473
R^2	0.19	0.01	0.01	0.02	0.04	0.00	0.04	0.06	0.11

**,*, + 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, 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.

	(1)	(2)	(3)	(4)	(5)
Left hand side variable	Change in home value 2002-2006 $thousands	Change in total debt 2002-2006 $thousands			
Housing supply inelasticity	63.433**				
	(17.773)				
Instrumented change in home value, 2002-2006		0.245**	0.298**	0.302**	0.289**
		(0.051)	(0.056)	(0.056)	(0.080)
Median home value, 2002	0.464**	0.017	-0.028	-0.030	-0.117
	(0.112)	(0.042)	(0.055)	(0.051)	(0.101)
(Credit score, 1997)/100			-6.902**		
			(1.092)		
Ln(household income, 2008)			25.425**		
			(4.770)		
Age, 1997			-2.123**		
			(0.238)		
Male dummy variable			11.302*	11.172*	8.889*
			(4.700)	(4.576)	(4.405)
Additional control variables				Individual dummy variables	Individual dummy, census, income variables
N	12152	12152	12137	12137	11473
R^2	0.57	0.03	0.06	0.08	0.10

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

Table IV
Examining Exclusion Restriction for MSA-level Analysis

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

Left hand side variable	(1) Business payroll growth 2002-2006	(2) IRS wage growth 2002-2006	(3) Employment growth 2002-2006	(4) Payroll growth shock	(5) Wage growth shock	(6) Employment growth shock
Housing supply inelasticity	-0.001	0.026**	-0.016	-0.027**	0.001	-0.006
	(0.009)	(0.005)	(0.022)	(0.010)	(0.008)	(0.020)
N	1990	2045	1990	1969	2045	1969
R^2	0.00	0.03	0.00	0.00	0.00	0.00

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

Sample	(1) Homeowners	(2) Homeowners	(3) Homeowners	(4) Homeowners	(5) Renters	(6) Renters
Left hand side variable	Home debt growth 2002-2006	Credit card balances growth 2002-2006	Change in home debt to income 2002-2006	Change in credit card balance to income 2002-2006	Total debt growth 2002-2006	Change in total debt to income 2002-2006
Instrumented HP growth, 2002-2006	0.628**	0.191	1.491**	0.021	0.103	0.022
	(0.177)	(0.183)	(0.311)	(0.024)	(0.160)	(0.043)
N	12161	12161	12160	12160	4625	4624
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 V
Motivation for Within-MSA Test Based on 1997 Subprime Share of Zip Code Population

Panel A shows the effect of subprime fraction in the zip code on mortgage origination growth for home purchase at the zip code level by MSA housing supply elasticity. The zip code level mortgage origination growth data come from HMDA. Panel B shows the effect of the 1997 fraction of subprime individuals in the zip code on house price growth from 2002 to 2006 by MSA housing supply elasticity. Panel C shows the correlation between the instrument, subprime share of total population interacted with housing supple elasticity, and measures of debt as of 2002. Individual dummy variables are quintile indicator variables for 2% bins of the 2002 median home value in the zip code, 1997 credit score, 2008 income, and 1997 age variables. All specifications include MSA fixed effects and standard errors are clustered at the MSA level.

Panel A: Mortgage origination growth for new home purchase (HMDA), 2002-2006

	(1) Full	(2) Most elastic	(3) 2nd quartile	(4) 3rd quartile	(5) Most inelastic
Fraction in zip code with credit score under 660, 1997	1.434**	0.696*	0.763*	1.820**	1.893**
	(0.185)	(0.252)	(0.297)	(0.187)	(0.216)

Panel B: House price growth, 2002-2006

	(1) Full	(2) Most elastic	(3) 2nd quartile	(4) 3rd quartile	(5) Most inelastic
Fraction in zip code with credit score under 660, 1997	0.282**	-0.014	0.113+	0.330**	0.459**
	(0.058)	(0.022)	(0.060)	(0.056)	(0.080)

Panel C: Correlation of instrument with measures of debt as of 2002

	(1)	(2)	(3)	(4)
Dependent variable	Ln(total debt, 2002)		Total debt to income ratio, 2002	
Fraction in zip code with credit score under 660, 1997	-0.214	0.055	0.584	0.227
*Housing supply inelasticity	(0.182)	(0.138)	(0.400)	(0.435)
Fraction in zip code with credit score under 660, 1997	-1.005**	-0.068	1.224	2.190*
	(0.332)	(0.310)	(0.733)	(0.873)
Additional control variables		Individual dummy variables		Individual dummy variables

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

Table VI
The Effect of House Prices on Household Borrowing for 1997 Homeowners
Using Within-MSA Variation

This table presents second stage estimates from a within-MSA instrumental variables specification where the first stage instrument for house price growth from 2002 to 2006 is the fraction in the zip code with a credit score under 660 as of 1997 interacted with MSA level housing supply inelasticity. Individual dummy variables are quintile indicator variables for 2% bins of the 2002 median home value in the zip code, 1997 credit score, 2008 income, and 1997 age variables. All specifications (both first and second stage) include MSA fixed effects and standard errors are clustered at the MSA level.

Dependent variable	(1)	(2) Total debt growth 2002-2006	(3)	(4)	(5) Change in total debt to income 2002-2006	(6)
Instrumented house price growth, 2002-2006	0.940**	0.899**	0.902**	4.177**	3.167**	2.360**
	(0.305)	(0.262)	(0.241)	(1.107)	(0.833)	(0.706)
Fraction in zip code with credit score under 660, 1997	-0.256**	-0.047	0.054	0.262	0.619*	1.162**
	(0.084)	(0.081)	(0.108)	(0.274)	(0.243)	(0.317)
Median home value, 2002		-0.000			-0.001**	
		(0.000)			(0.000)	
(Credit score, 1997)/100		-0.046**			-0.145**	
		(0.010)			(0.022)	
Ln(household income, 2008)		0.170**			0.527**	
		(0.026)			(0.048)	
Age, 1997		-0.009**			-0.027**	
		(0.001)			(0.002)	
Male dummy variable		0.013	0.015		0.135*	0.134*
		(0.025)	(0.022)		(0.057)	(0.052)
Additional control variables			Individual dummy variables			Individual dummy variables
N	12161	12137	12137	12160	12137	12137
R^2	0.01	0.03	0.05	0.04	0.10	0.12

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

Table VII
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 control variables for individual 1997 credit score, 2008 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	0.030			
	(0.035)			
Instrumented HP Growth, 2002-2006		-0.092	0.674**	0.578**
		(0.101)	(0.171)	(0.146)
N	45	12143	6167	5976
R^2	0.34	0.01	0.00	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	-0.039+			
	(0.023)			
Instrumented HP Growth, 2002-2006		-0.182**	0.652**	0.597**
		(0.048)	(0.123)	(0.177)
Change in # of mortgages, 2001-2005			0.628**	
			(0.033)	
N	11893	11893	11893	3569
R^2	0.02	0.01	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	0.801**	0.147	2.146**	0.026
	(0.153)	(0.169)	(0.417)	(0.025)
N	3031	3031	3031	3031
R^2	0.02	0.00	0.04	0.01

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

Table VIII
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 use data sorted by credit score before groups are formed. In columns 3 to 6, we use data sorted by each interaction variable before groups are formed. All standard errors are clustered at the MSA level.

Interaction variable	(1) (Credit score, 1997)/100	(2) Credit card utilization, 1997	(3) Ln(household income, 2008)	(4) Age, 1997	(5) Age>=65, 1997	(6) Male
Left hand side variable	Total debt growth 2002-2006					
Instrumented house price growth, 2002-2006	2.576**	0.292*	1.053+	1.253**	0.702**	0.609**
	(0.479)	(0.124)	(0.563)	(0.413)	(0.147)	(0.138)
Instrumented house price growth, 2002-2006	-0.255**	0.952**	-0.100	-0.011		0.089
*Interaction term (listed at top of column)	(0.055)	(0.226)	(0.114)	(0.007)		(0.143)
Age>=65 indicator					-0.358+	
					(0.186)	
Instrumented house price growth, 2002-2006					0.156	
*Age>=65					(0.096)	
(Credit score, 1997)/100	0.055+	-0.065**	-0.047	-0.032	-0.031	-0.089**
	(0.033)	(0.022)	(0.036)	(0.034)	(0.033)	(0.028)
Credit cart utilization, 1997	-0.158*	-0.609**	-0.092	0.023	0.027	-0.205**
	(0.064)	(0.094)	(0.061)	(0.050)	(0.048)	(0.067)
Ln(household income, 2008)	0.149**	0.151**	0.251**	0.165**	0.162**	0.156**
	(0.022)	(0.022)	(0.058)	(0.020)	(0.020)	(0.022)
Age, 1997	-0.010**	-0.010**	-0.012**	-0.009**	-0.014**	-0.010**
	(0.001)	(0.001)	(0.002)	(0.003)	(0.001)	(0.002)
Male dummy variable	0.023	0.024	-0.016	-0.021	-0.022	-0.036
	0.055+	-0.065**	-0.047	-0.032	-0.031	-0.089**
N	12145	12145	11576	11844	11844	10742
R^2	0.01	0.01	0.03	0.06	0.06	0.01

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

Table IX
The Effect of House Prices on Default Rates from 2002-2006 for 1997 Homeowners

This table presents the effect of house price growth on default rates from 2002 to 2006. In columns 3 to 6, 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 3 and 4 we use the data sorted by credit score before groups are formed. In columns 5 to 7, we use the 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)	(7)
Interaction variable			(Credit score, 1997)/100	Credit card utilization, 1997	Ln(HH income, 2008)	Age, 1997	Male
Left hand side variable				Change in default rate, 2002-2006			
Instrumented house price growth, 2002-2006	-0.029**	-0.039**	-0.300**	-0.002	0.093	-0.064	-0.033*
	(0.009)	(0.008)	(0.094)	(0.015)	(0.100)	(0.058)	(0.016)
Instrumented house price growth, 2002-2006			0.034**	-0.106*	-0.029	0.001	0.025
*Interaction term (listed at top of column)			(0.012)	(0.045)	(0.022)	(0.001)	(0.026)
(Credit score, 1997)/100		0.010**	-0.005	0.011**	0.008+	0.005+	0.006+
		(0.002)	(0.006)	(0.003)	(0.004)	(0.003)	(0.003)
Ln(household income, 2008)		0.003	0.003	0.003	0.015	0.001	-0.000
		(0.003)	(0.003)	(0.003)	(0.011)	(0.003)	(0.003)
Age, 1997		0.000	0.000	0.000	0.000	-0.000	0.000
		(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Male dummy variable		0.006	0.006	0.006	0.013+	0.008	-0.007
		(0.005)	(0.005)	(0.005)	(0.007)	(0.005)	(0.012)
Credit card utilization, 1997			0.005	0.054*	-0.012	-0.022*	-0.004
			(0.010)	(0.024)	(0.011)	(0.010)	(0.010)
N	12158	12144	12143	12143	11549	11836	10736
R^2	0.00	0.01	0.02	0.02	0.00	0.01	0.01

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

Table X
The Effect of House Prices from 2002-2006 on Default Rates from 2006-2008 for 1997 Homeowners

This table presents the effect of house price growth from 2002 to 2006 on default rates from 2006 to 2008. In columns 3 to 6, 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 3 and 4 we use the data sorted by credit score before groups are formed. In columns 5 to 7, we use the 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)	(7)
Interaction variable			Credit score, 1997	Credit card utilization, 1997	Ln(HH income, 2008)	Age, 1997	Male
Left hand side variable				Change in default rate, 2006-2008			
Instrumented house price growth, 2002-2006	0.093**	0.116**	0.685**	0.026	0.057	0.250**	0.110**
	(0.017)	(0.020)	(0.162)	(0.017)	(0.090)	(0.081)	(0.026)
Instrumented house price growth, 2002-2006			-0.075**	0.251**	0.011	-0.002+	-0.006
*Interaction term (listed at top of column)			(0.019)	(0.065)	(0.022)	(0.001)	(0.035)
(Credit score, 1997)/100		-0.024**	0.016+	-0.019**	-0.019**	-0.018**	-0.022**
		(0.002)	(0.009)	(0.004)	(0.006)	(0.005)	(0.005)
Ln(household income, 2008)		-0.005	-0.006	-0.006	-0.010	-0.012*	-0.010*
		(0.004)	(0.004)	(0.004)	(0.012)	(0.005)	(0.005)
Age, 1997		-0.001**	-0.001**	-0.001**	-0.001*	0.000	-0.001**
		(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Male dummy variable		-0.001	-0.001	-0.001	0.005	0.014*	0.002
		(0.006)	(0.006)	(0.006)	(0.008)	(0.006)	(0.017)
Credit card utilization, 1997			0.022	-0.097**	0.012	0.022+	0.017
			(0.014)	(0.030)	(0.015)	(0.013)	(0.015)
N	12153	12140	12139	12139	11536	11832	10731
R^2	0.02	0.04	0.05	0.05	0.02	0.04	0.03

**,*, + 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.

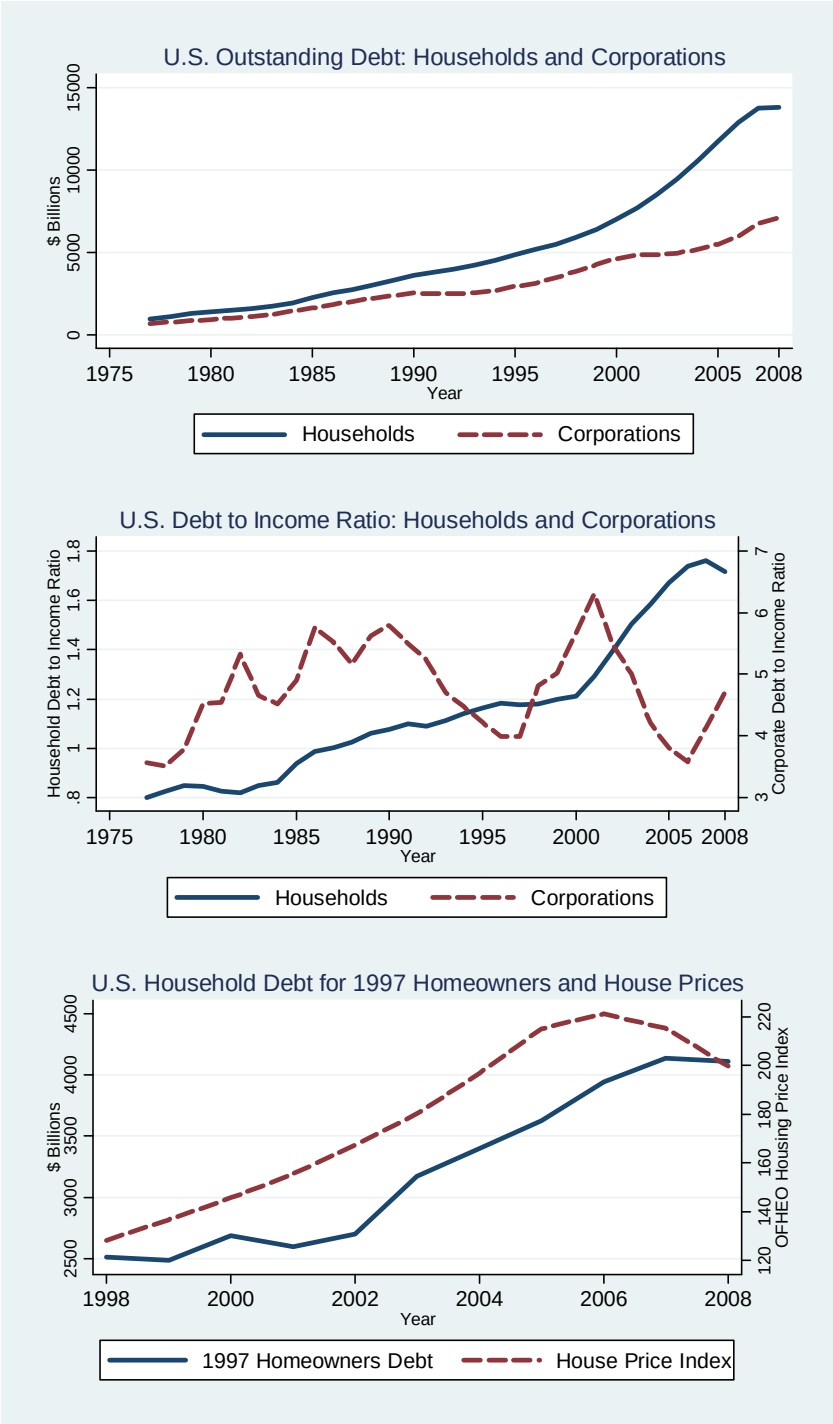


Figure 2

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 (2008). The sample includes individuals with mortgage debt outstanding as of 1997 or with a previous mortgage account.

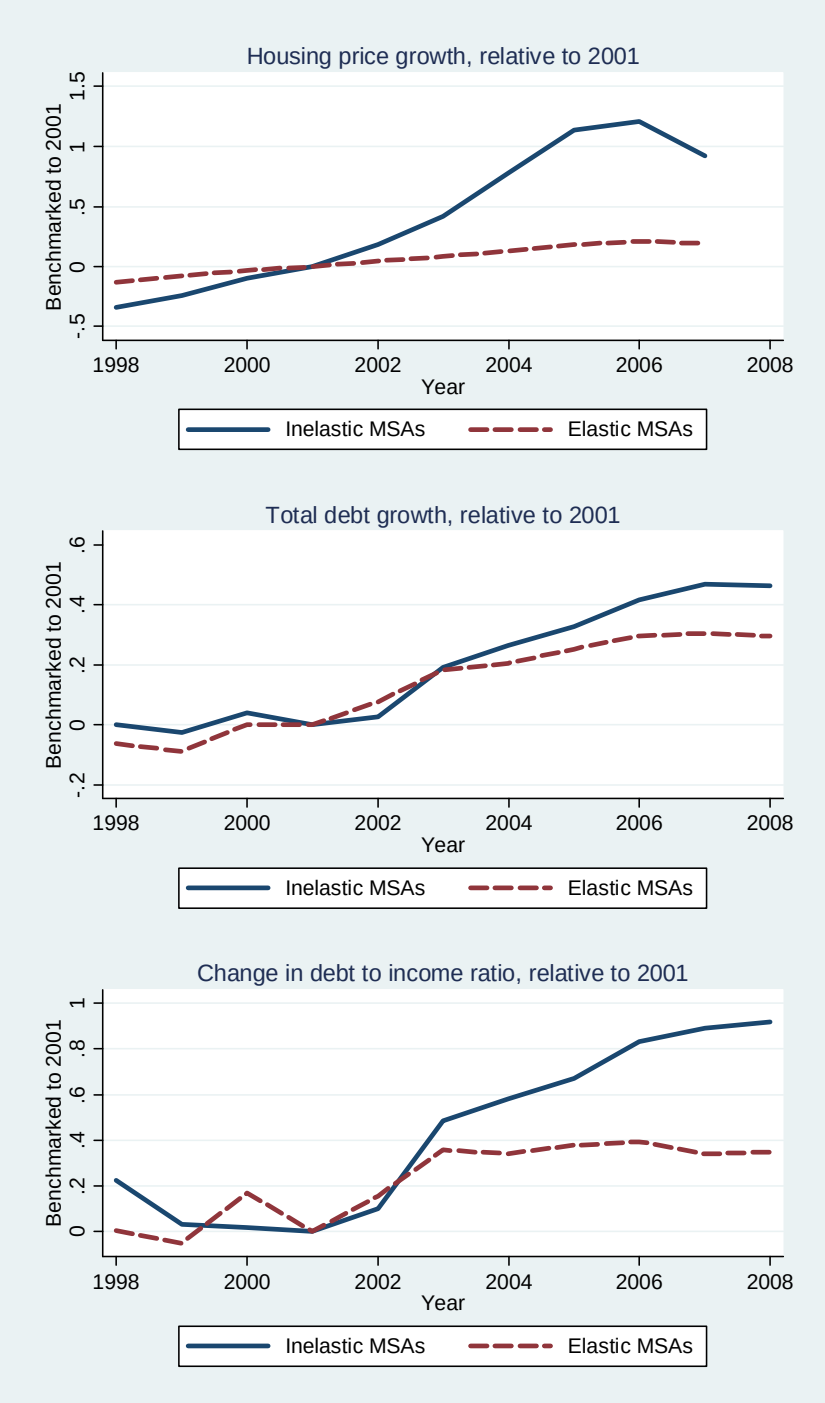


Figure 3
The Effect of House Prices on Total Debt Growth for 1997 Homeowners

This figure presents the effect of house price growth on total debt growth from 2002 to 2006 across the full distribution. The first stage instrument is the MSA-level housing supply elasticity from Saiz (2008). The sample includes individuals with mortgage debt outstanding as of 1997 who do not move zip codes between 1997 and 1999.

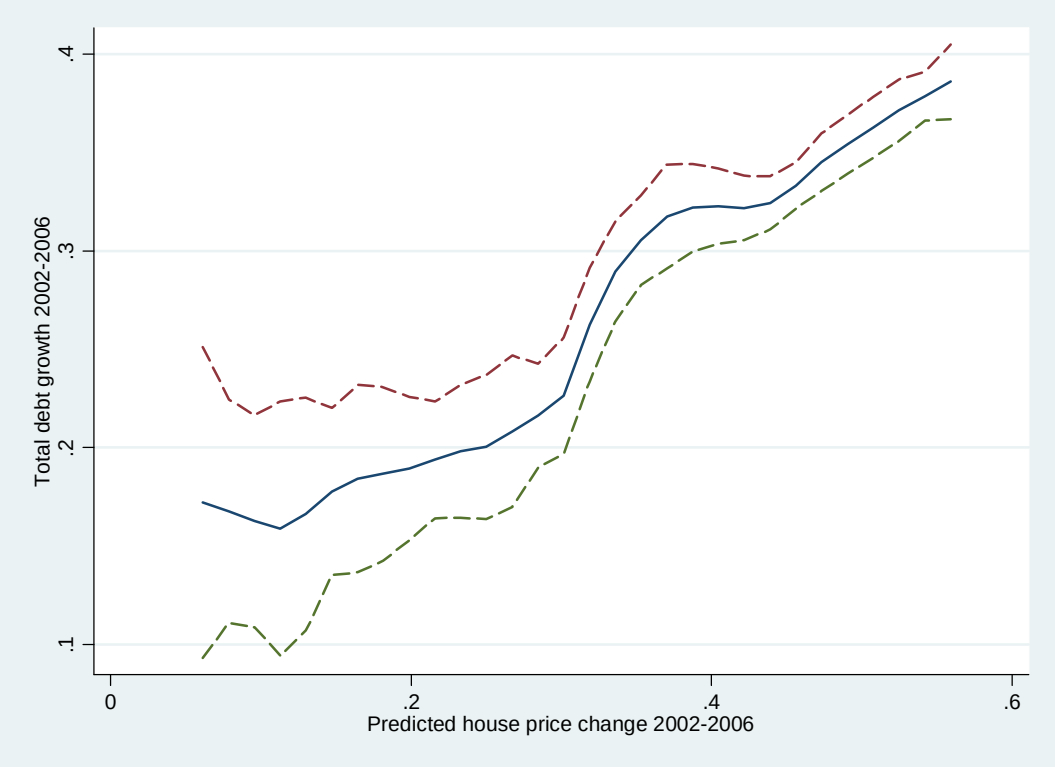


Figure 4
House Price and Leverage Patterns for
Homeowners Living in High Subprime Share Zip Codes in Inelastic Housing Supply MSAs

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.

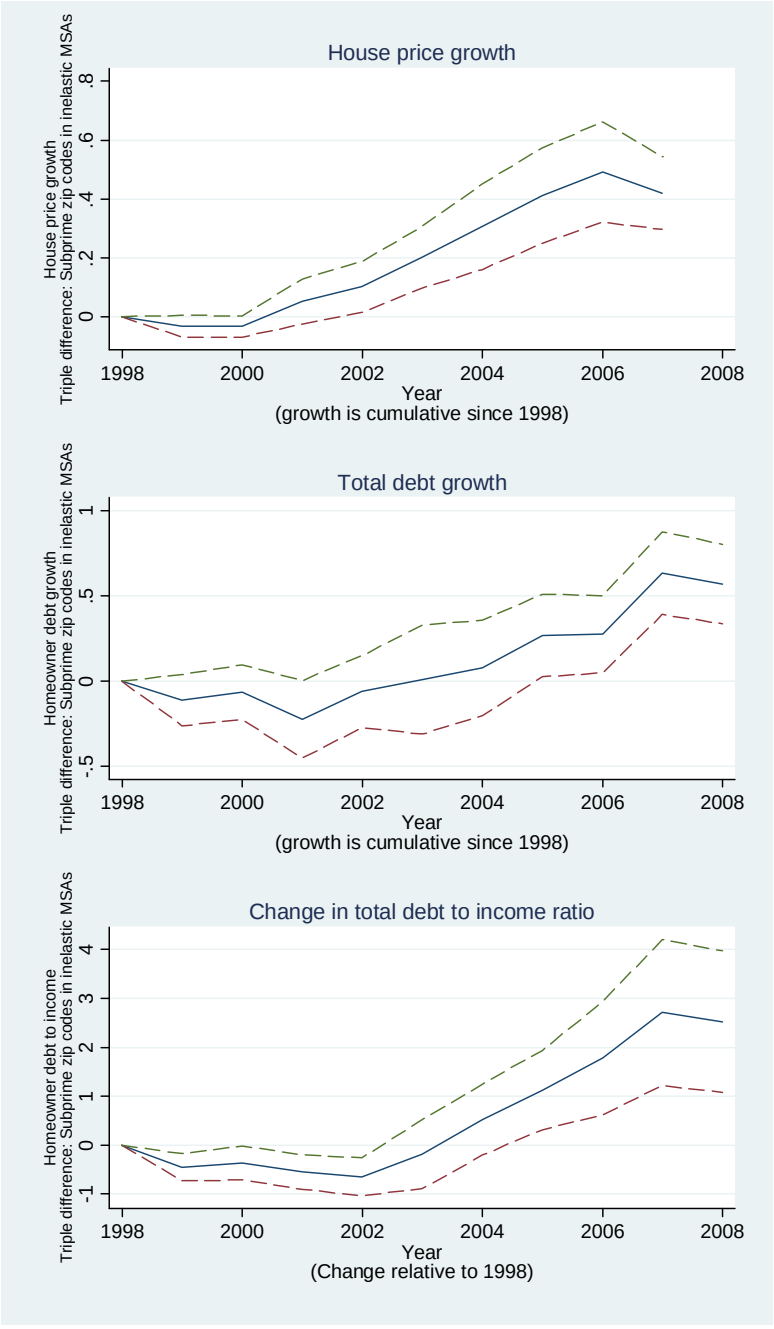


Figure 5
Cross-Sectional Heterogeneity in Leverage Patterns for 1997 Homeowners
By Housing Supply Elasticity

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.

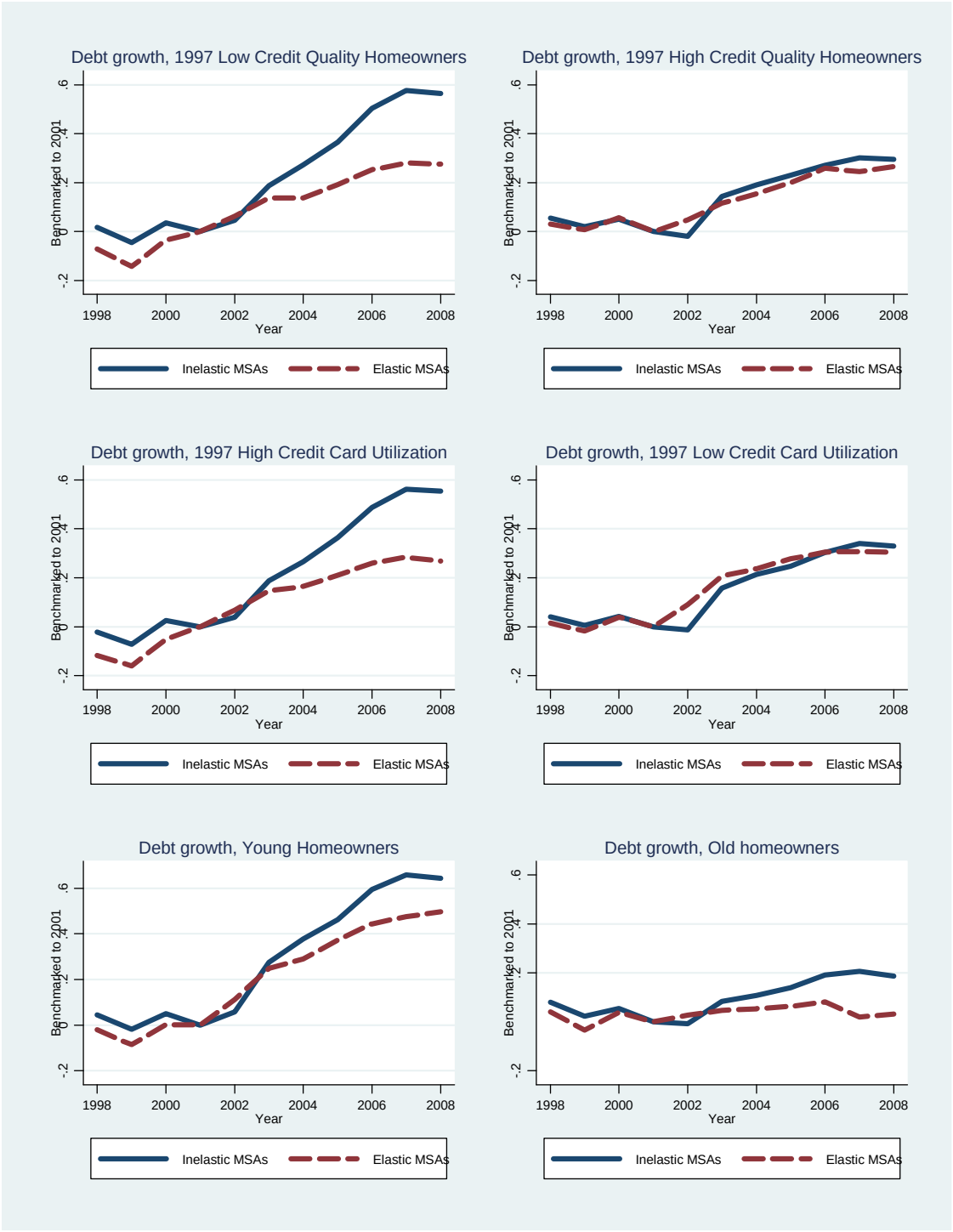


Figure 6
Default Patterns for Homeowners, By Housing Supply Elasticity and 1997 Credit Quality

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.

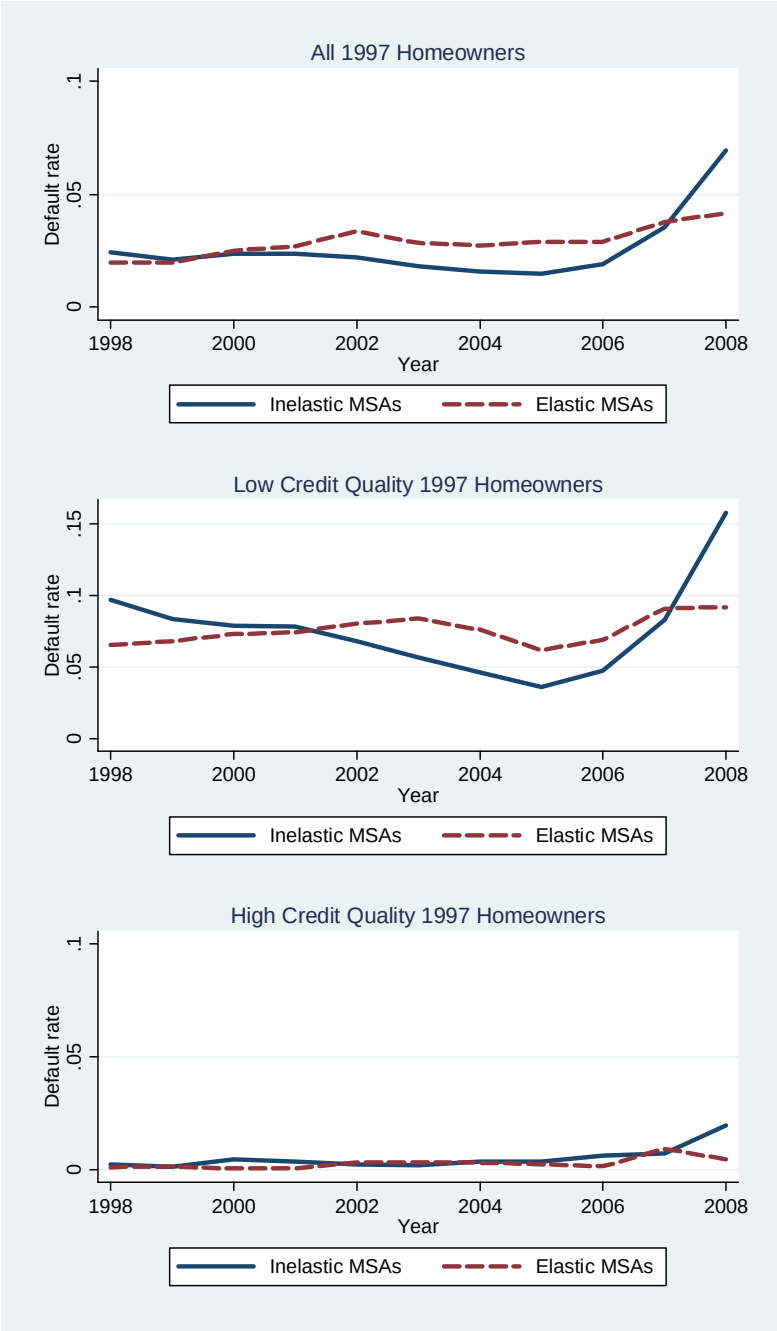
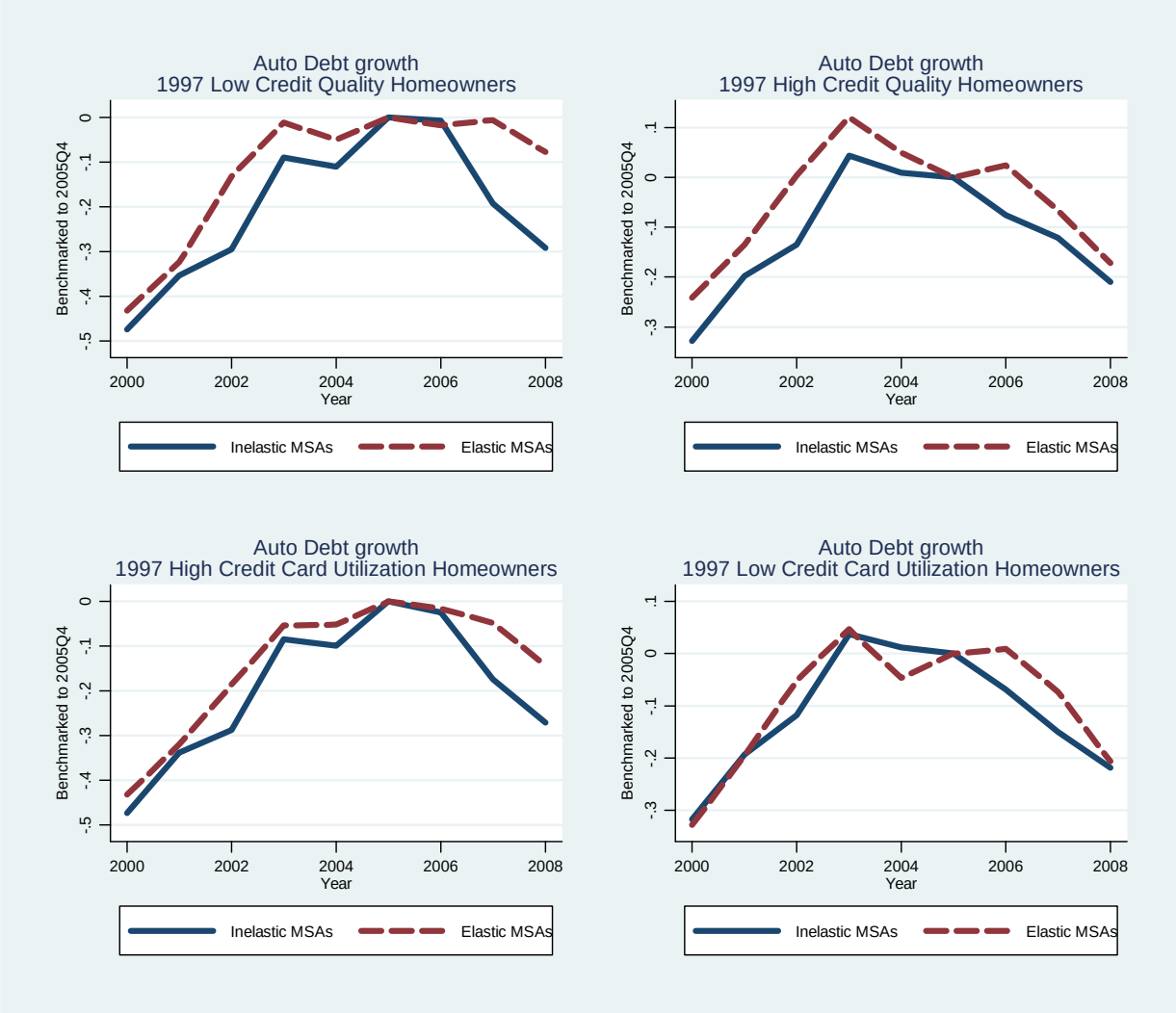


Figure 7
Cross-Sectional Heterogeneity in Auto Debt Growth for 1997 Homeowners By Housing Supply Elasticity

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



Appendix Table 1
Summary Statistics for Renters

This table presents summary statistics for individuals who have no current or previous mortgage debt outstanding. 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 2002 comes from the 2000 value reported in the decennial Census multiplied by the growth rate from 2000 to 2002 reported in the Fiserv Case Shiller Weiss data. The housing supply inelasticity measure we use is three – the Saiz (2008) measure. The Saiz (2008) measure is increasing in elasticity from 0 to 3. There are 2,075 zip codes and 45 MSAs that are represented in the sample.

	N	Mean	Median	St. Dev.
Equifax individual level data				
Total debt, 1997, $thousands	20369	6	4	5
Home debt, 1997, $thousands	20369	0.000	0.000	0.000
Growth in total debt, 1998-2002	20254	0.918	0.821	1.232
Growth in total debt, 2002-2006	20116	0.638	0.498	1.300
Growth in home debt, 1998-2002	20254	1.312	0.000	1.897
Growth in home debt, 2002-2006	20116	0.906	0.264	1.956
Total debt to income ratio, 1997	19541	0.168	0.126	0.161
Change in debt to income ratio, 1998-2002	20192	0.514	0.210	0.735
Change in debt to income ratio, 2002-2006	20099	0.796	0.248	1.336
Total debt default rate, 1997	20323	0.138	0.000	0.270
Change in default rate, 1998-2006	19609	-0.040	0.000	0.287
Change in default rate, 2006-2008	19336	0.046	0.000	0.273
Credit score, 1997	20369	705	704	103
Credit card utilization fraction, 1997	20337	0.471	0.451	0.343
Age, 1997	20157	53	50	14
Male	19237	0.482	0.500	0.343
Income, 1997, $thousands	20047	59	54	32
Fiserv Case Shiller Weiss zip level data				
House price growth, zip level, 1998-2002	20275	0.410	0.433	0.142
House price growth, zip level, 2002-2006	20369	0.497	0.497	0.233
Saiz (2008) MSA level elasticity measure				
Housing supply inelasticity	20369	2.015	2.140	0.463
Median home value, 2002, $thousands	20252	220	190	133
IRS zip level income data				
Per capita wage growth, 2002-2006	20351	0.117	0.111	0.062
Census business statistics zip level data				
Per capita payroll growth, 2002-2006	19763	0.120	0.120	0.122
Employment growth, 2002-2006	19763	0.067	0.055	0.188
Equifax zip level aggregate data				
Fraction of zip code with credit score under 659, 1997	20332	0.336	0.322	0.127

Appendix Table 2
Summary Statistics for Moving Homeowners

This table presents summary statistics for individuals who have either an existing mortgage account with positive balance as of 1997 or a previous mortgage account, and 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 2002 comes from the 2000 value reported in the decennial Census multiplied by the growth rate from 2000 to 2002 reported in the Fiserv Case Shiller Weiss data. The housing supply inelasticity measure we use is three – the Saiz (2008) measure. The Saiz (2008) measure is increasing in elasticity from 0 to 3. There are 3,016 zip codes and 83 MSAs that are represented in the sample.

	N	Mean	Median	St. Dev.
Equifax individual level data				
Total debt, 1997, $thousands	2270	121	115	79
Home debt, 1997, $thousands	2270	105	100	77
Growth in total debt, 1998-2002	2270	0.156	0.142	0.592
Growth in total debt, 2002-2006	2270	0.419	0.407	0.625
Growth in home debt, 1998-2002	2270	0.156	0.134	0.837
Growth in home debt, 2002-2006	2270	0.478	0.448	0.846
Total debt to income ratio, 1997	2134	2.983	2.909	1.632
Change in debt to income ratio, 1998-2002	2205	0.182	0.090	1.071
Change in debt to income ratio, 2002-2006	2253	1.124	0.820	1.562
Total debt default rate, 1997	2270	0.055	0.000	0.119
Change in default rate, 1998-2006	2270	-0.013	0.000	0.135
Change in default rate, 2006-2008	2270	0.053	0.000	0.174
Credit score, 1997	2270	762	765	79
Credit card utilization fraction, 1997	2269	0.352	0.310	0.216
Age, 1997	2270	54	54	6
Male	2270	0.563	0.571	0.242
Income, 1997, $thousands	2270	87	83	32
Fiserv Case Shiller Weiss zip level data				
House price growth, zip level, 1998-2002	2265	0.387	0.404	0.138
House price growth, zip level, 2002-2006	2270	0.498	0.505	0.225
Saiz (2008) MSA level elasticity measure				
Housing supply inelasticity	2270	1.986	2.080	0.461
Median home value, 2002, $thousands	2166	225	191	132
IRS zip level income data				
Per capita wage growth, 2002-2006	2253	0.114	0.108	0.067
Census business statistics zip level data				
Per capita payroll growth, 2002-2006	2169	0.124	0.123	0.126
Employment growth, 2002-2006	2169	0.119	0.091	0.230
Equifax zip level aggregate data				
Fraction of zip code with credit score under 659, 1997	2223	0.321	0.306	0.132

Appendix Table 3
Sample MSAs and Inelasticity Scores

This table reports the Saiz (2008) measure of housing supply inelasticity for the 45 MSAs in our sample.

	MSA name	Inelasticity
1.	Miami-Miami Beach-Kendall, FL	2.430
2.	Los Angeles-Long Beach-Glendale, CA	2.430
3.	San Francisco-San Mateo-Redwood City, CA	2.410
4.	New York-White Plains-Wayne, NY-NJ	2.360
5.	Boston-Quincy, MA	2.350
6.	Oakland-Fremont-Hayward, CA	2.340
7.	San Diego-Carlsbad-San Marcos CA	2.320
8.	Fort Lauderdale-Pompano Beach-Deerfield Beach, FL	2.290
9.	Chicago-Naperville-Joliet, IL	2.270
10.	San Jose-Sunnyvale-Santa Clara CA	2.250
11.	Seattle-Bellevue-Everett, WA	2.220
12.	New Haven-Milford CT	2.140
13.	Baltimore-Towson MD	2.140
14.	Riverside-San Bernardino-Ontario CA	2.080
15.	Newark-Union, NJ-PA	2.080
16.	Providence-New Bedford-Fall River RI-MA	2.030
17.	West Palm Beach-Boca Raton-Boynton Beach, FL	2.010
18.	Portland-Vancouver-Beaverton OR-WA	1.990
19.	Tampa-St. Petersburg-Clearwater FL	1.970
20.	Detroit-Livonia-Dearborn, MI	1.960
21.	Vallejo-Fairfield CA	1.940
22.	Jacksonville FL	1.940
23.	Philadelphia, PA	1.900
24.	Orlando-Kissimmee, FL	1.850
25.	Memphis TN-MS-AR	1.830
26.	Minneapolis-St. Paul-Bloomington MN-WI	1.820
27.	Denver-Aurora CO	1.820
28.	Hartford-West Hartford-East Hartford CT	1.810
29.	Washington-Arlington-Alexandria, DC-VA-MD-WV	1.720
30.	Phoenix-Mesa-Scottsdale AZ	1.710
31.	Fresno CA	1.690
32.	Bakersfield CA	1.660
33.	Raleigh-Cary NC	1.500
34.	Stockton CA	1.470
35.	Ann Arbor MI	1.300
36.	Las Vegas-Paradise NV	1.180
37.	Columbus OH	1.120
38.	Akron OH	1.100
39.	Toledo OH	1.070
40.	Atlanta-Sandy Springs-Marietta GA	1.060
41.	Youngstown-Warren-Boardman OH-PA	0.880
42.	Cincinnati-Middletown OH-KY-IN	0.850
43.	Greensboro-High Point NC	0.610
44.	Charlotte-Gastonia-Concord NC-SC	0.410
45.	Toledo, OH	0.090