Homeowner Balance Sheets and Monetary Policy

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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. Using geocoded microdata from the Consumer Expenditure Survey, I exploit regional heterogeneity in housing markets to identify the magnitude of this channel. Results show that a 25 basis point shock to the federal funds rate causes large house price responses in cities with the largest geographic and regulatory barriers to new construction compared with elastic-supply cities where construction holds prices in check. Using an instrumental variables strategy, the paper compares house price and consumption responses across these markets to identify a marginal propensity to consume out of housing of 0.05. I discuss the aggregate implications of these results as well as heterogeneity of effects across households.

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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 ex-

penditures 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. As evidenced in the left panel of Figure 1, fluctuations in household spending closely track household wealth. Given the large fraction of household wealth in housing assets, even small fluctuations in housing may generate large wealth effects. Secondly, housing is one of the most commonly used sources of collateral available to households. This is reflected in the close co-movement between house prices and household debt in the right panel of Figure 1. Since housing wealth forms a substantial portion of household balance sheets, even relatively small fluctuations in house prices can cause substantial changes to borrowing capacity, especially for new homeowners who tend to be younger and more credit constrained compared to older homeowners (Flavin and Yamashita, 2002). This makes housing an important source of collateral, facilitating access to financing to smoothing consumption over the life-cycle.

Heterogeneity in local housing markets also provide a means to understand the causality behind the co-movements between household spending and balance sheet quality shown in Figure 1. 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 2. 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. Specifically, I construct a measure of monetary shocks by purging target federal funds rate innovations of their endogenous responses to current and expected macroeconomic conditions (Romer and Romer, 2004). I then use these shocks to estimate impulse responses of house prices, allowing responses to vary across metropolitan statistical areas (MSAs) based on local housing supply elasticity as measured by land availability and local zoning regulation variables from Saiz (2010). Results show that house price responses vary substantially across MSAs, with the most inelastic-supply markets showing house price responses as large as 1-2% following a 25 bp shock to the federal funds rate and the most elastic-supply markets showing

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 interactions between supply elasticity measures and monetary shocks can be used as instruments to consistently estimate the consumption elasticity to housing wealth. 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] Mian et al. (2013) also include results on the effects of housing wealth on spending growth from 2005 to 2009 using data from MasterCard. While their results go a long way to identifying the causal relationship between housing wealth and spending, they focus on a data from the mid-2000's, a period of unusually high credit expansion potentially correlated with housing supply elasticity.

This paper complements the results in the literature by using a longer time frame to provide evidence that the relationship between home equity and consumption has been stable over time. Furthermore, while much of the literature focuses on cross-sectional variation in house price growth generated by the housing boom of the mid-2000's, this paper uses a specific demand shock–monetary policy shocks–to identify exogenous variation in house prices across MSAs. Specifying the driving shock explicitly in the empirical model lends additional credibility that the results are not driven by shocks specific

[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.

to the housing boom. In addition, by looking at household-level data, I am able to show that these effects arise solely from homeowners and not renters, providing additional evidence that these estimates do not reflect a common factor driving both consumption and housing demand. Finally, the results also provide empirical evidence for a quantitatively important effect of monetary policy on household spending acting through household balance sheets.

Results from the estimation show strong causal effect of housing wealth on consumption. The estimated elasticity of consumption to house prices for homeowners is 0.75, corresponding to an MPC of approximately 0.048. 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 MPCs 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 understand 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 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 0.22 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 MPCs 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, home-ownership 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 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 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. This study focuses on quarterly total expenditures less shelter costs to avoid mechanical relationships between house values and spending on housing services. Data from all waves between 1986 to 2008 is used and all expenditures, in-

come, and home value variables are deflated by CPI. Table 1 provides summary statistics on the sample used in the baseline regressions.[2]

Income and balance sheet data are only collected in the first and last interview, often making it difficult to track changes in these variables 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 even at an annual basis in much of the data. Using restricted-access geographic files from the CES, I match households with local-level housing market and income variables based on FIPS county codes.[3] 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 MSAs in the US. Sampling is also conducted at several smaller metropolitan and rural areas to form a nationally representative sample, but

[2]The time frame is constrained by major survey changes occurring in 1986 and the Zero-Lower-Bound period beginning in December 2008, after which monetary shocks cannot be computed using target federal funds rates. The sample also includes only households matched to one of the metropolitan statistical area for which housing supply and house price data are available. Changes to the survey design in 1996q1 and 2005q1 prevent linking all individuals across those two quarters. Finally, households reporting spending changes in the top and bottom 1% of spending growth between quarters (roughly 130% or more between quarters) are excluded from the sample. Results are robust to inclusion of these households. Some alternate specifications use a subset of this sample since certain variables included in those specifications are not available for the full time frame or geography.

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

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 3 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.[4] 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 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.[5] The index

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

[5]Further detail regarding the Wharton Land-Use Regulation Index can be found in Gy-

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.

Table 2 provides an additional description of the distribution of these variables across select metropolitan areas.[6] As can be seen, while the variables are somewhat correlated with city size in the tails, several large metro areas fall across the distribution from elastic supply to inelastic supply.

The use of metropolitan statistical areas as the relevant geographical area for defining local housing supply is not simply a convenience. MSAs 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.

ourko et al. (2008).

[6]For a more complete listing, please refer to the online appendix to Saiz (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 do not affect the relative distribution of the population across elastic and inelastic supply MSAs.

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 MSAs 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.

One potential drawback of the FHFA index is that it is constructed using transactions data acquired from Freddie Mac, and hence covers 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.[7] 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 ensures that the results are both stable over time and robust to the inclusion of non-conforming mortgages when measuring house price appreciation.

Federal Reserve Greenbook Forecasts This paper uses the method described by Romer and Romer (2004) to purge monetary policy innovations of endogenous responses to current and expected macroeconomic conditions as reflected in the Federal Reserve's Greenbook forecast. Prior to each FOMC meeting, the Fed staff constructs a forecast and current analysis of the state of the economy published in what is known as the Greenbook. These data reflect the Fed's own view of the current and future state of the economy, and hence are used to orthogonalize innovations in the fed funds target to endogenous

[7] 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/

policy actions.

Specifically, the data used in this study includes the target and effective federal funds rates and forecasts of output growth, inflation, housing starts, and the unemployment rate from one quarter prior to the FOMC meeting through two quarters after.[8] One observation is available for each FOMC meeting, which occurs approximately every six weeks, from 1969 through 2008 (the last available Greenbooks). 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.

For each meeting date, I use forecasts from 1 quarter prior to the meeting through 2 quarters ahead. While the 1 quarter lagged observation may be a published NIPA number, the value reflects the real-time information available at the time of the meeting and does not include subsequent revisions due to additional data received with a lag. The Greenbook forecast values therefore reflect the best available estimates of these variables as of a few days prior to the meeting when the policy rate is changed.

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 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 MSAs with little house price response and inelastic-supply MSAs with larger price response provides

[8] I thank the Romers for making their data available online and Lorenz Keung for providing data through 2006. Data for 2007-2008 and data on housing starts projections in all years were not included in the original data sets and have been collected by the author from Greenbook Part 1 public releases available on the Federal Reserve website.

a means to assess the quantitative 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. Housing supply elasticity, as determined by land availability and zoning laws, explains the relative increase in construction and price. After a monetary shock, MSAs with limited "buildable" land will have increasing marginal costs of new construction, resulting in higher house prices relative to land-rich areas. Similarly, in MSAs with stricter zoning regulations, new construction will be costly, raising the marginal value of an existing home.

To understand the effects of monetary policy on house price dynamics, I first identify monetary shocks using publicly released Federal Reserve Greenbook forecasts as in Romer and Romer (2004).[9] This method purges innovations in the fed funds target rate of endogenous responses to current and expected economic conditions. Failing to do so is likely to lead to spurious correlations between endogenous monetary policy innovations and economic outcomes.

Following Romer and Romer (2004), I estimate the following regression:

$$\Delta fft_m = \theta_0 + \theta_1 ffb + \sum_{i=-1}^{2} \theta_{2,i} F_{m,i} + \sum_{i=-1}^{2} \theta_{3,i} \left[F_{m,i} - F_{m-1,i}\right] + \theta_4 ue_{m,0} + \eta_m$$

where Δfft_m is the change in the target rate at meeting m and ffb_m is the effective rate prior to the meeting, included to capture mean-reversion. The variable $F_{m,i}$ denotes a vector of quarterly Greenbook forecasts for output growth, inflation, and housing starts for horizons i running from 1 quarter prior to the meeting through 2 quarters following the meeting. The regression allow for responses to both the level of the forecast as well as forecast innovations from the previous meeting. The concurrent forecast of the unemployment rate

[9] Results using alternative identification of monetary shocks and methods for estimating impulse responses yield similar results and are available upon request.

$ue_{m,0}$ is also included.[10]

The specification is identical to the one used in Romer and Romer (2004) with the exception that the above regression also controls for the forecast of housing starts. This ensures that the identified shocks are orthogonal to current and expected conditions both the housing market and the economy as a whole. The shocks η_m are aggregated to a quarterly frequency by summing together all shocks from meetings within a quarter. The identified shocks are displayed in Figure 4.

Using these shocks, I estimate the impulse response of house prices using the local projections method described by Jordà (2005). Unlike standard VAR-based estimates, impulse responses estimated by local projections are robust to a broader set of dynamic models including those not described by simple autoregressions. Furthermore, this approach is implemented through a simple OLS regression and can be easily adapted to allow for non-linear effects. This is especially important in the current application, as I am interested in both the effects of monetary shocks on house prices as well as the heterogeneity of responses across housing supply elasticity.

To understand these effects, I estimate impulse responses at each quarterly horizon h using an MSA-level panel regression given by:

$$q_{i,t+h} - q_{i,t} = \left(\psi_1^h + \psi_2^h z_i\right)\eta_t + \sum_{\ell=1}^{8}\left(\alpha_1^h + \alpha_2^h z_i\right)\eta_{t-\ell} + \sum_{\ell=1}^{8}\left(\alpha_3^h + \alpha_4^h z_i\right)\Delta q_{i,t} + \alpha_i^h + \epsilon_{it}^h$$

where $\psi_1^h + \psi_2^h z_i$ gives the effects of the monetary shock on house price growth over the horizon h, given by the log difference in house prices over the horizon $q_{i,t+h} - q_{i,t}$. This coefficient is interpreted as the causal effect of a monetary shock on house price growth for a given value of z_i, a vector including local land availability and an index of zoning regulations. The model includes lags of η and Δq along with their interactions with z_i to control for potential serial correlation that varies with geography and regulations. The MSA-level

[10] Because the Okun's Law relationship between output growth and unemployment is sufficiently strong during the sample, I follow Romer and Romer (2004) in excluding leads and lags of the unemployment rate.

fixed effect, α_i^h, allows for very general MSA-specific trends. Since η_t is already orthogonalized to a time-t forecast of macroeconomic and housing market conditions, the estimated coefficients are not biased due to common factors driving both the fed funds rate and local house prices.

The impulse response is given by $\hat{\psi}_1^h + \hat{\psi}_2^h z_i$, estimated by repeated fixed-effects regressions at each horizon h. The coefficients $\hat{\psi}_2^h$ are jointly significant at the 5% level for all but 3 horizons up to 24 quarters, indicating that house price responses vary with z_i, measures of housing supply elasticity. To illustrate this, Figure 5 plots these responses for hypothetical MSAs by setting values of z_i to be their averages in population-weighted quartiles of the housing supply elasticity from Saiz (2010). The dashed lines represent 95% confidence bands constructed based on Driscoll-Kraay standard errors which are robust to general forms of cross-sectional and temporal dependence of errors (Driscoll and Kraay, 1998). The results indicate that house price responses vary significantly across MSAs differing in land availability and zoning regulations. Specifically, the most inelastic supply MSAs see a 1 to 2 percent drop in home values following a 25 basis point surprise monetary loosening. Since the measure of monetary shocks has a persistent effect on interest rates, the effects on home values are prolonged. By comparison, house prices in more elastic MSAs are relatively unaffected at all horizons.

These results provide not only an insight into the heterogeneous effects of monetary policy across different housing markets, 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 identical in their responses to the shock. 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 these types of MSAs 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 fact that MSAs with different housing supply elasticities vary in their response to monetary shocks can be used to estimate the "homeowner balance sheet channel." Specifically, if household consumption responses to a monetary shock do not depend on local housing supply elasticity directly, the heterogeneity in house price responses can be used in an instrumental variables strategy. Rising house prices in inelastic cities will improve the balance sheet quality of homeowners in inelastic markets only while other effects of the monetary shock are felt by all households. Comparing consumption and house price responses across housing markets, I identify the marginal propensity to consume out of housing and the magnitude of the homeowner balance sheet channel.

Using the identified monetary shocks described in the previous section, I turn to the household-level consumption data in the Consumer Expenditure Survey. Household i's log real (non-shelter) 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[11] and $x_{i,t+1}$ is a set of household-level controls including age, family size, and income.[12] The empirical model is

[11] 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 does not affect results.

[12] The CES only collects income in the first and last waves, so household-level income growth is computed as the growth between these two observations. Controls for local per capita income growth are also included.

estimated in log-differences, and hence allows for unobserved heterogeneity in consumption levels due to household-specific tastes.

In the model described by (4.1) and (4.2), the coefficient β_1 provides a measure of the elasticity of consumption to housing wealth. The magnitude of this coefficient provides insight into how households use housing assets to smooth consumption over their lifetime. A small elasticity would imply that even if house prices respond dramatically to monetary shocks, household spending will not be affected by rising housing wealth or loosening of collateral constraints. On the other hand, sensitivity of consumption to house price fluctuations provides evidence of a quantitatively important balance sheet channel. 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 resulting in an upward biased OLS estimates of β_1. 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 given by (4.3) . 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 MSAs above and below the population-weighted median housing supply elasticity. The table indicates inelastic markets tend to have slightly higher nominal incomes, higher home values, and lower ownership rates compared to more elastic markets, though these margins are fairly small compared to within-region heterogeneity. 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 MSAs. 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 MSAs. 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

[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.

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 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 on top of additional costs related to searching for work and housing or non-pecuniary costs of moving away from social networks or familiar areas. The effects of the monetary shock are relatively short-lived, and are unlikely to elicit a large mobility responses.[14] This is in contrast to the large fluctuations in home values during the housing boom, which were seen by many as permanent at the time.

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 to rise in inelastic-supply areas with little effect on prices in elastic-supply areas. Specifically, interactions between monetary shocks and the supply elasticity variables is significant at most horizons. This provides evidence that there is substantial variation across MSAs in the response of house prices to monetary shocks. Furthermore, first-stage Cragg-Donald F-statistics from the baseline specification, reported in the last line of results in Table 3, exceed the Stock and Yogo (2002) thresholds for relative bias of 10%. Therefore, the instruments are sufficiently strong to identify the effect of house price growth on consumption.

[14]Data from the American Community Survey indicate no strong relationship between monetary policy and mobility, nor do they indicate a systematic movement of households between elastic and inelastic supply areas at a business-cycle frequency. For this reason, I do not discuss the effects of mobility or substitution between real spending on housing and non-housing goods and services.

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[15], and the combined sample of all households. Results show that the consumption elasticity to housing wealth, β_1, is positive and significant at 0.732 for owners with a slightly higher elasticity of 1.022 for those with mortgages. These results provide strong evidence that housing wealth plays a substantial role in amplifying consumption responses to monetary shocks. Given the mean (nominal) home value in the sample and mean quarterly expenditures given in Table 1, homeowners increase quarterly spending by approximately \$0.048 for a \$1 increase in home equity.

Unlike homeowners, renters 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 slightly negative. This result stands in contrast to findings of Attanasio et al. (2009) that rising home values are correlated with increased spending even by renters in the area. As acknowledged by the authors, 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.

The insignificant and small response for renters may appear striking considering renters are often future buyers of housing who should suffer negative wealth effects due to rising home values. However, 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.

[15] 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.

Table 4 provides evidence that these results are robust to several alternate specifications. First, it is possible that returns on financial assets may be correlated with house prices and also affect spending, biasing the results upward. Such a bias would only occur if stock ownership and portfolio holdings were correlated 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 returns for any household reporting stock ownership. Compared with baseline results in column 1 (included for convenience), results from column 2 shows that estimated elasticities for owners fall only slightly when controlling for financial wealth gains.

Secondly, 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 in the CES, I include the Consumer Sentiment Index from the Michigan Survey of Consumers as a control in column 3. To further control for heterogeneity in income expectations across MSAs, column 4 re-estimates the baseline model including realized MSA-level income growth over the next year. While household's may not have perfect foresight, their forecasts are likely to be centered at the true values of income growth. Results in both these specifications reduce the magnitude of the estimated response slightly, but households still increase consumption substantially in response to an increase in home equity.

In addition, differences in mortgage laws at a state-level may interact with the expansion of credit supply following a monetary shock. Credit supply may loosen more in areas with more lax mortgage laws, resulting in larger demand shocks in such areas. If mortgage laws are correlated with housing supply, this may bias the baseline results. To address this issue, column 5 controls for state-level mortgage recourse status and time to foreclosure. Results are essentially unchanged from baseline by the inclusion of these variables.

Finally, I first investigate whether the relationship between consumption and housing is specific to the mid-2000's period during which unconventional forms of lending grew, especially in areas with expected price appreciation (Barlevy and Fisher, 2010). In column 6, I exclude observations from so-called

"sand states" which saw large fluctuations in both house prices and residential construction during this period.[16] While excluding these states lowers the estimated response slightly, results still point to a robust spending response due to house price growth.

In the final column of Table 4, I exclude all observations prior to 1997 when house price growth began to accelerate. While somewhat less precise, results in the former period remain both statistically and economically significant. Despite concerns that the mid-2000's were unique, these results point to a stable causal relationship between housing wealth and spending.

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 the housing bubble from 1997 to 2008, the measure offers a variety of benefits over the baseline FHFA house price index. As discussed in Section 2, the inclusion of non-conforming loans, such as jumbo mortgages or sub-prime loans, accounts for a large amount of variation in prices during the late 1990's and early 2000's. This segment of homes saw more dramatically appreciation in home values making the Zillow measure more sensitive to monetary shocks. 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. While this finding rests on data only from the housing bubble, the results from all of these specifications point to a robust relationship between home values and spending over the past few decades.

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

[16] Specifically, I exclude observations for households living in Arizona, Colorado, Nevada, New Mexico, Utah, and California. Notably, this excludes MSAs such as Las Vegas for which land availability and zoning laws within the MSA do not completely explain housing supply elasticity. This improves the first-stage fit, as evidenced by the increased F-statistic.

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.

Pure wealth effects from rising house prices only occur when households are net buyers or sellers of housing (Sinai and Souleles, 2005). 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 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. Such a 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. Excluding foreign real estate investment, aggregate wealth effects are likely to be small unless there is a large wedge between MPCs of the buyers and sellers of housing.

Unlike wealth effects, collateral effects can lead to large effects on aggregate spending dynamics. 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.

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.

The baseline results for collateral effects use Debt-Service Ratios (DSR), a common ratio used by banks to assess credit quality defined as the ratio between debt service payments and after-tax income. This ratio is the preferred measure of credit constraints in this study for a couple reasons. First, this measure has been shown to predict the likelihood of being denied credit and is commonly used by both academics and banks (Johnson and Li, 2010). Secondly, households are more likely to recall periodic payments made on debt rather than the outstanding balance, meaning DSRs are more likely to be measured accurately in the CES than loan-to-value (LTV) ratios or other measures depending on loan balances.

Table 5 shows results splitting households by quartiles of DSRs.[17] Quar-

[17]Quartiles may not contain equal number of homeowners since they are measured for the full sample including renters. Since mortgage debt is a primary source of debt service

tiles are assigned for each year in the sample to ensure that groupings reflect cross-sectional heterogeneity in DSRs rather than aggregate fluctuations in debt or income over time. Compared to the first column, which repeats baseline results, the second column shows substantial heterogeneity in responses across DSRs. Specifically, households in the third and fourth quartiles have estimated elasticities of 3.57 and 3.06 corresponding to MPCs out of housing of 0.30 and 0.23. By comparison, households in the bottom quartiles have small and insignificant responses. I find similar results in columns 3 to 6 which show results for the fully interacted model, allowing demographic and income changes to affect each quartile differently.

Table 6 shows results splitting households along LTV ratios, a more commonly used proxy for credit constraints. Compared to baseline results in column 1, results in column 2 to 6 once again show substantial heterogeneity across households. Households with LTVs below 0.8–corresponding to the modal 20% down payment–are unlikely to be constrained by limited home equity. As such, they show small and insignificant spending responses to increased home values. Households with LTVs above 0.8 but below 1 have estimated elasticities of 2.74 (MPC of 0.24) reflecting the fact that their home equity is limited ex-ante, but rising home values loosen borrowing constraints. Unlike underwater, homeowners, however, they are more likely able to tap into the increase in home equity. Interestingly, underwater households in column 6 show smaller responses compared to those with high LTVs that are not underwater, reflecting the fact that rising home values may not impact households who remain underwater even after prices rise.

While high DSRs and LTVs may proxy for credit constraints, larger spending responses for these households is only indirect evidence of collateral effects. In addition to these measures, I look directly at households who refinanced their homes to a higher principal during the interview period. To understand how these households are using this debt, I flag all households increasing mortgage debt balances by more than 5% as "equity extractors" and compare their

payments, renters tend to be clustered in the lowest quartiles. Results do not differ if quartiles are computed for owners only.

spending responses 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 in Table 7 show households who extracted home equity have an estimated elasticity of 3.06 (MPC of 0.18), over triple that of "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.

5.3 Aggregate Implications of Homeowner Balance Sheet Channel

The results of this paper show that monetary policy has significant and heterogeneous effects on home values across different housing markets. These fluctuations result in changes to household borrowing capacity and wealth, which results in fluctuations in household spending. While the CES microdata provide a method to better identify these effects, the rotating panel structure of the survey makes computing dynamics of the consumption response to house price changes difficult. Nonetheless, the results of this paper provide insight into the cross-sectional heterogeneity in household-level responses and provides the means to quantify a peak aggregate response in spending through the homeowner balance sheet channel.

The magnitude of the homeowner balance sheet channel can be computed at a local level using the estimated consumption elasticity in (4.3) and the response of house price growth identified in Section 3. Since the consumption elasticities depend strongly on ownership status, I use local data on homeownership rates and consumption shares between owners and renters along with the estimated elasticities to quantify the effects on spending at a local level. Figure 6 shows the heterogeneity of these spending responses across different MSAs.

Cross-sectional patterns in the magnitude of the balance sheet channel largely follows patterns in housing supply elasticity, with coastal and mountainous regions seeing large effects. This is tempered somewhat by slightly lower homeownership rates in certain coastal markets, while MSAs such as Miami see extremely large effects. It is important to note that increased spending in inelastic markets does not detract from economic activity in elastic supply markets. Instead, the composition of activity following the shock likely differs across these areas. For example, increased demand for homes likely materializes in higher levels of residential investment in elastic supply markets, a channel which is not accounted for in this paper. Therefore, while the figure presents heterogeneity in one channel of monetary policy, it does not necessarily reflect heterogeneity in total effects.

Given this heterogeneity across markets, I attempt to aggregate these effects to provide an estimate of the homeowner balance sheet channel on aggregate spending. To compute aggregate effects acting through this channel, first consider the household-level homeowner balance sheet effect given by:

$$\hat{c}_{it}^{hobs} = \beta_{1i}\hat{q}_{m(i)t} = \beta_{1i}\left(\gamma_0 + \gamma_1 z_{m(i)}\right)\eta_t$$

where $\hat{x}$ denotes a percent change in a variable x and $_i$ is an ownership status dummy. This expression is simply the part of the reduced form model estimated previously that corresponds to the homeowner balance sheet channel. Following the monetary shock η_t, home values in MSA m move by $\hat{q}_{mt} = (\gamma_0 + \gamma_1 z_m)\,\eta_t$, estimated by the impulse response in Section 3. This results in an increase in spending of β_1 for owners and no significant change in spending for renters as found in the previous subsection. Aggregating these effects using consumption shares gives:

$$\begin{aligned}
\hat{C}_t^{hobs} &= \sum\left(\frac{c_{it}}{C_t}\right)\hat{c}_t^{hobs} \\
&= \beta_1\left(\sum_i \frac{c_{iti}}{C_t}\right)\left[\gamma_0 + \gamma_1\left(\sum_i \frac{c_{iti}}{\sum_i c_{iti}} z_{m(i)}\right)\right]\eta_t
\end{aligned}$$

The previous analysis has already provided estimates for most of the com-

ponents in this expression. Using these estimates along with ownership status and consumption shares across households in the CES sample, Table 8 provides an estimate of the homeowner balance sheet channel on aggregate spending. Given the estimated elasticities, I find that aggregate household spending increases by 58 basis points due to rising home values following a 25 basis point shock to the fed funds rate.[18]

This result provides strong evidence that homeowner balance sheets play an important role in the transmission of monetary policy. Given results from the previous section that these spending responses largely reflect collateral effects, this channel may be especially important in times when household balance sheets are weak and credit is tight. Loosening monetary policy during such times may provide additional home equity to a larger number of marginally credit constrained households. This would increasing the consumption elasticity, β_1, closer to the estimates for high DSR or LTV households, thus increasing the magnitude of aggregate effects.

6 Conclusions

This paper utilizes geographically linked data from the Consumer Expenditure Survey to exploit regional heterogeneity in land availability and land-use regulations and establish a causal link between monetary policy, house prices, and consumption behavior. Specifically, results show that a monetary loosening raises home values by lowering the cost of credit. Increases in home values depend on local barriers to new construction, resulting in large variation across MSAs in price responses. Following a 25 basis point reduction in the federal funds rate, cities with little available land and tight land-use regulations see increases in home values of as much as 1 percent, while price

[18] This estimate is calibrated using estimates of γ_0 and γ_1 at the peak house price response conditional on the weighted average of $z_{m(i)}$. It fixes ownership and consumption shares at the 2000 levels and only allows owners to have spending responses following the house price change. Allowing the renters' response to be the (statistically insignificant) point-estimate from the baseline model in Table 3 lowers the estimate of the homeowner balance sheet channel only slightly to 54 basis points of spending for a 25 basis point monetary shock.

responses in elastic-supply MSAs is muted. These rising home values result in increased spending, primarily due to increased collateral for constrained homeowners. Specifically, homeowners spend $0.05 for every additional dollar of home equity. Importantly, renters have little response to rising home values and homeowners with high levels of debt and those who extract equity from their homes have MPCs as large as 0.25. These results point to a strong role for collateral effects as rising home values loosen credit constraints by providing households with additional home equity. By comparison, pure wealth effects are found to be relatively small.

Altogether, the results of this paper provide evidence for a quantitatively important channel of monetary transmission which I refer to as the "homeowner balance sheet channel." 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, generating aggregate effects on spending.

Furthermore, the heterogeneity in household-level responses points to the importance of the distribution of credit access across households. The homeowner balance sheet channel acts primarily on credit constrained households who are able to access home equity lending when house prices rise. This means that monetary policy may have substantially more bite when household balance sheets are weakened by falling asset values, specifically in collateralizable assets. Such non-linearity may be important to take into account when considering policy responses to macroeconomic shocks.

In addition, the heterogeneity in responses have potentially important implications for inequality. As credit constrained households are likely to be poorer on average, a monetary loosening may work to shift resources towards constrained homeowners with little effect on even poorer renters. While the effects on inequality are ambiguous, the results are broadly consistent with findings in the literature that monetary policy serves to reduce inequality (Coibion et al., 2012).

It is important to note that while this paper focuses on the homeowner

balance sheet channel, the findings do not necessarily indicate that looser monetary policy shifts resources from elastic housing supply cities to inelastic cities. While it is not the focus of this paper, elastic-supply areas likely see increased residential investment relative to more inelastic areas. The heterogeneity across geographic areas lies primarily in the composition of the real effects of monetary policy rather than the magnitudes.

A Figures/Tables

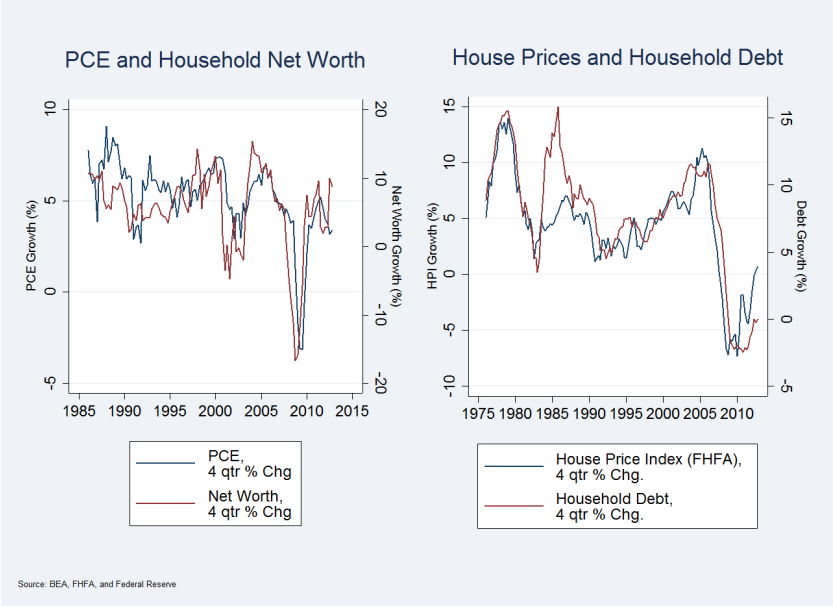

Figure 1: House Prices, Spending, and Household Balance Sheets: The left panel shows co-movements between personal consumption expenditures and household net worth–a measure of household financial resources. The right panel shows similar co-movement between house prices and household debt, suggesting that movements in house prices, a key contributor to net worth, likely increase spending partially by allowing households to increase debt holdings. (Source: BEA NIPA Accounts, Federal Reserve Board, Financial Accounts of the US, and FHFA All Transactions House Price Index for US)

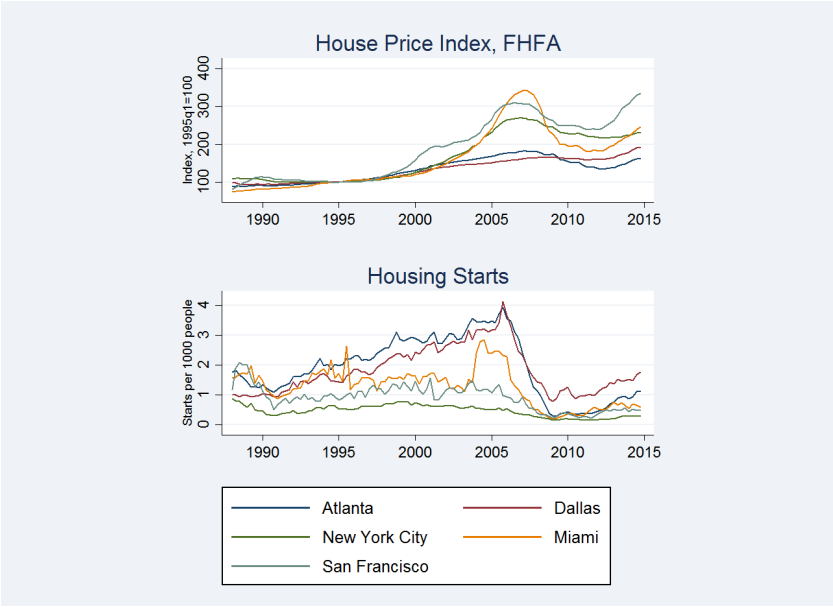

Figure 2: House Prices and Housing Starts - Select MSAs: Over the past decade, house prices rose and declined substantially in cities such as New York, Miami, and San Francisco where new construction was limited by geographic and regulatory constraints. By comparison, house price fluctuations were moderate in cities such as Dallas and Atlanta which saw large construction booms. (Source: FHFA All Transactions House Price Index for select MSAs and US Census Bureau Privately Owned Housing Starts)

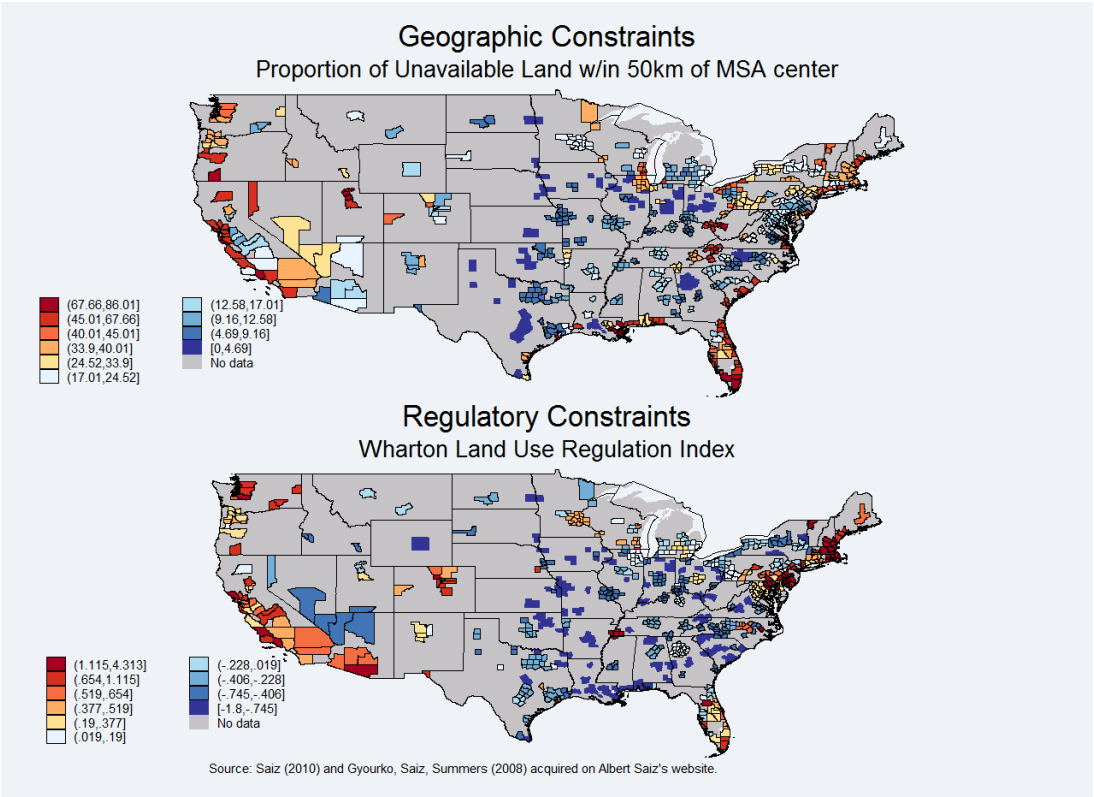

Figure 3: Housing Supply Elasticity Measures: Geographic and Regulatory Constraints: Geographic barriers, as measured by land lost to water and steep slopes, as well as zoning regulations increase the marginal cost of new construction making housing supply more inelastic. Intensity of these barriers varies from blue (low level of barriers) to red (high). (Source: Unavailable Land Share from Saiz (2010), Wharton Land Use Regulation Index from Gyourko et al. (2008) acquired from Albert Saiz's website)

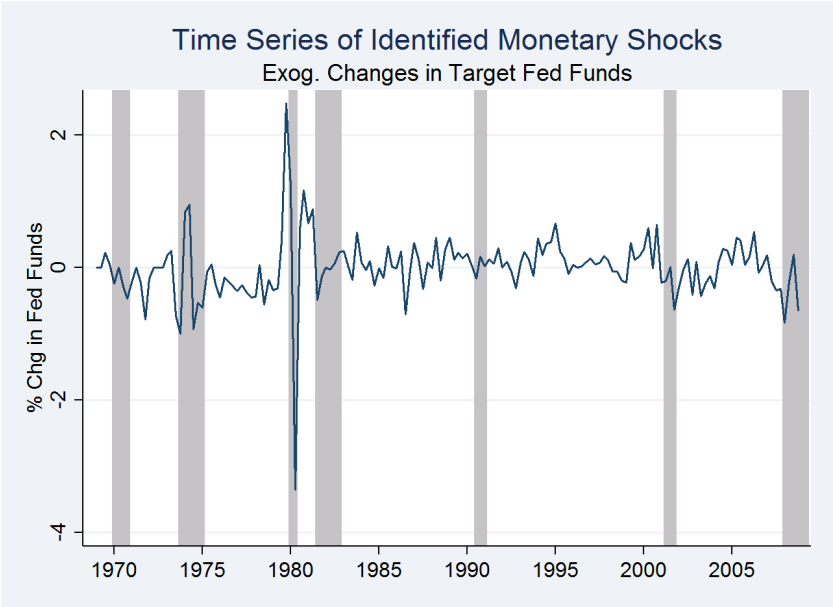

Figure 4: Time Series of Identified Monetary Shocks: Exogenous changes in target fed funds rate based on methodology of Romer and Romer (2004). Plot is of residuals from regressing changes in target fed funds rates on forecasts of current and lagged macroeconomic and housing market indicators. This purges the series of endogenous policy responses to current and future economic outlook. (Source:Author's calculation.)

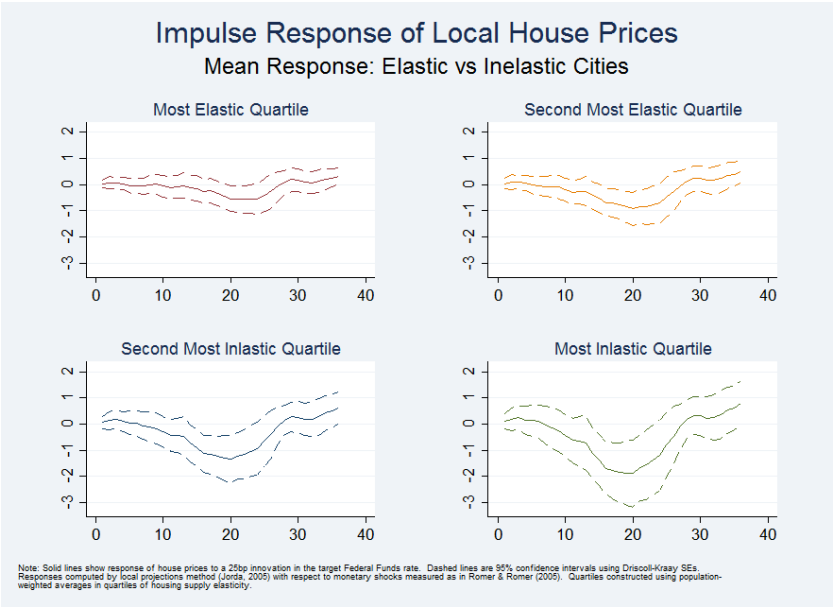

Figure 5: House Price Responses to 25bp shock to Fed Funds: Solid lines show impulse responses to a 25 basis point exogenous innovation in the federal funds rate estimated using a modified local projections method (Jordà, 2005). MSA-level responses are allowed to vary based on local land availability and zoning regulations. The plots show responses evaluated at averages of these measures within population-weighted quartiles from most elastic to most inelastic MSA. (Source: Author's calculation)

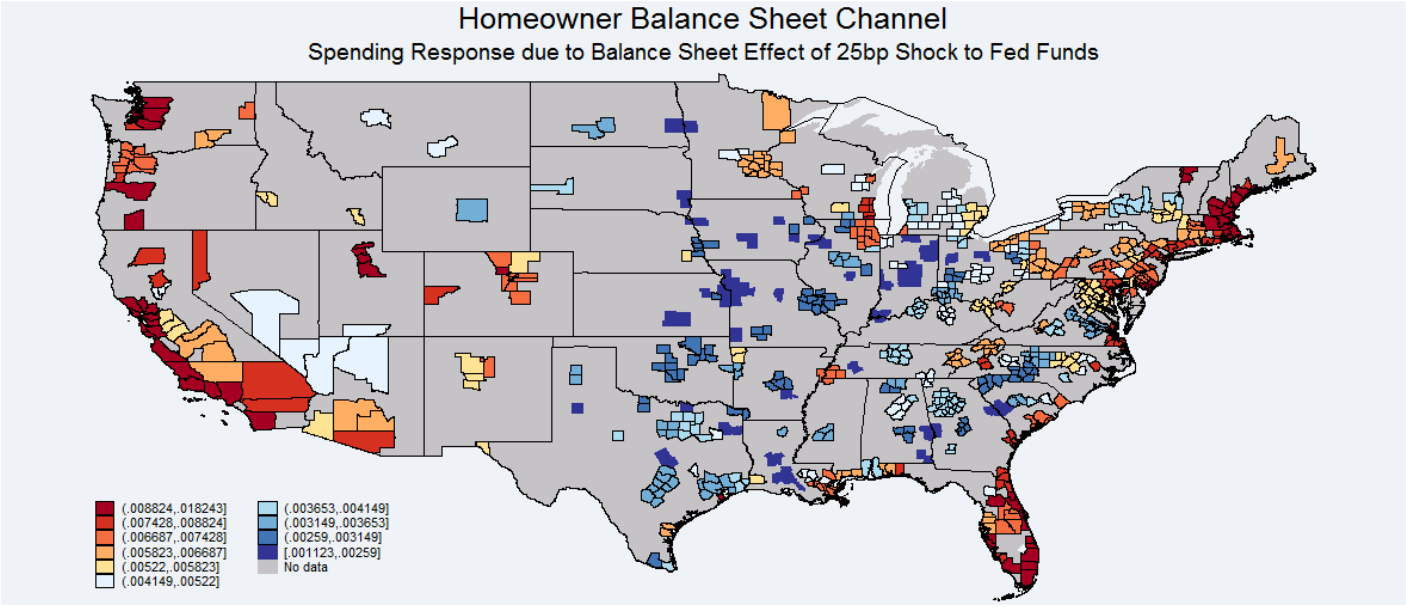

Figure 6: Homeowner Balance Sheet Channel - Geographic Heterogeneity: Using MSA-level house price responses and ownership rates, the map computes the increase in spending associated with rising home values following a monetary loosening of 25 basis points to the federal funds rate. This is computed using the peak house price response following a monetary shock summarized in Figure 5 and estimated elasticities of spending out of housing wealth shown in results from Table 3 along with data on local homeownership rates (Census) and housing supply elasticity variables (Saiz, 2010).

Consumer Expenditure Survey - Sample Summary Statistics			
	Overall	*Inelastic Supply*	*Elastic Supply*
Income (annual)			
before taxes	$ 50,607	$ 52,210	$ 49,197
	(45,681)	(48,167)	(43,326)
after taxes	$ 46,769	$ 47,986	$ 45,698
	(41,722)	(43,845)	(39,729)
Total Expenditures (annual)	$ 40,532	$ 42,301	$ 38,974
	(32,321)	(34,761)	(29,923)
Home Value (if owner)			
Self-reported	$ 158,350	$ 198,174	$ 127,372
	(153,617)	(187,469)	(111,466)
Zillow county-level	$ 164,164	$ 206,458	$ 123,872
	(101,597)	(118,008)	(59,679)
Percentage Owners	64.2%	61.4%	66.9%
Age (Reference Person)	49.4	49.2	49.5
Family Size	2.72	2.75	2.70

Note: Summary statistics are for sample used in baseline regressions. Except for Zillow home values, all values are average reported values from Consumer Expenditures Survey sample used in this study. Zillow home values are matched at county-level. Inelastic Supply and Elastic Supply refer to households living in MSAs falling above and below the population-weighted median housing supply elasticity from Saiz (2010).

Table 1: Consumer Expenditure Survey Summary Statistics

Housing Supply Elasticity Measures - Select Large MSAs					
MSA Name (Largest City)	*Wharton Land-Use Regulation Index*	*Unavailable Land (% in 50km of MSA center)*	*Supply Elasticity (Est from Saiz, 2010)*	*% of US Population in less elastic MSAs*	*MSA Population*
Atlanta, GA	0.03	4.1%	2.55	81.22%	4,144,774
Boston, MA	1.70	33.9%	0.86	24.94%	6,067,510
Chicago, IL	0.02	40.0%	0.81	20.73%	8,289,936
Dallas, TX	-0.23	9.2%	2.18	69.46%	3,541,099
Detroit, MI	0.05	24.5%	1.24	42.79%	4,444,693
Houston, TX	-0.40	8.4%	2.30	74.31%	4,199,526
Los Angeles, CA	0.50	52.5%	0.63	5.68%	9,546,597
Minneapolis, MN	0.38	19.2%	1.45	47.37%	2,979,245
New York, NY	0.65	40.4%	0.76	15.29%	9,321,820
Philadelphia, PA	1.13	10.2%	1.65	58.70%	5,104,291
Phoenix AZ	0.61	14.0%	1.61	54.96%	3,276,392
Riverside, CA	0.53	37.9%	0.94	28.16%	3,280,236
San Diego, CA	0.46	63.4%	0.67	8.65%	2,824,809
St. Louis, MO-IL	-0.73	11.1%	2.36	76.54%	2,606,023
Washington, DC	0.31	14.0%	1.61	53.38%	4,948,213

Note: Land Use Regulation Index, Percentage Unavailable Land values, and Supply Elasticity estimates are excerpted from Saiz (2010). For full table, see online appendix to Saiz (2010).

Table 2: Housing Supply Measures - Select MSAs

House Price Effects on Spending: Baseline Model				
	(1)	(2)	(3)	(4)
Dependent Variable:	*All*	*Owners w/*	*All*	*Pooled*
Total Consumption Growth	*Owners*	*Mortgage*	*Renters*	*Sample*
(Less housing expenditures)				
House Price Growth	0.732***	1.022***	-0.192	0.442*
	(0.272)	(0.339)	(0.383)	(0.235)
Household Income Growth	0.0266***	0.0325***	0.0294***	0.0278***
	(0.0011)	(0.0019)	(0.0019)	(0.0010)
Age (2nd Order Polynomial)	x	x	x	x
Change in Family Size	x	x	x	x
Local Income Growth	x	x	x	x
Monetary Shocks	x	x	x	x
Monthly Dummies	x	x	x	x
Observations	58,995	31,815	22,096	81,091
First-stage F-stat	74.963	45.408	33.029	107.589

Table 3: Effects of Housing on Consumption - Baseline

House price growth is endogenous and instrumented with interactions between monetary shocks and housing supply variables. All regressions are estimated in log-differences and coefficients are elasticity estimates.
*Standard errors in parenthesis are clustered at MSA-level. *** p<0.01, ** p<0.05, * p<0.1*

House Price Effects on Spending: Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable: Total Consumption Growth (Less housing expenditures)	*Baseline*	*Financial Wealth Control*	*Consumer Sentiment Control*	*Next Yr Income Growth*	*State Mortgage Law*	*Dropping "Sand States"*	*Pre-Bubble 1986-1997*	*Zillow Home Values*
House Price Growth	0.732***	0.667**	0.722***	0.675**	0.747***	0.544**	0.889*	0.563***
	(0.272)	(0.331)	(0.269)	(0.285)	(0.286)	(0.235)	(0.506)	(0.205)
Household Income Growth	0.0266***	0.0277***	0.0266***	0.0265***	0.0265***	0.0247***	0.0283***	0.0264***
	(0.00111)	(0.00123)	(0.00110)	(0.00115)	(0.00113)	(0.000911)	(0.00155)	(0.00164)
Age (2nd Order Polynomial)	x	x	x	x	x	x	x	x
Change in Family Size	x	x	x	x	x	x	x	x
Local Income Growth	x	x	x	x	x	x	x	x
Monetary Shocks	x	x	x	x	x	x	x	x
Monthly Dummies	x	x	x	x	x	x	x	x
Financial Wealth Growth		x						
Consumer Sentiment Index			x					
Realized Income Growth 1yr ahead				x				
State Foreclosure Time					x			
State Recourse Status Dummy					x			
Observations	58,995	53,920	58,995	58,013	58,995	48,867	26,762	25,861
First-stage F-stat	74.963	62.402	77.458	67.141	61.557	72.365	20.129	36.714

Table 4: Effects of Housing on Consumption - Select Robustness Checks

House price growth is endogenous and instrumented with interactions between monetary shocks and housing supply variables. All regressions are estimated in log-differences and coefficients are elasticity estimates. All samples include only owners. Column 1 is the baseline model repeated here for convenience. Column 2 adds a control for financial wealth growth. Columns 3 and 4 add controls for consumer sentiment (Michigan Survey of Consumers) and realized MSA-level per capita income growth in the following year. Column 5 includes controls for state-level mortgage foreclosure and recourse laws. Column 6 drops observations from the Southwest and California, regions which saw extreme price fluctuations during the 2000's. Column 7 focuses only on pre-1997 data to avoid any unique underlying factors during the housing boom which may interact with monetary shocks.
*Standard errors in parenthesis are clustered at MSA-level. *** p<0.01, ** p<0.05, * p<0.1*

Evidence for Collateral Channel: Effects across Debt-Service Ratios						
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable: *Total Consumption Growth (Less housing expenditures)*	*Baseline*	*Pooled/ Interacted*	*Lowest Quartile DSR*	*Second Quartile DSR*	*Third Quartile DSR*	*Highest Quartile DSR*
House Price Growth	0.732***					
	(0.283)					
House Price Growth (DSR lowest 25%)		0.287	0.214			
		(1.341)	(0.904)			
House Price Growth (DSR second 25%)		0.464		0.532		
		(1.334)		(1.183)		
House Price Growth (DSR third 25%)		3.567***			5.850***	
		(1.290)			(1.271)	
House Price Growth (DSR highest 25%)		3.058**				3.743***
		(1.249)				(1.279)
Household Income Growth	0.0266***	0.0361***	0.0464***	0.0274***	0.0345***	0.0325***
	(0.00113)	(0.00332)	(0.00538)	(0.00475)	(0.00442)	(0.00509)
Observations	58,995	35,370	6,193	8,857	10,149	10,171

Table 5: Evidence for Collateral Channel: Effects across Debt-Service Ratios

House price growth is endogenous and instrumented with interactions between monetary shocks and housing supply variables. The interacted model (2) also interacts all instruments with debt service ratio (DSR) quartile dummies. All regressions are estimated in log-differences and coefficients are elasticity estimates. Standard controls included in all models and (2) also includes DSR quartile dummies. Sample includes only homeowners, hence quartiles may not be equal in size.

Column 1 repeats the baseline results for convenience. Column 2 interacts house price growth with dummies for each quartile of debt service ratios. Columns 3 to 5 are from a fully interacted model.

*Standard errors in parenthesis are clustered at MSA-level. *** p<0.01, ** p<0.05, * p<0.1*

Evidence for Collateral Channel: Effects across Loan-to-Value Ratios					
	(1)	(2)	(3)	(4)	(5)
Dependent Variable: *Total Consumption Growth (Less housing expenditures)*	*Baseline*	*Pooled/ Interacted*	LTV<0.8	*0.8<LTV<1*	*LTV>1*
House Price Growth	0.732***				
	(0.283)				
House Price Growth (LTV<0.8)		1.167	0.465		
		(0.728)	(0.483)		
House Price Growth (0.8<LTV<1)		2.736**		2.144**	
		(1.219)		(1.001)	
House Price Growth (LTV>1)		2.634**			0.861
		(1.211)			(0.855)
Household Income Growth	0.0266***	0.0288***	0.0276***	0.0337***	0.0406***
	(0.00113)	(0.00298)	(0.00185)	(0.00546)	(0.00457)
Observations	58,995	29,783	20,827	5,648	3,308

Table 6: Evidence for Collateral Channel: Effects across Loan-to-Value Ratios

House price growth is endogenous and instrumented with interactions between monetary shocks and housing supply variables. The interacted model in Column 2 also interacts all instruments with LTV dummies for households under 80% LTV, between 80-100% LTV and above 100% LTV. All regressions are estimated in log-differences and coefficients are elasticity estimates. Standard controls included in all models and Column 2 also includes LTV group dummy. Samples include only owners.
Column 1 repeats the baseline results for convenience. Column 2 interacts house price growth with dummies for each LTV group. Columns 3 to 5 are from a fully interacted model.
*Standard errors in parenthesis are clustered at MSA-level. *** p<0.01, ** p<0.05, * p<0.1*

Evidence for Collateral Channel: Effects based on Equity Extraction				
	(1)	(2)	(3)	(4)
Dependent Variable: Total Consumption Growth (Less housing expenditures)	*Baseline*	*Pooled/ Interacted*	*Equity Extracted*	*No Equity Extracted*
House Price Growth	0.732***			
	(0.283)			
House Price Growth (Refi Up)		3.059***	1.887**	
		(1.050)	(0.893)	
House Price Growth (No Refi Up)		0.719		0.752***
		(0.518)		(0.276)
Household Income Growth	0.0266***	0.0270***	0.0213***	0.0269***
	(0.00113)	(0.00189)	(0.00608)	(0.00114)
Observations	58,995	58,995	3,500	55,495

Table 7: Evidence for Collateral Channel: Effects based on Equity Extraction

House price growth is endogenous and instrumented with interactions between monetary shocks and housing supply variables. The interacted model in Column 2 also interacts all instruments with equity extraction dummies. All regressions are estimated in log-differences and coefficients are elasticity estimates. Standard controls are included in all models and Column 2 also includes equity extraction dummy. Samples include only owners.
Column 1 repeats the baseline results for convenience. Column 2 interacts house price growth with dummies for equity extraction status. Columns 3 to 5 are from a fully interacted model.
*Standard errors in parenthesis are clustered at MSA-level. *** p<0.01, ** p<0.05, * p<0.1*

Aggregate Effects: Homeowner Balance Sheet Channel		
Monetary Shock (Exog. Deviation in Fed Funds)	**0.25%**	**(1)**
Consumption Weighted Avg Unavailable Land Share	0.230	(2)
Consumption Weighted Avg Land Use Regulation Index	0.125	(3)
House Price Response to monetary shock	**0.99%**	**(4)**
Consumption Share of Owners	80.3%	*(5)*
Consumption Elasticity to Home Value (for owners)	0.732	(6)
Homeowner Balance Sheet Effect:	**0.58%**	**(7)**

Table 8: Aggregate Homeowner Balance Sheet Channel

Note: Consumption weighted variables (lines 2 and 3) and consumption share of owners (line 5) computed for CES sample in year 2000. Line 4 computed using peak house price response estimate conditional on lines 2 and 3. Line 6 is from baseline regression estimate. Line 7 is computed by multiplying lines 4, 5, and 6.

References

Attanasio, O. P., L. Blow, R. Hamilton, and A. Leicester (2009, 02). Booms and Busts: Consumption, House Prices and Expectations. *Economica 76*(301), 20–50.

Attanasio, O. P. and G. Weber (1994). The uk consumption boom of the late 1980s: Aggregate implications of microeconomic evidence. *The Economic Journal 104*(427), pp. 1269–1302.

Barlevy, G. and J. D. M. Fisher (2010). Mortgage choices and housing speculation. Working Paper Series WP-2010-12, Federal Reserve Bank of Chicago.

Bernanke, B. S., M. Gertler, and S. Gilchrist (1999, October). The financial accelerator in a quantitative business cycle framework. *Handbook of Macroeconomics 1*, 1341–1393.

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

Campbell, J. Y. and J. F. Cocco (2007). How do house prices affect consumption? evidence from micro data. *Journal of Monetary Economics 54*(3), 591 – 621.

Carroll, C. D. and M. S. Kimball (1996). On the concavity of the consumption function. *Econometrica 64*(4), pp. 981–992.

Carroll, C. D., M. Otsuka, and J. Slacalek (2011, 02). How large are housing and financial wealth effects? a new approach. *Journal of Money, Credit and Banking 43*(1), 55–79.

Case, K. E., J. M. Quigley, and R. J. Shiller (2005). Comparing wealth effects: The stock market versus the housing market. Cowles Foundation Discussion Papers 1335, Cowles Foundation for Research in Economics, Yale University.

Chaney, T., D. Sraer, and D. Thesmar (2012). The collateral channel: How real estate shocks affect corporate investment. *American Economic Review 102*(6), 2381–2409.

Coibion, O., Y. Gorodnichenko, L. Kueng, and J. Silvia (2012, June). Innocent bystanders? monetary policy and inequality in the u.s. Working Paper

18170, National Bureau of Economic Research.

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

Davidoff, T. (2014, February). Supply constraints are not valid instrumental variables for home prices because they are correlated with many demand factors. Technical report, SSRN.

Driscoll, J. C. and A. C. Kraay (1998). Consistent covariance matrix estimation with spatially dependent panel data. *The Review of Economics and Statistics 80*(4), pp. 549–560.

Flavin, M. and T. Yamashita (2002). Owner-occupied housing and the composition of the household portfolio. *The American Economic Review 92*(1), pp. 345–362.

Glaeser, E. L., J. Gyourko, and A. Saiz (2008, July). Housing supply and housing bubbles. Working Paper 14193, National Bureau of Economic Research.

Gyourko, J., C. Mayer, and T. Sinai (2013). Superstar cities. *American Economic Journal: Economic Policy 5*(4), 167–99.

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

Hurst, E. and F. Stafford (2004). Home is where the equity is: Mortgage refinancing and household consumption. *Journal of Money, Credit and Banking 36*(6), pp. 985–1014.

Iacoviello, M. (2005). House prices, borrowing constraints, and monetary policy in the business cycle. *The American Economic Review 95*(3), pp. 739–764.

Johnson, K. W. and G. Li (2010, October). 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.

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American Economic Review 95*(1), 161–182.

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

Kiyotaki, N. and J. Moore (1997). Credit cycles. *Journal of Political Economy 105*(2), pp. 211–248.

Ludwig, A. and T. Sløk (2004, March). The relationship between stock prices, house prices and consumption in oecd countries. *The B.E. Journal of Macroeconomics 4*(1), 1–28.

Mian, A., K. Rao, and A. Sufi (2013). Household balance sheets, consumption, and the economic slump*. *The Quarterly Journal of Economics 128*(4), 1687–1726.

Mian, A. and A. Sufi (2009). The consequences of mortgage credit expansion: Evidence from the u.s. mortgage default crisis. *The Quarterly Journal of Economics 124*(4), 1449–1496.

Mian, A. R. and A. Sufi (2011, August). House prices, home equity-based borrowing, and the u.s. household leverage crisis. *American Economic Review 101*(15283), pp. 2132–2156.

Mishkin, F. S. (1996, May). The channels of monetary transmission: Lessons for monetary policy. NBER Working Papers 5464, National Bureau of Economic Research, Inc.

Romer, C. D. and D. H. Romer (2004). A new measure of monetary shocks: Derivation and implications. *The American Economic Review 94*(4), pp. 1055–1084.

Saiz, A. (2010). The geographic determinants of housing supply. *The Quarterly Journal of Economics 125*(3), 1253–1296.

Sinai, T. and N. S. Souleles (2005). Owner-occupied housing as a hedge against rent risk. *The Quarterly Journal of Economics 120*(2), 763–789.

Stock, J. H. and M. Yogo (2002, November). Testing for weak instruments in linear iv regression. NBER Technical Working Papers 0284, National Bureau of Economic Research, Inc.

Zeldes, S. P. (1989). Consumption and liquidity constraints: An empirical investigation. *Journal of Political Economy 97*(2), pp. 305–346.