Finance and Economics Discussion Series
Divisions of Research & Statistics and Monetary Affairs
Federal Reserve Board, Washington, D.C.

Homeowner Balance Sheets and Monetary Policy

Aditya Aladangady

2014-98

Homeowner Balance Sheets and Monetary Policy

Aditya Aladangady*†, Federal Reserve Board

October 21, 2014

Abstract

This paper empirically identifies an important channel through which monetary policy affects consumer spending: homeowner balance sheets. A monetary loosening increases home values, thereby strengthening homeowner balance sheets and stimulating household spending due to a combination of collateral and wealth effects. The magnitude of these effects on a given household depends on local housing market characteristics such as local geography and regulation. Cities with the largest geographic and regulatory barriers to new construction see 3-4% responses in real house prices compared with unconstrained, elastic-supply cities where construction holds prices in check. Using non-public geocoded microdata from the Consumer Expenditures Survey, house price and consumption responses are compared across areas differing in local land availability and zoning laws to identify a marginal propensity to consume out of housing of 0.07. Homeowners with debt service ratios in the highest quartile have MPCs as high as 0.14 compared with negligible responses for those with low debt service ratios. This indicates a strong role for collateral effects, as opposed to pure wealth effects, in driving the relationship between home values and spending. I discuss the implications of these results for the aggregate effects and regional heterogeneity in responses to monetary shocks.

*Contact: aditya.aladangady@frb.gov The latest version of this paper can be found at https://sites.google.com/site/aladangady/.

I am grateful for the helpful comments and discussion provided by Matthew Shapiro, Mel Stephens, Amiyatosh Purnanandam, Frank Stafford, Lutz Killian, and Yuriy Gorodnichenko. I would also like to thank Ryan Pfirrmann-Powell at the BLS for facilitating access to restricted data and answering questions about the Consumer Expenditure Survey. I also thank Ryan Nunn, Gabe Ehrlich, Cynthia Doniger, Desmond Toohey, Lasse Brune, and the seminar participants at the University of Michigan, NBER Summer Institute, Bureau of Labor Statistics, and FRB-SF/UCLA Housing and Monetary Policy Conference for their helpful comments regarding this paper. All remaining mistakes are my own.

†This research was conducted with restricted access to Bureau of Labor Statistics (BLS) data. The views expressed here do not necessarily reflect the views of either the Federal Reserve Board or the BLS.

1 Introduction

The collapse of the housing market between 2007 and 2009 left many homeowners with severely weakened balance sheets and unable to access credit markets. The impact of the recession on households is apparent in increased foreclosure rates, reduced mortgage lending, and sharply reduced consumption growth during the period. At the same time, we have seen one of the largest-scale monetary interventions in the history of the Federal Reserve System. An accurate assessment of the mechanisms by which monetary policy affects the real economy during deep balance sheet recessions is crucial to understanding the effects of such interventions.

While monetary policy may affect the real economy through a variety of channels (see Mishkin (1996) for a survey), the recent financial crisis has brought a new focus on the importance of borrower balance sheets for the propagation of macroeconomic shocks. Shocks that increase asset demand, such as a surprise monetary loosening, are amplified as asset prices increase, providing additional wealth and collateral to constrained borrowers. This is especially important in times when asset devaluation and debt overhang have left many borrowers unable to access credit. Increasing asset values provide collateral to constrained borrowers, mitigating agency costs between borrowers and lenders and allowing borrowers to finance higher levels of consumption or investment. Thus, the balance sheet channel amplifies small monetary shocks through large spending and investment responses from collateral constrained agents (Bernanke et al., 1999; Kiyotaki and Moore, 1997; Iacoviello, 2005). Though this mechanism has been described in the literature, there has been limited direct empirical evidence of its magnitude or importance for monetary policy transmission. The purpose of this paper is to empirically identify the balance sheet channel in a specific context: housing assets and homeowner balance sheets.

A monetary loosening lowers the user cost of housing, raising home values and strengthening balance sheets of homeowners. Improvement in homeowner balance sheet quality may have substantial impacts on real consumption expenditures due to wealth or collateral effects. This paper analyzes the quantitative importance of the "homeowner balance sheet channel" by exploiting heterogeneity in local housing markets. In addition, the paper provides evidence for the relative importance of wealth and collateral effects in explaining the response of consumption to housing wealth fluctuations. The results provide direct empirical evidence for the importance of both local housing markets and homeowner balance sheets in the transmission of monetary shocks to real economic activity.

Housing markets are a natural laboratory for studying the impact of household balance sheet quality on consumption. Though housing is not the only collateralizable asset held by

households, it is the most commonly used source of collateral. Furthermore, housing wealth forms a substantial portion of household balance sheets, and even relatively small fluctuations in house prices can cause substantial changes to borrowing capacity. New homeowners, who are most likely to be younger and more credit-constrained, are most affected by housing market shocks due to their high level of leverage compared to older homeowners (Flavin and Yamashita, 2002). This makes housing an important source of collateral for smoothing consumption over the life-cycle, and one which can have large effects on the borrowing capacity and consumption of young, credit constrained households.

Additionally, differences in local geography and land-use regulations provide natural variation in the impact of a national-level shock on house prices in different cities. These variables raise the cost of new construction and explain much of the cross-sectional heterogeneity in housing supply elasticities (Saiz, 2010; Gyourko et al., 2008). The importance of geographic and regulatory factors in driving heterogeneous price dynamics can be seen by examining the experience of various cities during the recent housing housing cycle in Figure 1. During the expansion period between 1996 and 2006, inland cities with few constraints on new construction, such as Dallas and Atlanta, saw little house price change and large levels of new construction. The collapse of the housing bubble halted new construction in these cities, but caused only moderate declines in house prices. Cities with limited land and strict zoning laws, such as San Francisco, Miami, or New York, saw limited new construction but large fluctuations in prices during the same period.

This variation provides a means to identify the homeowner balance sheet channel. Since a monetary loosening shifts housing demand, house price responses vary systematically with local geography and land-use regulations. Cities that are unconstrained by geographic or regulatory factors have small responses in house prices as new construction keeps prices in check. Homeowners in these cities form a natural control group, as they see little to no change in balance sheet quality due to the monetary policy shock but are still affected by other aggregate shocks that may drive both consumption and housing demand. On the other hand, the housing stock cannot adjust easily in land-constrained and regulation-constrained cities, resulting in dramatic swings in house prices and hence homeowner balance sheet quality. By comparing households across different local housing supply elasticities, I am able to identify the marginal propensity to consume (MPC) out of housing as well as the magnitude of the homeowner balance sheet channel.

I quantify the homeowner balance sheet channel in two steps. First, I identify the effect of monetary policy on real house prices and document the heterogeneity of house price responses in a structural vector autoregression (SVAR). House price responses vary substantially across metropolitan statistical areas (MSA's) with differing housing supply elasticities as measured

by land availability and local zoning regulation variables from Saiz (2010). The most inelastic-supply markets show house price responses as large as 3-4% following a 1 standard deviation shock to the federal funds rate, whereas the most elastic markets show no significant response in prices at all.

Second, given this variation, I turn to household-level survey data on consumption to understand the effects of house price growth on spending. Using restricted-access geographic data from the Consumer Expenditure Survey, I link households to local house price indices and the MSA-level housing supply elasticity measures (land availability and zoning regulations). Interactions between supply elasticity measures and monetary shocks are used as instruments for house price growth. Intuitively, house prices respond more strongly to monetary shocks in areas with tighter geographic or regulatory constraints. Under the assumption that these factors do not directly impact household consumption responses to monetary shocks, the instruments can be used to consistently estimate the MPC out of housing. Using this estimate along with estimated house price responses, I develop an estimate of the magnitude of the homeowner balance sheet channel.

This paper follows a long literature attempting to disentangle the relationship between housing wealth and consumption. While several recent studies (Case et al., 2005; Ludwig and Sløk, 2004; Carroll et al., 2011) have found strong relationships between consumption and housing wealth in aggregate data, the exact nature of these relationships may be complicated by a variety of factors. For example, Attanasio and Weber (1994) argue that common factors such as income expectations may drive both housing and consumption demand. This result is echoed in more recent work by Attanasio et al. (2009), who find strong effects of rising home values even on renters. They interpret this finding as evidence that common factors are driving housing demand along with consumption of both owners and renters. This paper attempts to separate the effect of common factors and establish a causal link between housing wealth and consumption.

The use of restricted-access geographic variables in the Consumer Expenditure Survey micro-data is crucial to the identification strategy used in this paper. Inclusion of county identifiers allows for household spending data to be linked to MSA and county-level variables on housing supply elasticity measures such as land availability and zoning laws (from Saiz (2010)) and local house price indices. This data makes this study unique since it is the first to use geographically linked micro-data on a broad set of consumption expenditures to identify the effect of housing wealth on spending.

Previous studies on household collateral constraints have focused on the link between home equity and borrowing or car purchases using related identification strategies. Mian and Sufi (2011) use geographically linked household credit data to find large responses in

household leverage due to home equity growth during the mid-2000's. While they find large effects of housing wealth on equity extraction during the housing boom, the effects on consumption may be muted if households use extracted equity to pay down other, more expensive forms of debt or save for future spending. While others in the literature attempt to address this issue by using automotive loans or registrations as a proxy for local-level spending (Mian et al., 2013; Kermani, 2013), the validity of extrapolating auto loans to total consumption is not clear.[1] While self-reported consumption measures used in this paper may contain more noise than administrative credit or car registration data, this study provides a more complete picture of household consumption responses to housing wealth. Furthermore, much of the literature focuses on the mid-2000's, a period of unusually high credit expansion potentially correlated with housing supply elasticity. By using data from 1986 to 2012 and specifically modeling the demand shock driving house price growth, this paper provides evidence that the relationship between home equity and consumption, while most prevalent during the recent housing boom, has been stable over time.

Results from the estimation show strong causal effect of housing wealth on consumption. The estimated elasticity of consumption to house prices for homeowners is 1.5, corresponding to an MPC of approximately 0.07. By contrast, renters show no significant responses to house price changes. This result stands in contrast to the findings in Attanasio et al. (2009) who find positive effects on both owners and renters. The difference highlights the importance of the identification strategy in controlling for common factors which may drive house price growth along with consumption for both owners and renters.

The relationship between housing and consumption is driven by a combination of collateral and pure wealth effects, and the distinction is important in understanding the aggregate implications of these results. While wealth effects may be large for a household who is selling housing in a high-price environment, these effects are likely to be offset by negative wealth effects on potential home buyers. Pure wealth effects are unlikely to cause aggregate spending growth in the absence of systematic heterogeneity in MPC's between buyers and sellers. By contrast, increases in home equity collateral improves borrower balance sheets and loosens credit constraints. Constrained borrowers are likely to have high MPCs, as they are constrained away from their first-best consumption path. Therefore, collateral effects are likely to increase aggregate consumption and welfare.

To test for the relative importance of these two effects, I compare responses of homeowners with high debt service ratios (debt service payments as percentage of income) to those with

[1]The use of auto loans is especially problematic when used in conjunction with housing supply elasticity variables to estimate consumption responses to home values. Urban sprawl,caused by availability of land, results in very different demand for cars in elastic and inelastic cities. This may cause housing supply elasticity instruments to be invalid in the absence of specific controls for preferences for cars.

lower debt service ratios. High DSR values have been shown to be strong predictors of a household's likelihood of being denied credit and are hence a good proxy for credit constraints (Johnson and Li, 2010). Results show that homeowners with DSRs in the highest quartile have MPCs of 0.14 compared to statistically insignificant responses for those with low DSRs. Furthermore, households who actively extracted equity from their homes in the past year display significantly larger spending responses than those who did not extract equity.

These results point to a relatively important role for collateral constraints as opposed to pure wealth effects in driving the relationship between housing and consumption. These results are in line with Hurst and Stafford (2004),Cooper (2009), and Bhutta and Keys (2014), who show that households may refinance to higher principals not only to capture lower interest rates, but also to smooth consumption. These estimates are also in line with results from Mian and Sufi (2011) showing households extracted \$0.25 of equity for every \$1 of house price growth in the mid-2000's. While short-run MPC's are slightly lower than the magnitude of equity extraction during this period, evidence points to a high level of spending following equity extraction as opposed to paying down more expensive forms of debt. Campbell and Cocco (2007) exploit heterogeneity over the life-cycle to show that older homeowners have larger MPCs out of housing relative to younger cohorts. While this result leads them to conclude that there are strong wealth effects from housing, results in this paper indicate that credit constraints play a more important role quantitatively.

Taken together, the results show that monetary shocks have heterogeneous effects on house prices which play an important role in determining household spending. The results therefore imply a quantitatively large household balance sheet channel which varies in magnitude across households based on local housing market conditions, homeownership status, and credit conditions. Renters and homeowners in the most elastic markets have minimal consumption response through this channel, while credit constrained homeowners in inelastic markets can have consumption effects as large as 4%. Effects are initially muted and become increasingly important after 8-12 quarters.

The importance of collateral effects in driving these relationships is crucial for understanding the aggregate impacts of monetary policy. First, aggregate consumption responses are likely to be small if wealth effects were to dominate, since wealth effects arise due to transfers of wealth between buyers and sellers of housing. The importance of collateral effects provides evidence that aggregate spending responses will be driven by large responses of constrained homeowners who enjoy increased collateral values. Secondly, the homeowner balance sheet channel provides a mechanism through which monetary policy may affect consumption inequality. Recent work by Coibion et al. (2012) finds that various measures of consumption inequality fall in response to a monetary loosening. By raising home values, a monetary

loosening provides collateral to low income, credit-constrained households allowing them to finance higher levels of spending. Effects are small for high income, unconstrained households who have a low marginal value of collateral. The homeowner balance sheet, therefore, compresses the distribution of spending, reducing inequality.

The next section discusses the various data sets used in this study including the Consumer Expenditure Survey, housing supply elasticity measures, and house price indices. Section 3 discusses the effects of monetary policy on house prices and provides support for the empirical strategy and identifying assumptions described in Section 4. Section 5 discusses results and provides tests for the relative importance of collateral and wealth effects in explaining the homeowner balance sheet channel, and Section 6 concludes.

2 Data

Consumer Expenditures Survey (Public-Use and Restricted-Access Geography Data) The Consumer Expenditure Survey (CES) consists of a rotating panel of households, each interviewed over four[2] quarters before being replaced by a new respondent. Each quarter, households report on over 300 categories of spending and household characteristics, with additional data on income and balance sheets collected in the first and last interview only. Quarterly summary expenditures on total spending, non-durable spending,[3] and a variety of summary categories are generated for each household in the sample from 1986-2008.[4] Expenditures are deflated by the CPI.[5] The sample period is selected to avoid major survey changes occurring prior to 1986 and the Zero-Lower-Bound (ZLB) period starting in December 2008 after which monetary shocks cannot be identified using Federal Funds rates. Households are linked across waves providing 4-quarter panels for each household.

Income and balance sheet data are only collected in the first and last interview, often making it difficult to track changes in wealth or income from quarter to quarter. Notably, home values were only reported in the final interview until 2007, so growth in home values is not directly observable in much of the data. Using restricted-access geographic files from the CES, I match households with local-level housing market variables based on FIPS county

[2]Households are actually interviewed for five quarters after which they are replaced by a new respondent. The first interview serves as an orientation for the household, and no expenditure data is collected.

[3]Non-durable spending includes expenditures on food, alcohol, tobacco, housing operations, utilities, gasoline, public transportation, personal care, reading/entertainment, apparel, healthcare and educational expenses. Results are robust to excluding semi-durable or ambiguous categories such as apparel, healthcare, and education.

[4]Alternate specifications using county-level Zillow house price data use only 1996-2008 observations as this house price data is unavailable prior to 1996. Changes to the survey design in 1996q1 and 2005q1 prevent linking individuals across those two quarters.

[5]Deflating each expenditure category by category-specific price indices did not substantially affect results.

codes.[6] Household's who have lived in the same location for more than one year are matched to county and MSA level house price indices to provide a history of house price growth and MSA-level annual per capita income growth. In addition, these households are matched to measures of housing supply elasticity allowing consumption responses to be compared across households with differing exposure to house price growth. These variables are the key to the identification strategy used in this paper.

The unit of observation is a "Consumer Unit" (CU) defined as a financially interdependent group of people living in the same home and making joint expenditure decisions. A physical home may contain more than one consumer unit if members of the household make independent spending decisions on housing, food, and living expenses. For purposes of this study, I adopt the CU definition when referring to households that make consumption choices over time.

The CES sample frame is selected to form representative samples of each Census Region as well as 18 "Type A" metropolitan areas comprising most of the largest MSA's in the US. Sampling is also conducted at several smaller metropolitan and rural areas to form a nationally representative sample, but sampled households are not representative of any specific smaller MSA. While this prevents construction of synthetic panels at the MSA-level, it provides nationally representative coverage of the local housing supply elasticities in cities where people live. Therefore, the consumption responses estimated using supply elasticity instruments can be interpreted as nationally representative.

Housing Supply Elasticity Measures Using restricted-access geographic variables in the CES, households are matched to local housing elasticity variables from Saiz (2010). The two measures of local housing supply elasticity used are the proportion of "unavailable" land in an MSA and the Wharton Land-Use Regulation Index at the MSA-level. The maps in Figure 2 describe the variation in these two variables across the United States. Taken together, these variables explain most of the across-MSA variation in housing supply elasticity (Saiz, 2010).

The measure of unavailable land is constructed from topographic maps and measures the proportion of land in a 50km radius of the city center that is lost to steep slopes (above 15% grade) and bodies of water.[7] The definition considers land with a structure currently on it to be "available", so provides a time-invariant measure of total land, not currently unused land, available for construction. Therefore, the variable provides a constraint on available resources for housing construction and proxies for long-run elasticity in the MSA. Higher values of "unavailable land" imply larger geographic barriers to new construction, and

[6] MSA-level data is linked using a crosswalk from NBER between counties and the OMB's MSA definitions as of 2001.

[7] For further detail regarding the construction of the measure, refer to Section 2 of Saiz (2010).

therefore more inelastic housing supply.

The second measure, the Wharton Land-Use Regulatory Index constructed by Gyourko et al. (2008), is based on a national survey regarding the difficulty and cost of completing a residential construction project in various metropolitan areas. Survey measures attempt to capture the time and financial cost of acquiring permits and beginning construction on a new residential structure. The principal component of 11 survey measures used in the study is interpreted as an index for the stringency of local zoning laws.[8] The index provides a measure of how difficult it is to convert real resources such as labor, materials, and land into a house. Higher values of the index imply tighter regulatory barriers to new construction.

The use of metropolitan statistical areas as the relevant geographical area for defining local housing supply is not simply a convenience. MSA's are defined by the Office of Management and Budget based on economic and cultural dependencies. For example, a large presence of commuters may cause a county to be included in a larger MSA. Such labor market or cultural linkages cause housing to be substitutable between counties within the same MSA. This means land availability and regulations in one county are likely to influence housing values in neighboring counties. By comparison, MSA-level housing markets are sufficiently isolated from each other and are unlikely to be viewed as close substitutes.

Both land availability and regulation variables are available only as a cross-section, which raises issues regarding their stability over the sample period. While local geography is constant over the sample period, regulations have changed. For example, many states in the Southwest tightened zoning laws to limit sprawl and control the area to which public resources (mainly water) is provided. Such changes would only bias results if cities that currently have inelastic supply formerly were amongst the most elastic-supply markets. Results using only the "unavailable land" measure as an instrument are consistent with baseline results suggesting that regulatory changes were too small to cause cities to move in the relative ordering of elasticities. Furthermore, Saiz (2010) shows that both land and regulatory measures predict housing supply elasticity remarkably well even when sample periods for elasticity estimation are constrained to various time frames between 1970-2010.

A related issue is migration during the sample period. For example, a systematic population shift from elastic to inelastic areas may change the relative likelihoods with which cities are sampled in the CES. Migration patterns from the American Community Survey's do not indicate such systematic migration patterns correlated with housing supply elasticity measures. Furthermore, the CES sample frame is only updated once a decade to each Decennial Census, and the distribution of local housing supply elasticity variables in the CES sample is stable across these breaks. While population shifts may affect sampling between cities, they

[8]Further detail regarding the Wharton Land-Use Regulation Index can be found in Gyourko et al. (2008).

do not affect the relative distribution of the population across elastic and inelastic supply MSA's.

House Price Indices Disaggregated house price data is essential to the identification strategy used in this study. The CES provides only a single observation of self-reported home values for each household. Therefore, I use non-public geographic data in the CES to merge households with local house price histories. The consumption response to housing wealth is identified using local heterogeneity in house price growth which is not sufficiently captured in state or regional indices.

The baseline house price index used in this study is the all-transactions index produced by the Federal Housing Finance Agency (FHFA). House price indices are available quarterly from 1976-present for most MSA's in the United States. This provides both geographic coverage of nearly 80% of the U.S. population and a long time series that includes several business cycles, the recent national housing boom, and the regional housing bubble of the early 1990's in the Northeast. Each MSA-level index is constructed using a weighted, repeat-sales method which compares transaction prices of homes to their previous sale price. By comparing each home to itself, this method avoids composition biases from quality changes in the stock of homes transacted from quarter to quarter.

While this index is attractive in its geographic scope and relatively long time series, it suffers a fundamental drawback. The FHFA indices are constructed using transactions data acquired through Freddie Mac, and hence cover only homes purchased with conforming mortgages. Aside from cash transactions, this excludes all sub-prime, jumbo, and other non-conforming loans which were largely responsible for the rapid house price growth in the mid-2000's, especially in inelastic supply regions (Barlevy and Fisher, 2010; Mian and Sufi, 2009). This causes the FHFA index to understate the the sensitivity of house prices to alternative credit in the inelastic-supply regions which may be linked to loose monetary policy.

To address this issue, I also estimate the baseline specification using an alternate index from Zillow.com. Unlike FHFA's repeat sales method, Zillow uses a proprietary hedonic pricing model to estimate the value of most US homes based on home characteristics and price data collected from county registrars, real-estate agencies, and self reports. These individual home value estimates are then averaged into county, MSA, state, and national level indices. Like the repeat-sales methodology, the Zillow index does compare a home's estimated price with its past value to avoid composition biases. Furthermore, Zillow estimates each house price in a manner similar to repeat-sales methods to address composition biases in the stock

of transacted homes.[9] Despite its superior coverage of homes and availability at the county level, the Zillow house price index extends only back to 1996 and covers only one housing cycle and two NBER recessions. Use of both FHFA and Zillow indices provides a robust estimate for the homeowner balance sheet channel.

Figure 3 provides a comparison of national-level indices from FHFA, Zillow, and Case-Shiller along with mean and median self-reported home values from the CES. Self-reported values closely track the house price indices used in this paper.

Other Variables In order to identify national-level credit and monetary shocks, I use a time series of macroeconomic variables in a recursive vector autoregression. Variables include log real GDP, CPI inflation, effective federal funds rates, 30 year conventional mortgage rates, and the national house price index (FHFA all transactions) at a quarterly frequency from 1954-2012. While the full time series is used to estimate the monetary shocks, only those shocks within the CES sample period are used in the analysis.

3 Monetary Policy & House Price Dynamics

Since the propensity to consume out of housing will be identified using cross-sectional differences in house price responses to monetary policy, it is instructive to first understand the impact of monetary policy is on local house prices and how this differs across cities. The "homeowner balance sheet channel" requires that monetary policy actions affect house prices, and therefore homeowner balance sheets. Furthermore, the heterogeneity in price responses is crucial to the identification. Land availability and regulation variables will be used to compare house price and spending responses to monetary shocks across regions. The difference between elastic-supply MSA's with little house price response and inelastic-supply MSA's with larger price response provides insight into the importance of homeowner balance sheets in the transmission of monetary shocks. Without heterogeneity in price responses, identification using such comparisons will be weak.

Easier monetary policy reduces the user cost of housing, boosting housing demand, and leading to stronger construction and higher home values.[10] Housing supply elasticity, as determined by land availability and zoning laws, explains the relative increase in construction

[9] A thorough discussion of the methodology can be found on Zillow's Research website: http://www.zillowblog.com/research/2012/01/21/zillow-home-value-index-methodology/

[10] While housing supply may also be shifted by monetary shocks due to financing constraints on home builders, house price responses will be correlated with housing supply elasticity variables so long as monetary policy shifts demand more than supply (Aladangady, 2014). The relevance of instruments used rests on house prices responding relatively more in areas with limited land and strict zoning laws. Empirical results indicate that this is the case, implying shifts in housing supply following a monetary shock are quantitatively small.

and price. After a monetary shock, MSA's with limited "buildable" land will have increasing marginal costs of new construction, resulting in higher house prices relative to land-rich areas. Similarly, in MSA's with stricter zoning regulations, new construction will be costly, raising the marginal value of an existing home.

To provide a simple means of empirically identifying this heterogeneity in house price responses, I use a simple monetary vector autoregression (VAR) to estimate impulse responses of house prices to monetary shocks in different areas. Using housing supply elasticity estimates of house prices from Saiz (2010), I combine MSA-level FHFA house price indices (henceforth HPI's) into 4 indices for quartiles of the elasticity distribution weighted by population.[11] A VAR is then estimated using national GDP, CPI inflation, federal funds rate, 30yr fixed mortgage rate, and the four constructed quartile HPI's. Baseline identification of monetary shocks allows Fed Funds rates to respond contemporaneously to GDP and inflation, but to mortgage rates and HPI's only with a lag.

The assumption that GDP and inflation are predetermined in the Fed's policy rule is standard in the literature (Bernanke and Blinder, 1992; Christiano et al., 1999). This is supported by the fact that production and pricing decisions are often made in advance and are difficult to change on the fly. Prices of goods in the CPI are adjusted approximately once every 4-7 months (Bils and Klenow, 2004; Klenow and Kryvtsov, 2008), and hence are planned in advance and unlikely to respond to changes in monetary policy or financial markets within a quarter.

While the ordering of GDP, inflation, and Fed Funds is standard, the inclusion of housing variables is not. While many studies leave these variables out of the VAR when identifying monetary shocks, it is important in this context to purge Fed Funds innovations of endogenous policy responses to housing or mortgage market conditions. The Fed Funds rate is ordered prior to mortgage rates and house prices, therefore restricting the Fed from responding to end-of-quarter mortgage rates and house price indices. Financial markets are quick to respond to monetary policy movements, hence long-term mortgage rates are likely to react to monetary shocks within the quarter. Furthermore, house prices are determined at the time of transaction and hence are based on the full information sets of the transacting parties at the time the sale occurs. Therefore, house prices likely reflect concurrent movements in monetary policy. Since only monetary shocks are identified, relative ordering of other variables does not affect the identification of impulse responses to monetary shocks (Bernanke and Blinder, 1992; Christiano et al., 1999).

[11] Cities are partitioned into population-weighted quartiles based on housing supply elasticity estimates. House price indices q_{it} for MSA's i at time t are combined using population weights ω_i from the 2000 Census: $Q_{mt} = \frac{\sum_{i \in m} \omega_i q_{it}}{\sum_{i \in m} \omega_i}$ where m is the set of MSAs in the quartile.

Resulting impulse responses for each quartile are plotted in Figure 5. As can be seen in the first panel, the most elastic cities show little house price response to a monetary shock with approximately 0.5-1% decline in house prices over 3-4 years after a 1 standard deviation (71 basis point) shock to Federal Funds rates. As the housing supply elasticity falls, house price responses become more dramatic. The most inelastic areas display a house price response of 3-4% from trend after 3-4 years after the same shock.

Closer analysis of the underlying VAR reveals that monetary shocks move 30-year fixed mortgage rates causing a shift in housing demand. Results provide further evidence that monetary shocks shift housing demand along heterogeneous local housing supply curves. While housing supply may also shift, the crucial identifying assumption that house prices respond heterogeneously to monetary shocks is supported by these results.

These results provide not only an insight into the distributional effects of monetary policy, but also a means to identify the homeowner balance sheet channel. While the most elastic-supply locales see little house price response to monetary shocks, the effect is pronounced in more inelastic areas. Under the assumption that homeowner consumption behavior does not depend directly on determinants of housing supply elasticity, homeowners in elastic or inelastic areas are ex-ante similar. Following the shock, only those in inelastic cities enjoy increased home equity while both are affected by non-housing channels such as increased income and employment or lower interest rates. Differencing across areas provides a means of understanding the importance of housing and balance sheet effects in the transmission of monetary shocks. The following section formalizes this intuition and provides conditions under which the homeowner balance sheet channel is identified.

4 Empirical Specification

The goal of this paper is to estimate the "homeowner balance sheet channel" of monetary policy. Non-durable consumption responses to monetary shocks will be decomposed into the component arising due to fluctuations in housing wealth and those arising through other channels.

The intuition for the identification strategy is to compare household-level consumption and house price responses to monetary shocks across MSA's with different housing supply elasticities. The general procedure first identifies and estimates monetary shocks using a recursive vector autoregression. This provides a measure of deviations of federal funds rates from the endogenous policy responses to economic conditions. These shocks are then combined with land availability and zoning regulation measures to estimate consumption and house price responses to monetary shocks using the CES. Using an instrumental variables

approach, I compare these responses across MSA's with different housing supply elasticity to identify the propensity to consume out of housing, house price responses to monetary shocks, and the homeowner balance sheet channel.

Monetary shocks are identified using a recursive ordering. The VAR includes log-real GDP, CPI inflation, the federal funds rate, the 30-year fixed mortgage rate, and the log-real national house price index.

As in Section 3, the federal funds rate is allowed to respond to log-real GDP & inflation concurrently, but can be affected by mortgage rates and house prices only with a lag. Financial markets react to new information quickly and end of quarter 30-year mortgage rates likely reflect changes in monetary policy during the quarter. Similarly, house prices are set at the time of sale and likely reflect all information known to the transacting parties including recent monetary shocks. Therefore, mortgage rates and national house prices are allowed to respond to innovations in other variables including monetary policy within the quarter, and are hence ordered after fed funds in the baseline model.

Only the national house price index is included in the VAR when identifying shocks, implicitly assuming that the Fed does not react to house prices in any specific city or region. The focus on national aggregates is consistent with the Fed's mandate and the information contained in the publicly available Greenbook forecasts used in the FOMC minutes. Identified monetary shocks are displayed in Figure 4.

Household i's log real non-durable consumption growth $\Delta c_{i,t+1}$ and log real house price growth $\Delta q_{i,t+1}$ are modeled as:

$$\Delta c_{i,t+1} = \beta_1 \Delta q_{i,t+1} + \beta_2(L)\eta_t + \beta_3 \Delta x_{i,t+1} + u_{i,t+1} \tag{4.1}$$

$$\Delta q_{i,t+1} = \gamma(L)\eta_t + \gamma_4 \Delta x_{i,t+1} + v_{i,t+1} \tag{4.2}$$

where η_t is the monetary shock[12] and $x_{i,t+1}$ is a set of household-level controls including age, family size, and income. The empirical model is estimated in log-differences, and hence allows for unobserved heterogeneity in consumption levels due to household-specific tastes.

The model described by (4.1) and (4.2) provides insight into a number of objects of interest. The coefficient β_1 provides a measure of the elasticity of non-durable consumption to housing wealth. The magnitude of this coefficient provides insight into how households use housing assets to smooth consumption over their lifetime.

[12]The lag-order on $\beta_2(L)$ and $\gamma(L)$ are selected to be 20 quarters. Since the procedure used directly estimates the impulse response from the Wold Form, a sufficiently long lag order is necessary to capture the full dynamic response of house prices following a monetary shock. Inclusion of only monetary shocks near the peak-response period of 8-16 quarters does not affect results.

Furthermore, estimated values of β_1 along with the impulse responses identified in the previous section provide a means to quantify the homeowner balance sheet channel. The impulse responses describe the MSA-specific impacts of monetary shocks on house prices based on the local geographic and regulatory environment. These movements result in consumption responses through homeowner balance sheets depending on the magnitude of β_1. The importance of this channel, therefore, rests jointly on the ability of monetary policy to move home values and the effect that home values have on household spending.

The consumption elasticity β_1 is not identified in the current specification. The error terms $u_{i,t+1}$ and $v_{i,t+1}$ capture unobserved, time-varying national and local shocks. This means $u_{i,t}$ and $v_{i,t}$ are likely correlated, resulting in an omitted variables bias in any OLS estimates of β_1 from (4.1). For example, a shock to expected income raises lifetime wealth, causing a simultaneous increase in both spending and housing demand. Estimation by OLS results in overstating the causal effect of housing wealth on spending since the effect of unobserved expected income shocks will be partially attributed to housing wealth. This issue highlights the importance of micro-data in addressing the issue of endogeneity in these variables. Cross-sectional variation in the responses of consumption and housing values provides insight into the causal link between the two.

This paper exploits MSA-level heterogeneity in housing markets to consistently estimate β_1 using an instrumental variables estimator. Since monetary shocks η_t will shift housing demand, I allow the effect of monetary shocks on house price growth to vary with determinants of housing supply elasticity: land availability and local land-use regulations. I also allow for local house price trends to directly depend on these local supply elasticity measures. In the context of the model presented above, the coefficient on η_t in (4.2) becomes $\gamma(L) = \gamma_1(L) + \gamma_2(L)z_i$ where z_i is a vector of "unavailable land" and Wharton Land-Use Regulation measures in the household's MSA. This yields:

$$\Delta c_{i,t+1} = \beta_1 \Delta q_{i,t+1} + \beta_2(L)\eta_t + \beta_3 \Delta x_{i,t+1} + u_{i,t+1} \tag{4.3}$$

$$\Delta q_{i,t+1} = [\gamma_1(L) + \gamma_2(L)z_i]\,\eta_t + \gamma_3 z_i + \gamma_4 \Delta x_{i,t+1} + v_{i,t+1} \tag{4.4}$$

The interaction between local supply elasticity and national monetary shocks determines the magnitude of $\Delta q_{i,t+1}$, but does not enter the consumption growth equation. The system can be interpreted as an IV estimation for β_1 under the exclusion restriction that z_i and $z_i\eta_t$ do not directly affect consumption growth. Intuitively, the coefficient β_1 is identified under the assumption that consumption responses to monetary policy do not systematically vary with local supply elasticity measures conditional on $\Delta x_{i,t+1}$. While it is unlikely that local geography or zoning laws directly cause households to respond differently to monetary

shocks, it is possible that households select into housing markets or are impacted by local shocks which are correlated with these housing supply measures. The remainder of this section discusses an appropriate conditioning set, $\Delta x_{i,t+1}$, and alternate specifications which address these concerns.

While it is unlikely that consumption responses to monetary policy depend directly on local geography or zoning laws, households may select into housing markets based on income prospects or demographics. Table 1 provides basic summary statistics for household income and demographics in the highest, middle, and lowest thirds of the elasticity distribution weighted by population. The table indicates inelastic markets tend to have slightly higher nominal incomes, higher home values, and lower ownership rates compared to more elastic markets. To avoid attributing life-cycle effects or income growth to the effect of house prices, I include controls for growth in household income over the interview period, a polynomial in age of the head, and changes in OECD adult-equivalent family sizes. The inclusion of income growth helps to explicitly account for potential differences in income profiles across households living in different MSA's. Age and family size, while unlikely to be correlated with monetary shocks, help absorb variation in consumption due to life-cycle and family composition effects and their differences across MSA's. Together, these variables help address basic demographic and income differences which may be correlated with housing supply elasticity. In order for a shock to bias estimates of β_1, it must be correlated with both national monetary shocks and local housing supply elasticity and not fully captured by the inclusion of household income growth or demographics.

Aside from these household-specific factors, a number of variables may jointly drive house price growth and consumption at a local level. For example, spurious correlations between home values and consumption may be generated by common local shocks to wealth or permanent income. It is possible that a monetary loosening can stimulate income growth in specific markets due to industry composition or other factors which may be related to housing supply. It may also be the case that rising home values cause cost of living adjustments to incomes, driving a correlation between home values and income growth. Even households not enjoying an explicit income increase during the interview period may enjoy effects of the local shock. To address these concerns, I include MSA-level income growth over the past year in addition to the household-specific income growth during the interview period. This controls for relative trends in income that reflect different productivity or amenity growth in elastic and inelastic markets.

Unobserved local shocks may also cause errors in the consumption regression to be correlated across households in a given area. Such correlations may cause estimated standard errors to be understated since observations are not independent across observations. To

address this concern, all specifications in this paper use cluster-robust standard errors at the MSA-level. This allows for arbitrary correlations over time between observations in the same MSA. Since households are only observed in one MSA, this also allows for arbitrary correlations within a household due to measurement error or habits.

It is also possible that zoning regulations may be chosen by the local population to drive up prices (Saiz, 2010; Davidoff, 2014). Households living in the area have an incentive to vote for laws that limit supply of housing and cause house price appreciation when demand rises. This may mean regulations are correlated with areas expecting high housing demand growth due to expected employment or productivity increases. To address this issue, I provide robustness checks excluding zoning regulations and its interaction as an instrument. Results from such a specification, though having slightly larger standard errors, provides quantitatively similar estimates to the baseline model. This indicates that while households may choose to influence local housing supply elasticity, pre-existing factors determining supply elasticity play an important role in the identification. Furthermore, while zoning regulations may be endogenous in the first-stage regression, household consumption growth does not vary directly with regulations.

Finally, household financial wealth may be correlated with housing wealth. A monetary loosening is likely to generate an increase in both types of wealth, and hence may cause consumption responses to housing to be overstated. The identification strategy used in this paper is robust to this type of bias unless households are more likely to hold financial wealth in inelastic markets. It is possible, however, that portfolio choice is correlated with housing market risk, resulting in a correlation between housing supply elasticity and financial risk exposure. To address this potential concern, I provide an additional robustness check including S&P 500 returns and 10-year Treasury returns as controls. Once again, results point to an important role of house price appreciation in determining consumption growth.

While this paper follows a growing trend in the literature of using housing supply elasticity measures as instruments for house price growth (Mian and Sufi, 2011; Mian et al., 2013; Kermani, 2013), it differs in an important way. Whereas much of the existing literature simply compares elastic and inelastic markets across the housing boom or bust, this paper is among the first to explicitly use the cost of credit as a housing demand shifter in this framework.[13] This approach helps address correlations between housing supply elasticity and amenities growth. Levels of amenities are likely to be different in inelastic and elastic areas due to preferences for coasts and mountains. Such amenities are likely to attract highly productive workers whose income profiles may differ from less productive workers (Gyourko

[13]Recent work by Chaney et al. (2012) is an exception. Using interactions between interest rates and housing supply elasticity as instruments for commercial real estate values, they find substantial effects of a firm's owned commercial real estate value on investment.

et al., 2013). While this concern is valid, this paper uses a novel estimation that interacts monetary shocks and housing supply as instruments for house price growth. While amenities may differ between the markets, they are unlikely to fluctuate systematically with relatively high frequency monetary shocks. Furthermore, the baseline specifications include income growth which likely absorbs much of the productivity growth differences across these regions.

Another issue related to identifying MPCs from house price growth during the housing boom and bust is that local housing demand shocks may vary systematically with housing supply elasticities during this period (Davidoff, 2014). For example, Glaeser et al. (2008) show that inelastic housing supply markets are more prone to severe asset bubbles causing both current and future house prices to rise. The increase in future collateral values induced "alternative" lending behavior such as interest-only or low-down-payment mortgages in areas with high anticipated price growth (Barlevy and Fisher, 2010). Monetary shocks will change the path of house prices, moving both current prices and expectations of future prices. While the omission of *expected* house price growth may overstate the importance of *current* house price growth in explaining consumption, the total response to monetary policy acting through housing markets is identified. The homeowner balance sheet effect identified in this paper incorporates consumption growth due to both the increase in concurrent housing wealth and alternative credit due to future price increases in inelastic-supply cities. Furthermore, I find quantitatively similar results when the sample is restricted to the pre-bubble period when such alternate lending was less common. This indicates that even while alternative lending was prevalent during the 2000's, monetary policy played a minimal role in changing relative lending between high and low elasticity markets during this period. I return to this point when discussing alternative specifications in Section 5.

Identification in this paper is based on the underlying assumption that there are limits to migration across MSAs at a business-cycle frequency. In the absence of frictions, households would respond to relative movements in house prices and wages by moving to areas with lower costs of living relative to wages and amenities, causing a simultaneity bias in $\hat{\beta}$. In reality, fixed costs associated with moving likely outweigh the benefits of moving in response to a temporary monetary shock. Closing costs on a home amount to 2-5% of home value. This does not include additional costs of searching for work and housing or non-pecuniary costs of moving away from social networks or familiar areas. On the other hand, the effects of the monetary shock are relatively short-lived, and are unlikely to elicit a large mobility responses. As discussed in the previous section, results from the American Community Survey indicate no strong relationship between monetary policy, mobility, and housing supply elasticities both before and after the move.

In addition to exogeneity assumptions on instruments used, another key assumption is

that the excluded instruments are sufficiently strong predictors of Δq. If monetary shocks do not affect real house prices differentially across elastic and inelastic supply housing markets, identification may be weak, resulting in non-normal asymptotic distributions of the 2SLS estimator and poor coverage probabilities of confidence intervals. As described in Section 3, monetary loosening causes national-level house prices and housing starts to rise. Furthermore, inelastic MSA's see increases in house prices of 4-6% over the course of 8-10 quarters while the most elastic-supply MSAs see little movement in real house prices. This provides evidence that there is substantial variation across MSAs in the response of house prices to monetary shocks. Furthermore, LIML and 2SLS procedures provide similar estimates and first-stage F-statistics from the baseline specification exceed the Stock and Yogo (2002) thresholds for relative bias of 10%. The instruments are sufficiently strong to identify the effect of house price growth on consumption.

5 Results and Discussion

5.1 Consumption Response to House Prices

Table 3 provides estimates from the baseline specification for all home owners, only those with mortgages, all renters[14], and the combined sample of all households. Results show that the consumption elasticity to housing wealth, β_1, is positive and significant at 1.503 for owners. These results provide strong evidence that housing wealth plays a substantial role in amplifying consumption responses to monetary shocks. Given the mean (nominal) self-reported home value in the sample of approximately \$200k and mean quarterly non-durable expenditures of approximately \$9.3k, homeowners increase quarterly spending by approximately \$0.07 for a \$1 increase in home equity.

Unlike homeowners, renters (non-owners) do not enjoy strengthened balance sheets or increased wealth due to rising home values, and estimates of β_1 in Table 3 are insignificant and essentially zero. This result stands in contrast to findings in the literature that rising home values are correlated with increased spending even by renters in the area (Attanasio et al., 2009). As acknowledged by the authors of these papers, this finding is due to important common factors that may be driving both variables. These factors are differenced away by the identification strategy used in this paper, providing evidence that rising home values have a causal impact on spending for homeowners while having minimal effect on renters.

This result may appear striking considering renters are often future buyers of housing

[14]A small fraction of renters report owning a vacation home or other home in which they do not live. Results are robust to the exclusion of these households.

who should suffer negative wealth effects due to rising home values. Renters may be able to adjust on other margins by delaying the home purchase or adjusting the size of the home they purchase. Furthermore, these results are consistent with small wealth effects and a dominant role for collateral effects in determining the relationship between housing and consumption. I return to the issue of the relative roles of wealth and collateral effects after discussing several robustness checks for the baseline estimates.

Table 4 provides evidence that these results are robust to several alternate specifications. I first investigate whether the relationship between consumption and housing is specific to the mid-2000's bubble period during which unconventional forms of lending grew, especially in areas with expected price appreciation (Barlevy and Fisher, 2010). Related work by Mian and Sufi (2011) find a propensity to borrow $0.25 cents for $1 of house price growth during 2002-2006, indicating there may have been an especially high demand for credit during the period as well. The first column of Table 4 displays results constraining the sample to the pre-bubble period prior to 2000. Despite concerns that the mid-2000's were unique, results in Column 1 excluding this period remain both statistically and economically significant. Evidence points to a strong and persistent relationship between consumption and housing which became especially noticeable as house prices began to appreciate dramatically in the 2000's.

A second potential issue is that homeowners vote for strong zoning regulations in anticipation of an increase in the demand for housing in the area. This generates increased house price appreciation in such areas. To address this issue, I include a specification that excludes regulation measures from z_i in the estimated model. Results to this specification, given in Column 2, are less statistically significant, but show little quantitative difference in estimated effects. Therefore, it is unlikely that endogenously chosen regulations bias the effects measured in the baseline model.

Additionally, it is possible that returns on assets other than housing may affect consumption growth, and the omission of these factors causes an upward bias on the propensity to consume out of housing. Such bias would only occur if asset holdings and asset returns were uncorrelated with measures of housing supply elasticity, potentially due to differences in housing market risk, total wealth, or income levels. To address this concern, I include S&P 500 and Treasury Bill returns as control variables. Column 3 shows that estimated elasticities for owners are unchanged by the inclusion of these variables.

Conditioning on concurrent income growth may not reflect anticipated changes in productivity growth that may affect consumption and housing demand in the MSA. Since income expectations are not observed, column 4 re-estimates the baseline model including realized MSA-level income growth over the next year. While household's may not have perfect fore-

sight, their forecasts are likely to be centered at the true values of income growth. Results including expected income growth reduce the magnitude of the estimated response to house prices slightly, but households still increase consumption substantially in response to an increase in home equity.

The final column of Table 4 repeats the baseline estimation using the county-level Zillow Home Value Index. While this constrains the sample period to 1997-2008, the measure offers a variety of benefits over the baseline FHFA house price index.[15] First, Zillow home values are available at finer geographic levels than FHFA indices. While land and regulation instruments are still MSA-level measures, using county-level price data allows house price growth the first stage to be weighted appropriately based on the areas within an MSA in which the observed households live. Secondly, Zillow price indices are constructed using transactions data from all homes in the regions covered, whereas FHFA indices rely on data on conforming mortgage loans acquired from Fannie Mae and Freddie Mac. The inclusion of non-conforming loans, such as jumbo mortgages or subprime loans, accounts for a large amount of variation in prices during the late 1990's and early 2000's. As indicated in Figure 3, Zillow home values move more dramatically than FHFA indices during this period and are likely more sensitive to monetary shocks. The same monetary shocks move Zillow home values more dramatically than FHFA indices while consumption responses to monetary shocks remain the same. This is reflected in slightly lower estimates of consumption elasticity to Zillow house price changes compared with baseline results using FHFA indices. Nonetheless, the results indicate that homeowner consumption responds robustly to changes in home values.

5.2 Collateral vs Pure Wealth Effects

Results from the estimation provide evidence that homeowners increase consumption due to rising home values whereas renters see no significant effects on spending. These results appear robust to a variety of potential concerns and alternate specifications. Given these results, I now turn to the relative importance of wealth and collateral effects in driving the relationship between housing and consumption.[16]

Pure wealth effects from rising house prices only occur when households are net buyers or sellers of housing. To understand this, consider an infinitely lived household which owns its home. By living in the home, the homeowner forgoes rental income on the property, and

[15] Further details regarding differences in the construction of the Zillow Home Value Index (ZHVI) and FHFA house price index are presented in Section 2.

[16] Adjustment costs make it unlikely that a small change in house prices, such as those arising from monetary and credit shocks, will induce a household to move. Given that house prices respond by at most 4-5% given a 1-standard deviation shock to Federal Funds, the substitution effects between housing and non-durables are ignored from this discussion.

hence is implicitly acting both as the landlord and tenant. Since a house's price is determined by the present value of rents, changes in the price correspond exactly with the present value liability to the tenant. The homeowner is hedged against fluctuations in home values. Any wealth effects arise simply from a wedge between expected rent liabilities and income due to downsizing or upsizing one's home. The net wealth effect is negative for a household expecting to move to a larger home since the increase in the price of the smaller home only partially hedges against expected rental payments in the future. The opposite is true for a household expecting to downsize. In the aggregate, wealth effects are likely to be small unless there is a large wedge between MPCs of the natural buyers and sellers.

Collateral effects arise as household borrowing constraints are loosened by rising home values. By posting their homes as collateral, households can credibly commit to repayment when agency costs may cause credit rationing in uncollateralized markets. Home values determine borrowing capacity, and hence may loosen constraints on homeowners desiring higher levels of current consumption. This may result in large MPCs for constrained households with little or no effect on households who are consuming closer to the first-best consumption path. Unlike wealth effects, this can lead to large effects on aggregate spending dynamics.

The fact that consumption responses for renters were not significantly different from zero provides some evidence that pure wealth effects may be small. Renters are often households who plan to buy homes in the future, and would be expected to have negative wealth effects. Given the negligible magnitudes of these effects, wealth effects may be small relative to large collateral effects driving homeowner responses. Of course, renters may differ from homeowners in other respects and the issue warrants further investigation. To do this, I attempt to compare the house price effects on the consumption of "constrained" and "unconstrained" homeowners.

Identifying collateral constrained households is a challenge. The distinction between "constrained" and "unconstrained" becomes somewhat blurred in the presence of risk. A household with a loan-to-value ratio near the collateral limit may choose to conserve some debt capacity as insurance against a negative shock. This precautionary savings motive affects a household that may not appear to have maxed out their borrowing limit, blurring the line between feeling the effect of the constraint and having it bind in the current period. Put differently, the likelihood of the constraint binding in the future motivates precautionary savings in the present (Carroll and Kimball, 1996). This effect diminishes as the loan-to-value ratio becomes substantially smaller than the collateral limit, since the likelihood of the constraint binding in the future falls. Therefore, in reality, households fall on a spectrum between constrained and unconstrained. Since the shadow value of the constraint is not directly observable, this paper follows the approach of the literature (Zeldes, 1989; Cooper,

2009; Johnson and Li, 2010) in identifying the level of credit constraints through observed balance sheet and debt payment variables.

Several common ratios are used both by academics and banks to assess credit risk and credit constraints. The choice of an appropriate ratio in this paper is motivated by the strengths of the data used and the nature of lending behavior during the time period used. The Consumer Expenditure Survey is designed to measure expenditure with relatively high precision, while partial balance sheet data is only collected in the first and last wave with substantial misreporting. Furthermore, households are more likely to recall periodic payments made on debt rather than the outstanding balance. This motivates the use of debt service payments, including all payments to interest and principal on debt obligations (primarily mortgage and car loans), rather than outstanding debt values. A common ratio used by banks to assess credit quality is the Debt-Service Ratio (DSR), defined as the ratio between debt service payments and after-tax income. This measure both exploits the strengths of the data set used and has been shown to predict the likelihood of being denied credit (Johnson and Li, 2010). Households falling in the top 25% of non-missing DSRs are flagged as "constrained" while those in the bottom 75% are flagged "unconstrained."

In addition to using these ratios to identify constrained homeowners, I also compare households who actively extracted equity prior to the interview period. Households who increased their home equity-based debt are accessing the collateral in their homes in order to either pay down other debt, save, or increase consumption. I flag all households increasing mortgage debt balances by more than 5% as "equity extractors" and compare their responses to house price growth to those who did not extract equity. While equity extraction may not be exogenous, households who access home equity in response to (temporary) negative income shocks are likely to decrease spending, biasing the difference between "equity extractors" and "non-extractors" downwards. Results indicating a higher propensity to consume for equity extractors will still suggest a strong role for collateral effects in driving the relationship between housing and spending.

Testing if the elasticity of consumption to house prices, β_1, of constrained households is larger than the baseline estimate provides a means of checking the importance of credit constraints as opposed to wealth effects. Results from the credit constraints regressions can be found in Table 5. To put the results in perspective, an individual in the highest quartile of Debt Service Ratios has an elasticity of consumption to housing wealth that is roughly double that of the baseline estimate found in column 1. By comparison, unconstrained households in the bottom 75% of debt-service ratios have slightly negative, but insignificant, spending responses to house price changes.

Results for those increasing home debt are seen in columns 4 and 5 of Table 5. Households

who extracted home equity have an estimated elasticity of 3.56, over twice as large as "non-extractors." While the inter-relationship between refinancing, house prices, and spending is complex, this result provides evidence that home-equity-based borrowing is a very important driver of the relationship between home values and non-durable spending.

The homeowner balance sheet channel is the effect of monetary policy on non-durable spending acting through changes in home equity. As discussed previously, a monetary loosening lowers the user cost of housing and raises real house prices. This raises consumption through the collateral and wealth effects discussed above. This channel acts in parallel with other channels of monetary policy such as increases in incomes or decreases in interest rates. Identification of the balance sheet channel separately is achieved through comparing house price and spending responses across housing supply elasticities.

The magnitude of this channel can be computed at the household level using the consumption elasticity to housing identified in (4.3) and the impulse response of house price growth. Results of the estimation are available in Figures 6, 7, and 8 which aggregate these effects to an MSA-level using ownership rates and housing supply elasticity variables. Figure 6 plots the deviations of consumption from trend for each MSA after 4, 8, 12, and 16 quarters due to a monetary shock. The graphs depict a clear relationship between the housing supply elasticity measures and consumption responses. Like house prices, spending responses peak after approximately 12 quarters and display larger movements in areas with low land availability and stricter zoning laws.

Geographic heterogeneity in the spending responses can be seen in the maps presented in Figures 7 and 8. Each map depicts the spending response response to a 1 standard deviation (71 basis point) shock to the federal funds rate at lags of 4, 8, 12, and 16 quarters respectively. Patterns generally follow those seen in maps of the elasticity measures in Figure 2. Coastal and mountain cities display larger spending responses since house prices rise more substantially in those areas compared to MSA's in the middle of the country. The map also depicts a strong heterogeneity in responses across regions of the US.

Taken together, the results point to an important causal effect of house price growth on consumption. While pure wealth effects may play a role, they are not as quantitatively important as collateral effects in explaining the link between house prices and consumption. Given large positive effects for constrained homeowners and near-zero effects for unconstrained households and renters, aggregate effects of house price growth are likely to be large. While it is possible that increased spending in inelastic markets may result in general equilibrium spillovers to other markets, such effects are likely small at the frequency considered in this paper. These results indicate a quantitatively important role for homeowner balance sheets in explaining the impact of monetary policy on real outcomes, especially in times when in-

creased unemployment, falling asset prices, and tight credit supply have increased the number of credit-constrained households.

6 Conclusions

This paper utilizes consumption expenditure micro-data and attempts to exploit regional heterogeneity in land availability and land-use regulations to address several related research questions. The paper establishes a clear link between monetary policy, house prices, and consumption behavior. It shows that monetary policy has heterogeneous impacts on non-durable expenditures through a homeowner balance sheet channel. In the process, it establishes patterns in the responses of home values to monetary shocks and provides a novel technique for identifying the propensity to consume out of housing wealth. Furthermore, it provides evidence for the importance of housing as collateral to constrained homeowners.

Using heterogeneity in housing supply elasticity measures, I compare consumption and house price responses to monetary shocks between elastic and inelastic supply MSA's. Elastic-supply MSA's such as Dallas with large amounts of land and loose zoning laws see little house price growth after the shock whereas land-constrained and tightly regulated housing markets such as San Francisco see large real house price responses. Specifically, the most inelastic MSA's in the US display a 4% increase in home values over 2-3 years after a 1 standard deviation (71bp) reduction in the federal funds rate. By comparison, the most elastic-supply cities display little house price response as new construction holds home values in check. Under the assumption that housing supply elasticity measures have no direct impact on consumption, I use an IV estimator to identify the elasticity of consumption to house prices. Baseline estimates indicate an elasticity of 1.5 for homeowners, corresponding to an average increase in spending of 6-9 cents for a $1 increase in home equity. Results indicate no significant impact on renters.

These effects are largely driven by collateral effects as opposed to pure wealth effects. Households with high debt service ratios and those who recently extracted equity from their homes have spending responses of as much as 14 cents for a $1 of home equity growth. This is consistent with rising home values loosening credit constraints, allowing households to borrow against higher collateral values. Furthermore, renters, who are younger and likely future potential home buyers, have no significant consumption response to rising home values indicating small pure wealth effects.

These findings point to a quantitatively important role for homeowner balance sheets in explaining the impact of monetary policy on real outcomes. A monetary loosening raises the demand for housing, raising home values and improving homeowner balance sheets. While

households may not be very sensitive to changes in the risk-free rate, rising home values loosen borrowing constraints, likely generating large aggregate effects on spending.

Furthermore, the heterogeneity in household-level responses also points to an importance in the distribution of access to credit across households in determining the magnitude of spending responses to policy changes. The homeowner balance sheet channel acts primarily on credit constrained households who are able to access home equity lending when house prices rise. As these households are likely to be poorer, a monetary loosening may work to reduce inequality in consumption, consistent with findings in Coibion et al. (2012). Furthermore, the effects may be especially large in times when increased unemployment, tightening of credit supply, and falling asset prices have left many households credit constrained.

Consumption responses also display substantial geographic heterogeneity. Coastal cities and those in the mountains see large responses in consumption while those in the Great Plains see smaller changes in spending. Given patterns in house price responses, the effects are likely reversed when considering residential investment. This points to a difference in the composition of output growth following a monetary shock, which may interact in important ways with the allocation of resources across these regions. Future work hopes to better understand these issues.

A Figures/Tables

Figure 1: Local House Prices and Housing Starts for Select MSA's

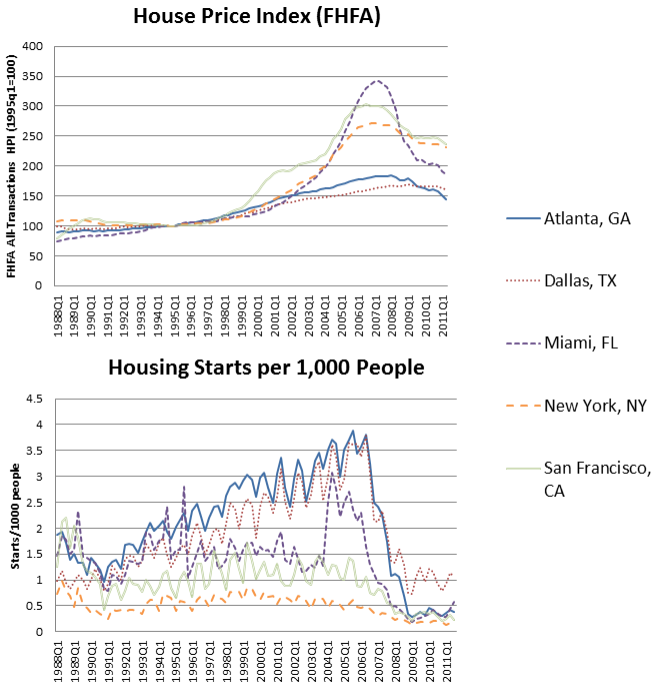

Figure 2: Housing Supply Elasticity Measures: Land Availability & Zoning Regulations

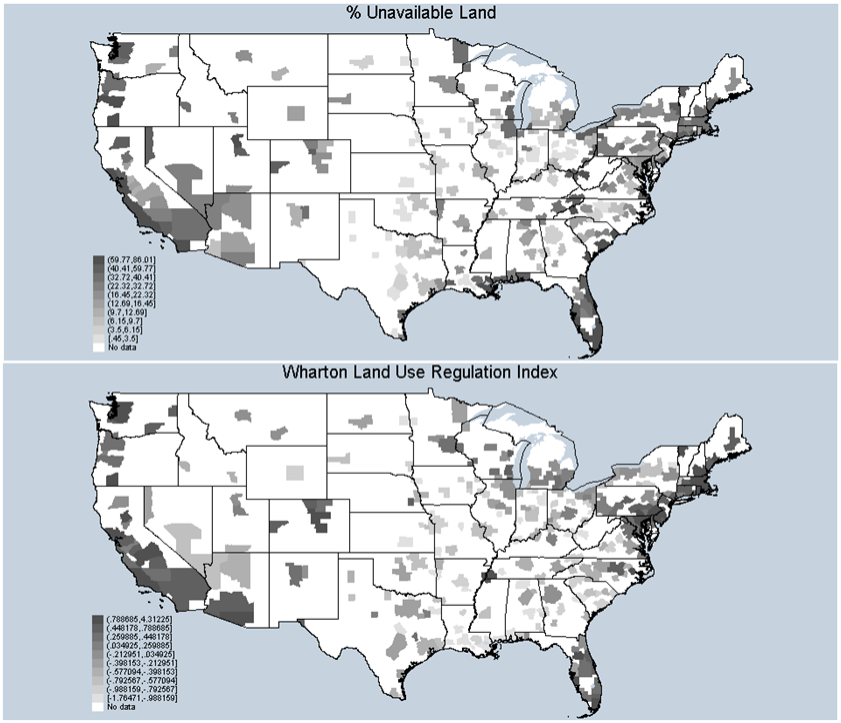

Figure 3: Comparison of National House Price Indices

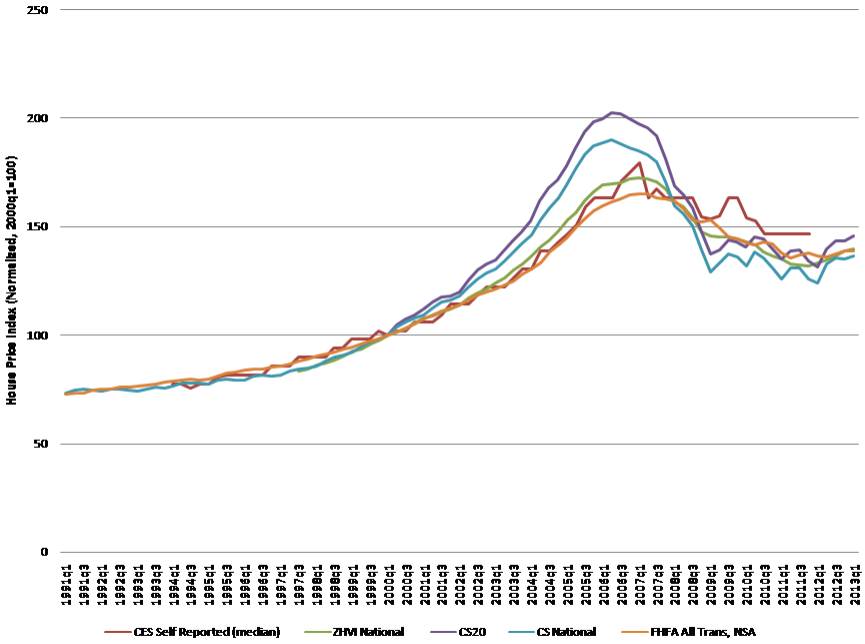

Figure 4: Time Series of Identified Monetary and Credit Shocks

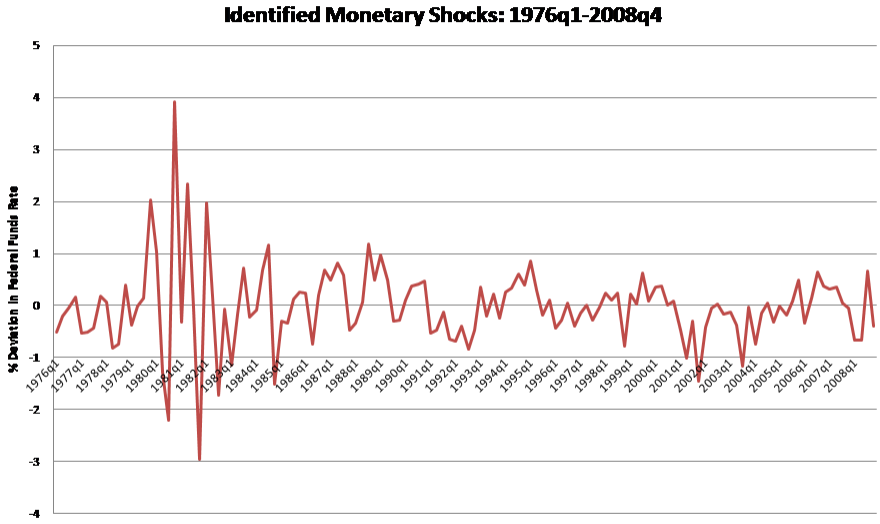

Figure 5: HPI Responses to 1sd Monetary Shock

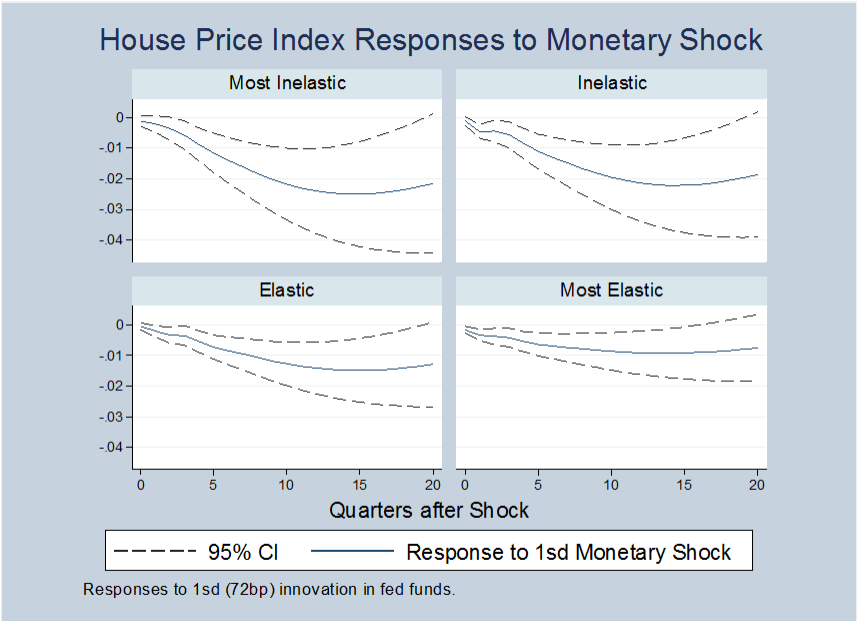

Figure 6: Spending Responses to 1sd Monetary Shock by Elasticity Measures

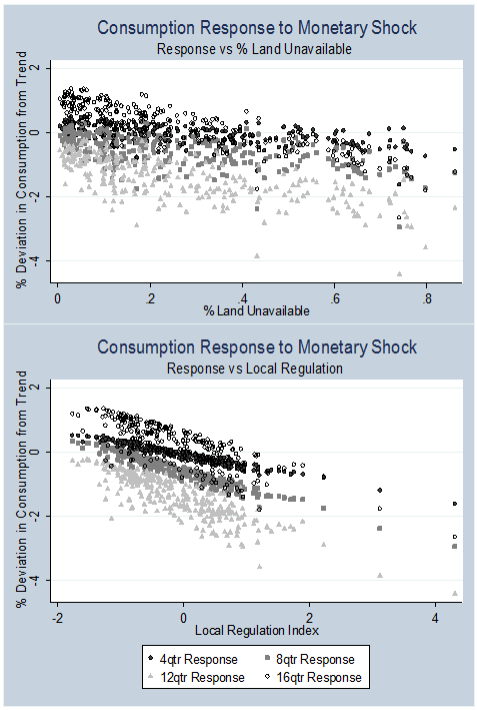

Figure 7: Map of Heterogeneous Spending Responses to 1sd Monetary Shock

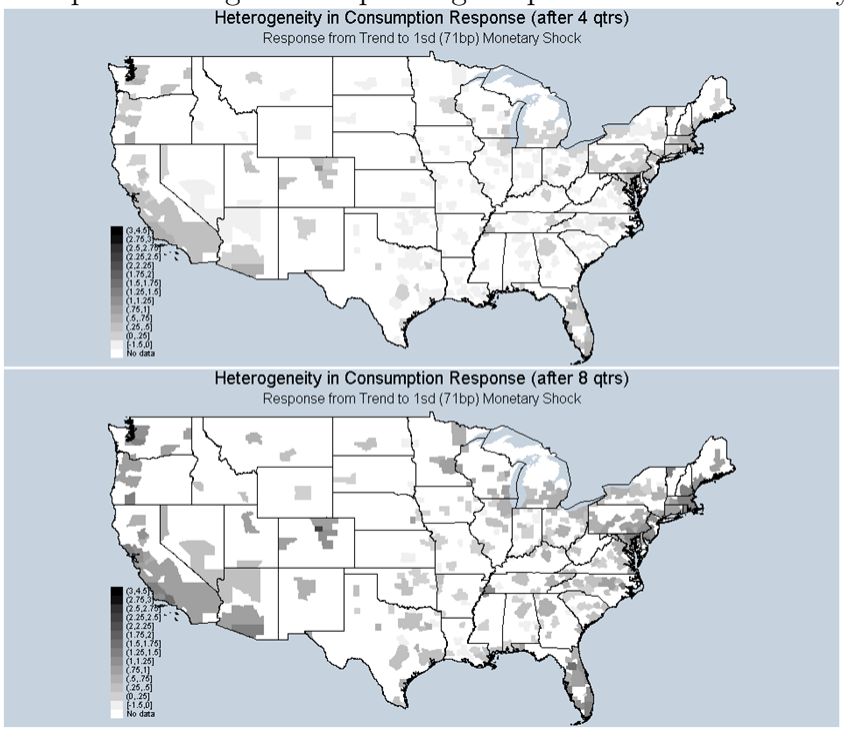

Figure 8: Map of Heterogeneous Spending Responses to 1sd Monetary Shock

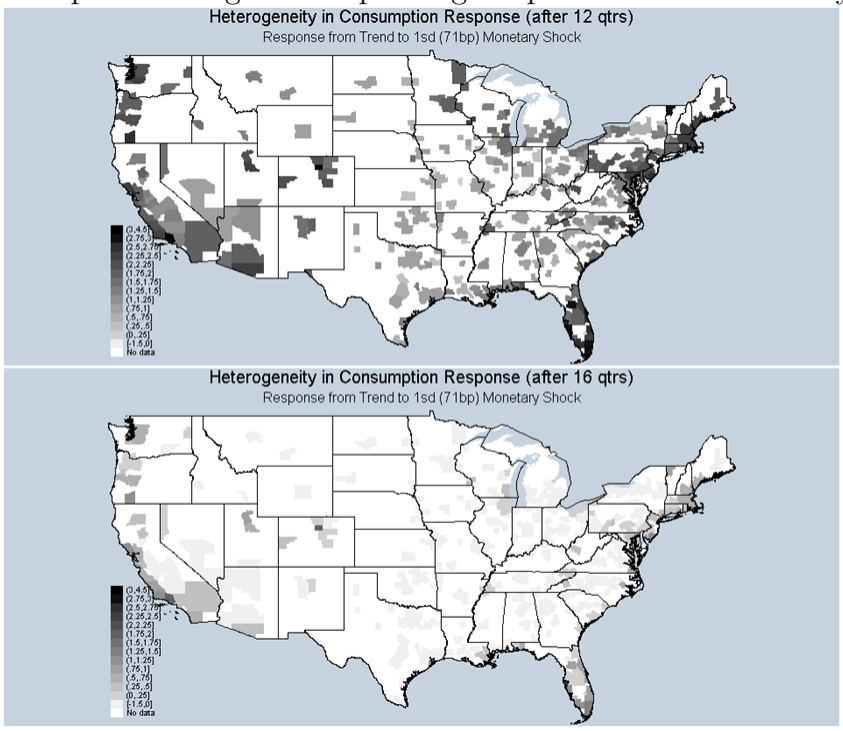

Table 1: Consumer Expenditure Survey Summary Statistics by Elasticity

	Lowest (33%) Elasticity	Middle (33%) Elasticity	Highest (33%) Elasticity	No Elasticity Data
Elasticity	0.8300	1.5439	2.9502	-
Mean Regulation Index	0.4590	0.4712	-0.3796	-
Mean % Unavailable Land	48.76%	25.40%	10.00%	-
% Owners	58.44%	67.45%	66.77%	71.06%
Age	47.96	46.83	46.96	46.17
Family Size	2.65	2.67	2.60	2.63
Home Value (Self-Reported)	$127,023.60	$227,781.50	$154,965.40	$104,095.10
Annualized Expenditures	$34,029.15	$40,096.96	$37,845.27	$34,761.22

Table 2: Land Availability, Regulation, and Supply Elasticity Measures of Select Large MSA's (Saiz, 2010)

MSA Name (Largest City)	Land-Use Regulation Index	Percentage Unavailable Land	Supply Elasticity (Saiz, 2010)	% Population less Elastic	MSA Population
St. Louis, MO-IL	-0.7286	11.08%	2.3558	76.54%	2,606,023
San Diego, CA	0.4628	63.41%	0.6728	8.65%	2,824,809
Minneapolis, MN	0.3777	19.23%	1.4474	47.37%	2,979,245
Phoenix AZ	0.6109	13.95%	1.6136	54.96%	3,276,392
Riverside, CA	0.5259	37.90%	0.9432	28.16%	3,280,236
Dallas, TX	-0.2287	9.16%	2.1753	69.46%	3,541,099
Atlanta, GA	0.0349	4.08%	2.5537	81.22%	4,144,774
Houston, TX	-0.3982	8.40%	2.3022	74.31%	4,199,526
Detroit, MI	0.0545	24.52%	1.2411	42.79%	4,444,693
Washington, DC	0.3105	13.95%	1.6058	53.38%	4,948,213
Philadelphia, PA	1.1267	10.16%	1.6451	58.70%	5,104,291
Boston, MA	1.7025	33.90%	0.8581	24.94%	6,067,510
Chicago, IL	0.0193	40.01%	0.8114	20.73%	8,289,936
New York, NY	0.6544	40.42%	0.7588	15.29%	9,321,820
Los Angeles, CA	0.4950	52.47%	0.6266	5.68%	9,546,597

Sources: Land-Use Regulation Index, unavailable land, and housing supply elasticity estimates from Saiz (2010). Population from 2000 Census for MSA.

Table 3: Consumption-Housing Elasticity Estimates - Baseline
Consumption Growth Regressions

	(1)	(2)	(3)	(4)
	Owners Only	Owners w/ Mtg Rpt	Renters Only	All Households
House Price Growth	1.503***	1.077***	-0.002	0.178
	(0.400)	(0.404)	(0.447)	(0.295)
Household Inc. Growth	0.024***	0.033***	0.017***	0.024***
	(0.006)	(0.006)	(0.006)	(0.004)
Local Inc. Growth	-0.017	-0.224*	0.238*	0.139*
	(0.111)	(0.129)	(0.123)	(0.080)
Age Polynomial	X	X	X	X
Chg. in Family Size	X	X	X	X
Observations	24,270	16,741	10,345	34,615

MSA-level cluster-robust standard errors in parentheses.
All regressions include qtr. dummies & direct effects of monetary shocks.
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Consumption-Housing Elasticity Estimates - Select Robustness Checks

Consumption Response (Selected Robustness Checks)					
	(1) Pre-Bubble (1986-2000)	(2) Excl. Zoning Regulations	(3) Asset Returns	(4) Expected Inc. Growth	(5) Zillow House Prices
House Price Growth	1.201**	0.950*	1.533***	0.756*	0.962***
	(0.487)	(0.505)	(0.401)	(0.406)	(0.160)
Household Inc. Growth	0.015***	0.0333***	0.025***	0.032***	0.046***
	(0.005)	(0.007)	(0.006)	(0.006)	(0.006)
Exp. Local Inc. Growth				-0.023	-0.149**
				(0.080)	(0.063)
10-yr Treasury Return			0.653***		
			(0.123)		
1year SP500 Return			-0.010		
			(0.017)		
Observations	16,083	38,694	24,270	24,320	12,864

All regressions include age, family changes, qtr. dummies & direct effects of monetary shocks.
MSA-level cluster-robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Consumption-Housing Elasticity Estimates - Collateral Constraints
Consumption Growth Regressions (Constrained vs Unconstrained)

	(1) Baseline Owners	(2) Constrained (high DSR)	(3) Unconstrained (low DSR)	(4) Increased Home Debt	(5) No Increase Home Debt
House Price Growth	1.503***	2.857***	-0.0655	3.569***	1.389***
	(0.400)	(1.028)	(0.495)	(1.203)	(0.374)
Household Inc. Growth	0.0235***	0.0516***	0.0188**	0.00943**	0.0544***
	(0.00552)	(0.0103)	(0.00845)	(0.00468)	(0.0111)
Local Inc. Growth	-0.0171	0.252	0.131	-0.592**	-0.123
	(0.111)	(0.310)	(0.0967)	(0.260)	(0.127)
Age Polynomial	X	X	X	X	X
Chg. in Family Size	X	X	X	X	X
Observations	24,270	3,496	14,700	3,586	15,273

MSA-level cluster-robust standard errors in parentheses.
All regressions include qtr. dummies & direct effects of monetary shocks.
*** p<0.01, ** p<0.05, * p<0.1

References

A. Aladangady. *Chapter 2: Monetary Policy and Housing Market Dynamics*. PhD thesis, University of Michigan, 2014.

O. P. Attanasio and G. Weber. The uk consumption boom of the late 1980s: Aggregate implications of microeconomic evidence. *The Economic Journal*, 104(427):pp. 1269–1302, 1994. ISSN 00130133. URL http://www.jstor.org/stable/2235449.

O. P. Attanasio, L. Blow, R. Hamilton, and A. Leicester. Booms and Busts: Consumption, House Prices and Expectations. *Economica*, 76(301):20–50, 02 2009. URL http://ideas.repec.org/a/bla/econom/v76y2009i301p20-50.html.

G. Barlevy and J. D. M. Fisher. Mortgage choices and housing speculation. Working Paper Series WP-2010-12, Federal Reserve Bank of Chicago, 2010. URL http://ideas.repec.org/p/fip/fedhwp/wp-2010-12.html.

B. S. Bernanke and A. S. Blinder. The federal funds rate and the channels of monetary transmission. *The American Economic Review*, 82(4):pp. 901–921, 1992. ISSN 00028282. URL http://www.jstor.org/stable/2117350.

B. S. Bernanke, M. Gertler, and S. Gilchrist. The financial accelerator in a quantitative business cycle framework. *Handbook of Macroeconomics*, 1:1341–1393, October 1999. URL "http://ideas.repec.org/h/eee/macchp/1-21.html".

N. Bhutta and B. J. Keys. Interest rates and equity extraction during the housing boom. Technical Report 3, University of Chicago Kreisman Working Papers Series in Housing Law and Policy, January 2014.

M. Bils and P. J. Klenow. Some evidence on the importance of sticky prices. *Journal of Political Economy*, 112(5):pp. 947–985, 2004. ISSN 00223808. URL http://www.jstor.org/stable/10.1086/422559.

J. Y. Campbell and J. F. Cocco. How do house prices affect consumption? evidence from micro data. *Journal of Monetary Economics*, 54(3):591 – 621, 2007. ISSN 0304-3932. doi: http://dx.doi.org/10.1016/j.jmoneco.2005.10.016. URL http://www.sciencedirect.com/science/article/pii/S0304393206001279.

C. D. Carroll and M. S. Kimball. On the concavity of the consumption function. *Econometrica*, 64(4):pp. 981–992, 1996. ISSN 00129682. URL http://www.jstor.org/stable/2171853.

C. D. Carroll, M. Otsuka, and J. Slacalek. How large are housing and financial wealth effects? a new approach. *Journal of Money, Credit and Banking*, 43(1):55–79, 02 2011. URL http://ideas.repec.org/a/mcb/jmoncb/v43y2011i1p55-79.html.

K. E. Case, J. M. Quigley, and R. J. Shiller. Comparing wealth effects: The stock market versus the housing market. Cowles Foundation Discussion Papers 1335, Cowles Foundation for Research in Economics, Yale University, 2005. URL http://EconPapers.repec.org/RePEc:cwl:cwldpp:1335.

T. Chaney, D. Sraer, and D. Thesmar. The collateral channel: How real estate shocks affect corporate investment. *American Economic Review*, 102(6):2381–2409, 2012. doi: 10.1257/aer.102.6.2381. URL http://www.aeaweb.org/articles.php?doi=10.1257/aer.102.6.2381.

L. J. Christiano, M. Eichenbaum, and C. L. Evans. Monetary policy shocks: What have we learned and to what end? Working Paper 6400, National Bureau of Economic Research, February 1999. URL http://www.nber.org/papers/w6400.

O. Coibion, Y. Gorodnichenko, L. Kueng, and J. Silvia. Innocent bystanders? monetary policy and inequality in the u.s. Working Paper 18170, National Bureau of Economic Research, June 2012. URL http://www.nber.org/papers/w18170.

D. Cooper. Impending spending bust? the role of housing wealth as borrowing collateral. *FRB Boston Public Policy Discussion Paper Series*, 09(9):1, 2009.

T. Davidoff. Supply constraints are not valid instrumental variables for home prices because they are correlated with many demand factors. February 2014.

M. Flavin and T. Yamashita. Owner-occupied housing and the composition of the household portfolio. *The American Economic Review*, 92(1):pp. 345–362, 2002. ISSN 00028282. URL http://www.jstor.org/stable/3083338.

E. L. Glaeser, J. Gyourko, and A. Saiz. Housing supply and housing bubbles. Working Paper 14193, National Bureau of Economic Research, July 2008. URL http://www.nber.org/papers/w14193.

J. Gyourko, A. Saiz, and A. A. Summers. A new measure of the local regulatory environment for housing markets: Wharton residential land use regulatory index. *Urban Studies*, 45:693–729, March 2008.

J. Gyourko, C. Mayer, and T. Sinai. Superstar cities. *American Economic Journal: Economic Policy*, 5(4):167–99, 2013. doi: 10.1257/pol.5.4.167. URL http://www.aeaweb.org/articles.php?doi=10.1257/pol.5.4.167.

E. Hurst and F. Stafford. Home is where the equity is: Mortgage refinancing and household consumption. *Journal of Money, Credit and Banking*, 36(6):pp. 985–1014, 2004. ISSN 00222879. URL http://www.jstor.org/stable/3839098.

M. Iacoviello. House prices, borrowing constraints, and monetary policy in the business cycle. *The American Economic Review*, 95(3):pp. 739–764, 2005. ISSN 00028282. URL http://www.jstor.org/stable/4132738.

K. W. Johnson and G. Li. The debt-payment-to-income ratio as an indicator of borrowing constraints: Evidence from two household surveys. *Journal of Money, Credit and Banking*, 42(7):1373–1390, October 2010. URL http://ideas.repec.org/a/mcb/jmoncb/v42y2010i7p1373-1390.html.

A. Kermani. *Cheap Credit, Collateral and the Boom-Bust Cycle*. PhD thesis, Massachusetts Institute of Technology, 2013.

N. Kiyotaki and J. Moore. Credit cycles. *Journal of Political Economy*, 105(2):pp. 211–248, 1997. ISSN 00223808. URL http://www.jstor.org/stable/10.1086/262072.

P. J. Klenow and O. Kryvtsov. State-dependent or time-dependent pricing: Does it matter for recent u.s. inflation? *The Quarterly Journal of Economics*, 123(3):863–904, 2008. doi: 10.1162/qjec.2008.123.3.863. URL http://qje.oxfordjournals.org/content/123/3/863.abstract.

A. Ludwig and T. Sløk. The relationship between stock prices, house prices and consumption in oecd countries. *The B.E. Journal of Macroeconomics*, 4(1):1–28, March 2004. URL http://ideas.repec.org/a/bpj/bejmac/vtopics.4y2004i1n4.html.

A. Mian and A. Sufi. The consequences of mortgage credit expansion: Evidence from the u.s. mortgage default crisis. *The Quarterly Journal of Economics*, 124(4):1449–1496, 2009. doi: 10.1162/qjec.2009.124.4.1449. URL http://qje.oxfordjournals.org/content/124/4/1449.abstract.

A. Mian, K. Rao, and A. Sufi. Household balance sheets, consumption, and the economic slump*. *The Quarterly Journal of Economics*, 128(4):1687–1726, 2013. doi: 10.1093/qje/qjt020. URL http://qje.oxfordjournals.org/content/early/2013/09/20/qje.qjt020.abstract.

A. R. Mian and A. Sufi. House prices, home equity-based borrowing, and the u.s. household leverage crisis. *American Economic Review*, 101(15283):pp. 2132–2156, August 2011. URL http://www.nber.org/papers/w15283.

F. S. Mishkin. The channels of monetary transmission: Lessons for monetary policy. NBER Working Papers 5464, National Bureau of Economic Research, Inc, May 1996. URL http://ideas.repec.org/p/nbr/nberwo/5464.html.

A. Saiz. The geographic determinants of housing supply. *The Quarterly Journal of Economics*, 125(3):1253–1296, 2010. doi: 10.1162/qjec.2010.125.3.1253. URL http://qje.oxfordjournals.org/content/125/3/1253.abstract.

J. H. Stock and M. Yogo. Testing for weak instruments in linear iv regression. NBER Technical Working Papers 0284, National Bureau of Economic Research, Inc, Nov. 2002. URL http://ideas.repec.org/p/nbr/nberte/0284.html.

S. P. Zeldes. Consumption and liquidity constraints: An empirical investigation. *Journal of Political Economy*, 97(2):pp. 305–346, 1989. ISSN 00223808. URL http://www.jstor.org/stable/1831315.