Essays on Household Balance Sheets and Consumption

by

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy (Economics) in the University of Michigan 2014

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DEDICATION

To all of my greatest teachers

We are like dwarfs sitting on the shoulders of giants. We see more, and things that are more distant, than they did, not because our sight is superior or because we are taller than they, but because they raise us up, and by their great stature add to ours.

-John of Salisbury,

Metalogicon

ACKNOWLEDGMENTS

I am very grateful to my committee members, Matthew Shapiro, Mel Stephens, Amiyatosh Purnandam, and Frank Stafford for their feedback and advice throughout this long process. I am also thankful to Bob Barsky who advised me early in my research career. I appreciate the hours of discussions and constructive comments I received from them over the years. All of them have been influential in how I think about economics and conduct research.

I also wish to thank my graduate school colleagues and friends. I am especially thankful to Bartek, Breno, Christina, Desmond, Gabe, Lasse, Peter, and Ryan for both their academic and personal support throughout this process. They have been my constant source of honest feedback on research and a check for my sanity. I am very fortunate to have had the opportunity to know and work with them here at the University of Michigan. I hope these friendships will long outlast our stay here in Ann Arbor.

I also want to thank the staff at the Bureau of Labor Statistics and the Panel Study of Income Dynamics for providing access to restricted-access geographic identifiers in their respective data sets. I am especially grateful to Ryan Pfirrmann-Powell at the BLS who tirelessly answered all my questions about the data throughout the process. The empirical work in Chapter 2 would not have been possible without his help.

I gratefully acknowledge use of the services and facilities of the Population Studies Center at the University of Michigan, funded by NIA Grant (T32 AG000221) over the past two years. I also thank the Department of Economics for their financial support through teaching opportunities over the previous several semesters. Working with students has greatly shaped the way I understand economics and the way I approach teaching and presenting.

I am also immensely lucky to have a family who has been a constant foundation in my life through all its ups and downs. This dissertation is nothing without their love and support throughout my life. I thank my grandparents who went out of their way to make education a priority even when life put all the obstacles in the way. I wish I had known them better. I thank my parents for braving the challenge of coming to the US and giving me all the opportunities they may not have had. They have always encouraged me to challenge myself intellectually and keep the right attitude about my work and life. I also thank my brother Chinmay who has always kept a smile on my face, even in rough times. I thank him for being a true friend to me from the day he was born. I apologize for falling behind with all things fun-related while working on this, and I promise to catch up so we can laugh about them as we always have. I also want to thank my cousins Swati Akka, Anirudh Dada, and Vidya Akka along with my close family friends, especially Ananth Uncle, Laxmi Auntie, Chaya Auntie, and Ajay Uncle. Along with my parents, they encouraged me to take on the challenge of a PhD, and I am thankful to have been pushed to do so.

Finally, I would like to thank my fiance Cynthia Doniger for her love and support over these past years. She has been my partner in both this program and in life. Her comments and our discussions about these chapters helped shape their content, but this dissertation would never have been written at all without her loving support and appropriately timed nudges to keep fighting on. Thank you for being at my side always.

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CHAPTER 1

Monetary Policy and Housing Market Dynamics

1.1 Introduction

Monetary policy can affect the economy through a number of channels, but the importance of its effect on asset prices, especially collateral, has become an increasingly important mechanism in recent years. According to the National Association of Realtors' Profile of Home Buyers and Sellers, 87% of housing purchases in 2012 were financed by mortgage lending, making the value of their collateralized homes a primary determinant in their balance sheet quality. Furthermore, heterogeneity in recent housing market experiences between coastal and central regions emphasizes the differences in local housing market characteristics and their responses to potential shocks. This paper attempts to understand the effects of monetary policy on local housing markets and the heterogeneity of responses across different metropolitan areas.

To do this, this paper first develops a model of housing under adjustment costs that vary with the amount of available land and then provides empirical support for the dynamics characterized by this model. The theoretical model is a natural extension of the adjustment costs models of Poterba (1984) and Topel and Rosen (1988) who characterize housing-market equilibrium dynamics following a shock to user cost. This paper extends these models by modeling housing adjustment costs with a capacity constraint. As the housing stock exhausts available land resources, the marginal cost of new construction rises.

Dynamics are characterized for different levels of land availability to show that land-constrained cities are relatively more price-sensitive compared with areas where new construction buffers the price response. The model predicts an increase in house prices and residential investment following an unanticipated decrease in interest rates. Furthermore, magnitudes of these effects depend on the level of available land in the city. Specifically, land-constrained areas are exposed to substantial price movements compared with land-rich areas where residential construction keeps house prices in check.

The model also highlights the importance of long-run housing supply in determining construction and price dynamics. While new residential investment may not provide housing until the future, the expectation of a higher housing stock causes future house prices to remain low. This expectation leaves current house prices low despite the fact that the housing stock remains fixed. In land-constrained areas where new construction cannot occur, expected future house prices will be high making investment in housing attractive. Since the housing stock cannot respond, current house prices rise to match. Therefore, in the short-run, despite the fact that housing stocks may be relatively fixed in both land-rich and land-constrained areas, house prices will rise in proportion to expected steady state prices.

Given the predictions of the model, I turn to the data to understand the effects of monetary shocks on housing market dynamics. In order to do this, it is first necessary to identify a measure of monetary shocks. Several commonly used methods of identifying monetary shocks have employed structural vector autoregressions. Identification in such models can take the form of short-run or recursive exclusion restrictions (Bernanke and Blinder, 1992;

Christiano et al., 1999), long-run restrictions which rely on long-run equilibrium conditions (Gali, 1999; Blanchard and Quah, 1989; Shapiro and Watson, 1988) or sign restrictions that restrict the direction of responses in certain variables (Uhlig, 2005; Kilian and Murphy, 2012; Fry and Pagan, 2011). The use of such models when working with a panel of MSA-level housing market variables can become cumbersome since each additional variable added to the system requires several new exclusion restrictions. Instead of the VAR identification strategies, this paper uses a more parsimonious measure of monetary shocks derived from using the Federal Reserve's "Greenbook" forecasts (Romer and Romer, 2004; Coibion et al., 2012).

Prior to each FOMC meeting, the Fed produces a forecast of its economic outlook as of the meeting date published in the "Greenbook". These forecasts represent the Fed's best estimate of current and future economic conditions which it uses to set policy. By regressing policy changes on forecasts, these papers construct a series of monetary shocks purged of endogenous responses to the economic outlook. These shocks are shown to have substantial effects on industrial output and inflation (Romer and Romer, 2004)and on inequality in income and consumption across households (Coibion et al., 2012). I update this measure to include all available forecasts up to 2008 and additionally purge the series of responses to housing market forecasts.

Given the shock series, I then estimate impulse responses of housing market variables using a "single equation" approach (Romer and Romer, 2004; Coibion, 2012). The single-equation model is modified in this context to allow for a panel of MSA-level housing variables. Panels for most variables are sufficiently long to avoid short-panel bias arising in dynamic panel fixed-effects estimators (Nickell, 1981), and robustness checks using a system GMM-IV estimator as in Arellano and Bover (1995) and Blundell and Bond (1998).

Responses to monetary shocks are allowed to vary with land availability and zoning regulation measures taken from Saiz (2010). At mean values of the housing supply measures, house prices exhibit a drop of 2% over 8-12 quarters following a 100 basis point increase to the Federal Funds rate. This response varies across MSA's, with areas 1 standard deviation above mean in geographic and regulatory constraints seeing a 4-6% response and those 1 standard deviation below the mean showing no significant response at all.

Responses in residential investment, as measured by housing starts and permit applications, also display dynamics as predicted by the model. Following a contractionary shock in monetary policy, both residential investment measures show a temporary decline lasting 10-12 quarters. However, responses do not vary across measures of land availability and zoning regulations as one might expect. While this result is puzzling, it may be due to differences in the stock of existing structures or types of zoning regulations in place.

Past evidence has pointed to the importance of fluctuations in user costs primarily shifting demand, though aggregate responses in house prices and residential investment have been found to be rather small (Glaeser et al., 2010). This paper finds significant effects on housing market dynamics arising from monetary shocks for two potential reasons. First, I estimate effects using a monetary shock series constructed by purging policy changes of endogenous responses to the economic outlook. Since policy responses typically "lean against the wind", an expected rise in home values would likely be met with a contraction in monetary policy to reduce inflationary effects. The use of the Fed's target rate directly would likely bias responses towards zero. Secondly, I estimate responses across MSA's with differing housing supply elasticities as measured by local land-use regulations and geographic constraints that limit land resources that can be used for homes. While many elastic-supply housing markets display little response in house prices, several inelastic supply regions have substantial responses.

Results in this paper show that monetary policy has substantial effects on housing markets. The results of this paper are in line with mechanisms described in the literature. The relation between monetary policy and long-term interest rates is important for understanding housing dynamics. The policy rate which the Federal Reserve targets is an overnight rate, and hence its ability to affect long-term rates relies on the expectations markets have of its future policies. Such relationships are crucial to the dynamics of mortgage rates and housing markets following a monetary shock.

Other links between monetary policy and housing markets have been described in the literature. Iacoviello (2005) develops a DSGE model based on that of Bernanke et al. (1999) in which housing is purchased on crest through collateralized borrowing as it is in mortgage markets. This collateralized lending generates an amplification mechanism for monetary shocks, as a monetary loosening raises home values and shifts the collateral level of constrained households. This in turn provides households with higher borrowing capacity, allowing for a further increase in home values. This paper provides empirical evidence that monetary policy does move house prices, hence providing these owners with further collateral. These results are extended in Chapters 2 and 3 to provide empirical evidence that these house price fluctuations increase non-durable consumption through a collateral channel.

Fratantoni and Schuh (2003) studies the effects of monetary policy on regional housing markets using a Heterogeneous Agents VAR. They find that local housing markets display a remarkable amount of heterogeneity in their responses to monetary policy and discuss the efficacy of policy in the presence of the coastal housing boom. Paciorek (2013) employs a structural model to show that house price volatility rises with geographic and regulatory constraints. This paper extends the results of these papers by describing the relationship between local housing supply, national monetary shocks, and housing market dynamics.

The finding that geographically constrained and tightly regulated markets display larger price responses is supported by evidence in the literature. Recent work by Saiz (2010) and Gyourko et al. (2008) shows that land availability and regulation influence the supply elasticity of housing in MSA level housing markets. Furthermore, Glaeser et al. (2008) show that this housing supply elasticity may influence the length and size of housing bubbles in different markets.

The following section develops a model of a housing market with construction costs dependent on local land availability. This model is used to characterize responses to interest rate shocks which are tested in Section 3 using a panel of housing data from metropolitan statistical areas (MSA's) across the US. Section 4 discusses these results and concludes.

1.2 A Model of Construction Costs and Housing Market Dynamics

In this section, I develop an asset-pricing model of housing based on Poterba (1984) and Topel and Rosen (1988). The model is modified to include construction costs that depend on available land and allows for comparative dynamics across locales with tight or loose constraints on new residential construction. These comparative dynamics provide insight into how these costs may affect price and construction responses following an interest rate shock.

The basic model has three main agents: construction firms, land-lords, and tenants.[1] New

[1] While owner-occupied housing is not explicitly modeled, a owner-occupier household can be thought of

homes are constructed by the construction sector subject to convex housing stock adjustment costs. These costs depend both on the level of investment and the current stock of housing. Newly constructed homes are sold to landlords who rent them in a competitive rental market to tenants.

1.2.1 Construction Sector

I model the housing construction sector as perfectly competitive with a sequence of firms $i \in (0,1)$ maximizing their respective value functions by choosing an investment rate I_{it} to maximize the present value of flow profits:

$$\max_{I_{it}} \left\{ V_i^C = \int_0^\infty e^{-rt} \left[Q_t I_{it} - \frac{\phi}{2} \frac{I^2}{(\bar{H}-H)^2} \right] dt \right\}$$

Each firm is subject to a construction cost $c(I,H) = \frac{\phi}{2}\frac{I^2}{(\bar{H}-H)^2}$ that is convex and increasing in firm-level investment rate, I_{it}, and in the total stock of housing, H_t. The economy also faces a capacity constraint on the housing stock of $\bar{H}$ at which point costs rise asymptotically to infinity. Hence, it is easily shown that $c_I > 0$, $c_{II} > 0$, $c_H > 0$, $c_{HH} > 0$, $c_{IH} > 0$, and $c \to \infty$ as $H \to \bar{H}$. While the assumption that costs rise in I_{it} is standard, the assumption that marginal construction costs rise as H_t approaches $\bar{H}$ is especially notable. This convexity proxies for the limited land resources available in a given area to construct housing. As an area is developed, the marginal unit of available land becomes more costly to prepare for construction. Therefore, while the replacement cost of structures may remain constant, increasing values of marginal land units will drive up the marginal cost of housing

as a landlord and tenant. In the absence of agency costs between landlords and tenants, the model presented here is equivalent to one where households live in homes directly purchased from construction firms.

construction. This may happen to varying degrees depending on how developed an area is relative to the stock of available flat land $\bar{H}$.

Since each construction firm is atomistic with respect to the market, I_{it} has a negligible effect on future values of H_t. This causes the first-order conditions to be purely static. Denoting $\frac{\partial c}{\partial I_{it}} = c_I(.)$, the first-order condition yields investment policy function:

$$I_{it} = h(Q_t, H_t) = \frac{1}{\phi} Q_t (\bar{H} - H_t)^2$$

By the implicit function theorem, the partial derivatives of h are given by:

$$\begin{aligned} h_Q(Q_t, H_t) &= \frac{1}{c_{II}(I_{it}, H_t)} > 0 \\ h_H(Q_t, H_t) &= -\frac{c_{IH}(I_{it}, H_t)}{c_{II}(I_{it}, H_t)} < 0 \end{aligned}$$

This implies a higher rate of new construction as real house prices rise making investment more profitable. Furthermore, it implies a lower rate of construction as the housing stock rises, causing new construction to become more costly due to limited remaining land resources.

Aggregating individual firm investment yields a total investment level:

$$\begin{aligned} I_t &= \int_0^1 I_{it} di \qquad = \int_0^1 h(Q_t, H_t) di \\ &= h(Q_t, H_t) \\ &= \tfrac{1}{\phi} Q_t (\bar{H} - H_t)^2 \end{aligned} \tag{1.2.1}$$

1.2.2 Landlords

Landlords purchase I_t homes from the construction sector each period at a (real) price of Q_t. They then rent the housing stock, H_t, at a competitive rental rate, R_t, to tenants. Landlords maximize the present value of flow profits from rental income subject to a law of motion for their current housing stock:

$$\max_{I,H} \left\{ V^L = \int_0^\infty e^{-rt} \left[R_t H_t - Q_t I_t \right] \right\}$$

$$st: \;\; \dot{H}_t = I_t - \delta H_t \tag{1.2.2}$$

The landlord's decision problem is inherently dynamic, since investment decisions I_t affect future values of their housing stock. The maximization problem is characterized by the present-value Hamiltonian:

$$\mathscr{H}_t = R_t H_t - Q_t I_t + \lambda_t \left(I_t - \delta H_t \right)$$

First-order conditions with respect to the control variable I_t and state variable H_t yields the standard user cost formula that gives the no-arbitrage condition between renting and buying:

$$R_t - \delta Q_t \;\; = \;\; -\dot{Q}_t + r Q_t$$

$$R_t = Q_t(r + \delta) - \dot{Q}_t \tag{1.2.3}$$

1.2.3 Tenants

Tenants rent a stock of housing H_t at the competitive rental rate R_t for a period of length dt. This housing stock produces housing service flows enjoyed by the household during that period. For simplicity, I do not explicitly model the tenant's decision problem or the production of housing services from H_t. Instead, I simply posit that decreasing returns to producing housing services from housing results in a decreasing marginal benefit to housing. This gives a decreasing demand curve given by function:

$$R_t = R(H)$$

where $R_H(H) < 0$ for all H. Households are willing to make flow payments of R_t in order to rent H_t units of housing which provide flow services for one period.

1.2.4 Equilibrium Characterization

The equilibrium is given by laws of motion for Q_t and H_t given the optimizing behavior characterized above along with a transversality condition ruling out explosive paths of prices. The asset-market equilibrium condition (1.2.3), combined with the law of motion for H_t given in (1.2.2), the optimal policy for I_t given by (1.2.1), and housing demand curve yield:

$$\dot{Q}_t = Q_t(r+\delta) - R(H_t) \tag{1.2.4}$$

$$\dot{H}_t = h(Q_t, H_t) - \delta H_t \tag{1.2.5}$$

$$\lim_{T\to\infty} e^{-rT} Q_T = 0 \tag{1.2.6}$$

Equations (1.2.4) and (1.2.5) can be characterized in a phase diagram as in Figure 1.4.1. The $\dot{Q}_t = 0$ locus is given by a downward sloping line $Q_t(r+\delta) = R(H_t)$. The slope and curvature of this line depends on the elasticity of demand for housing service $R(H)$, with more elastic demand resulting in a flatter locus. Intuitively, any deviations from this locus would have to be warranted by beliefs about $\dot{Q}$. If price Q_t is above the locus, it must be that prices are expected to rise reducing user cost and making agents indifferent between renting and buying despite the high current price. This is evident from the blue lines pointing upward at all points above the $\dot{Q} = 0$ locus and pointing downwards at all points below the locus.

The main departure from the canonical model lies in the $\dot{H} = 0$ locus. The $\dot{H}_t = 0$ locus is given by $h(Q_t, H_t) = \delta H_t$ and depends on the investment policy function $h(\bullet, \bullet)$. The locus shown in Figure 1.4.1 is drawn based on construction costs rising asymptotically as the housing stock approaches the capacity constraint $\bar{H}$. The locus rises quickly at the capacity constraint as new construction can only be supported by extremely high prices in steady state. Furthermore, areas with lower values of $\bar{H}$ will tend to have higher asset prices in steady state. At points to the left of the locus, construction firms have sufficiently low costs and wish to construct homes faster than depreciation. This results in an increase in housing stock, hence all blue arrows point right at points to the left of the locus.

The steady state point (Q^*, H^*) is given by the intersection of the two loci. Off-steady-state dynamics are characterized by saddle-point stability, as is common with q-theoretic models of investment. This stable arm is characterized by the solid black arrows in Figure 1.4.1. All points off of the stable line have explosive paths which violate the transversality condition given in (1.2.6). Any deviation from steady state will result in prices adjusting to place the economy on the unique stable arm that will lead to the steady state value following (1.2.4) and (1.2.5).

The contribution of the model presented here is the inclusion of construction costs that rise as the housing stock approaches a capacity. Namely, differences in land availability and zoning laws between cities results in heterogeneity in the shape of the marginal cost of construction. In some cities, limited land and tight zoning laws results in quickly rising marginal costs of new construction as c_{IH} is rather high. As new homes are built, land becomes increasingly scarce in these areas causing c_I to rise quickly.

As discussed previously, the impact of land constraints that drive c_{IH} to be large appear in the optimal construction function $h(Q, H)$. Specifically, $\frac{\partial h}{\partial H} = -\frac{c_{IH}}{c_{II}}$ causing land constraints to raise the slope of the $\dot{H} = 0$ locus. Cities with less available land will have quickly rising $\dot{H} = 0$ loci relative to those where new homes can be cheaply constructed due to lax zoning or plentiful flat land.

1.2.5 Comparative Dynamics of a Shock to User Cost

The first panel of Figure 1.4.2 displays the equilibrium phase diagram for two cities that differ only in the available capacity for housing $\bar{H}$. This parameter controls the marginal cost of additional construction c_{IH}, with lower land availability causing higher marginal costs of construction. City A, drawn in red, has a larger land capacity and therefore a less convex marginal cost than City B drawn in blue ($\bar{H}_A > \bar{H}_B$). This results in City B having a steeper$\dot{H} = 0$ locus as construction costs rise quickly as the housing stock approaches the land capacity.At the land capacity $\bar{H}$ the marginal costs of additional construction become infinite and the $\dot{H} = 0$ locus would rise asymptotically to infinity at this point.

The difference in $\bar{H}$ does not affect the $\dot{Q} = 0$ locus which is determined solely by the asset-market equilibrium condition given in (1.2.3), so both share the same locus. Despite this, the difference in $\bar{H}$ causes the land-constrained City B to have larger price sensitivity due to a shift in $\dot{Q} = 0$ caused by a change in the user cost of housing. This is shown in the second panel of Figure 1.4.2 as a drop in the interest rate shifts the $\dot{Q} = 0$ locus outwards. This shift leaves both Cities out of equilibrium, and prices must jump to the new stable arm.

The initial price jump in City A is relatively small compared to City B. This is caused by the relative slopes of the stable arms and locations of the new steady states. Intuitively, agents in City A know that long-run prices will not be very high (relative to City B), so current prices will not jump dramatically. Prices jump above the steady state point, however, since the current housing stock is insufficient to meet the new demand in either city.

The third panel of 1.4.2 depicts the dynamics as the cities move towards steady state along their respective stable arms. City A has relatively large amounts of construction since costs are lower than they are in City B. Because of this, City A reverts to a low price relative to City B. Price and construction dynamics are consistent with the beliefs agents had initially after the shock (as depicted by the jumps in price in Panel 2).

The relative paths of house prices, housing stock, and new residential construction over time are given in Figure 1.4.3. As described, the housing stock in both cities adjusts slowly to the new steady state value. House prices jump more dramatically in the more inelastic supply city whereas new construction keeps the elastic supply city's house prices in check. These revert to new steady state values consistent with Figure 1.4.3. New residential investment given by $h^{(i)}(Q, H)$ for each city (i) is given in the third panel. As house prices rise, construction firms in both cities wish to construct more housing since $h_Q > 0$. However, responses are dampened in City 2 since firms face higher marginal costs of new construction making $h_H^{(A)} < h_H^{(B)} < 0$.

The model delivers two qualitative results which can be tested in the data. First, a shock that lowers interest rates will raise house prices and residential investment by lowering the cost of holding housing. Secondly, the effects will vary depending on local land availability and land use regulations. Specifically, areas with abundant land and loose zoning will have low marginal costs of new construction allowing the housing stock to adjust and absorb the shock. This will lead to large responses in residential construction, but dampened effects on house prices. On the other hand, areas with geographic barriers or stringent zoning regulations will have limited land availability and quickly rising marginal costs of new construction. These areas will not be able to construct new housing as easily, causing a dramatic swing in house prices.

1.3 Empirical Evidence of Monetary Shocks and Housing Market Dynamics

Understanding heterogeneity in local housing market responses to monetary shocks requires computation of impulse responses at a smaller geography. Using a full data set containing house prices, starts, and permit applications for 200+ MSA's in a vector autoregression becomes computationally cumbersome since the number of parameters increases dramatically with each additional endogenous variable. Several alternative methods have been proposed in the literature (Bernanke et al., 2005; Fratantoni and Schuh, 2003). This paper modifies the "single-equation" approach used in Romer and Romer (2004) to constructing impulse responses for a panel of MSA-level housing variables.[2] These responses are allowed to vary

[2]The correspondence between such a method and a structural vector autoregression is discussed in the appendix of Aladangady (2014). The single-equation approach at a disaggregated level corresponds to a

systematically across MSA's based on measures of local land availability and zoning regulations. This provides an intuitive and simple way to understand how local housing supply affects housing market dynamics following a monetary policy shock.

1.3.1 Data

House Price Indices Primary results are based on quarterly, MSA-level house price indices from the Federal Housing Finance Agency (FHFA, formerly known as OFHEO). The FHFA indices are constructed using quality-adjusted transaction prices acquired through Freddie Mac. The indices provide a large cross-section of 384 MSA's from 1976 to present. This includes 6 NBER recessions and several regional and national housing cycles.

One potential drawback of relying solely on the FHFA indices is that they are based on conforming mortgage data collected from Freddie Mac. This excludes all sub-prime, jumbo, and non-arms-length contracts which may respond dramatically to the monetary environment. As a robustness check, I also provide results based on monthly Zillow house price indices. Zillow constructs these indices based on a hedonic pricing algorithm using all transactions registered with the county tax office as input data. This provides provides a more comprehensive index, effectively covering the universe of transactions in the areas surveyed. Unfortunately, the time series for these data are rather short, with data only available after 1997 for major MSA's and as late as 2000 for smaller MSA's. Therefore, these data are not used for the primary results.

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large-scale VAR under the assumption that local house prices and construction do not enter the Fed's decision rule conditional on national-level house prices and construction. Given the Fed's national mandate, this is a reasonable assumption.

Housing Starts and Permit Applications Prior to construction, any structure requires a building permit. The Building Permits Survey conducted by the Census provides monthly data on single-family residential permit applications for most MSA's. In addition to these data, single-family housing starts data from the Census Bureau's Survey of Construction. These variables provide a comprehensive picture of new residential construction on single-family structures.

Housing Supply Elasticity Variables The housing supply elasticity measures from Saiz (2010) are an MSA-level data set including land availability, a zoning regulation index, and estimated housing supply elasticity. The land availability metric is constructed by counting the proportion of "buildable land" in a 50 km radius around the city-center of the largest city in the MSA. Land is considered buildable based on the absence of water bodies, dense vegetation, or steep grades. It is important to note that land containing a building is considered "buildable" by this definition and the amount of "buildable land" for a given city does not vary (in the relevant time frames) and is unaffected by the growth or decline of a city. The zoning regulation index from Gyourko et al. (2008) is measured based on the difficulty of acquiring a residential building permit in various cities.

The use of Metropolitan Areas rather than counties or cities is important. MSA's are defined based on cultural and economic interrelationships between counties and one or more city center. This means that a household living in one MSA most likely works, shops, and has friends within that MSA. This may not be true at a county or city level. Given this, a housing in different counties in an MSA may be largely substitutable causing geography and regulations in adjacent counties to affect house prices in this county. It is less likely that such spill-overs occur across MSA's since housing between MSA's is not as substitutable.

Federal Reserve Greenbook Data Prior to each Federal Open Market Committee (FOMC) meeting, the Federal Reserve produces a forecast which is published in the "Greenbook". These forecasts are made public with a five-year lag along with other FOMC meeting materials, so the data spans all FOMC meetings from 1969-2008. Variables in the Greenbook include actual published amounts where available and Fed forecasts and nowcasts for any unpublished data. Forecasts are made using non-public models and all data available to the Fed at the time the Greenbook is published, two weeks prior to the meeting. The forecasts represent the best estimates the Fed has of these variables when it enters the FOMC meeting.

These forecasts can be used to "purge" endogenous responses in policy (ie, changes in the target Federal Funds rate) to changes in the Fed's current and expected economic outlook. Following Romer and Romer (2004) and Coibion et al. (2012), I use lagged and forecasted values output growth, inflation, and current unemployment.[3] In addition, I supplement this dataset with lagged and current Greenbook values of housing starts. The inclusion of housing data in this application is important to avoid endogenous policy responses to current or forecasted housing market conditions from being included in the shock series.

1.3.2 Constructing a Modified Romer & Romer Monetary Shock Measure

To understand the effects of monetary policy on real outcomes, it is necessary to pay careful attention to endogenous movements in policy that reflect expectations of the economic outlook. For example, if the Fed anticipates a recession, they may choose to lower their

[3] I thank Lorenz Kueng for providing updated Greenbook data for these variables through 2005. The shock series in this paper differs slightly from Romer and Romer (2004) and Coibion et al. (2012) who use Blue Chip Economic Indicators forecasts for 2003+. Since Greenbook data is now available through 2008, I use these numbers rather than substituting Blue Chip forecasts.

Fed Funds target in an effort to stimulate the economy. If this action is insufficient, the outcome may be a small recession. An econometrician that does not pay attention to the endogenous actions of the Fed may conclude incorrectly that looser monetary policy leads to small recessions. The correct conclusion can only be reached by "purging" changes in the target rate of endogenous responses to changes in the economic outlook.

To do this, I follow the work of Romer and Romer (2004)who use the Fed's Greenbook forecasts as a proxy for the Fed's outlook on the economy. Changes in the Fed's announced Federal Funds Target are regressed on these forecasts to remove any endogenous responses to current or expected economic conditions. Like Romer and Romer (2004) and the papers that follow them (Coibion, 2012; Coibion et al., 2012), I include current unemployment along with inflation and output growth from the previous quarter up to 2 quarters in the future. The Fed Funds rate prior to the meeting is also included to allow for interest rate smoothing or mean reversion behavior. I supplement this specification with housing starts forecasts from the Greenbook to further purge any endogenous responses to housing market conditions that may be of special concern in my application.

To construct the shocks, I allow the unit of observation to be meeting-level forecasts and policy changes. The policy variable used is the target Federal Funds rate ff_t at meeting number t. The change in the target rate is regressed on actual Fed Funds rate immediately prior to the meeting, ffb_t, and a set of macroeconomic forecasts, $\tilde{x}_{t,h}$. Let $\tilde{x}_{t,h}$ be a vector of time t forecast of time $t+h$ values for GDP growth, inflation (GDP deflator growth), and housing starts. Furthermore, denote $\Delta\tilde{x}_{t,h}$ be the change in the forecast for $t+h$ from last meeting and $ue_{t,0}$ be the "nowcast" for unemployment. Monetary shocks are given by the residual η_t in the following regression:

$$\begin{aligned} \Delta ff_t &= \alpha + \beta ffb_t + \sum_{h=-1}^{2} \gamma_i \tilde{x}_{t,h} + \sum_{h=-1}^{2} \delta_i \Delta\tilde{x}_{t,h} \\ &\quad + \lambda \tilde{ue}_{t,0} + \eta_t \end{aligned}$$

To convert the meeting-level data into a quarterly time series, I simply aggregate all shocks in a quarter to arrive at the quarterly shock.[4] Figure 1.4.4 provides a time plot of the shock series.

1.3.3 Estimating Housing Market Responses

Given the exogenous measure of monetary shocks, I now turn to estimating the responses of various housing market variables to these shocks. I employ a modified version of the "single-equation" method of estimating impulse responses (Romer and Romer, 2004; Coibion, 2012; Coibion et al., 2012). This method simply models the dependent variable as an autoregressive process which depends on lagged values of the monetary shock. I modify this to a panel-setting in an effort to understand the effects of local geography and zoning regulations on housing market dynamics.

The dependent variables considered include house prices, housing permit applications, and housing starts for MSA i at time t. Using y_{it} to denote the dependent variable, the estimated model is given by:

$$y_{it} = \rho(L) y_{i,t-1} + (\beta(L) + \gamma(L) z_i)\, \eta_t + \delta D_t + f_i + \varepsilon_{i,t} \tag{1.3.1}$$

[4]The same procedure is done for monthly data to be used with Zillow house prices and construction data. In the event that no meeting was held during the month, the shock is assigned as zero.

The dependent variable is modeled as a function of its own lags as well as lagged monetary shocks. Monetary shocks η_t can affect $y_{i,t}$ heterogeneously across MSA's depending on local factors z_i which include zoning regulations and land availability. This allows me to test the hypothesis that areas with strict zoning restrictions and less available land will have larger price responses and smaller construction responses relative to those with loose regulations and plentiful land.

The specification also includes quarterly dummies and a quadratic time trend in D_t to remove any seasonality and trend inherent in y_{it}. The error structure allows for an MSA fixed effect and an idiosyncratic term. The inclusion of fixed effects in a dynamic panel setting gives rise to an important econometric issue. Consistent ($N \to \infty$) estimation of $\rho(L)$ using a fixed-effects estimator can be compromised if the time dimension is short (Nickell, 1981). The time series used in this paper cover quarterly data from 1976-2008 on a wide panel of over 200 MSA's. Appendix 1.4 provides robustness checks using a dynamic panel estimator that is robust to small sample biases and shows bias in estimates of $\rho(L)$ are small given the sample size. In the interest of efficiency, all estimates in the main body of the paper use a standard fixed-effects estimator to estimate (1.3.1).

Identification follows from the fact that $\eta_{t-\ell}$ is purged of endogenous responses to forecasted economic conditions, and is therefore orthogonal to any unmodeled variation in ε_{it}. Furthermore, since ε_{it} will be contained in future information sets of the Fed, future values of $\eta_{t+\ell}$ will also be orthogonal to ε_{it}, making the monetary shocks predetermined in the regression.

The model is estimated for house prices, housing permit applications, and housing starts using 8 quarters (2 years) of lags on the dependent variable and 16 quarters (4 years) of lags on monetary shocks. Joint significance tests on coefficients $\gamma(L)$ are significant for each outcome variable. Furthermore, impulse responses are computed by inverting the model given in (1.3.1) to identify the total effect of $\eta_{t-\ell}$ on y_t both directly and through lagged values of y_t.[5]

Figure 1.4.5 provides a graph of impulse responses of house prices in two hypothetical cities with differing land availability and zoning regulations to illustrate the importance of $\gamma(L)$ in driving the heterogeneity of responses across cities. The elastic city, with 80% available land and a zoning index of -1, has negligible price response as compared to the inelastic city, with 20% available land and a zoning index of +1, which shows a dramatic fall in house prices over several quarters following a 100 basis point shock to Federal Funds. Differences are less pronounced when looking at housing starts and permit applications across the two cities, but both show a contraction in residential investment following a contractionary monetary shock.

The average effects across cities display clear evidence of a shock to user cost consistent with the model presented above. Tighter monetary policy causes an increase in long-term rates resulting in a decline in demand for homes. This lowers residential investment and real house prices in the short-run, but returns to the initial steady state as the effects of the shock die out. Heterogeneity across cities is also pronounced in house prices. Inelastic-supply cities with lower available land and tighter regulations face a sharper price response since construction cannot absorb the impact of the shock. This means coastal or mountainous cities, or those with tighter regulations will face higher house price volatility, consistent with results in Paciorek (2013) and Fratantoni and Schuh (2003).

The slight uptick in house prices immediately after the shock is somewhat puzzling. This

[5]Standard errors are computed by Monte Carlo methods. Specifically, the model given in 1.3.1 is estimated with standard errors clustered by MSA. The coefficients $\hat{\rho}(L)$, $\hat{\beta}(L)$, $\hat{\gamma}(L)$, and $\hat{\delta}$ are drawn from the joint normal distribution implied by the point estimates and standard errors from the estimated model. For each of 1000 draws, an impulse response is computed at horizons $h \in \{1, 2, ...\}$. The standard deviation of each h-horizon impulse responses over 1000 draws is used as the standard error.

could be the result of endogenous responses in Fed policy to very short-run inflation (Sims, 1992; Eichenbaum, 1992). An alternative story could be that sellers of homes search harder for a higher bid or are loss averse as prices fall leaving them down-payment constrained when purchasing their next home (Genesove and Mayer, 2001; Stein, 1995). This initial uptick is short-lived, however, and the dominant effect of the contractionary shock is to depress home values below steady state for several quarters.

The results do not, however, point to substantial heterogeneity in permit applications or housing starts based on local geography or regulations. This is likely due to the fact that several cities are more developed than other cities despite having similar geography. For example, the Miami metropolitan area saw substantial price increases during the housing boom due to limited land. Unlike other land-constrained, coastal cities, however, it also had substantial residential development during the early 2000's making it look similar to a more elastic-supply city in this respect. The land availability measure used simply aggregates all available land resources, both currently developed and undeveloped. Furthermore, cities in secular decline may have large numbers of vacant homes dampening the effect of a demand shock on construction activity. For example, rising demand would likely result in the purchase and renovation of vacant homes in Detroit rather than an uptick in housing starts or new construction applications. To address these issues, a superior land availability measure incorporating existing used and vacant structures would be necessary.

1.3.4 Asymmetric Effects of Expansionary vs Contractionary Shocks

Unlike the standard structural VAR framework, the single-equation set-up is flexible enough to allow for many forms of non-linearity. As discussed above, the data displays large cross-sectional heterogeneity between areas with varying geographic and regulatory constraints on construction. In this section, I turn the focus to asymmetry between expansionary and contractionary shocks.

Impulse responses in Figures 1.4.8, 1.4.9, and 1.4.10 were produced using a specification which allows positive shocks to have a differential effect relative to negative shocks at each horizon. For each outcome variable, joint tests that coefficients on positive and negative shocks are the same are rejected confirming that responses are asymmetric for house prices and both measures of residential investment. Such responses are consistent with a strong curvature or a local kink in the marginal cost of new construction $c_I(I, H)$. For example, existing homes or planned investments may cause negative shocks to housing demand to face a fairly elastic housing supply curve relative to expansionary shocks which cause costly adjustments to higher investment levels.

This means a monetary loosening tends to have a large stimulatory effect on residential investment and house prices, whereas a tightening has little effect. Furthermore, lagged responses in investment evident in Figures 1.4.9, and 1.4.10 suggests that residential investment is planned several quarters in advance. Expansionary shocks cause a delayed response in construction only after several quarters as acquiring new permits and planning new investments is fairly costly. On the other hand, contractionary shocks have little impact on residential investment suggesting costs to starting construction are already sunk for planned investments resulting in only a moderate decrease in new permit applications and starts.

To assess the robustness of this result, I re-estimate the model excluding large shocks in the early 1980's associated with reserve targeting. Estimated IRF's still show marked asymmetry with large effects for expansionary shocks and smaller effects from contractionary shocks.

This asymmetry in responses is striking. While the model presented in this paper does not predict an asymmetry in responses to positive and negative shocks, the result is consistent with models discussed in the literature. One likely explanation is that investments are planned in advance and cannot respond easily to a negative shock (Millar, et al, 2012). In such a case, a monetary contraction would lead to little decline in residential construction since short-run investment is predetermined and long-run investment is only moderately affected by the transitory monetary shock. The flood of houses on the market may depress house prices temporarily, since these excess inventories will decline as investment adjusts over subsequent quarters. This would lead to a dampened effect due to an expectation that prices would rise again as investment fell. On the other hand, an expansionary shock would allow for additional investment causing larger effects.

1.4 Conclusion

This paper seeks to characterize the relationship between monetary policy and housing market dynamics. First, the paper develops a user cost model of housing with housing adjustment costs that increase as available land is exhausted. Shocks to interest rates reduce the user cost and raise house prices and residential investment in the short run. These then return to new steady state values over time. These effects are also shown to vary systematically with the marginal cost of new housing production. In areas where these costs are relatively high due to limited land resources, house prices tend to rise more dramatically compared to areas where cheap new construction keeps house prices in check.

The paper then provides evidence of how these predictions relate to monetary policy shocks using an MSA-level panel of housing market data linked to measures of local land availability and zoning regulations (Saiz, 2010). I construct a measure of monetary shocks by purging policy innovations of endogenous responses to economic conditions reflected in the Federal Reserve's Greenbook forecasts as in Romer and Romer (2004). This series is updated to include data up to the zero-lower bound period in December 2008 and is also purged of responses to housing market forecasts. A positive innovation in the Federal Funds rate of 100 basis points cause both house prices and housing starts to fall over the subsequent several quarters before returning to baseline levels.

The heterogeneity in price responses is also consistent with model predictions. Cities with tighter regulations and more land lost to geographic barriers see larger increases in home values due to higher marginal costs of new construction. Heterogeneity in housing starts and permit applications across cities is less pronounced, however. This is likely due to the nature of the geographic and regulatory measures used. While the model has increasing marginal costs due to limited available land, in reality cities with similar geographies may differ in the amount of land availability in the medium-run. For example, despite geographic similarities, older cities like New York may be substantially more constrained than less developed cities like Miami where there may be vacant areas fit for development. Further analysis is required to fully address this puzzle.

An unanticipated change in monetary policy can affect housing markets through a variety of channels. Monetary policy is likely to affect household credit and mortgage markets which determine housing investment decisions. The ability of the Fed to affect mortgage rates drives the primary link between monetary policy and housing market dynamics, but the relationship between Fed policy and mortgage markets is complicated by a variety of factors.

First, the Fed's target rate is an overnight rate compared with 15- or 30-year fixed rate mortgage contracts. Even considering early refinancing, mortgage rates tend to track a 10-

year bond on the yield curve. To affect mortgage markets, the Fed's policy must decrease long-term interest rates to have substantial effect on mortgage lending. This may be accomplished through affecting market expectations of future short-term rates. The fact that housing markets move in response to policy changes reflects that the Fed may have some influence over expectations. These results are consistent with work by Rudebusch (1995) and others on the link between Fed policy and the yield curve.

In addition, the Fed's policy can affect credit spreads between risk-free such as the Federal Funds Rate and returns on riskier forms of lending such as mortgages. The ability of the Fed to improve current and expected output and employment drives credit spreads down, thereby reducing mortgage rates. This impact on the real economy may have direct wealth effects on housing demand in addition to providing lower credit spreads. These effects are likely compounded by the fact that mortgages are collateralized by houses which may rise in value after a monetary shock. Lower interest rates may stimulate house price growth, which in turn lowers risk premia associated with mortgages. This means that there is a feedback from rising house prices back to mortgage rates (Iacoviello, 2005). Such effects may also lead to cheaper credit and increased borrowing or consumption for homeowners whose homes appreciate in value (Mian and Sufi, 2011).

The results in this paper indicate that monetary policy has the ability to influence home values, hence providing an important policy lever for household borrowing and spending behavior. Given the important role of housing as a source of collateral to the household sector, house prices play an important role in determining balance sheet quality, especially in land-constrained areas. Furthermore, regions with abundant land enjoy increased levels residential construction allowing renters to more easily purchase homes. While the magnitudes of house price elasticities to a monetary shock may be dwarfed by the size of the housing bubble produced by financial innovation and other factors, the ability to affect the housing market may be crucial to influencing both local economic growth as well as inequality between renters, credit constrained home-owners, and wealthier home-owners.

APPENDIX 1.A: Dynamic Panel Estimator for Impulse Responses

The Fixed Effects estimator used in the body of the paper is subject to potential biases in the persistence parameters $\rho(L)$ due to "Nickell Bias" if the time dimension is insufficiently long (Nickell, 1981). The size of this bias depends on the magnitude of true persistence parameters, serial correlations in errors, and the length of the time dimension in the sample. To better understand the extent of the bias in my application, this appendix provides a comparison of estimates using the standard Fixed Effects estimator and an alternative robust estimator. I find the bias in the estimates of persistence parameters is small in the given application.

The bias in the standard fixed effects estimator can be seen by considering the endogeneity of lagged $y_{i,t-1}$ terms in the de-meaned model estimated using fixed effects:

$$\tilde{y}_{it} = \rho(L)\tilde{y}_{i,t-1} + \beta(L)\tilde{\eta}_t + \tilde{\varepsilon}_{i,t}$$

In this equation, the variable $\tilde{y}_{i,t-\ell} = y_{i,t-\ell} - \frac{1}{T}\sum_s y_{i,s}$ is negatively correlated with the error term $\tilde{\varepsilon}_{it} = \varepsilon_{i,t} - \frac{1}{T}\sum_s \varepsilon_{i,s}$ causing a downward bias in the estimate of $\hat{\rho}_1$. As the time dimension becomes long, however, the contribution of $\varepsilon_{i,t-\ell}$ to the mean $\frac{1}{T}\sum_s \varepsilon_{i,s}$ becomes negligible, and the estimator is unbiased asymptotically as $T \to \infty$. Nonetheless, estimates of $\rho(L)$ using a fixed-effects estimator are inconsistent and biased as $N \to \infty$ if the time dimension is short (Nickell, 1981).

The time series used in this paper covers 1976-2008 in quarterly data, representing a total of 132 quarters or nearly 400 months. Given the length of the time series, it is unlikely that such an issue will give rise to substantial bias. To consider the size of this bias, I estimate the model using house prices with a robust dynamic panel estimator proposed in the dynamic panels literature (Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1998).

This estimator estimates the first-differenced and levels equations using an IV-GMM approach. The first-differenced equation is given by:

$$\Delta y_{it} \quad = \quad \rho(L)\Delta y_{it-1} + \beta(L)\Delta\eta_{it} + \Delta\varepsilon_{it}$$

While the fixed effect is removed by first-differencing, the term Δy_{it-1} is correlated with the first-differenced error term $\Delta\varepsilon_{it}$. The solution proposed by Arellano and Bond (1991) is to use all available lagged values of $y_{it-\ell}$ as instruments for this term. These values do not appear in the first-differenced error $\Delta\varepsilon_{it}$ and are hence valid instruments. Since lagged levels may become weak instruments if persistence is very high, lagged first-differences are also used as instruments for levels of y_{it-1} in the standard levels equation given in 1.3.1 as proposed by Arellano and Bover (1995); Blundell and Bond (1998). These instruments are used to construct a standard GMM instrumental variables estimator.

A comparison of estimates using a standard Fixed Effects model as well as a more robust dynamic panel system estimator (Arellano and Bover, 1995; Blundell and Bond, 1998) provides similar results in Figure 1.4.11. As expected, the robust estimator suggests a slightly higher persistence due to the downward Nickell Bias induced by negative correlations between $\tilde{y}_{it-\ell}$ and $\tilde{\varepsilon}_{it}$ in the Fixed Effects estimator. Nonetheless, the magnitude of this bias is not substantial.

As is often the case, the tradeoff for robustness is efficiency. This is evidenced by substantially larger standard error bands in the dynamic panel estimator. In this application, the benefit of reduced bias is small given a relatively long time series. The cost of efficiency outweighs the benefit of the robust estimator, and hence this paper opts for the use of a standard Fixed Effects specification in estimating impulse responses.

Figures and Tables

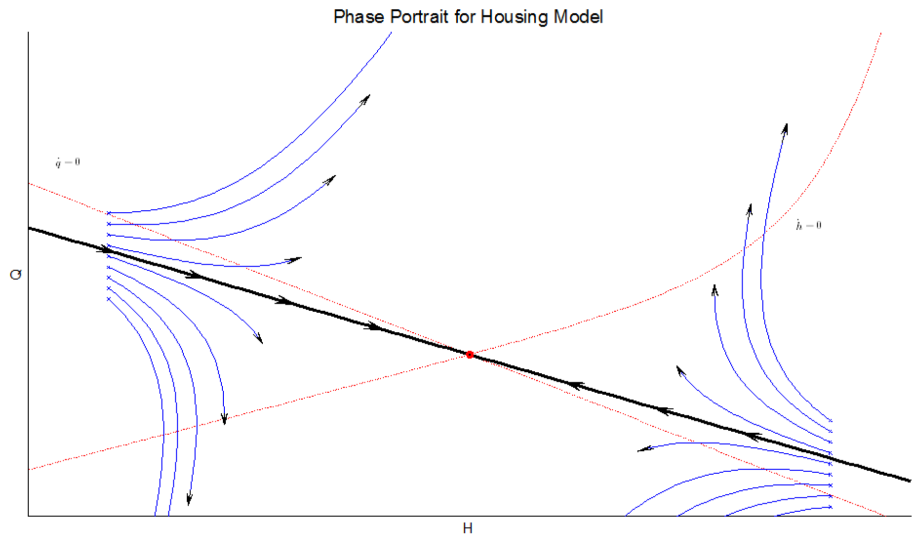

Figure 1.4.1: Phase Diagram of Housing Model with Adjustment Costs

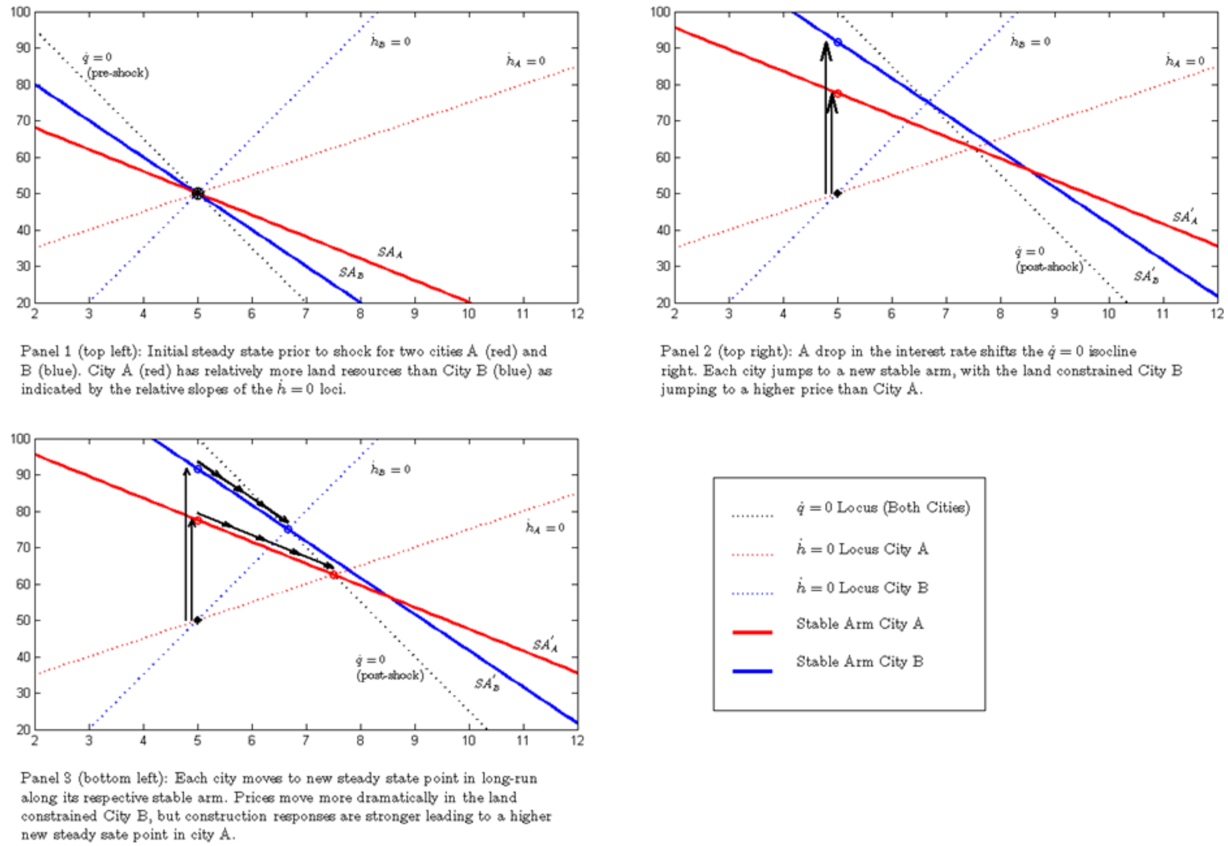

Figure 1.4.2: Phase Diagrams with Differing Land Availability and Shock to r

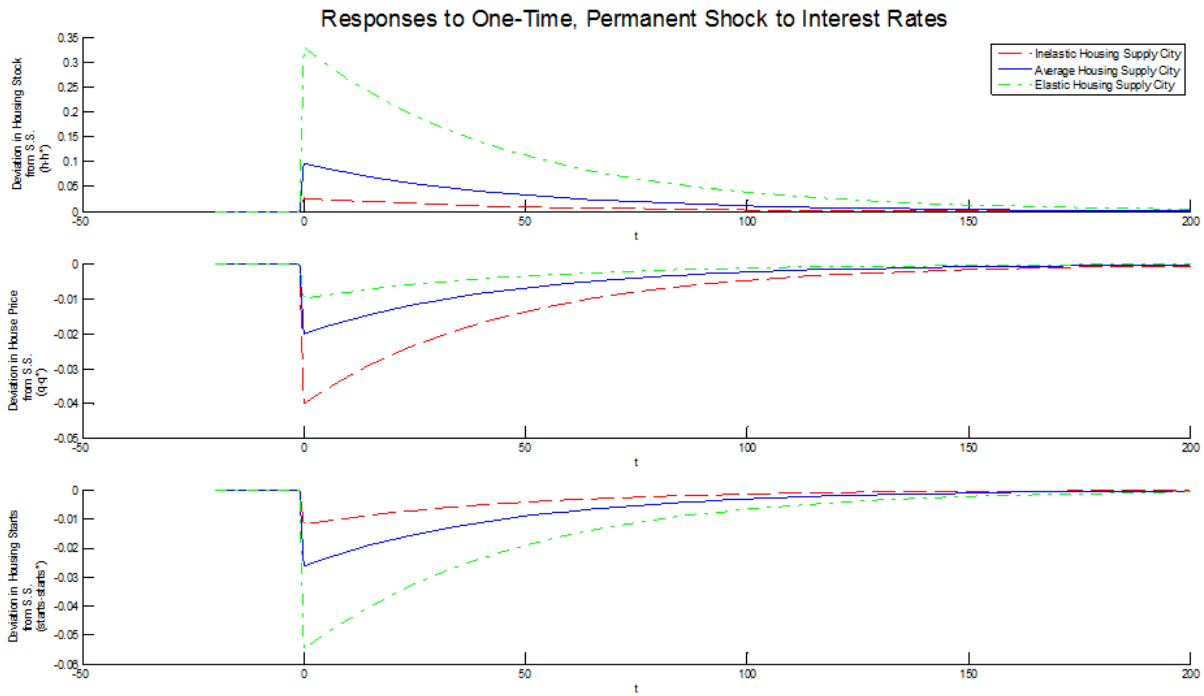

Figure 1.4.3: Responses to Shock to r across Land Availability

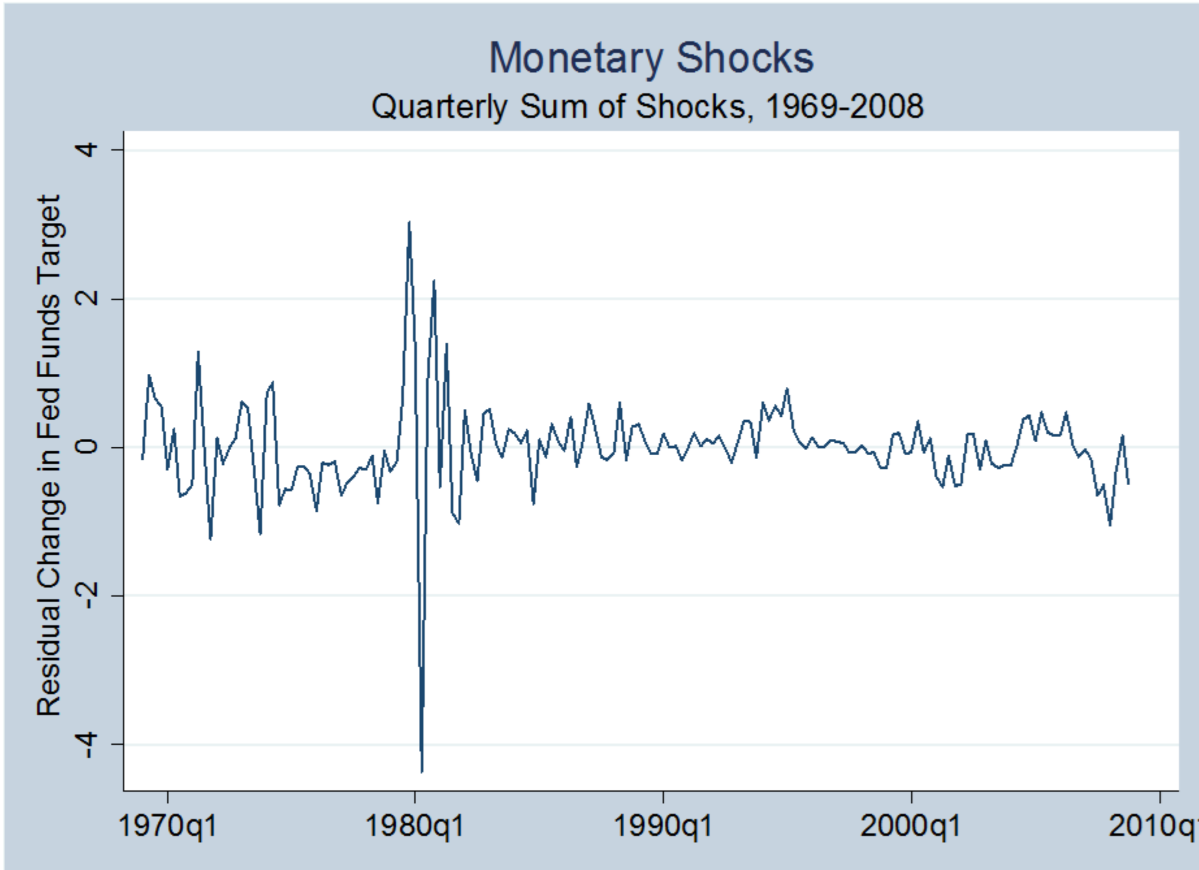

Figure 1.4.4: Monetary Policy Shock Measure

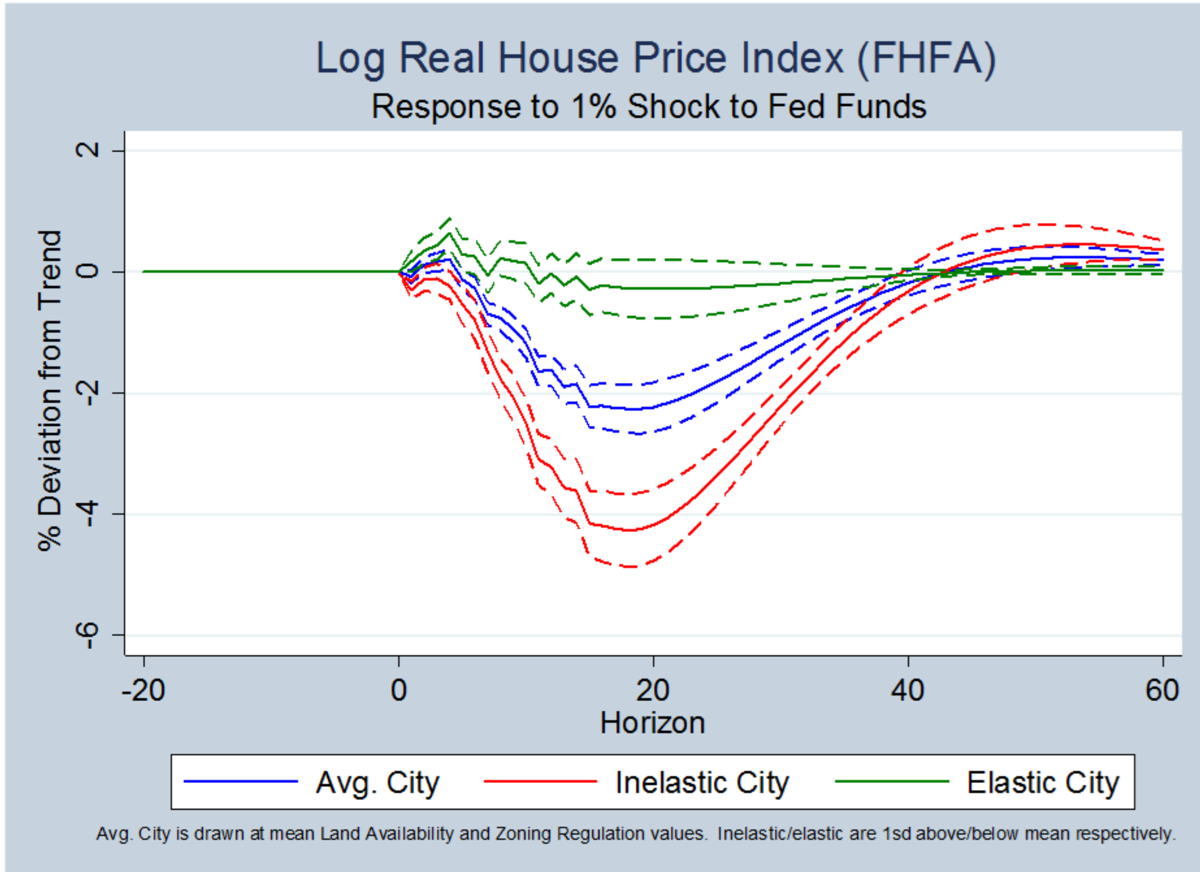

Figure 1.4.5: Impulse Response of House Prices

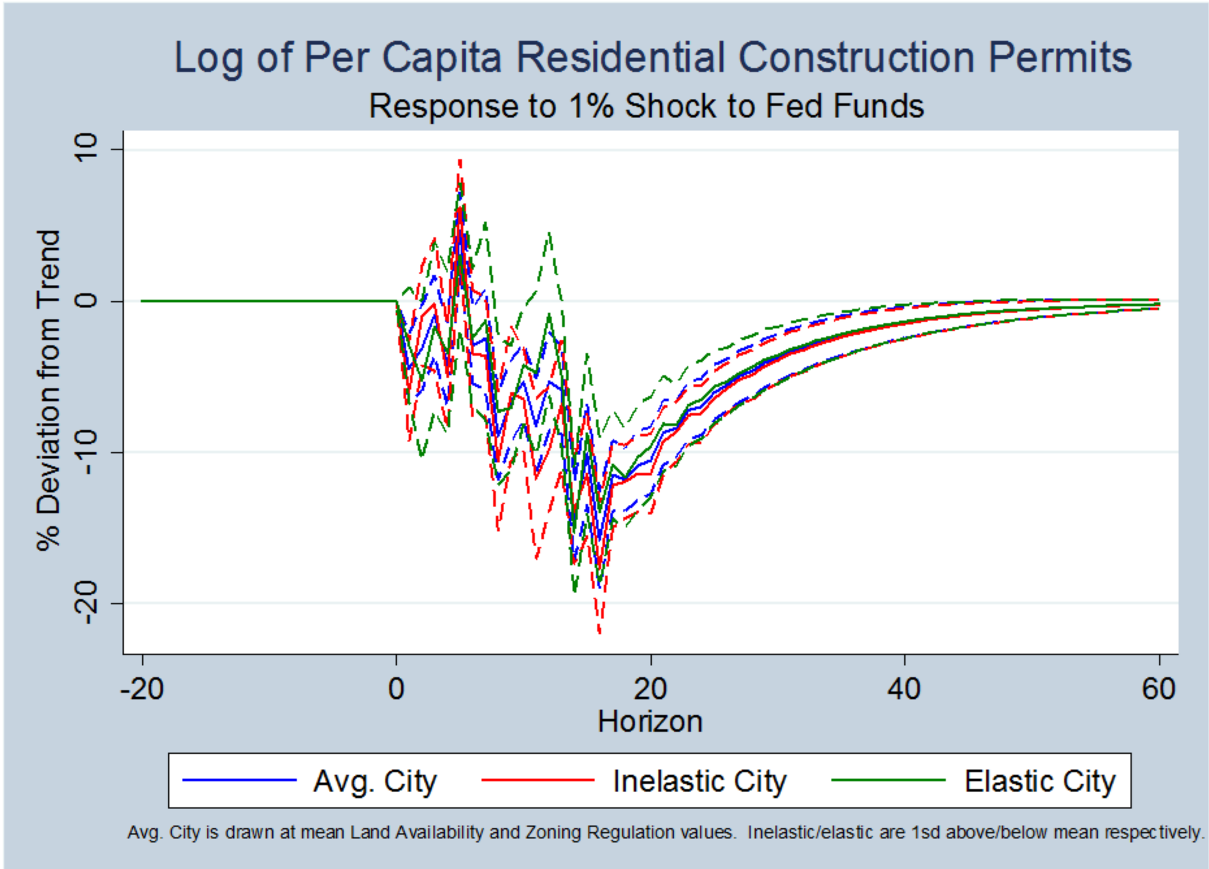

Figure 1.4.6: Impulse Response of Construction Permit Applications

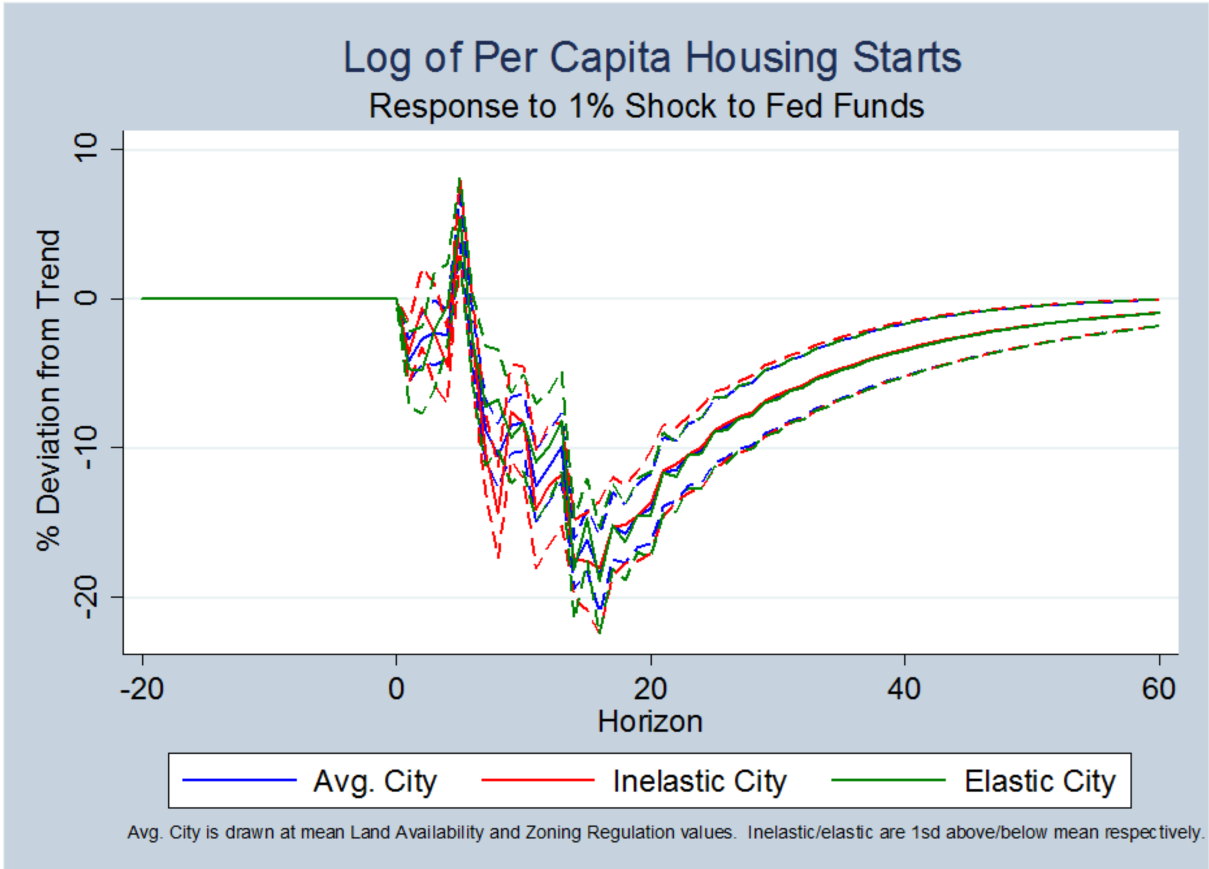

Figure 1.4.7: Impulse Response of Housing Starts

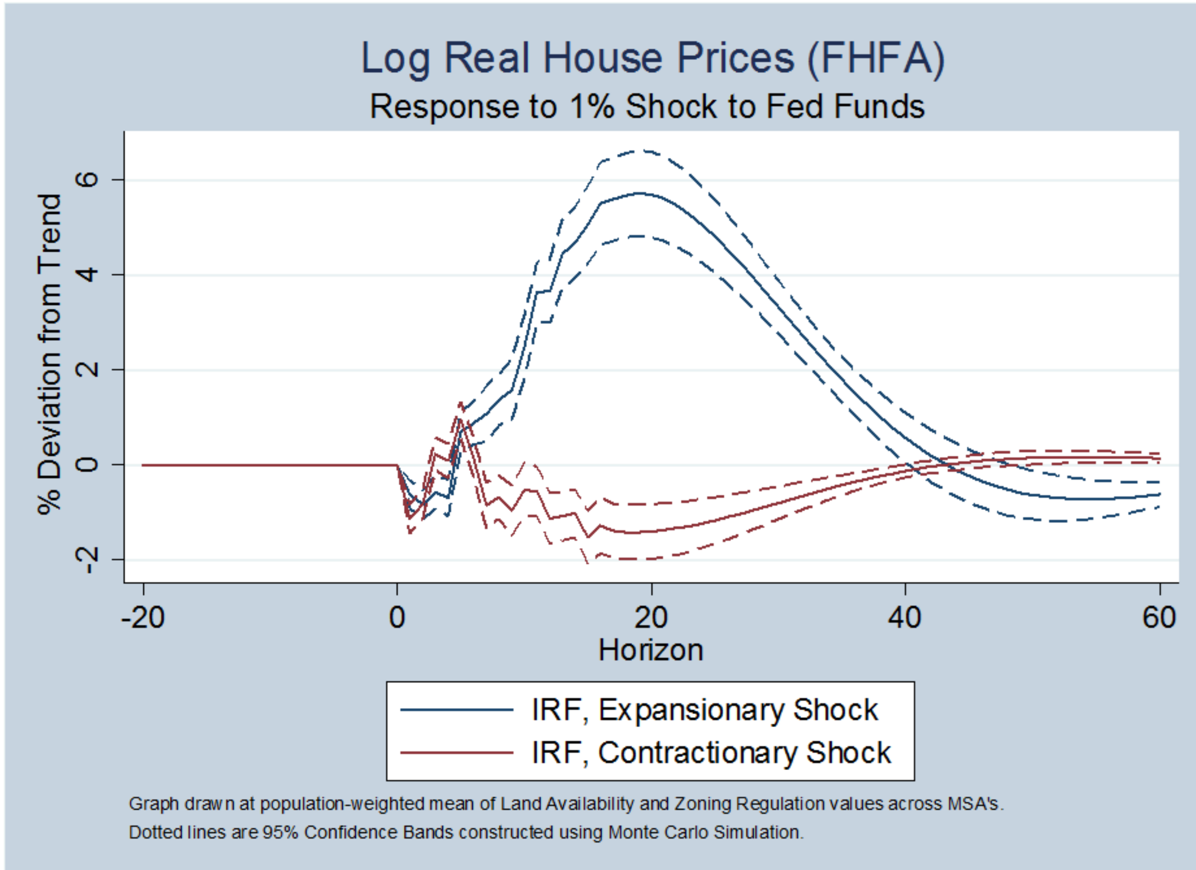

Figure 1.4.8: Asymmetric Impulse Response of Housing Prices

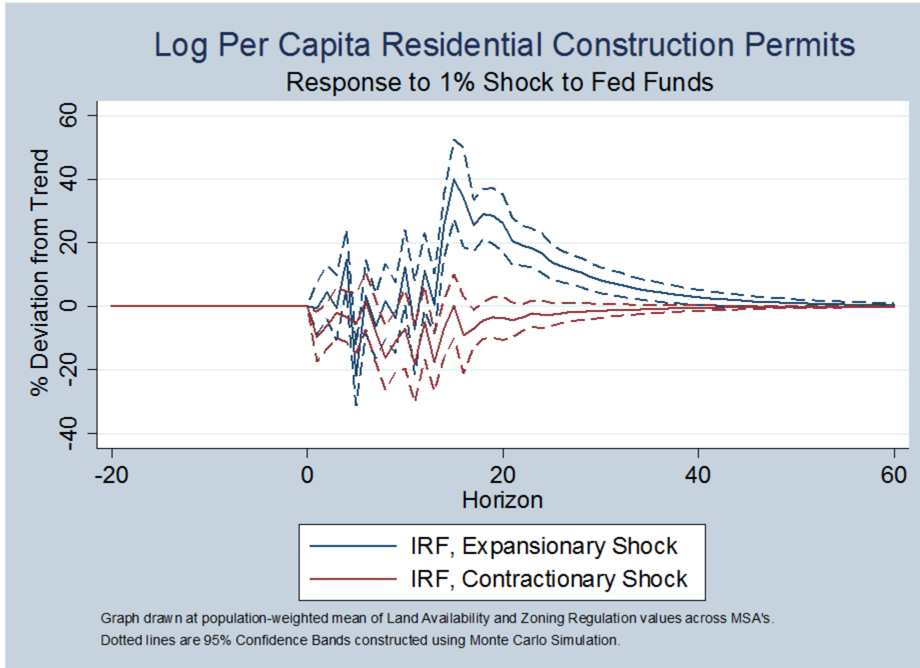

Figure 1.4.9: Asymmetric Impulse Response of Construction Permit Applications

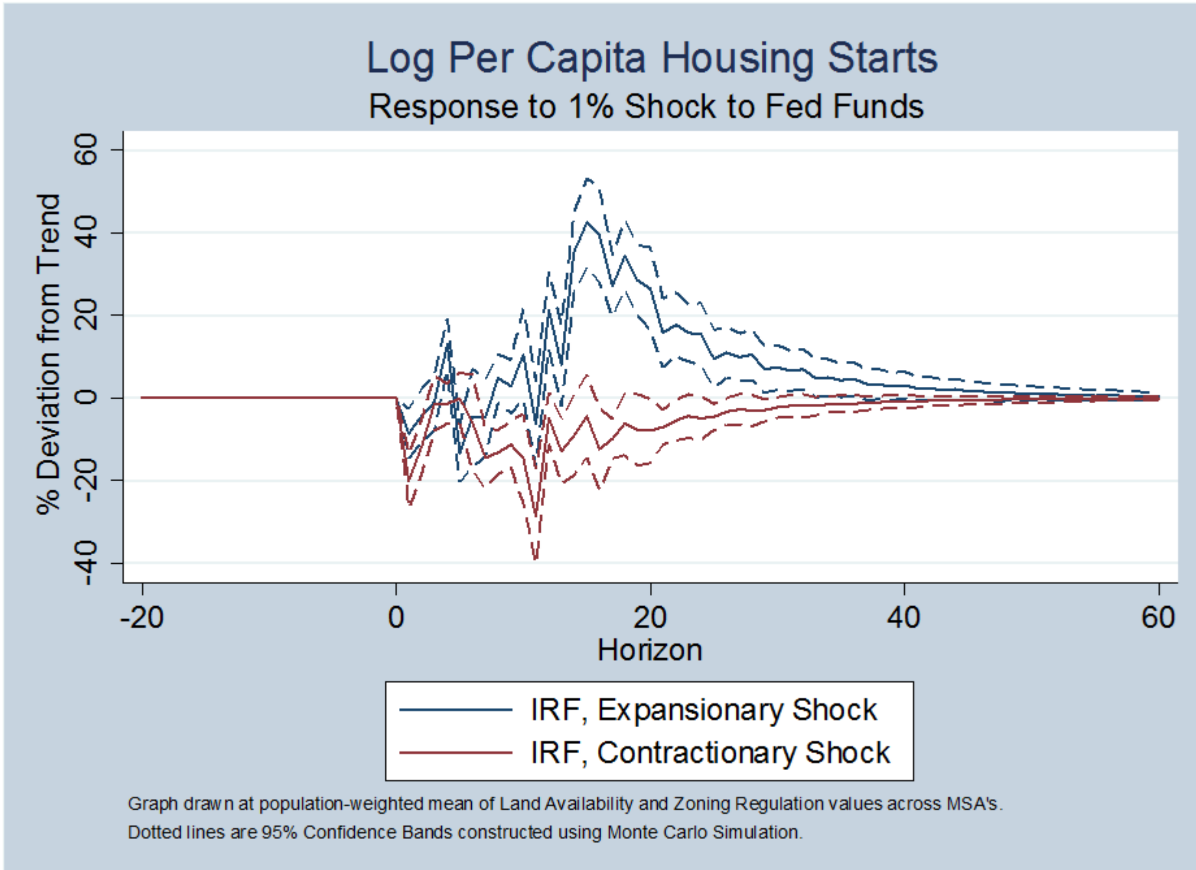

Figure 1.4.10: Asymmetric Impulse Response of Housing Starts

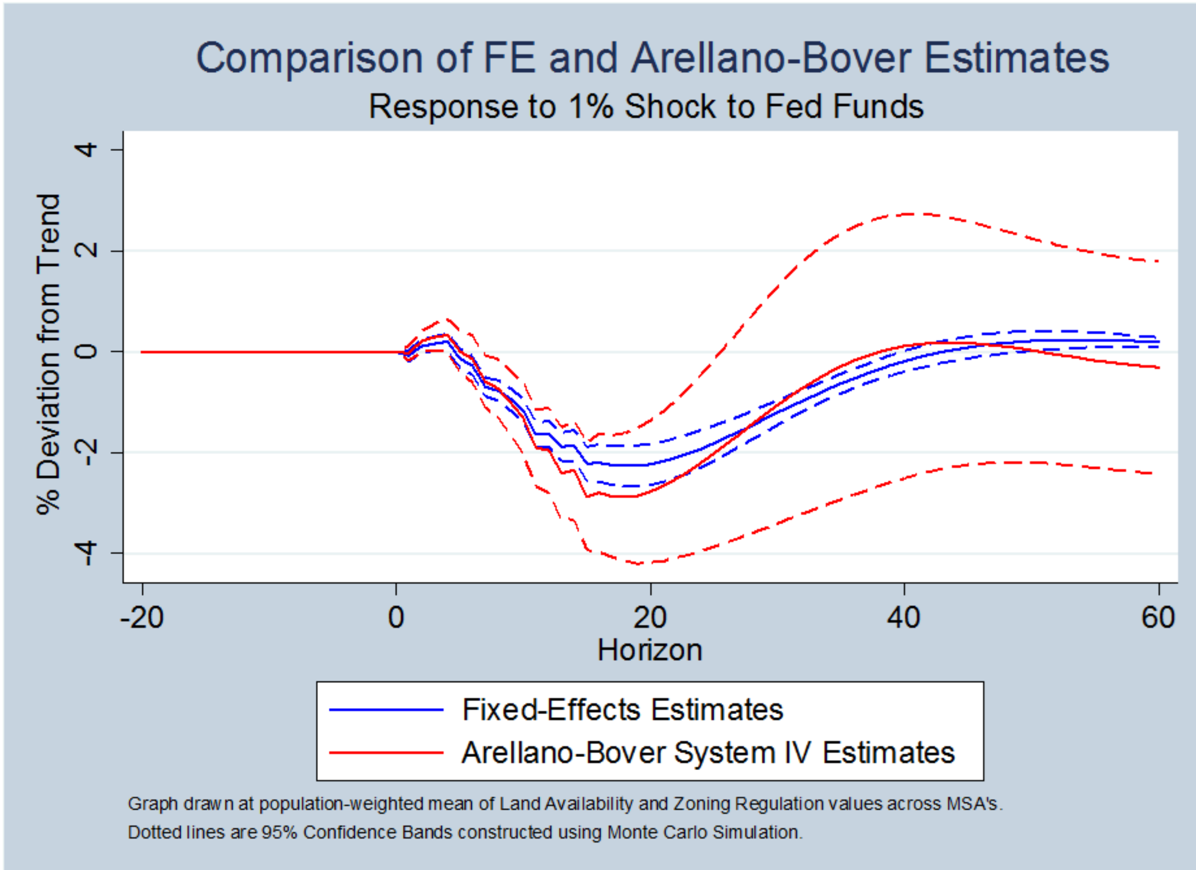

Figure 1.4.11: Comparison of Fixed Effects and Arellano-Bover/Blundell-Bond Estimators

CHAPTER 2

Household Balance Sheets and Monetary Policy[6]

2.1 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 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

[6]Research for this chapter was conducted with restricted access to Bureau of Labor Statistics (BLS) data. The views expressed here do not necessarily reflect the view of the BLS.

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. While monetary policy may affect consumption and investment by increasing income expectations or lowering risk-free interest rates, the balance sheet channel amplifies small monetary shocks through large spending and investment responses from collateral constrained agents (Bernanke et al., 1999; Kiyotaki and Moore, 1997; Iacoviello, 2005). Though this mechanism has been described in the literature, there has been limited direct empirical evidence of its magnitude or importance for monetary policy transmission. The purpose of this paper is to empirically identify the balance sheet channel in a specific context: housing assets and homeowner balance sheets.

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

Housing markets are a natural laboratory for studying the impact of household balance sheet quality on consumption. Though housing is not the only collateralizable asset held by households, it is the most commonly used source of collateral. Furthermore, housing wealth forms a substantial portion of the household balance sheet, and even relatively small fluctuations in house prices can result in substantial changes in borrowing capacity. New homeowners, who are most likely to be younger and more credit-constrained, are most affected by housing market shocks due to their high level of leverage compared to older homeowners (Flavin and Yamashita, 2002). This makes housing an important source of collateral for smoothing consumption over the life-cycle, and one which can have large effects on the borrowing capacity and consumption of young, credit constrained households.

Additionally, differences in local geography and land-use regulations provide natural variation in the impact of a national-level shock on house prices in different cities. These variables have been shown to affect housing supply elasticity, and hence drive heterogeneity in housing market dynamics in various cities (Saiz, 2010). 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 2.7.1. During the expansion period between 1996 and 2006, inland cities with few constraints on new construction, such as Dallas and Atlanta, saw little house price change and large levels of new construction. The collapse of the housing bubble halted new construction in these cities, but caused little collapse in house prices. Cities such as San Francisco, Miami, or New York, with limited land and stricter zoning laws saw limited new construction, but large fluctuations in prices during the same period.

This variation provides a natural 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. Regions 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 see little to no change in balance sheet quality due to the shock and are only affected through other channels. On the other hand, housing stocks cannot adjust easily in land-constrained and regulation-constrained regions, resulting in dramatic swings in house prices and hence home owner balance sheet quality. By comparing responses to monetary shocks across these types of cities, I identify the effect of monetary policy arising through household balance sheet fluctuations driven by house prices.

This paper quantifies the homeowner balance sheet channel in two steps. First, I identify the effect of monetary policy on real house prices and document the heterogeneity of house price responses in a structural vector autoregression (SVAR). The response varies substantially across metropolitan statistical areas (MSA's) with differing housing supply elasticity as measured by land availability and local zoning regulation variables from Saiz (2010). Second, I exploit this heterogeneity in housing markets to identify the propensity to consume out of housing wealth. Variation in cross-sectional house price responses caused by differing housing supply elasticity allows for the separate identification of the homeowner balance sheet channel and non-housing channels.

Evidence from a monetary SVAR shows that real house prices have a hump-shaped response to monetary shocks, peaking after approximately 10-12 quarters. Furthermore, house price responses are shown to differ substantially across housing markets. Land constrained and tightly regulated MSA's display a pronounced 4% response in house prices after a one standard deviation shock to Federal Funds rates. By contrast, highly elastic supply regions show little response in house prices as construction keeps price appreciation in check.

Using restricted-access geographic data from the Consumer Expenditure Survey, I link households to local housing supply elasticity measures (land availability and zoning regulations).

Since local housing supply elasticity is unlikely to have direct effects on consumption, these variables are used to construct instruments for house price growth. This provides a means to compare the responses of consumption and housing between elastic and inelastic supply areas. Following a monetary loosening, consumption responses in a highly elastic-supply city will only reflect non-housing channels since house prices will be held in check by new construction. By comparison, a highly inelastic-supply market experiences large house price appreciation and a more pronounced consumption response in the presence of a homeowner balance sheet channel. Comparing consumption responses across these regions provides a measure of both the propensity to consume out of housing wealth and the total magnitude of the homeowner balance sheet channel.

The use of restricted-access geographic variables in the Consumer Expenditure Survey micro-data is crucial to the identification strategy used. 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 leverage by using geographically linked household credit data (Mian and Sufi, 2011). While some of the existing literature has attempted to use automotive loans or registrations as a proxy for spending (Mian et al., 2013; Kermani, 2013), the validity of extrapolating auto loans to total consumption is not clear. While the self-reported consumption measures used in this study are likely to be contain more noise than administrative credit or car registration data, they provide a more complete picture of household consumption-saving decisions over time.

In addition, direct measures of consumption better address the issue of substitution between forms of credit. For example, increasing home values may cause home equity-based credit to become relatively cheap compared to credit cards, school loans, etc. This may result in financing of activities through home equity that would have been otherwise undertaken with more expensive forms of credit. Such behavior is likely to have smaller macroeconomic impacts compared to increases in total credit or consumption. Furthermore, the CES data provides self-reported consumption measures and spans 1986-2012 and includes several business cycles providing a robust time frame compared with administrative credit data sets that span only the past decade. This provides evidence that the relationship between home equity and consumption, while most prevalent during the recent housing boom, has been stable over time.

Comparing household consumption responses across different local housing markets, I estimate the elasticity of consumption with respect to house prices to be 1.5 for homeowners. This corresponds to roughly a \$0.06-0.09 spending increase for a \$1 increase in home equity. In contrast, renters display a small and statistically insignificant consumption response to local house prices. This provides initial evidence that household balance sheets have a strong effect on spending.

The full empirical model describing the relationship between house prices, consumption, and monetary shocks provides a means to explore the channels through which monetary policy affects consumption. Estimated parameters are used to separately identify the homeowner balance sheet channel from other, non-housing channels. While homeowner balance sheet effects are small immediately after the monetary shock, the mechanism has an increasingly important effect as house prices rise over the course of 10-12 quarters after the initial shock. Homeowner consumption increases by 4-6% over this interval in the most inelastic-supply areas, whereas more elastic areas see smaller consumption responses due to only small house price fluctuations. Consumption responses are shown to primarily be driven by coastal cities and those in mountainous areas.

The relationship between housing and consumption is driven by a combination of collateral and wealth effects. While wealth effects may be large for a household who is selling housing in a high-price environment, these effects are likely to be reversed by negative wealth effects on home buyers. Since wealth effects are transfers between home buyers and home sellers, they have little effects on aggregate spending or welfare. By contrast, increases in home equity collateral improves borrower balance sheets and mitigates agency costs between borrowers and lenders. Collateral constrained borrowers are likely to have high propensities to consume out of housing since they are initially prevented from achieving their first-best consumption profile. Therefore, collateral effects are likely to increase aggregate consumption and welfare.

To test for the relative importance of the two effects, I compare responses of various types of households. First, I split the sample into "constrained" and "unconstrained" households based on the household's debt-service ratio (Debt service payments as percentage of income). 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). Households in the top quartile of the DSR distribution are shown to spend roughly \$0.14 for every \$1 of home equity increase, whereas those in the bottom 75% display little response. This provides evidence that credit constrained households look to housing wealth to finance consumption.

To further test this claim, I split the sample between households which increased their home debt and those that did not. This provides a good measure of which households extract home equity to finance spending when their incomes fall. While these households are few in number, they drive the majority of the response in spending to house price changes. These households have a pronounced spending response of nearly $0.30 for a $1 consistent with the estimates for the propensity to borrow out of home equity estimated by Mian and Sufi (2011). This also provides strong evidence that, while wealth effects may play a role, collateral effects drive the relationship between house prices and consumption.

The importance of collateral effects in driving these relationships is crucial for the aggregate impacts of monetary policy. First, aggregate consumption responses are likely to be small if wealth effects were to dominate since wealth effects arise due to transfers of wealth between buyers and sellers of housing. The importance of collateral effects provides evidence that aggregate spending responses will be driven by large responses of constrained homeowners who enjoy increased collateral values. Secondly, the homeowner balance sheet channel provides a mechanism through which monetary policy may affect consumption inequality. Recent work by Coibion et al. (2012) finds that various measures of consumption inequality fall in response to a monetary loosening. By raising home values, a monetary loosening provides collateral to low income, credit-constrained households allowing them to finance higher levels of spending. Effects are small for high income, unconstrained households who have a low marginal value of collateral. The homeowner balance sheet, therefore, compresses the distribution of spending, reducing inequality.

The next section discusses the various data sets used in this study including the Consumer Expenditure Survey, housing supply elasticity measures, and house price indices. Section 2.3 discusses the effects of monetary policy on house prices and provides support for the empirical strategy and identifying assumptions described in Section 2.4. Section 2.5 discusses results and provides tests for the relative importance of collateral and wealth effects in explaining the homeowner balance sheet channel. Section 2.6 discusses related literature and the contributions made in this paper, and Section 2.7 concludes.

2.2 Data

Consumption Expenditures Survey (Public-Use and Restricted-Access Geography Data) The Consumer Expenditure Survey (CES) consists of quarterly interviews kept by respondents over the course of 5 quarters. The first interview is serves as an orientation for the household, and no expenditure data is collected. The 2nd through 5th interviews collect data on expenditures and household characteristics after which households are rotated out and replaced by new respondents. The unit of observation is a “Consumer Unit” (CU) defined as a financially interdependent group of people living in the same home and making joint expenditure decisions. A physical home may contain more than one consumer unit if members of the household make independent spending decisions on housing, food, and living expenses. For purposes of this study, I adopt the CU definition when referring to households that make consumption choices over time.

The CES sample frame is selected to form representative samples of each Census Region as well as 18 “Type A” metropolitan areas comprising most of the largest MSA’s in the US. Sampling is also conducted at several smaller metropolitan and rural areas to form a nationally representative sample. Though the survey is not representative of any specific small geography, 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.

A Census interviewer administers the quarterly Interview Survey in which households report demographic information and data on over 200 categories of expenditures. Assets and income data are only collected during either the 2nd or 5th interview. Notably, self-reported home values are only reported in the final interview, so house price growth cannot be observed within the survey. Quarterly summary expenditures values on total spending, non-durable spending,[7] and a variety of summary categories are generated for each household in the sample from 1986-2008.[8] Each expenditure category is deflated by the respective CPI. The sample period is selected to avoid major survey changes occurring prior to 1986 and the Zero-Lower-Bound (ZLB) period starting in December 2008 after which monetary shocks cannot be identified using Federal Funds rates. Households are linked across waves providing 4-quarter panels for each household.[9]

In the restricted-access version of the CES, I match households with local-level housing market variables using FIPS county codes.[10] Identification rests crucially on the use of this geographic data. Household's who have lived in the same location for more than one year are matched to county and MSA level house price indices to provide a history of house price growth. 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. Finally, MSA-level annual per capita private income from the BEA is matched to households to provide an improved measure of local productivity growth.

Housing Supply Elasticity Measures Using restricted-access geographic variables in the CES, households are matched to local housing elasticity variables from Saiz (2010). The

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

[8]Alternate specifications using county-level Zillow house price data use only 1996-2008 observations as this house price data is unavailable prior to 1996.

[9]Changes to the survey design in 1996q1 and 2005q1 prevent linking individuals across those two quarters.

[10]This is done using a crosswalk from NBER to link counties to MSA's using the "old MSA" definitions.

two measures of local housing supply elasticity are "proportion of unavailable land" and the Wharton Land-Use Regulation Index at the MSA-level. 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.[11] 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 limit on a necessary resource in 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.[12] The index provides a measure of how difficult it is to convert real resources such as labor, materials, and land into a house. Higher values of the index imply tighter regulatory barriers to new construction.

The use of metropolitan statistical areas as the relevant geographical area for defining local housing supply is not simply a convenience. MSA's are defined by the Office of Management and Budget based on economic and cultural dependencies. For example, commuting patterns

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

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

may cause a certain county to be included into the larger MSA of its neighboring major city. This means housing is substitutable between counties within an MSA causing land unavailability or regulations in one county to influence prices of housing in neighboring MSA's. MSA-level housing markets are sufficiently isolated from each other by comparison, but do not vary substantially in geography and regulations compared to broader definitions such as states.

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

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

House Price Indices Disaggregated house price data is essential to the identification strategy used in this study. The consumption response to house price changes is identified using local heterogeneity in house price increases which are not captured in state or regional indices. Additionally, 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. This provides a means to understand how balance sheets and consumption behavior are affected by house price growth.

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

While this index is attractive in its geographic scope and relatively long time series, it suffers a fundamental drawback. The FHFA indices are constructed using transactions data acquired through Freddie Mac, and hence cover only homes purchased with conforming mortgages. Aside from cash transactions, this excludes all sub-prime, jumbo, and other non-traditional 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 understating 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 "zestimate" 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.[13] Despite its superior coverage of homes and availability at the county level, the Zillow house price index extends only back to 1996 and covers only one housing cycle and two NBER recessions. Use of both FHFA and Zillow indices provides a robust estimate for the homeowner balance sheet channel.

Since house prices are only observed once for each household during much of the sample period, house price growth cannot be constructed using self-reported values. Using the restricted-use geographic data in the CES, I link each household to local house price histories using the FHFA and Zillow indices. Figure 2.7.4 provides a comparison of national-level indices from FHFA, Zillow, and Case-Shiller along with mean and median self-reported home values from the CES. Self-reported values closely track the house price indices used in this paper.

[13] 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/

Macroeconomic Variables In order to identify national-level credit and monetary shocks, I use a time series of macroeconomic variables in a recursive vector autoregression. Variables include log real GDP, CPI inflation, effective federal funds rates, 30 year conventional mortgage rates, and the national house price index (FHFA all transactions) at a quarterly frequency from 1954-2012.

2.3 Monetary Policy & House Price Dynamics

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

Monetary policy affects the user cost of housing, shifting demand.[14] This increases housing starts and higher home values. The relative increase in construction and price driven

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

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

To provide a simple means of empirically identifying this heterogeneity in house price responses, I use a simple monetary vector autoregression (VAR) to estimate impulse responses of house prices to monetary shocks in different areas. Using housing supply elasticity estimates of house prices from Saiz (2010), I combine MSA-level FHFA house price indices (henceforth HPI's) into 4 indices for quartiles of the elasticity distribution weighted by population.[15] A VAR is then estimated using national GDP, CPI inflation, Fed Funds rate, 30yr Fixed Mortgage Rate, and the four constructed quartile HPI's. Baseline identification of monetary shocks allows Fed Funds rates to respond contemporaneously to GDP and inflation, but to mortgage rates and HPI's only with a lag.

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

While the ordering of GDP, inflation, and Fed Funds is standard, the inclusion of housing

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

variables is not. The Fed Funds rate is ordered prior to mortgage rates and house prices, therefore restricting the Fed from responding to end-of-quarter mortgage rates and house price indices. Financial markets are quick to respond to monetary policy movements, hence long-term mortgage rates are likely to react to monetary shocks within the quarter. Furthermore, house prices are determined at the time of transaction and hence are based on the full information sets of the transacting parties at the time the sale occurs. Therefore, house prices likely reflect concurrent movements in monetary policy. Since only monetary shocks are identified, relative ordering of other variables does not affect the identification of impulse responses to monetary shocks (Bernanke and Blinder, 1992; Christiano et al., 1999).

Resulting impulse responses for each quartile are plotted in Figure 2.7.6. As can be seen in the first panel, the most elastic cities show little house price response to a monetary shock with approximately 0.5-1% decline in house prices over 3-4 years after a 1 standard deviation (71 basis point) shock to Federal Funds rates. As housing supply elasticity falls, house price responses become more dramatic. The most inelastic areas display a house price response of 3-4% from trend after 3-4 years after the same shock.

Closer analysis of the underlying VAR reveals that monetary shocks move 30 year fixed mortgage rates causing a shift in housing demand. While housing supply may also shift, the crucial identifying assumption that house prices respond heterogeneously to monetary shocks is supported by these results. Chapter 1 provides further analysis of this phenomenon on both house prices and residential investment. Results provide further evidence that monetary shocks shift housing demand along heterogeneous local housing supply curves.

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

2.4 Empirical Specification

The goal of this paper is to estimate the "homeowner balance sheet channel" of monetary policy. Non-durable consumption responses to monetary shocks will be decomposed into the component arising due to fluctuations in housing wealth and those arising through other channels. The balance sheet channel will be separated by first identifying monetary shocks orthogonal to any endogenous policy responses to current or anticipated economic conditions. These shocks will then be used to identify the effect of monetary policy on house prices and non-durables spending across regions with differing housing supply elasticity. After a monetary shock house prices in the most elastic-supply MSA's are held in check by new construction and homeowners are only affected by non-housing channels. On the other hand, inelastic-supply MSA's see large house price responses and homeowners are affected both by housing wealth increases and other non-housing channels. Comparing these regions allows for a decomposition of the total consumption response to monetary policy into it's homeowner balance sheet component and it's non-housing component.

The intuition for the identification strategy is to difference household-level consumption responses to monetary shocks across households in different housing supply elasticity regions. The general procedure first identifies and estimates monetary shocks using a recursive vector autoregression. This provides a measure of deviations of Federal Funds Rates from the endogenous policy responses prescribed by a Taylor rule. These shocks are then combined with land availability and zoning regulation measures to estimate consumption and house price responses to monetary shocks in the Consumer Expenditure Survey (CES). Using an instrumental variables approach, I compare these responses across MSA's with different housing supply elasticity to identify the propensity to consume out of housing, house price responses to monetary shocks, and the homeowner balance sheet channel.

Monetary shocks are identified as in Bernanke and Blinder (1992) using a recursive ordering. The VAR includes log-real GDP, CPI inflation, federal funds rate, 30 year mortgage rate, and the log-real national house price index. As in Section 2.3 the federal funds rate is allowed to respond to log-real GDP & inflation concurrently, but can be affected by mortgage rates and house prices with a lag. Mortgage rates and house prices are allowed to respond quickly to innovations in other variables including monetary policy. Financial markets react to new information quickly and end of quarter 30-year mortgage rates likely reflect changes in monetary policy during the quarter. Similarly, house prices are set at the time of sale and likely reflect all information known to the transacting parties including recent monetary shocks. Identified monetary shocks are displayed in Figure 2.7.5.

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

$$\begin{aligned}\Delta c_{i,t+1} &= \beta_1 \Delta q_{i,t+1} + \beta_2(L)\eta_t + \beta_3 \Delta x_{i,t+1} + u_{i,t+1} && (2.4.1)\\ \Delta q_{i,t+1} &= \gamma(L)\eta_t + \gamma_4 \Delta x_{i,t+1} + v_{i,t+1} && (2.4.2)\end{aligned}$$

where η_t is the monetary shock[16] and $x_{i,t+1}$ is a set of household-level controls including age, family size, and income. The empirical model is estimated in first-differences, and hence allows for unobserved heterogeneity in consumption levels due to household-specific tastes. Appendix 2.7 formalizes the assumptions under which a vector of household-level variables follow a distributed lag of monetary shocks (ie, a "partial" Wold Decomposition exists).

Identification of the model provided in (2.4.1) and (2.4.2) provides insight into a number of objects of interest. The coefficient β_1 provides a measure of the elasticity of non-durable consumption to housing wealth. The magnitude of this coefficient provides insight into how households use housing assets to smooth consumption over their lifetime. Furthermore, the system provides a means to understand the effects of monetary policy on consumer expenditures and housing wealth. This can be seen by taking the total derivative of consumption and house price growth with respect to a monetary shock yields:[17]

$$\begin{aligned}\frac{d\Delta c_{i,t+1}}{d\eta_{t-h}} &= \beta_1 \frac{d\Delta q_{i,t+1}}{d\eta_{t-h}} + \beta_2(h) + \beta_3 \frac{d\Delta x_{i,t+1}}{d\eta_{t-h}} && (2.4.3)\\ \frac{d\Delta q_{i,t+1}}{d\eta_{t-h}} &= \gamma(h) + \gamma_3 \frac{d\Delta x_{i,t+1}}{d\eta_{t-h}} && (2.4.4)\end{aligned}$$

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

[17]As discussed in Appendix 2.7, monetary shocks η_t are orthogonal to $u_{i,t+1}$ and $v_{i,t+1}$since the latter are sums of non-monetary structural shocks.

The total derivative captures the effect of monetary policy on consumption growth at various lags, in a manner similar to an impulse response function. The equations above also shed light on the various channels through which monetary policy affects consumption.

The homeowner balance sheet channel is captured in the first term of (2.4.3). This term combines the effect of monetary policy on house prices $\frac{d\Delta q_{i,t+1}}{d\eta_{t-h}}$ given in (2.4.2) and the effect of house prices on spending β_1. Not surprisingly, the magnitude of this channel is determined largely by the propensity of the household to spend out of housing wealth β_1. If the homeowner's spending does not respond to increases in housing value, it is unlikely that balance sheet effects will matter in the transmission of monetary shocks to homeowner spending. Therefore, identification of β_1 is crucial to identifying the homeowner balance sheet channel.

The remaining terms, $\beta_2(h) + \beta_3 \frac{d\Delta x_{it}}{d\eta_{t-h}}$, capture non-housing effects of monetary policy. These may include indirect effects through control variables such as income or effects on spending through channels not explicitly included in the specification.

2.4.1 Identification

The marginal propensity to consume out of housing, β_1, cannot be identified using the model as specified. Consumption growth, Δc, and house price growth, Δq, are simultaneously determined. Furthermore, all covariates in the specification above appear in both equations violating the order condition. A monetary shock causes changes in both house prices and consumption growth, but the effect on consumption due to the homeowner balance sheet channel cannot be identified since both variables move together. This issue highlights the importance of micro-data in addressing the issue of simultaneity in these variables. Cross-sectional variation in the responses of consumption and housing values can provide some insight into the causal link between the two.

Secondly, the error terms $u_{i,t+1}$ and $v_{i,t+1}$ capture unobserved national and local shocks. This means $u_{i,t}$ and $v_{i,t}$ are correlated with each other, resulting in an omitted variables bias in (2.4.1). For example, a shock to productivity raises wealth causing a simultaneous increase in both spending and house prices. Estimation by OLS results in overstating the causal effect of housing wealth on spending since the effect of unobserved productivity shocks will be partially attributed to housing wealth.

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 (2.4.2) 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.[18] This yields:

$$\Delta c_{i,t+1} = \beta_1 \Delta q_{i,t+1} + \beta_2(L)\eta_t + \beta_3 \Delta x_{i,t+1} + u_{i,t+1} \tag{2.4.5}$$

$$\Delta q_{i,t+1} = [\gamma_1(L) + \gamma_2(L)z_i]\,\eta_t + +\gamma_3 z_i + \gamma_4 \Delta x_{i,t+1} + v_{i,t+1} \tag{2.4.6}$$

The interaction between supply elasticity and demand shocks, such as monetary shocks, determines the magnitude of $\Delta q_{i,t+1}$. As discussed in Section 2.3, monetary shocks shift housing demand causing local house price q_{it} changes to be proportional to the land avail-

[18]Details regarding these measures are provided in Section 2.2.

ability and zoning laws. This provides support for the relevance of the excluded instruments in the model.

Excluded instruments, z_i and $\eta_t z_i$, provide a means to identify β_1, the response of consumption to changes in housing wealth. Using an IV estimator, impulse responses of consumption and house prices are compared across high and low elasticity housing markets. This provides cross-sectional variation in the magnitude of house price responses which affect consumption behavior through β_1. Identification requires that housing supply instruments do not have direct effects on consumption. Formally, the set of orthogonality conditions required for identification of the full system in (2.4.5) and (2.5.2) is:

$$\eta_{t-h} \perp u_{i,t+1}, v_{i,t+1} \tag{2.4.7}$$

$$z_i \perp u_{i,t+1}, v_{i,t+1} \tag{2.4.8}$$

$$\Delta x_{i,t+1} \perp u_{i,t+1}, v_{i,t+1} \tag{2.4.9}$$

Assumption (2.4.7) follows from the identification of monetary shocks in the structural VAR. Since monetary shocks are orthogonal to other structural shocks, it follows that $\eta_t \perp u_{it}, v_{it}$. This highlights the importance of "purging" Fed Funds innovations of endogenous policy responses to non-monetary shocks. Failing to do this would cause monetary shock measures to be correlated with non-monetary structural shocks appearing in $u_{i,t+1}$ and $v_{i,t+1}$.

Assumption (2.4.8) requires that land availability and zoning regulations are uncorrelated with consumption growth conditional on monetary shocks, η_{t-h}, and other covariates, Δx_{it}. Though it is unlikely that consumption growth is directly affected by the availability of land or zoning laws in a given city, one might be concerned that inelastic cities tend to attract a different type of consumer than more elastic cities. Nonetheless, closer inspection reveals that this is not the case. First, while consumers in relatively inelastic cities such as New York and San Francisco tend to have higher levels of consumption, income, and housing wealth, the specification above only requires that they do not have higher growth in consumption. Furthermore, demographic characteristics between “elastic supply” and “inelastic supply” MSA’s displayed in Table 2.1 show that households in the highest, middle, and lowest thirds of the elasticity distribution appear similar in observable characteristics overall. Several observable factors that may vary between cities are controlled for by the inclusion of income growth, changes in family size, and age.

A second worry is that inelastic supply cities may be larger or more socially desirable and hence may attract households with differing consumption patterns. This is only a concern if consumption growth varies systematically across housing supply elasticity variables. Results show little effect for renters in both regions, indicating such selection issues are unlikely. This concern is also allayed by closer inspection of cities across elasticities, land availability, and zoning laws listed in Table 2.2. Several smaller coastal or mountain cities such as Galveston, Texas, and Eugene, Oregon, appear on the list of most inelastic MSA’s. Furthermore, large MSA’s such as Atlanta, San Antonio, and Oklahoma City are amongst the most elastic supply cities. Overall, the correlation between MSA population and land availability is only 0.086 while the correlation between population and zoning regulations are slightly higher at 0.209. Alternate specifications excluding zoning regulations from the regression yield in quantitatively similar results for the magnitude of the homeowner balance sheet channel.

Another issue that may cause housing supply elasticity to be correlated with consumption growth is that the magnitude of local housing demand shocks varies systematically with housing supply elasticity. This is likely to be the case based on evidence in the literature. 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 expected house price appreciation lowers user cost and raises expected collateral values 2-3 years in the future. This may induce "alternative" lending behavior such as interest-only or low down payment mortgages in areas with high anticipated price growth (Barlevy and Fisher, 2010). Such amplification of credit shocks due to future price growth cannot be addressed in the given specification. While this may overstate the importance of current house price growth in explaining consumption growth, the total response to monetary policy acting through housing markets is identified. The homeowner balance sheet effect identified in this paper incorporates both the increase in concurrent housing wealth and alternative credit due to future price increases in inelastic-supply cities.

Finally, the inclusion of variables $\Delta x_{i,t+1}$ attempts to control for a variety of factors that may influence both house prices and spending. First, life-cycle variables are included to control for discrepancies in homeowner age and family structure between elastic and inelastic supply MSA's. For example, if homeowners sampled in inelastic areas tended to be older than those in elastic supply areas, one may observe differential consumption growth between elastic and inelastic markets arising due to life cycle effects, not housing wealth. Conditioning consumption growth on a polynomial of household age and family size (OECD adult-equivalent scale) prevents this type of error. While homeowner demographics in the sample are broadly similar across elasticities, the specification avoids attributing cross-MSA differences in consumption growth driven by demographics to housing wealth fluctuations.

A second issue is conditioning on household or local income growth. The importance of controlling for these factors can understood by considering a local productivity shock such as the introduction of "fracking" providing means to cheaply access natural gas deposits in Western Pennsylvania. By improving the employment outlook and lifetime wealth of residents, this type of shock stimulates both housing demand and non-durable spending in the MSA. Ignoring this source of endogeneity would overstate the causal relationship between home equity and spending. This bias is partially addressed through the instruments, since it is unlikely that local productivity shocks are correlated with land availability or zoning laws. Conditioning on local income growth controls for any concurrent changes in local productivity or economic conditions that may be correlated with the elasticity instruments. Both household and MSA income growth are included to control for household-specific and regional economic fluctuations that may drive both spending and housing demand.

In addition to exogeneity assumptions on instruments used, another key assumption is that the excluded instruments is 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 2.3, monetary loosening causes national-level house prices and housing starts to rise. Furthermore, inelastic MSA's see increases in house prices of 4-6% over the course of 8-10 quarters while the most elastic-supply MSA's see little movement in real house prices. This provides evidence that there is substantial variation across MSA's in the response of house prices to monetary shocks. Furthermore, LIML and 2SLS procedures provide similar estimates and first-stage F-statistics from the baseline specification exceed the Stock & Yogo (2001) thresholds for relative bias of 10%.

A final econometric issue is the appropriate correction of standard errors to account for generated regressors. The procedure first estimates monetary shocks, $\hat{\eta}_t$, and then treats these as data in the 2SLS estimation of (2.4.5) and (2.4.6). This ignores estimation error in $\hat{\eta}_t$. Under regularity conditions discussed in the Appendix 2.7, the generated regressors do not affect consistency of parameter estimates, but will affect the consistency of the standard errors (Wooldridge, 2002; Murphy and Topel, 1985; Pagan, 1984). Regularity conditions and adjusted standard errors are described in Appendix 2.7.

The identification strategy used here provides a consistent estimate of β_1, the elasticity of consumption to house prices. This elasticity of non-housing consumption to housing wealth has been studied by others in the literature Case et al. (2005); Cooper (2009); Campbell and Cocco (2007), but the specification used here provides a novel instrument that better controls for endogeneity in house price growth. In addition to baseline results estimating the relationship between home values and spending, I present two extensions attempting to test for the relative importance of collateral and wealth effects.

Secondly, taking the system as a whole provides a decomposition of consumption responses to monetary shocks into the baseline effect and the amplification that occurs through homeowner balance sheets. As discussed previously, the parameter β_1 along with the response of house prices to monetary shocks from the first stage determine the magnitude of consumption responses arising through homeowner balance sheet effects. This provides insight into the importance of collateral and balance sheet quality in propagating and amplifying monetary policy to the real economy. Furthermore, it provides a measure of the regional wealth transfers and inequality that occur due to monetary and credit shocks.

2.5 Results and Discussion

2.5.1 Consumption Response to House Prices

Table 2.3 provides estimates from this baseline specification home owners, owners with mortgages, renters, and the combined sample of all households. Results show that the consumption elasticity to housing wealth,β_1, is positive and significant and roughly 1.5 for owners. These results provide strong evidence that housing wealth plays a substantial role in amplifying consumption responses to monetary shocks. Given the mean (nominal) home value in-sample of approximately \$200k and mean quarterly non-durable expenditures of approximately \$9.3k, homeowners increase quarterly spending by \$0.06-0.09 for a \$1 increase in home equity within the quarter. These results are in line with related estimates in the literature. For example, Cooper (2009) finds a propensity to consume \$0.06-0.18 per \$1 increase in housing wealth using data from the PSID. Related work by Mian and Sufi (2011) find a propensity to borrow \$0.25 cents for \$1 of house price growth during 2002-2006. MPCs estimated in this paper are slightly smaller than this number, implying that not all of this equity extraction is spent within the CES interview period and may result in increased savings in the short-run. Furthermore, Barlevy and Fisher (2010) provide evidence that unconventional forms of leverage grew substantially in the mid-2000's in areas of expected price growth such as California, likely indicating that the sample period used by Mian and Sufi (2011) is one in which asymmetric leverage growth between elastic and inelastic-supply areas was large due to expected future house price appreciation.

Unlike homeowners, renters (non-owners) do not enjoy strengthened balance sheets or increased wealth due to rising home values. This is supported by low and insignificant elasticities of consumption to house price changes in the "renters" column in Table 2.3 . While estimates of β_1 are slightly negative for renters, they are not significantly different from zero. While one may expect negative wealth effects for renters who plan to purchase housing in the future, these effects may be small due to the ability to adjust the timing or size of future home purchases. Furthermore, rising home values may cause purchase prices to be high, but may also result in laxer lending standards as home equity is expected to rise.

Moreover, the negligible effects on renters compared to those for owners highlights the dual role of housing as wealth and collateral.[19] A house's price is determined by the present value of flow rental payments. Even if the house is occupied by the owner, the owner forgoes the rental payment, or alternately can be perceived as implicitly "renting to herself". An increase in house prices implies the present value of rental payments has risen, increasing the wealth of the household but simultaneously increasing the cost of living. The net wealth effect is likely to be small unless the household is a net-buyer or net-seller of housing. Furthermore, wealth effects arise simply from a transfer of wealth between buyers and sellers of housing, and are likely to be symmetric in the absence of collateral constraints. The large effect on owners compared to renters likely indicates the importance of collateral effects.

The importance of this often subtle distinction between wealth and collateral effects can be seen by thinking about the source of collateralized lending. Agency costs between the borrower and lender often arise since the lender cannot easily enforce repayment. In such a case, the borrower may post collateral to insure the lender against default. The value of collateral becomes an essential state variable in determining the amount of credit that can be secured. If the household has insufficient collateral to meet its borrowing demand, the

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

lender will not provide additional credit despite the fact that the household has the capacity to repay the loan. Such a market failure can be avoided by providing the household with additional collateral, as is the case when home values rise. This is especially important since higher collateral values mitigate agency costs and are welfare improving.

Furthermore, the magnitude of collateral effects is likely to be large compared with wealth effects. Unconstrained households are able to equalize marginal utility across time. Loosening collateral constraints will have little to no effect on current consumption as the unconstrained household is already able to smooth consumption over time. Alternately, a household with low home equity may not have access to its desired borrowing capacity due to limited collateral. This drives a wedge between marginal utility of consumption today and next quarter, leaving the household wishing it could borrow more. Higher home equity collateral provides such a household with borrowing capacity and can have dramatic effects on consumption.

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 causes the household to behave differently in the present Carroll and Kimball (1996). This effect diminishes as the loan-to-value ratio becomes substantially smaller than the collateral limit, since the likelihood of the constraint binding in the future falls. Therefore, in reality, households fall on a spectrum between constrained and unconstrained. Since the shadow value of the constraint is not directly observable, this paper follows the approach of the literature (Zeldes, 1989;

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

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

An alternative test for the importance of collateral effects is to directly look directly at collateralized borrowing. Households who increased their home equity-based debt are accessing the collateral in their homes in order to either pay down other debt, save, or increase consumption. I flag these households as "equity extractors" in comparison to those that did not extract home-equity and compare their propensity to consume out of housing wealth with that of other households. While equity extraction may not be exogenous, households who access home equity in response to (temporary) negative income shocks are likely to decrease spending, biasing the difference between "equity extractors" and "non-extractors" downwards. Results indicating a higher propensity to consume for equity extractors will still suggest a strong role for collateral effects in driving the relationship between housing and spending.

Testing if the elasticity of consumption to house prices, β_1, of constrained households is larger than the baseline estimate provides a means of checking the importance of credit constraints as opposed to wealth effects. Results from the credit constraints model can be found in Table 2.4. To put the results in perspective, an individual in the highest quartile of Debt Service Ratios has an elasticity of consumption to housing wealth of 3, roughly double that of the baseline estimate found in column 1. By comparison, unconstrained households in the bottom 75% of debt-service ratios have slightly negative, but insignificant, spending responses to house price changes.

Results for those increasing home debt are seen in columns 4 and 5 of Table 2.4. Households who extracted home equity have an estimated elasticity of 3.56, over twice as large as "non-extractors." While the inter-relationship between refinancing, house prices, and spending is complex, this result provides evidence that home-equity-based borrowing is a very important driver of the relationship between home values and non-durable spending.

These results are useful in understanding the implications of monetary policy for inequality. Recent work by Coibion et al. (2012) uses the CES to show that monetary loosening can reduce measures of consumption and income inequality. My finding that collateral effects drive the relationship between house prices and spending provide a specific mechanism through which monetary policy may affect inequality. By raising house prices, a monetary loosening provides constrained homeowners with collateral. This allows low-income, constrained households with the means to finance spending and smooth consumption. In contrast, richer, unconstrained households have little to no response in spending since their marginal value of collateral is small and wealth effects are negligible. This compresses the cross-sectional distribution of spending, reducing inequality.

Table 2.5 provides evidence that these results are robust to several alternate specifications. First, it is possible that returns on assets other than housing may affect consumption growth, and the omission of these factors causes an upward bias on the propensity to consume out of housing. This is unlikely to be the case given that asset holdings and asset returns are uncorrelated with measures of housing supply elasticity. Furthermore, column 1 shows that estimated elasticities for owners are unchanged by the inclusion of these variables.

As discussed previously, conditioning on income growth prevents spurious results arising from local productivity or wealth changes that may affect both housing demand and non-durable consumption. Baseline results include household after-tax income growth and MSA per capita income growth measures. Column 2 provides estimates using only household income with little change to estimates. The consumption response to household income remains low while the response to housing is rather high. Since the CES collects pre-tax income and income taxes separately, pre-tax income is likely to be measured with less noise than after-tax income. Using pre-tax income is shown to have little effect on estimates in Column 3.

Conditioning on concurrent income growth may not reflect anticipated changes in productivity growth that may affect consumption and housing demand in the MSA. Since income expectations are not observed, column 4 re-estimates the model including realized 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 including expected income growth reduce the magnitude of the estimated response to house prices slightly, but households still increase consumption substantially in response to an increase in home equity.

Table 2.5 also repeats the baseline estimation using the county-level Zillow Home Value Index. While this constrains the sample period to 1997-2008, the measure offers a variety of benefits over the baseline FHFA house price index.[20] First, Zillow home values are available at finer geographic levels than FHFA indices. While land and regulation instruments are still MSA-level measures, using county-level price data allows house price growth the first stage to be weighted appropriately based on the areas within an MSA in which the household lives. Secondly, Zillow price indices are constructed using transactions data from all homes in the regions covered, whereas FHFA indices rely on data on conforming mortgage loans acquired from Fannie Mae and Freddie Mac. The inclusion of non-conforming loans, such as jumbo mortgages or subprime loans, accounts for a large amount of variation in prices during the late 1990's and early 2000's. As indicated in Figure 2.7.4, Zillow home values move more dramatically than FHFA indices during this period and are likely more sensitive to monetary shocks. This is reflected in slightly lower estimates of consumption responses to Zillow house price changes compared with baseline results using FHFA indices as seen in by comparing column 5 to column 1 in Table 2.5 . The same monetary shocks move Zillow home values more dramatically than FHFA indices while consumption responses remain the same.

When taken together, results from the baseline model and robustness regressions indicate that homeowners have substantial non-durable spending responses to house price growth whereas renters see little or even negative response. Furthermore, I have provided tests for the relative importance of collateral and wealth effects in driving this relationship. Using

[20] Further details regarding differences in the construction of the Zillow Home Value Index (ZHVI) and FHFA house price index are presented in Section 2.2.

the DSR and Home-Equity-Debt measures, I find that potentially constrained homeowners who use home-equity debt are responsible for the bulk of the response in spending, whereas unconstrained households have negligible spending responses to home value increases. This provides strong evidence that, though wealth effects may play a role, the collateral effect drives the relationship between consumption and home values. Given these results, I now turn back to understanding the importance of homeowner balance sheets in propagating monetary shocks.

2.5.2 Homeowner Balance Sheet Channel

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

The response of consumption and house prices to an h quarter lagged monetary shock η_{t-h} is given by (2.4.3) and (2.4.4) in Section (2.4). Updating these expressions using the housing supply elasticity measures z_i used for identification yields:

$$\frac{d\Delta c_{i,t+1}}{d\eta_{t-h}} = \beta_1 \frac{d\Delta q_{i,t+1}}{d\eta_{t-h}} + \beta_2(h) + \beta_3 \frac{d\Delta x_{i,t+1}}{d\eta_{t-h}} \tag{2.5.1}$$

$$\frac{d\Delta q_{i,t+1}}{d\eta_{t-h}} = \gamma_1(h) + \gamma_2(h) z_i + \gamma_3 \frac{d\Delta x_{i,t+1}}{d\eta_{t-h}} \tag{2.5.2}$$

As before, the homeowner balance sheet channel is captured in the first term of (2.5.1). This term combines the effect of monetary policy on house prices $\frac{d\Delta q_{i,t+1}}{d\eta_{t-h}}$ given in (2.5.2) and the effect of house prices on spending β_1. The total effect on spending acting through this channel is given by $\beta_1\left(\gamma_1(h)+\gamma_2(h)z_i+\gamma_3\frac{d\Delta x_{i,t+1}}{d\eta_{t-h}}\right)$. The role of β_1 in driving this channel is evident from this expression. Given the significant effects of house prices on consumption estimated above, there is strong evidence that the homeowner balance sheet channel is a non-negligible component of the spending response to monetary policy in any area where $\frac{d\Delta q_{i,t+1}}{d\eta_{t-h}} \neq 0$.

The second and third terms, $\beta_2(h)+\beta_3\frac{\partial\Delta x_{it}}{\partial\eta_{t-h}}$, capture non-housing effects of monetary policy acting through interest rates, incomes, and general economic conditions affected by the shock. Since income variables are included in x, any effect monetary policy has on income appears through $\beta_3\frac{\partial\Delta inc}{\partial\eta}$. I assume that age and family size are unaffected by the shock, so $\frac{\partial\Delta x}{\partial\eta}=0$ for these variables. In addition, monetary policy may impact spending through channels not explicitly included in the specification. This is captured by the coefficient $\beta_2(L)$.

Results of the estimation are available in Figures 2.7.7, 2.7.8, and 2.7.9. Figure 2.7.7 plots the deviations of consumption from trend after 4, 8, 12, and 16 quarters after a shock depending on land availability and zoning regulations in the household's MSA. Homeowner spending follows a similar pattern to house price responses discussed previously. Spending responses peak after approximately 12 quarters and display larger movements in areas with low land availability and stricter zoning laws.

Geographic heterogeneity in the spending responses can be seen in the maps presented in Figures 2.7.8, and 2.7.9. Each map depicts the spending response response to a 1 standard deviation (71 basis point) shock to the Federal Funds rate at lags of 4, 8, 12, and 16 quarters respectively. Patterns generally follow those seen in maps of the elasticity measures in Figure

2.7.3. Coastal and mountain cities display larger spending responses since house prices rise more substantially in those areas compared to MSA's in the middle of the country. This also depicts a strong heterogeneity in responses across regions of the US.

2.6 Contributions to Literature

This paper builds on a several strands of the literature. First, it establishes an empirical link between monetary policy and house price dynamics. It then describes the effect of house price fluctuations on non-durable expenditures. Following aggregate shocks, regions with larger house price responses also display larger consumption responses. This is evidence that increases in housing wealth loosen collateral constraints allowing consumers to borrow and spend more than they would be able to otherwise. Secondly, this paper estimates the amplification of macroeconomic shocks through the housing balance sheet channel in inelastic regions. By exploiting geographic and regulatory heterogeneity across Metropolitan Statistical Areas (MSA's), I decompose the impulse response of consumption to monetary and credit shocks into a baseline contribution without collateral constraints and the amplification occurring due to house price changes. This decomposition provides evidence of the relative importance of balance sheets in the transmission of monetary and credit shocks as well as the heterogeneous responses across various MSA's.

The recent financial crisis has brought into focus the importance of agency costs and borrower balance sheets in the amplification of small macroeconomic shocks. This literature on so-called "financial accelerators" contains several models stemming from early work by Bernanke and Gertler (1989); Kiyotaki and Moore (1997); Carlstrom and Fuerst (1997). These models feature agency costs in borrower-lender relationships that cause borrowing contracts to be linked to the value of collateral on the borrower's balance sheet. Shocks that increase asset values amplify output responses by improving balance sheet quality and loosening collateral constraints on borrowers. While the majority of this literature on the "balance-sheet channel" focuses on firm balance sheets and investment decisions, notable exceptions include work by Iacoviello (2005) and Aoki et al. (2004) who extend the sticky-price DSGE model of Bernanke et al. (1999) to household collateral constraints tied to housing values. They show that the presence of home-equity borrowing causes an amplification of housing demand shocks, providing a theoretical foundation for a "homeowner balance-sheet channel". My work empirically identifies the magnitude of this channel by decomposing the contribution of monetary and credit shocks into their baseline and "balance sheet" components.

Identification of the "homeowner balance-sheet channel" follows in two steps. I first identify the response of house prices to monetary policy. I then identify elasticity of non-durable spending to changes in housing wealth. The first step has been analyzed in the housing economics literature. Early work by Poterba (1984) describes an asset-pricing approach to house price dynamics where fluctuations in user cost of housing cause varying dynamics in prices as housing stock adjusts over time. Recent work by Glaeser et al. (2008) and Kermani (2013) extend this model to a framework where local housing supply is allowed to vary across regions. Regions with more inelastic housing supply display larger fluctuations in house prices due to changes in the user cost of housing. This paper empirically identifies this effect. Using measures of housing supply elasticity developed by Saiz (2010) and Gyourko et al. (2008), I show that metropolitan areas with large amounts of available land and loose zoning regulations have little response to monetary shocks while areas with geographic or regulatory constraints to new construction see substantial movements in house prices.

The second step in identifying the homeowner balance sheet channel is to empirically establish the link between housing wealth and non-durable spending. This can occur for one of two main reasons: wealth effects or collateral effects. A pure wealth effect from an increase in home value to an infinitely lived household is likely small as implicit rental payments rise along with the asset value of the home. While life cycle effects may cause young home buyers or older home sellers to have wealth effects, spending responses are likely muted as households smooth the wealth fluctuations over their life cycle. On the other hand, collateral constraints may result in a substantial effect of housing assets on spending. This paper follows a long line of literature on household liquidity and borrowing constraints (Carroll and Dunn, 1997; Zeldes, 1989). The existing literature has established the importance of borrowing constraints in explaining violations of the Permanent Income Hypothesis, specifically excess sensitivity of consumption to current income for constrained households. Several authors have focused on the importance of housing assets in partially mitigating the effect of these constraints. Flavin and Yamashita (2002) and Flavin and Nakagawa (2008) discuss the effects of housing and mortgages on life-cycle consumption and portfolio decisions in the presence of collateral constraints and adjustment costs. One major finding is that optimal household portfolios often cause the collateral constraint to bind at certain points in the life-cycle. This prevalence of constrained households is a motivating factor for studying the amplification in interest rate responses that work through fluctuations in collateral values.

Work by Hurst and Stafford (2004) and Cooper (2009) study the propensity to consume out of housing wealth and the use of refinancing to smooth income fluctuations over the life-cycle. Cooper (2009) uses PSID consumption data to analyze how changes in the value of housing, stock market wealth, and other assets affect the consumption behavior of households. Related work by Case et al. (2005) and Campbell and Cocco (2007) attempt to separate the propensity to consume out of housing wealth into the collateral and wealth effect components. Hurst and Stafford (2004) look at refinancing decisions and post-refinancing consumption behavior in the PSID. This paper builds on the literature by exploiting regional differences in housing supply elasticity to more precisely identify the causal effect of changes in home values on homeowner consumption. Evidence for collateral effects is presented by comparing the responses of potentially credit-constrained and unconstrained households to a home equity increase. It further addresses regional heterogeneity in consumption growth after national level shocks.

Several recent papers have also utilized variation in MSA-level housing supply elasticity as a means to compare local markets based on exposure to home equity changes. Barlevy and Fisher (2010) study the variation in lending practices based on differences in expected house price growth across cities. They find inelastic-supply cities saw higher levels of interest only mortgage lending during the housing bubble period due to the anticipation of future house price growth. Recent work by Mian and Sufi (2011) analyzes collateralized home-equity borrowing and finds that the average homeowner borrowing increased with house price growth during the housing bubble. This provides strong evidence that many households are constrained by the quality of their balance sheets and may wish to increase spending as house prices rise. A related paper by Kermani (2013) provides a theoretical foundation for the different evolution of house prices, leverage, and consumption dynamics in different housing supply environments. While these papers provide evidence that household borrowing is linked to home equity fluctuations, only indirect empirical evidence is provided regarding consumption responses. Using self-reported consumption expenditures on various categories of spending from the Consumer Expenditures Survey (CES), this paper complements the existing results on household credit by providing an empirical link between interest rates, home equity fluctuations, and consumption expenditures over time. Furthermore, it establishes the prevalence of these relationships even prior to the mid-2000's when home equity based lending skyrocketed due to rapidly rising house prices.

2.7 Conclusions

This paper utilizes consumption expenditure micro-data and attempts to exploit regional heterogeneity in land availability and land-use regulations to address several related research questions. Regional heterogeneity in geography and regulation is shown to cause heterogeneity in the responses of MSA-level house price growth following a national shock to monetary policy. This heterogeneity in responses is interpreted as shifts in housing demand resulting in different local outcomes due to heterogeneity in local housing supply elasticities. Specifically, the most inelastic MSA's in the US display a 4% reduction in home values over 2-3 years after a 1 standard deviation monetary shock of 71 basis points. By comparison, the most elastic-supply cities display little house price response as new construction holds home values in check. This heterogeneity in local housing markets is then exploited to identify the amplification of monetary shocks arising through the "homeowner balance sheet channel".

The homeowner balance sheet channel arises as a monetary loosening raises house values which provide collateral and wealth to homeowners, hence increasing their consumption. While monetary policy may affect household spending or, more generally, the real economy in a number of ways, balance sheet amplification mechanisms play an important role in propagating small monetary shocks. Furthermore, heterogeneity in ownership and local housing markets causes heterogeneous responses to monetary shocks across households and regions.

Estimation of this channel relies crucially on identifying the consumption response to house price growth. Using heterogeneity in housing supply, consumption and house price responses to monetary shocks are compared between elastic and inelastic supply MSA's. MSA's such as Dallas with large amounts of land and loose zoning laws see little house price growth after the shock whereas land-constrained and tightly regulated housing markets such as San Francisco see large real house price responses. Under the assumption that housing supply elasticity measures have no direct impact on consumption, a homeowner balance sheet only exists in regions with inelastic housing supply since home values are constant in highly elastic-supply markets. Using an IV estimator, consumption responses are compared across cities with differing land availability and zoning regulations to identify the elasticity of consumption to home value changes. Baseline estimates indicate an average increase in spending of 6-9 cents for a $1 increase in home equity.

Housing provides homeowners with both asset wealth as well as collateral against which they may borrow to finance spending. Differentiating between these roles is useful for understanding the economic consequences of monetary and credit shocks, and, more generally, fluctuations in home values. As discussed in the paper, collateralized lending arises due to agency costs between borrowers and lenders resulting in a market failure. Collateral mitigates this market failure by allowing borrowers to commit to repayment. For example, a household expecting higher wages in the future cannot credibly promise to provide labor and hence will not be extended a loan. Collateral, such as housing, is used to secure financing and insure the lender in the event of default. Increasing home values provide constrained borrowers with necessary collateral to access credit they would otherwise be unable to get despite potentially having the capacity to repay at a later date. This is different from a wealth effect as wealth does not affect the ability to access credit directly. Secondly, a collateral constrained individual is much more likely to spend an additional dollar of collateral since she is unable to equalize marginal utilities of consumption across periods and wishes to consume more today. An unconstrained individual will only have a wealth increase which will be smoothed over the life-cycle. This difference causes the collateral effect to be a much larger and more important effect in amplifying and propagating shocks.

While a variety of metrics are used by banks to assess credit-worthiness, ratios that employ flows and expenditures are used to utilize the strengths of the Consumer Expenditure Survey's design. Because of this, the Debt-Service Ratio is used as the preferred measure of credit constraints. Households in the top 25% of the DSR distribution spend approximately 14 cents per $1 of home equity increase compared with unconstrained households who have negligible responses. Furthermore, households who extracted home equity in the past year are shown to have even larger responses, spending as much as 28 cents per $1 of home value increase. This provides some strong evidence that collateral effects are the primary driving force in explaining the propensity to consume out of housing wealth.

Given the evidence that home values affect household consumption and that national shocks to credit and money move home values, it is natural to see that housing markets are important in amplifying monetary shocks. Consumption responses are shown to vary substantially across housing supply elasticity measures and ownership rates across regions. Increasingly land constrained or tightly regulated MSA's see larger responses in consumption compared with more elastic housing supply cities. The total response of consumption arising due to the homeowner balance sheet channel is initially small, but the channel becomes increasingly important as house prices responses peak after 10-12 quarters.

Furthermore, substantial geographic heteregeneity is present in the responses of consumption. Coastal cities and those in the mountains see large responses in consumption while those in the Great Plains see smaller changes in spending. This is not to say that elastic-supply regions are unaffected by monetary policy. In fact, these regions see the largest responses in residential construction compared to coastal and mountainous regions. In addition, the heterogeneity of consumption and investment responses may have important implications for the allocation of resources across the country. Future work hopes to better understand the cross-sectional spillovers between elastic and inelastic-supply housing markets.

This paper establishes a clear link between monetary policy, house prices, and non-durable consumption behavior. It shows that monetary policy has heterogeneous impacts on non-durable expenditures through a homeowner balance sheet channel. In the process, it establishes patterns in the responses of home values to monetary shocks and provides a novel technique for identifying the propensity to consume out of housing wealth. Furthermore, it provides evidence for the importance of housing as collateral to constrained homeowners.

APPENDIX 2.A: Empirical Model as Partial Wold Form of VAR

Consider the VAR for the vector of aggregate variables Y_t^{agg} augmented by a household-level observation Y_t^{hh}. The assumption that household variables do not affect monetary shocks is captured by the exclusion restriction in the VAR given by:

$$\begin{bmatrix} A_{11}(L) & 0 \\ A_{21}(L) & A_{22} \end{bmatrix} \begin{pmatrix} Y_t^{agg} \\ Y_{it}^{hh} \end{pmatrix} = \begin{bmatrix} B_{11} & 0 \\ B_{21} & B_{22} \end{bmatrix} \begin{pmatrix} e_t^{agg} \\ e_{it}^{hh} \end{pmatrix}$$

The triangular exclusion restriction that $A_{12}(L) = 0$ allows the top block of the VAR to be separated from the bottom. Put differently, local or household-level variables do not enter the national VAR except through aggregates present in Y_t^{agg}. Therefore, the monetary authority is assumed to respond only to aggregate information, not individual or local variation unexplained by national aggregates. This assumption is supported both by the absence of local or distributional information from the Green Book Forecasts and other documents used by the FOMC when setting policy. Furthermore, the mandate of the Federal Reserve indicates stability in national aggregates rather than individual local markets.

Taking the top block alone, the national VAR can be estimated separately using only national aggregate data. Under stability conditions and the identifying restrictions discussed in the paper, aggregate variables will have a Wold Form and can be written as a moving average of structural shocks e_t^{agg}:

$$Y_t^{agg} = A_{11}^{-1}(L) B_{11} e_t^{agg}$$

This allows the lower block of the VAR, corresponding to household-level variables, to be written as a function of household variables and a distributed lag of aggregate shocks:

$$A_{22}Y_t^{hh} = C_1(L)e_t^{agg} + C_2 e_{it}^{hh}$$

where $C_1(L) = A_{21}(L)A_{11}^{-1}(L)e_t^{agg} + B_{21}$ and $C_2 = B_{22}$. Given that structural monetary shocks η_t are identified using the recursive formulation, these shocks can be separated from both non-monetary national shocks in e_t^{agg} and local shocks e_{it}^{hh}. Denoting $\tilde{e}_{it}$ as a vector of non-monetary shocks, we get:

$$A_{22}Y_t^{hh} = C_{11}(L)\eta_t + C_{12}(L)\tilde{e}_{it}$$

Finally, the use of MSA house price indices allows for the exclusion of any household's consumption from the house price equation. Denoting monetary shocks as η_t, house prices in the MSA of household i as $q_{i,t}$, and household i's non-durable spending as $c_{i,t}$, the above equation yields:

$$\begin{aligned} \Delta c_{i,t+1} - \beta_1 \Delta q_{i,t+1} &= \beta_2(L)\eta_t + \beta_3 \Delta x_{i,t+1} + u_{i,t+1} \\ \Delta q_{i,t+1} &= \gamma(L)\eta_t + \gamma_3 \Delta x_{i,t+1} + v_{i,t+1} \end{aligned}$$

The error terms $u_{i,t+1}$ and $v_{i,t+1}$ capture unobserved national and local shocks in $\tilde{e}_{it}$. This raises two issues. First, since $\eta_t \perp e_t^{agg}, e_t^{hh}$ based on the identification of monetary shocks in the VAR, it follows that $\eta_t \perp u_{it}, v_{it}$. This allows for identification of causal effects of monetary policy conditional on Δq and Δx. Total effects of monetary policy must account for the effect of monetary policy on Δq and Δx explicitly. Second, $u_{i,t}$ and $v_{i,t}$ are correlated within period and over time. Identification of β_1 requires an instrument for Δq that is exogenous to $u_{i,t+1}$ as discussed in the body of the paper.

APPENDIX 2.B: Standard Error Correction for Generated Regressors

The full model is specified as:

$$\begin{aligned}
\theta(L)Y_t &= \eta_t \\
\Delta c_{i,t+1} &= \beta \Delta q_{i,t+1} + \gamma_1(L)\eta_t^{hd} + \gamma_2 x_{t+1} + u_{it+1} \\
\Delta q_{i,t+1} &= \delta_1 inelast_i + \delta_2(L)\left\{inelast_i * \eta_t^{hd}\right\} + \delta_3(L)\eta_t^{hd} + \delta_4 x_{t+1} + \varepsilon_{it+1}
\end{aligned}$$

Simplifying notation, combine terms to form the following system:

$$\begin{aligned}
\eta_t &= \eta(\theta, Y_t) \\
y_{it} &= X_{it}\alpha + u_{it} \\
X_{it} &= Z_{it}\delta + \varepsilon_{it}
\end{aligned}$$

where $y_{it} = \Delta c_{it}$, $X_{it} = \begin{bmatrix} \Delta q_{it} & \eta_{t-L} & x_{it} \end{bmatrix}$, and $Z_{it} = \begin{bmatrix} inelast_i & \{inelast_i * \eta_{t-L}\} & X_{it} \end{bmatrix}$. Furthermore, since $\eta = \eta(\theta, Y_t)$, define each variable as a function of θ: $X_{it} = g_1(\theta)$ and

$Z_{it} = g_2(\theta)$. Let $\hat{X}$ and $\hat{Z}$ be defined as the variables evaluated at $\hat{\theta}$.

The variable of interest is α, and the goal is to derive correct standard errors for the plug-in 2SLS estimator for this variable.

Assumption 1: $\hat{\theta} \xrightarrow{p} \theta$ and $\sqrt{T}\left(\hat{\theta}-\theta\right) \xrightarrow{d} N\left(0, V_\theta\right)$ as $T \rightarrow \infty$ where $\hat{\theta}$ is the estimator for the SVAR parameters.

***Assumption 2*:** $\sqrt{\frac{N}{T}} \rightarrow k < \infty$where N is the total number of consumption observations and T is the length of the time series data used in the VAR. This is not unreasonable given sample sizes remain stable in the CE over time.

Assumption 3: $\eta(\theta, Y)$ is differentiable in θ such that $\sqrt{T}\left(\eta_t(\hat{\theta})-\eta_t(\theta)\right) \xrightarrow{d} N\left(0, \nabla\eta(\theta)' V_\theta \nabla\eta(\theta)\right)$

Assumption 4: $\hat{Q}_{ZX} = \frac{1}{N}\hat{Z}'\hat{X} \xrightarrow{p} E[Z'X] = Q_{ZX}$ and $\hat{Q}_{ZZ} = \frac{1}{N}\hat{Z}'\hat{Z} \xrightarrow{p} E[Z'Z] = Q_{ZZ}$

Assumption 5: $\frac{1}{N}\nabla g_2(\theta)' u \xrightarrow{p} E\left[\nabla g_2(\theta)' u\right] = 0$

The 2SLS estimator for α using the estimate $\hat{\theta}$ is:

$$
\begin{aligned}
\hat{\alpha} &= \left[\hat{X}'\hat{Z}\left(\hat{Z}'\hat{Z}\right)^{-1}\hat{Z}'\hat{X}\right]^{-1}\left[\hat{X}'\hat{Z}\left(\hat{Z}'\hat{Z}\right)^{-1}\hat{Z}'Y\right] \\
&= \alpha + \left[\hat{Q}'_{ZX}\hat{Q}^{-1}_{ZZ}\hat{Q}_{ZX}\right]^{-1}\hat{Q}'_{ZX}\hat{Q}^{-1}_{ZZ}\frac{1}{N}\sum_i\left(\hat{z}'_i(x_i-\hat{x}_i)\alpha + \hat{z}'_i u_i\right) \\
\sqrt{N}(\hat{\alpha}-\alpha) &= \left[\hat{Q}'_{ZX}\hat{Q}^{-1}_{ZZ}\hat{Q}_{ZX}\right]^{-1}\hat{Q}'_{ZX}\hat{Q}^{-1}_{ZZ}\frac{1}{\sqrt{N}}\sum_i\left(\underbrace{\hat{z}'_i(x_i-\hat{x}_i)\alpha}_{\text{Term 1}} + \underbrace{\hat{z}'_i u_i}_{\text{Term 2}}\right)
\end{aligned}
$$

Term 1 : $\frac{1}{\sqrt{N}}\sum_i \hat{z}'_i(x_i-\hat{x}_i)\alpha$**...** Plugging in $X = g_1(\theta)$

$$
\begin{aligned}
\frac{1}{\sqrt{N}}\sum_i \hat{z}_i{}'\left(f_i(\theta)-f_i(\hat{\theta})\right)\alpha &= \left(\frac{\sqrt{NT}}{\sqrt{NT}}\right)\frac{1}{\sqrt{N}}\sum_i(\alpha\otimes\hat{z}_i)'\left(f_i(\theta)-f_i(\hat{\theta})\right) \\
&= \frac{\sqrt{N}}{\sqrt{T}}\left[\frac{1}{N}\sum_i(\alpha\otimes\hat{z}_i)'\nabla f_i(\theta)\right]\sqrt{T}(\theta-\hat{\theta})+o_p(1) \\
&= k\hat{G}\sqrt{T}(\theta-\hat{\theta})+o_p(1)
\end{aligned}
$$

The MLE for θ is such that $\frac{1}{T}\sum_t s(\hat{\theta},Y_t) = 0$. Rearranging the Taylor expansion of this equation around θ (as in Murphy and Topel, 1985) gives...

$$
\sqrt{T}(\theta-\hat{\theta}) = -\frac{1}{\sqrt{T}}\left[\frac{ds}{d\theta}(\theta,Y)\right]^{-1}\sum_t s(\theta,Y_t)+o_p(1)
$$

Plugging this in above, you get...

$$
\begin{aligned}
\frac{1}{\sqrt{N}}\hat{Z}'\left(X-\hat{X}\right)\alpha &= -k\hat{G}\left[\frac{ds}{d\theta}(\theta,Y_t)\right]^{-1}\frac{1}{\sqrt{T}}\sum_t s(\theta,Y_t)+o_p(1) \\
&= -\hat{G}k\hat{H}^{-1}\frac{1}{\sqrt{T}}\sum_t s(\theta,Y_t)+o_p(1) \\
&= -\hat{G}\frac{1}{\sqrt{N}}\sum\hat{r}_i(\theta)+o_p(1)
\end{aligned}
$$

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[21] Simply summing $s(\theta,Y_{t_i})$ over i will give $\sum_i s(\theta,Y_{t_i}) = \sum_t ks(\theta,Y_{t_i})$ since each time t has k identical values $s(\theta,Y_t)$ associated with it, one for each $i\in\{i \text{ such that } t_i=t\}$. In practice, I can use $\frac{1}{\sqrt{N}}\sum_i s(\theta,Y_{t_i})$. Combining this with the Hessian matrix, define $\hat{r}_i(\theta)=\hat{H}^{-1}s(\theta,Y_{t_i})$.

Term 2 : $\frac{1}{\sqrt{N}}\sum_i \hat{z}_i' u_i = ...$

$$\begin{aligned}
\frac{1}{\sqrt{N}}\sum_i \hat{z}_i' u_i &= \frac{1}{\sqrt{N}}\sum_i g_i(\hat{\theta})' u_i \\
&= \frac{1}{\sqrt{N}}\sum_i g_i(\theta)' u_i + \left(\frac{\sqrt{N}}{\sqrt{T}}\right)\left(\frac{1}{N}\sum \nabla g_i(\theta)' u_i\right)\sqrt{T}\left(\theta - \hat{\theta}\right) + o_p(1) \\
&= \frac{1}{\sqrt{N}}\sum_i g_i(\theta)' u + O_p(1) o_p(1) O_p(1) + o_p(1)
\end{aligned}$$

by Assumption 5 above, the second term is also $o_p(1)$. This yields...

$$\frac{1}{\sqrt{N}}\hat{Z}' u = \frac{1}{\sqrt{N}} g_2(\theta)' u + o_p(1)$$

Combining all terms together, the estimator $\hat{\alpha}$ is given by ...

$$\begin{aligned}
\sqrt{N}(\hat{\alpha} - \alpha) &= \left[\hat{Q}_{ZX}' \hat{Q}_{ZZ}^{-1} \hat{Q}_{ZX}\right]^{-1} \hat{Q}_{ZX}' \hat{Q}_{ZZ}^{-1}\left(-\hat{G} k \hat{H}^{-1}\frac{1}{\sqrt{T}}\sum_t s(\theta, Y_t) + \frac{1}{\sqrt{N}}\sum_i g_2(\theta)' u_i\right) + o_p(1) \\
&\xrightarrow{d} \mathcal{N}(0, \Omega)
\end{aligned}$$

where

$$\Omega = \left[Q_{ZX}' Q_{ZZ}^{-1} Q_{ZX}\right]^{-1} Q_{ZX}' Q_{ZZ}^{-1} M Q_{ZZ}^{-1} Q_{ZX}\left[Q_{ZX}' Q_{ZZ}^{-1} Q_{ZX}\right]$$

and

$$\begin{aligned}
M &= E\left[(z_i' u_i - G r_i)(z_i' u_i - G r_i)'\right] \\
&= E\left[z' u u' z - z' u r' G' - G r u' z + G r r' G\right] \\
&= E[z' V z - z' u r' G' - G R u' z + G G']
\end{aligned}$$

Figures and Tables

Figure 2.7.1: Local House Prices and Housing Starts for Select MSA's

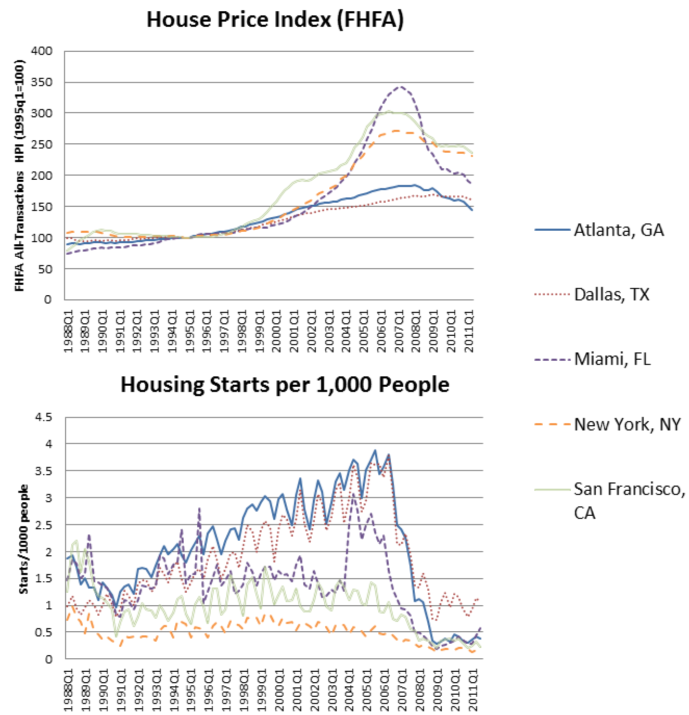

Figure 2.7.2: Housing Supply Elasticity vs House Price Growth

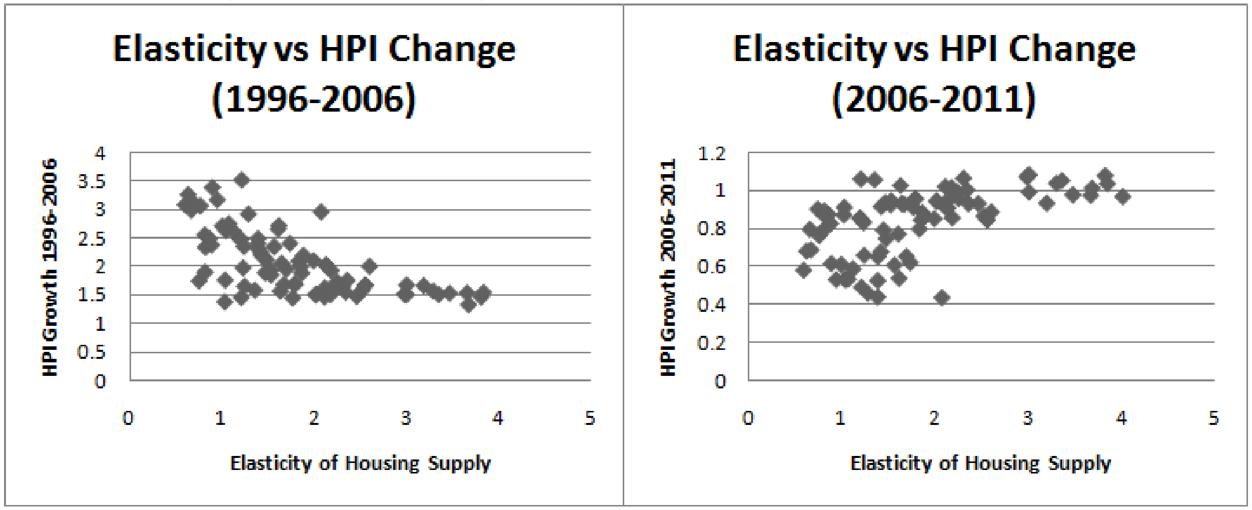

Figure 2.7.3: Housing Supply Elasticity Measures: Land Availability & Zoning Regulations

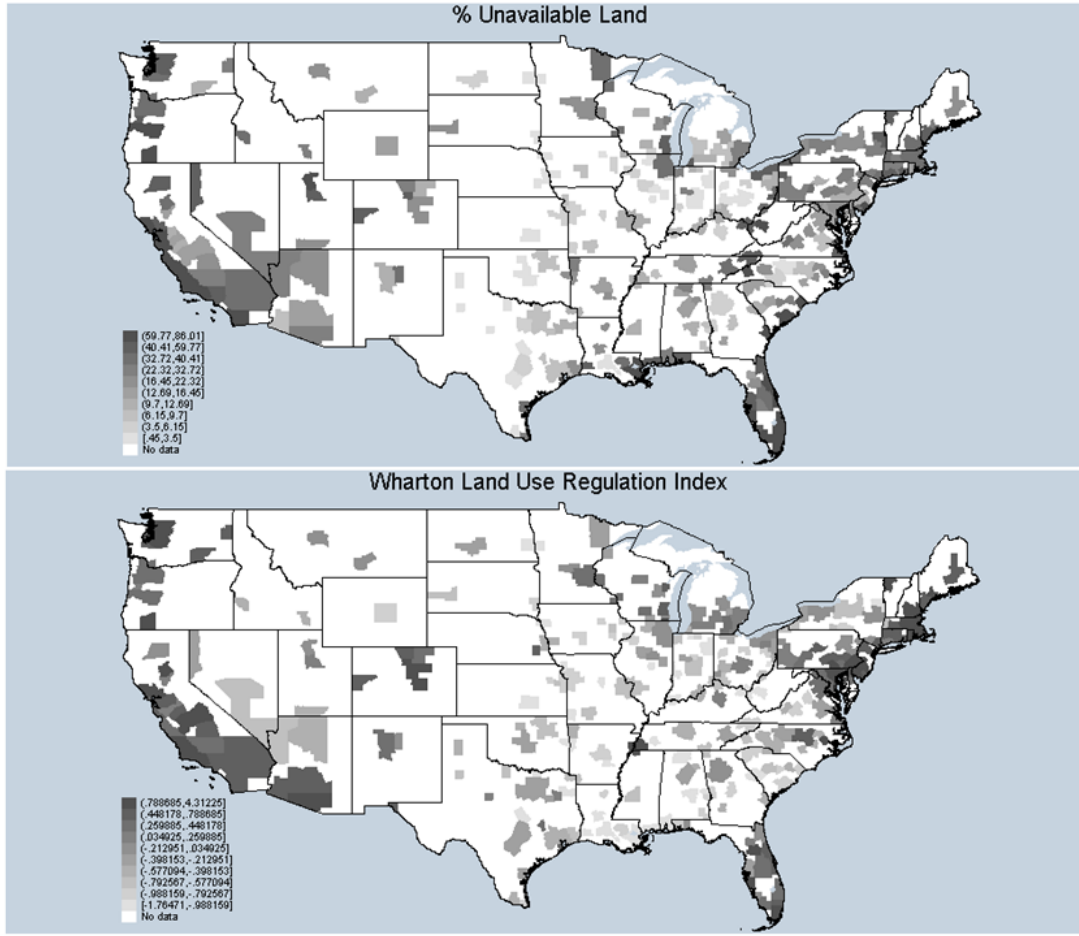

Figure 2.7.4: Comparison of National House Price Indices

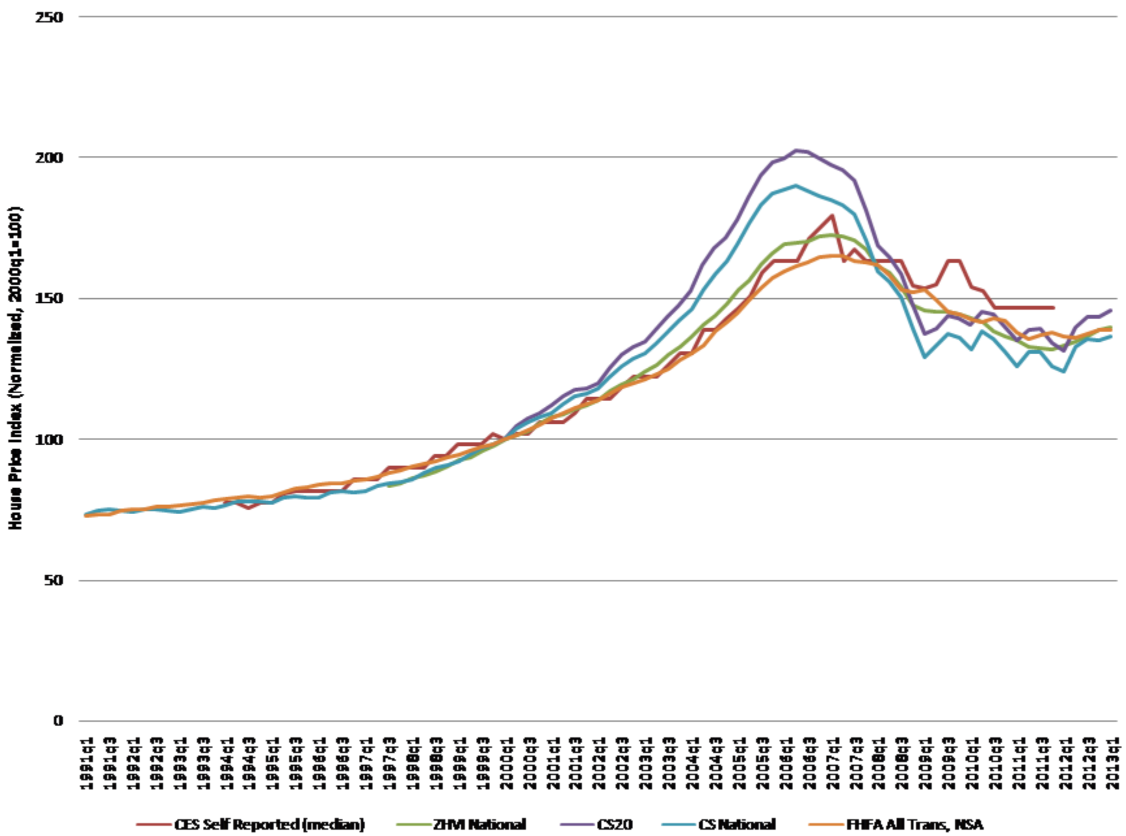

Figure 2.7.5: Time Series of Identified Monetary and Credit Shocks

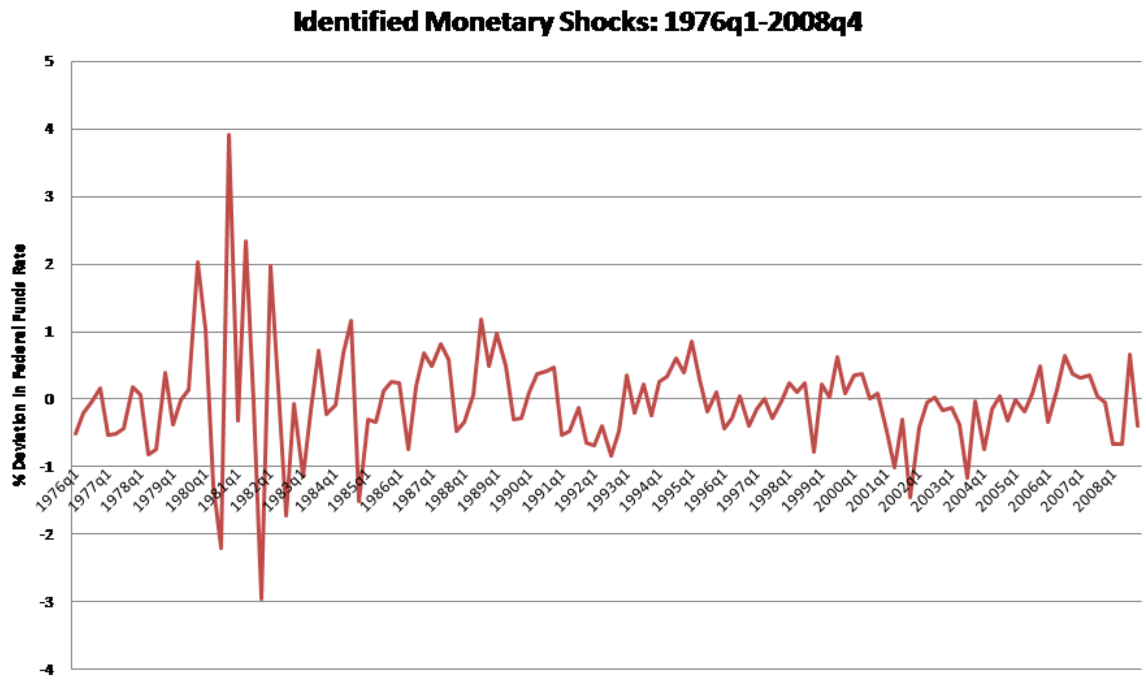

Figure 2.7.6: HPI Responses to 1sd Monetary Shock

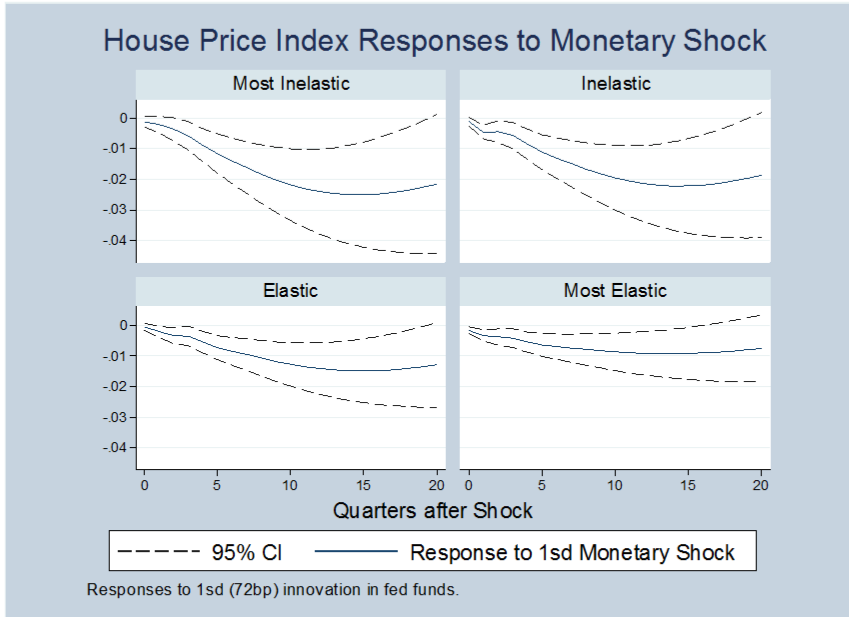

Figure 2.7.7: Spending Responses to 1sd Monetary Shock by Elasticity Measures

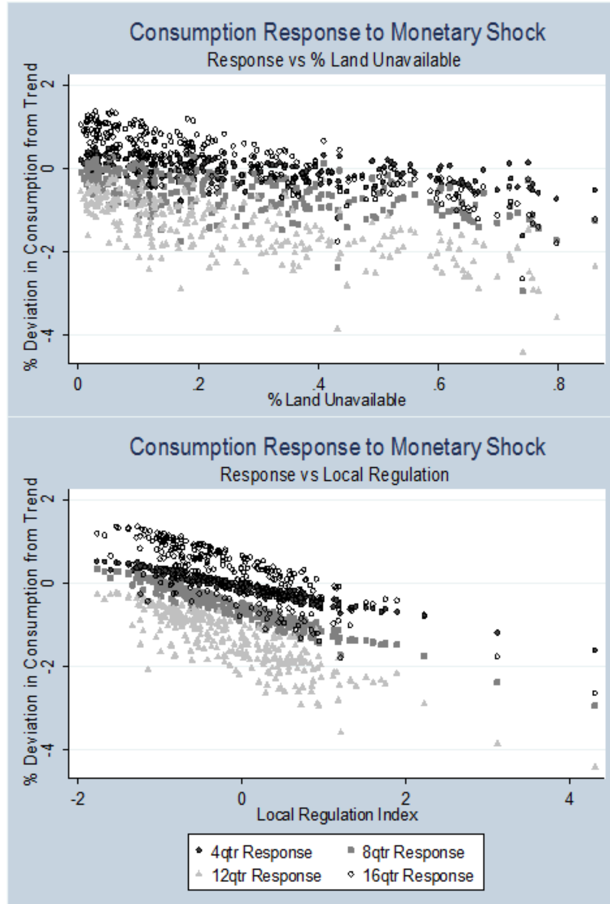

Figure 2.7.8: Map of Heterogeneous Spending Responses to 1sd Monetary Shock

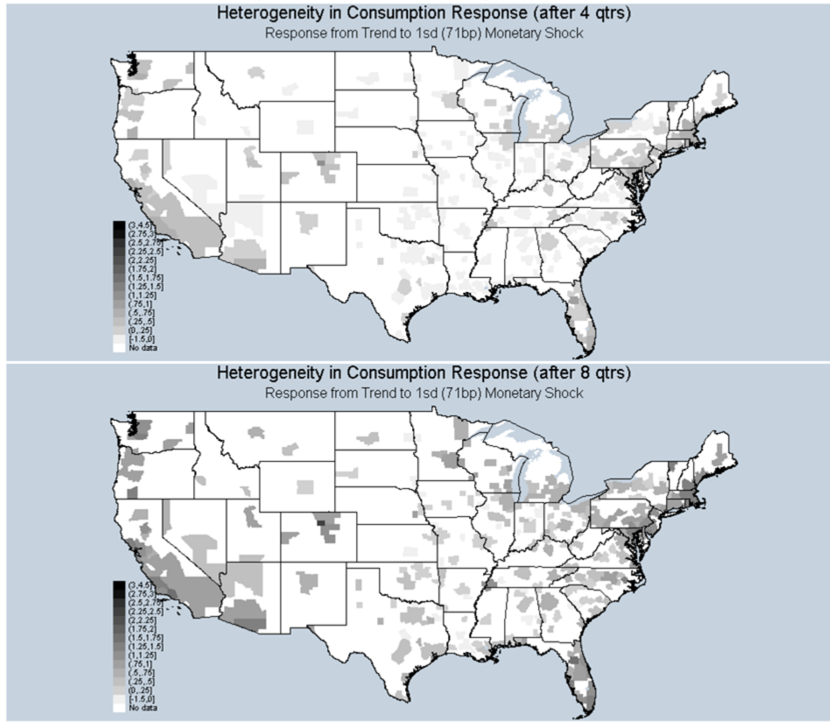

Figure 2.7.9: Map of Heterogeneous Spending Responses to 1sd Monetary Shock

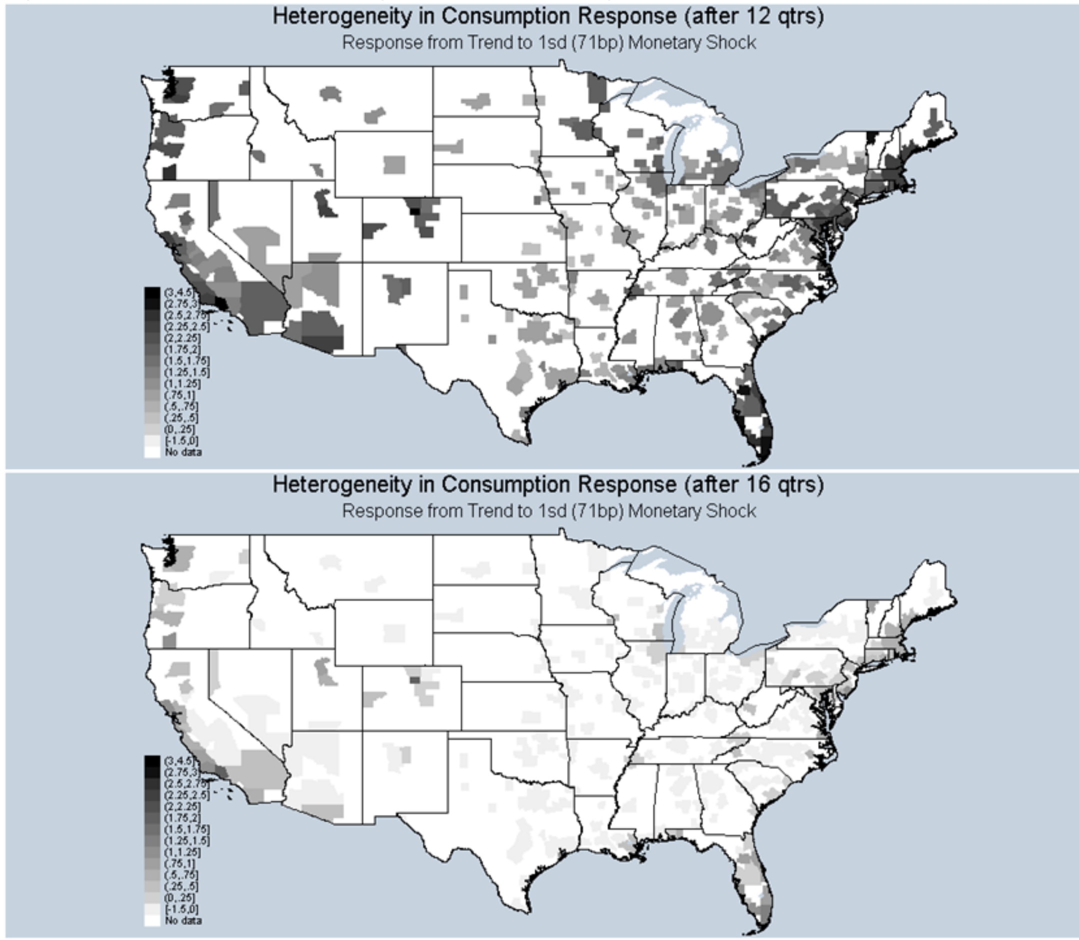

Table 2.1: Consumer Expenditure Survey Summary Statistics by Elasticity

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

Table 2.2: Land Availability, Regulation, and Supply Elasticity Measures of Select Large MSA's (Saiz, 2010)

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

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

Table 2.3: Consumption-Housing Elasticity Estimates - Baseline Consumption Growth Regressions

	(1) Owners Only	(2) Owners w/ Mtg Only	(3) Renters Only	(4) All Households
House Price Growth	1.503***	1.077***	-0.00227	0.178
	(0.400)	(0.404)	(0.447)	(0.295)
Household Inc. Growth	0.0235***	0.0326***	0.0174***	0.0239***
	(0.00552)	(0.00635)	(0.00609)	(0.00456)
Local Inc. Growth	-0.0171	-0.224*	0.238*	0.139*
	(0.111)	(0.129)	(0.123)	(0.0798)
Age	-0.104**	-0.136**	0.0360	0.0163
	(0.0442)	(0.0598)	(0.0727)	(0.0425)
Age^2	0.00139***	0.00154**	0.000202	0.000231
	(0.000394)	(0.000622)	(0.000699)	(0.000400)
Chg. Family Size	9.932***	7.200***	6.655***	7.296***
	(0.896)	(0.998)	(0.929)	(0.709)
Observations	24,270	16,741	10,345	34,615

All regressions also include qtr. dummies & direct effects of monetary shocks.
Standard errors in parentheses are clustered at MSA-level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.4: Consumption-Housing Elasticity Estimates - Collateral Constraints
Consumption Growth Regressions (Constrained vs Unconstrained)

	(1)	(2)	(3)	(4)	(5)
	Baseline Owners	Constrained (high DSR)	Unconstrained (low DSR)	Increased Home Debt	No Increase Home Debt
House Price Growth	1.503***	2.857***	-0.0655	3.569***	1.389***
	(0.400)	(1.028)	(0.495)	(1.203)	(0.374)
Household Inc. Growth	0.0235***	0.0516***	0.0188**	0.00943**	0.0544***
	(0.00552)	(0.0103)	(0.00845)	(0.00468)	(0.0111)
Local Inc. Growth	-0.0171	0.252	0.131	-0.592**	-0.123
	(0.111)	(0.310)	(0.0967)	(0.260)	(0.127)
Age	-0.104**	-0.900***	0.124**	-0.253*	0.0365
	(0.0442)	(0.139)	(0.0542)	(0.137)	(0.0632)
Age^2	0.00139***	0.00966***	-0.000607	0.00257*	0.000167
	(0.000394)	(0.00146)	(0.000488)	(0.00143)	(0.000603)
Chg. Family Size	9.932***	0.803	7.516***	10.63***	7.988***
	(0.896)	(1.893)	(1.120)	(1.570)	(1.108)
Observations	24,270	3,496	14,700	3,586	15,273

All regressions include qtr. dummies & direct effects of monetary shocks.
Standard errors in parentheses are clustered at MSA-level
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2.5: Consumption-Housing Elasticity Estimates - Select Robustness Checks

Consumption Response (Selected Robustness Checks)					
	(1) Asset Returns	(2) No Local Inc. Growth	(3) Pre-tax Labor Inc.	(4) Expected Inc. Growth	(5) Zillow House Prices
House Price Growth	1.533***	1.070***	1.917***	0.756*	0.962***
	(0.401)	(0.387)	(0.351)	(0.406)	(0.160)
Household Inc. Growth	0.0245***	0.0294***		0.0316***	0.0463***
	(0.00555)	(0.00599)		(0.00630)	(0.00608)
Local Inc. Growth	0.00274		-0.122		
	(0.112)		(0.102)		
Pre-Tax Labor Inc. Growth			0.0601***		
			(0.00693)		
Exp. Local Inc. Growth				-0.0231	-0.149**
				(0.0799)	(0.0629)
10-yr Treasury Return	0.653***				
	(0.123)				
1year SP500 Return	-0.00984				
	(0.0173)				
Observations	24,270	27,979	18,711	24,320	12,864

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

CHAPTER 3

Home Equity Extraction and Consumption over the Life Cycle

3.1 Introduction

The relationship between household consumption and house prices over time is evident in the macrodata. Figure 3.5.1 depicts annual growth in personal consumer expenditures and the FHFA house price index since 1999. A correlation between the variables is evident over these years, and the link appears especially pronounced in the recent downturn. By using a longitudinal panel of households from the PSID linked to geographic housing market data, this paper attempts to establish a causal link between the two variables and better understand the mechanisms through which house price fluctuations affect household borrowing and consumption behavior.

This relationship between home values, consumer credit, and consumption can arise for several reasons (Attanasio et al., 2009; Campbell and Cocco, 2007). First, the correlation may be driven by a common macroeconomic factor such as expectations of income growth. High income growth expectations would result in an increase in consumption and housing demand financed by borrowing though there may be no causal link between housing and consumption. Secondly, rising home values may result in wealth effects for homeowners. These effects are complicated by the fact that increased home values also raise the cost of living, but positive wealth effects are likely to increase the spending and borrowing of net sellers of housing or decrease spending and borrowing for net buyers. Finally, homeowners may use their homes as a source of collateral. Rising home values may put collateral in the hands of credit-constrained homeowners, thereby increasing borrowing and spending.

To identify consumption and borrowing responses to house price fluctuations, I link PSID households to housing market data using non-public geographic identifiers. The use of geographically-linked data provides a basis to construct a natural experiment comparing homeowners living in elastic-supply housing markets to those living in inelastic-supply housing markets. Households are linked to measures of local geographic constraints and zoning regulations that explain the majority of cross-sectional heterogeneity in MSA-level housing supply elasticity (Saiz, 2010). Cities with relatively inelastic supply such as San Francisco or Miami experienced dramatic house price fluctuations during the housing bubble relative to land-rich, elastic-supply cities such as Dallas or Atlanta. Between the 1999 and 2005 waves of the PSID, house price grew by an average of 66% across the country, varying from as low as 25% in land-rich areas such as Dallas with to as much as 130% or more in tightly regulated and geographically constrained markets such as San Francisco (see Figure 3.5.2). While expectations may drive housing demand in both types of markets, home values will rise more dramatically in inelastic supply markets. The difference between these markets allows me to identify the marginal propensity to borrow and consume out of housing arising from wealth and collateral effects.

Interactions between interest rates and the housing supply elasticity measures provide instruments for house prices when estimating consumption and borrowing responses. Under the assumption that consumption and borrowing behavior does not vary systematically with local geography or zoning laws, the use of these instrument identifies the marginal propensities to borrow and consume out of housing wealth.

Geographic data also allows me to connect both renters and homeowners with local house prices. The PSID only collects self-reported home values from homeowners, while renters only report their monthly rents. By linking both owners and renters to measures of local house prices, this paper identifies the responses of both types of households to changes in house prices. While only owners can have collateral effects from rising home values, both groups are affected by common macroeconomic shocks that may drive common trends between the variables. Therefore, the fact that renters in the PSID have no significant consumption response to local house prices provides a validity test for the instruments used.

Results are consistent with the existence of important wealth and collateral effects in driving correlations between consumption and house prices in the past several years. By using local geography and zoning regulations as instruments for house price growth during the period, this paper exploits heterogeneity in local housing supply to identify a marginal propensity to consume out of housing wealth of 0.04-0.05, with no significant effects on spending for renters. This spending is financed by an increase in household debt as evidenced by an estimated marginal propensity to borrow out of home equity of 0.24-0.32.

These results are consistent with other findings in the literature. Mian and Sufi (2011) find that households borrowed up to \$0.25 for an additional dollar of home equity during the 2000's. Similarly, Aladangady (2014) shows that households increased consumption by \$0.06-\$0.09 for each dollar increase in home values. The results of these two papers are suggestive of a mechanism through which housing affects consumer credit and thereby stimulates spending. Rising home values provide collateral to homeowners and lower the cost of credit, thereby allowing them to increase spending. In this paper, I use data on both homeowner borrowing behavior and consumption patterns to provide direct evidence of this channel showing that consumption increases were driven primarily by those homeowners who extracted equity from their homes.

The second main contribution of this paper involves analyzing households' use of home equity over the life-cycle. Doing so provides a test of the relative importance of wealth and collateral effects in driving the link between housing and consumption. This test exploits the fact that wealth and collateral effects imply different MPC's out of housing over the life-cycle.

Households tend to have a hump-shaped housing wealth profiles over the life-cycle (Flavin and Yamashita, 2002). This hump-shaped life-cycle profile implies that households are natural buyers of housing when young as family sizes grow and household move to increasing larger and more expensive homes. As households age, family sizes shrink once again and households are natural sellers of housing as they downsize to smaller homes in retirement and old age. The fact that households are natural buyers or sellers at various points in their life-cycle induces positive wealth effects for older net sellers of housing and negative effects for younger net buyers. Furthermore, older households who are natural sellers of housing and have fewer years over which to smooth consumption are likely to have substantially larger responses to rising house prices compared to younger net buyers.

If wealth effects are strong, this life-cycle profile would imply MPC's that rise with age. On the other hand, collateral effects imply an opposite pattern in consumption responses over the life cycle. Younger households who have fewer liquid assets and rising income paths tend to be more credit constrained than their older counterparts. Rising house prices may relax borrowing constraints for these homeowners by providing them with additional collateral.

Therefore, strong collateral effects would induce a falling MPC out of housing over the life-cycle as homeowners rely less on home equity to smooth consumption as they age.

While a formal decomposition of MPC's into the collateral and wealth effect would require a much more sophisticated model, the change in marginal propensities to consume out of housing over the life-cycle provide a convenient test for the relative importance of the two effects determines whether MPC's rise or fall with age. Rising MPC's as households age would imply the link between housing and consumption is largely driven by wealth effects whereas falling MPC's would suggest collateral effects are a more dominant factor.

Estimated MPC's suggest a slight decline in consumption responses as households age. Homeowners under 40 have an MPC of 0.08 from home equity compared an MPC of 0.04 for households approaching retirement age and beyond. These results are suggestive of collateral effects dominating wealth effects over the life cycle.

The distinction between these types of effects is important when considering the aggregate implications of house price changes. Collateralized lending likely arises due to agency costs between borrowers and lenders. For example, young homeowners may be unable to commit to repayment despite having rising income streams since they are unable to credibly commit to providing labor in the future. Collateral provides them with a means to insure their lenders against default. Therefore rising collateral values can be welfare improving by mitigating agency costs.

Furthermore, increases in the value of this collateral may loosen borrowing constraints allowing constrained households to more easily smooth consumption. Credit constrained households are likely to have a very high MPC as loosening borrowing constraints allows them to move closer to their first-best consumption path. This can result in very large aggregate effects relative to largely redistributive wealth effects.

The next section provides a review of related literature and discusses the contributions of this paper. Section 3 describes the geographically linked PSID data used in this study. Section 4 details the identification strategy used to estimate the causal effects of house price growth on borrowing and consumption. It then uses heterogeneity in marginal propensities to consume over the life-cycle to provide evidence that collateral effects, and not wealth effects, are the dominant factor driving the link between home values and consumption. Finally, Section 4 discusses the results and concludes.

3.2 Literature Review

Results in this paper primarily build on work by Mian and Sufi (2011) and in Chapter 2 by establishing a link between home equity, household debt, and consumption. Mian and Sufi (2011) finds that homeowners extract as much as $0.25 for a dollar of home equity at the margin during 2002-2006. This combined with results from Chapter 2 that household consumption responds to local house values implies the existence of a channel through which home values cause home equity extraction which is used to finance consumption. Using data on local housing markets, household balance sheets, and consumption, this paper establishes the link between these three variables in a single data set.

The identification strategy used in all three of these papers relies on two measures of local housing supply elasticity: local land availability from Saiz (2010) and a measure of MSA-level zoning regulations from Gyourko et al. (2008). The two measures jointly explain the majority of cross-sectional variation in housing supply elasticity across the US (Saiz, 2010) and have been used in a variety of studies to construct instruments for house price growth

Mian and Sufi (2011); Chaney et al. (2012); Kermani (2013); Mian et al. (2013).

Several studies have attempted to tackle the relationship between housing wealth and consumption in the past. Hurst and Stafford (2004) use PSID data to analyze consumption smoothing and financial motives involved in the household decision to refinance. They find that liquidity constrained households are very likely to extract home equity after an employment shock. In addition, they show that little of this equity is converted to active savings, implying much of it is used to finance spending in subsequent years. These results are confirmed in this paper using the new PSID consumption data from 1999 onwards. I find households extract as much as $0.18-0.25 home equity for a $1 increase in home values. Furthermore, those who extract equity have a large MPC out of housing wealth, and hence convert much of their equity extraction into spending within subsequent years.

Cooper (2009) also uses the PSID to identify the propensity to consume out of housing and non-housing wealth. He finds that households increase spending by as much as $0.06 for a dollar in home values, often financed by equity extraction. This paper builds on this work by providing a natural experiment that is robust to common macroeconomic factors that may drive both consumption and home values to rise together. Consumption responses estimated using the IV approach in this paper provides slightly smaller, but still significant, consumption responses, confirming these results in a more robust specification. Furthermore, by identifying the heterogeneity in MPC's across the life-cycle, this paper provides a test of the relative contributions of wealth and collateral effects in driving this relationship.

Results in the literature on the relative importance of these two effects have been mixed. Campbell and Cocco (2007) find positive MPC's for older households and small, and statistically insignificant MPC's for renters using cross-sectional data on consumption from the Family Expenditures Survey in UK. They then test if predictable house price movements affect consumption, and find that while national house prices cause consumption growth, there is no direct link between predictable local home values and spending. This is indicative of a common factor driving the relation between the two variables. By using local geography and zoning regulations as instruments for house price growth, this paper controls for this common factor allowing me to identify the MPC out of housing wealth.

A related paper by Attanasio et al. (2009) also uses the Family Expenditures Survey to analyze the link between housing and consumption. Like this paper, the authors find that the MPC out of housing falls with age, but are unable to control for common factors driving both variables. While this likely contributes to the correlation between these variables, results using local housing supply elasticity variables presented here provide strong evidence that it is not the only effect at play.

Case et al. (2005) analyze a state-level panel of aggregate housing stock, financial wealth, and consumption to understand the links between different forms of wealth and spending. While their estimates cannot rule out common factors, they find a strong link between housing wealth and consumption that is largely absent in financial wealth. These results are suggestive of a collateral channel, consistent with the findings of this paper.

Sinai and Souleles (2005) show that homeownership decisions are often made in an effort to hedge rental market risk. They argue that all households are "short" housing services since they require a home in which to live. Homeowners, therefore, are hedging this risk by purchasing the home in which they live. This argument is important when considering the importance of wealth and collateral effects of housing. House price increases increase the wealth of homeowners, but also increase the cost (or opportunity cost) of renting housing services. Therefore, only net buyers or sellers are likely to have strong wealth effects.

Comparing MPC's out of housing wealth over the life-cycle can provide a test of the importance of such wealth effects since households tend to accrue housing over the early part of the life-cycle and downsize in old age (Flavin and Yamashita, 2002). Older households are more likely to downsize and, in the absence of beneficiaries, are more responsive to wealth shocks as they have fewer years over which to smooth consumption. An alternative scenario, also consistent with the model of Flavin and Yamashita (2002), is that young households are more credit constrained, and hence more likely to use home equity to smooth consumption. This would imply falling MPC's over the life cycle. Results from this paper point to the latter scenario being a dominant mechanism in the link between housing and consumption.

While the use of home equity has been primarily studied in the consumption literature, recent studies apply similar methods to find that firms use residential real estate to smooth investment financing. Chaney et al. (2012) analyze investment behavior across firms who own and rent their headquarters in various real estate markets. Like this study, they compare investment responses following an increase in house prices across elastic and inelastic supply real estate markets to find that small firms who rely on bank credit increase investment in response to house price increases. A similar study by Schmalz et al. (2013) shows that French entrepreneurs were more likely to invest in a new business if they had access to home equity. Those with real estate in Paris and areas with high price growth were substantially more likely to start a new business than those in other parts of the country.

3.3 Data

3.3.1 Expenditure and Wealth Data in the PSID

The PSID is a longitudinal panel of individuals and households from 1968 to present in a series of annual, and later biannual, interview waves. The original sample included approximately 5000 families and has been supplemented over time as the original sample members and their children have formed new households and gotten married. Interviews collect a variety of data on income, labor, and financial information in addition to consumption data available after 1999. This paper focuses on a sample of 2-year waves from 1999 to 2011 containing the new consumer expenditure modules and including over 7000 families tracked over the period. It also uses a longer panel from 1984-2011 on home values and mortgage debt to estimate the prevalence of home equity extraction.

The PSID is used in this study for several reasons. First, the longitudinal nature of the PSID offers several benefits over alternate datasets on consumption such as the Consumer Expenditure Survey (CES). Households in the CES are interviewed for at most 4 quarters before they are rotated out of the sample. This makes the analysis of long-run consumption responses rather difficult. Given that a large time and effort cost is associated with refinancing or acquiring new home-equity-based credit, it is unlikely that the full response to a house-price change is observed within this one year span. Furthermore, unlike the CES, households are tracked across moves allowing for the analysis of wealth effects arising from up-sizing or down-sizing housing wealth. The PSID allows the ability to track individuals over a longer period and better track consumption changes in response to house price changes, refinancing, and moves that may have occurred over a year ago.

Secondly, the PSID offers a superior survey design with higher response rates and accuracy than the CES and other surveys. For example, the households are allowed to choose a reporting period for expenditures. This prevents households from having to scale up mortgage payments or grocery bills to annual amounts, and instead report them on a weekly or monthly basis. Furthermore, non-response households are provided the opportunity to report ranges of possible expenditure amounts through the use of "unfolding brackets" allowing the PSID to provide imputed consumption measures for non-response households. Finally, the survey non-response rate is extremely low with over 97% responding to most consumption questions. Altogether, this likely reduces measurement error and non-response bias relative to other surveys.

The start of the sample period is constrained by the availability of comprehensive consumption data. Prior to 1999, the PSID only contained limited information on food, housing, and child-care costs. While several studies have used these measures to impute broader measures of spending (Cooper, 2010), such methods have been criticized in the literature. For example, Attanasio and Weber (1995) show that the elasticity of intertemporal substitution is poorly estimated when using food as a proxy for total non-durable expenditures. This is caused by non-separability of food from other expenditures, the fact that food is a necessity while other goods are not, and the fact that the relative prices of food fluctuate over time. Since business-cycle fluctuations in imputed aggregate spending values are likely driven by food expenditures rather than demographics, these measures are poorly suited for the purposes of this paper.

Starting in 1999, the PSID began collecting data on several broad categories of household spending. In addition to food, housing, and childcare questions asked prior to 1999, questions on transportation expenditures, education, and healthcare were added.[22] The baseline consumption measure used in this study is an aggregate of all consumption categories asked in the PSID as of 1999. These include total spending on food, shelter, transportation, education, childcare, and health. Together, these categories comprise 72% of expenditures reported in the Consumer Expenditures Survey (CES) and align closely with each spending category over the time frame (Geng Li, 2010).

In addition to consumption data, the PSID provides data on sources of household income and wealth in higher detail than the CES. Households are asked questions about pre-tax income from jobs, businesses, and assets for the head, spouse, and other members of the household. These numbers are aggregated to a family-level pre-tax income. Due to changes in the PSID's procedures for imputing tax liabilities across waves, I use NBER's TaxSim program to consistently estimate federal and state tax liabilities for each household based on their filing status, pre-tax labor and asset income, and various deductions reported in the survey. After-tax income, as estimated by the TaxSim program, are used as the primary measure of income. Use of pre-tax income levels does not affect results substantively.

The PSID also includes wealth supplements asked every 5 years prior to 1999 and in each 2-year wave thereafter. These questions collected data on both levels and changes in the family unit's net wealth in cash and liquid assets, stocks, annuities/pensions, real estate, businesses, vehicles, and other savings or debt. These variables provide a picture of the household's financial and housing wealth and debts, and allow me to better control for variations in non-housing wealth over time.

[22] A more comprehensive set of measures were added in 2005, including home repairs and furnishings, clothing, vacation trips, and recreation. These categories comprise nearly all spending covered by the CES, but are only available during the short time-frame from 2005-2011. Unfortunately, these data provide only a limited time series that overlaps largely with a single economic downturn.

3.3.2 Geographically Linked Housing Market Data

This study incorporates various geographic data on local housing markets linked to households using the PSID restricted-access geocodes. Each household's zip-code, county, and metropolitan statistical area (MSA) are used to link them with two types of data: measures of land availability and zoning restrictions, and local house price histories.

Land availability and zoning regulation measures are taken from Saiz (2010) and Gyourko et al. (2008) respectively. Saiz (2010) uses topographic terrain maps of each MSA in the US to compute the proportion of land lost to water or steep slopes in a 40km radius around the city center of the first-named city in the MSA. This provides a measure of constraints on land resources that can be used for construction of new homes. Gyourko et al. (2008) collect survey data on the financial and time costs of acquiring permits and beginning construction to develop an index for the strictness of zoning regulations by MSA. These two measures account for the majority of the heterogeneity in MSA-level housing supply elasticity (Saiz, 2010).

The use of MSA-level measures of housing supply elasticity is important. Housing is more likely to be substitutable within an MSA than across MSA's. Since MSA's are defined by economic and cultural ties, households are likely to move between adjacent municipalities in an MSA. This causes limited land availability in San Francisco to affect not only house prices in San Francisco, but also in Mountainview or Oakland. On the other hand, it is less likely that land availability in San Francisco would affect home values in Chicago as few households would consider housing Chicago to be a substitute for housing in San Francisco. To avoid such spillovers, housing supply measures are taken at the MSA-level.

In addition to these measures of housing supply elasticity, I link households to a history of their county-level house price taken from Zillow Research. Zillow is a company specializing in providing real estate information to households, brokers, and researchers. The company collects transactions-level data from county tax offices on the prices and characteristics of the homes sold in the county. Zillow uses a proprietary hedonic pricing model to construct a house price estimate for all homes in the county, and price estimates are aggregated to a county level. The model explicitly accounts for differences in the housing stock sold each period to avoid composition bias. Price estimates are then aggregated to a county level to provide a house price index for the county.

These indices closely match Case-Shiller indices, but are available at a more disaggregated level and cover a larger portion of the US. Furthermore, unlike Federal Housing Finance Agency (FHFA) indices which exclude data on subprime and non-conforming mortgages, the Zillow indices cover the universe of homes. The advantage of Zillow home value indices is the richness of the data-set that underlies these indices. Unlike FHFA which uses only conforming loans data from Fannie Mae to construct its index, Zillow uses transactions data from county registrars which include all sub-prime, jumbo, and cash transactions. This causes FHFA indices to understate the magnitude of the recent housing boom and likely understate responses of house prices to various shocks. Furthermore, Zillow's public data covers a substantially larger geographic region than Case-Shiller's 20-city public use indices.[23]

3.4 Home Equity Extraction and Consumption

The primary goal of this paper is to identify the causal effect of house price fluctuations on household borrowing and consumption. The correlations between these variables is evident

[23]Core Logic provides a richer set of Case-Shiller Indices at a larger geographic coverage, but is only available for purchase.

in Figure 3.5.1, and is especially pronounced in the recent housing bubble and downturn. This correlation can arise for a variety of reasons, and the distinction between various types of mechanisms that link housing, credit, and spending is important in understanding causal effects or policy implications of these results.

The literature has described three broad mechanisms that may drive a correlation between house values, credit, and consumption (Sinai and Souleles, 2005; Campbell and Cocco, 2007; Attanasio et al., 2009). First, the correlation between these variables may be driven by a common macroeconomic factor such as expectations of income growth. I refer to this as the "common factor" mechanism. Secondly, rising home values may provide homeowners, namely natural sellers of housing, with positive "wealth effects". The opposite is true of natural buyers of housing who suffer negative wealth shocks. Finally, rising home values can cause a "collateral effect" by providing credit-constrained homeowners with additional collateral that can be used to increase mortgage debt and smooth consumption.

Causality cannot be inferred from correlations like those in Figure 3.5.1 due to the existence of a "common factor" mechanism. Econometrically, this amounts to an omitted variable bias that causes home values to be endogenous in the consumption equation. For example, high income growth expectations would result in an increase in consumption and housing demand financed by borrowing. Since current income levels are unchanged, these increases would be financed by borrowing, resulting in a simultaneous increase in home values, consumer credit, and expenditures. In the absence of an observed measure of expectations, correlations between consumption, credit, and housing would not yield meaningful causal relationships between these variables. The identification strategy presented in this section will attempt to eliminate this channel to identify a causal link between housing, credit, and spending.

Parsing wealth and collateral effects is complicated by the fact that the two effects are often not mutually exclusive. Rising home values may cause wealth effects, but simultaneously relax borrowing constraints. Even households who are not currently credit constrained may be affected by expectations of future borrowing constraints (Carroll and Kimball, 1996). A formal decomposition of the two effects would require a theoretical model specifying how households form expectations about future home values and borrowing constraints. Instead, I exploit heterogeneity in MPC's over the life-cycle to test for the relative importance of the two effects.

The remainder of this section is separated into three parts. First, I present an identification strategy that exploits regional heterogeneity in local geography and zoning laws to estimate marginal propensities to borrow and consume out of housing. Next, I present baseline estimates of marginal propensities to borrow and consume out of housing wealth and provide a series of robustness checks to address potential concerns with the identification strategy used. Finally, I provide a test of the relative importance of wealth and collateral effects by exploiting differences in MPC's over the life-cycle.

3.4.1 Identification of Marginal Propensities to Borrow and Consume

I estimate the propensity to borrow or consume out of housing by specifying each outcome, mortgage debt or consumption, as:

$$y_{it} = \beta_0 + \beta_1 q_{it} + \beta_2 X_{it} + \varepsilon_{it} \tag{3.4.1}$$

where the outcome y_{it} is either household i's (annualized) consumption or mortgage debt level at year t, q_{it} is the value of housing owned by the household, X_{it} is a set of controls including age, family size, and income, and ε_{it} is an unobserved error term. The unobserved error ε_{it} is assumed to have a form $\varepsilon_{it} = f_t + f_i + u_{it}$ where f_t is a time-fixed effect component, f_i is a household-level fixed effect component, and u_{it} is an idiosyncratic error term.

The marginal propensity to borrow (MPB) or marginal propensity to consume (MPC) are given by β_1 when y_{it} is specified as mortgage debt or consumption, respectively. As mentioned previously, identification of β_1 relies on appropriately controlling for unobserved idiosyncratic components, such as expected income growth, that may drive both q_{it} and y_{it}. In terms of the model given by (3.4.1), this gives rise to a correlation between the unobserved component u_{it} and home value q_{it}.[24]

This paper utilizes heterogeneity in MSA-level geography and zoning regulations to develop a consistent estimate of β_1 using instrumental variables (IV). The IV estimator rests on the assumption that national-level shocks to housing demand result in heterogeneous house price responses depending on local housing supply elasticity. For example, falling interest rates raise demand for mortgages across the country, thereby increasing demand for housing. These demand shifts result in heterogeneous house price changes depending on local housing supply elasticity. In a city like Dallas, with lax zoning regulations and plentiful flat land, new construction absorbs this demand and house prices remain relatively steady. On the other hand, in a city like San Francisco with stringent zoning regulations and limited land due to the presence of water and mountains, construction is costly and house prices rise.

[24] It is important to point out that national-level common factors are likely removed by the inclusion of time fixed effect terms f_t. Nonetheless, local labor markets and housing markets are likely linked. For example, discovery of shale gas in Pennsylvania probably raises both expected incomes and the value of homes in the area, but is not captured by a time fixed effect.

This implies that interactions between national-level demand shifter, r_t, and MSA-level land availability and zoning regulation measures, z_i, (from Saiz, 2010) can be used as instruments for q_{it}. The 2-stage system to be estimated is given by:

$$y_{it} = \beta_0 + \beta_1 q_{it} + \beta_2 X_{it} + f_t + f_i + u_{it} \tag{3.4.2}$$

$$q_{it} = \gamma_0 + \gamma_1 r_t z_i + \gamma_2 z_i + \gamma_3 X_{it} + g_t + g_i + \eta_{it} \tag{3.4.3}$$

Requirements for consistent estimation using an 2SLS IV estimator are that the excluded instruments are relevant and are uncorrelated with respect to u_{it}. The strength of these instruments is supported by the fact that r_t shifts demand for homes causing price changes across z_i, a result established in Chapter 1. Changes in interest rates drive heterogeneous responses in local house prices from little response in the most elastic MSA's to responses as large as 4% in the most inelastic MSA's. Furthermore, in baseline specifications, the Cragg-Donald F statistic for weak instruments is 33.412, nearly twice the 5% relative bias threshold provided in Stock & Yogo (2005). The instruments are, therefore, sufficiently strong to identify β_1.

To identify β_1 using an IV estimator, it must also be the case that $E[u_{it}|r_t, z_i] = 0$. Intuitively, this assumption requires that household consumption and borrowing do not respond differently to interest rates in elastic and inelastic supply housing markets, except through changes in housing wealth. This ensures that the only channel through which land availability and zoning regulations affect the outcome variable is due to their effect on house prices following a change to interest rates. Since sevaral instruments are available for the single endogenous variable q_{it}, validity of instruments can be tested under that all instruments are orthogonal to u_{it}. The Sargan-Hansen J statistic for the baseline estimates fails to the reject the null of joint validity at the 5% level.

One potential concern with the use of these instruments is that lenders treated households differently across these types of regions during the recent housing bubble (Barlevy and Fisher, 2010). Expectations of future house price increases in inelastic areas spurred lenders to lend to households with lower down payments since collateral values at the time of potential default would be higher. The effects estimated in this paper cannot address this without an explicit measure of expectations of house prices in the future. Due to the low frequency of the PSID, however, most of the effects of the interest rate change are likely capitalized into prices within the two year interview period.

The estimates use a 10-year Treasury bill rate as the relevant interest rate for constructing instruments. While mortgage rates may seem like an appealing alternative, credit spreads may be related to unobserved movements in borrowing and consumption. Mortgage rates closely track the 10-year Treasury rate, making the 10-year rate a sensible candidate for use in this application.

Table 3.1 provides some basic summary statistics for PSID households across local housing supply elasticity. Demographic characteristics are relatively similar across areas, and income and wealth characteristics are fairly constant across all but the most inelastic markets. All regressions use a vector of controls X_{it} including after-tax household income,[25] a quadratic polynomial in age, family size, and year dummies to account for aggregate shocks. Furthermore, estimates are constructed using fixed effects and hence use within-household variation comparing movements in house prices and consumption across elastic and inelastic markets.

The use of metropolitan statistical areas (MSA's) as the relevant geographic unit of measure

[25] PSID reports pre-tax income and previously imputed taxes. Due to changes in the nature of this imputation, the data in this paper imputes taxes consistently over all years using TaxSim. Results are largely unchanged by the use of pre-tax income and are available upon request.

is crucial to the strength of the instruments. MSA's are defined by cultural and economic ties, and households are more likely to move within and MSA rather than across MSA's due to an economic shock. Houses in adjacent municipalities within an MSA are more highly substitutable than houses in different MSA's. This means house values likely depend on geography and zoning regulations both within the municipality and also in nearby municipalities. These spillovers cause measures of z_i in a very fine geographic definition to become weaker instruments than those at an MSA level.

3.4.2 Estimates of MPB's and MPC's for Housing

Using interactions between interest rates and housing supply elasticity measures as instruments provides a means to consistently estimate the marginal propensity to borrow and consume out of housing. Table 3.2 provides results from equation (3.4.2) using mortgage debt as the outcome variable. All specifications pool observations from 1984 to 2011 and provide estimates of marginal propensities to borrow out of housing debt in the first row. The first two columns provide OLS estimates of equation (3.4.1) using self-reported house values and Zillow county-level house values respectively. Marginal propensities to borrow (MPB's) are slightly lower in the OLS specification compared to the IV specifications given in columns (3) and (4) indicating that unobserved common factors that move house prices up have a tendency to reduce mortgage debt. This is not surprising in general, as factors such as rising expected income growth may cause households to reduce their precautionary savings and pay down debt. The results indicate a propensity to borrow as much as \$0.24-0.30 for a dollar of home equity, and are consistent with estimates from Mian and Sufi (2011).

Table 3.3 provides results using consumption as the outcome variable. Once again, columns

(1) and (2) provide OLS estimates using self-reported and Zillow home values. Columns (3) and (4) provide the same results using the IV estimator. Since consumption data is available for renters, these households are matched to Zillow home values to check if house prices affect their spending. Results point to an MPC of 0.04-0.05 for owners[26] and an insignificant response by renters.

Tables 3.4 and 3.5 provide a series of robustness checks. Column (1) in each table replicates baseline results for ease of comparison. Column (2) includes the age of the current or most recent mortgage as a control variable to better address the natural amortization of mortgage debt over time. The slightly higher propensity to borrow is likely due to the fact that households without mortgage debt during the PSID sample period do not have an origination date for their last mortgage recorded. Inclusion of mortgage age data constrains the sample to overweight households with mortgage debt during the sample period. Nonetheless, propensities to consume out of housing remain largely unchanged from the baseline specification.

Column (3) in each table provides estimates only for homeowners who have lived in their current home for a minimum of two years. This reduces potential worries that home value and consumption may have short-run correlations immediately after a move due to moving expenses or a change in the composition of expenditures caused by the move. Propensities to borrow and consume out of housing appear only slightly changed after two years in residence.

Finally, Columns (4) and (5) in each table provide estimates controlling for liquid wealth holdings and total non-housing wealth. The inclusion of liquid wealth better controls for precautionary savings behavior that may be induced by volatility in income or house values

[26]Slightly lower MPC's for owners in the IV regression using the Zillow measure are likely due to discrepancies in the way households form beliefs about home values when home values are growing quickly.

that is correlated with local housing supply (Paciorek, 2013). The inclusion of total wealth addresses potential concerns that households in inelastic-supply and elastic-supply areas may hold different portfolios of financial wealth. Such correlations may bias MPC's in the absence of explicit controls for shocks to financial wealth. Results indicate no significant change due to the inclusion of liquid wealth, and a slight increase in MPC due to the inclusion of financial wealth.

3.4.3 MPC's over the Life-cycle: A Test of Wealth and Collateral Effects

As mentioned previously, correlations between house values, credit, and consumption arise for three main reasons: "common factors," "wealth effects," and "collateral effects." Unobserved common factors, such as expectations of future income growth, may cause comovements in these variables, preventing a causal interpretation of estimated coefficients. The IV identification strategy used previously addresses this issue and provides estimates of MPC's due to a combination of wealth and collateral effects.

To understand the mechanisms that drives these MPC's, first consider wealth effects in the context of housing. Housing wealth, unlike financial wealth, is both an asset and a durable good that provides utility in the form of housing services. A homeowner simultaneously plays the roles of a landlord who owns the asset and a tenant who consumes service flows. Rising home values may provide increased financial wealth for the landlord, but increase the cost of living for the tenant. In the words of Sinai and Souleles (2005), the homeowner is "hedged" against fluctuations in home values. Households are naturally "short" housing services, as they must rent or own a home in which to live. This means taking a "long" position by purchasing one's home hedges the natural risk associated with rental rates on housing.

This logic rests on the assumption that the home-owner is taking a "buy-and-hold" strategy, and breaks down if the homeowner is a net buyer or seller of housing. One reason why certain households may be natural buyers or sellers is life-cycle effects. As family size grows and shrinks over the life-cycle, households on average have a hump-shaped profile of housing wealth. Young households are natural buyers of housing as they have growing families and incomes. Older households are natural sellers as family size shrinks and liquidating housing wealth becomes attractive for spending in retirement. House price growth would results in positive wealth effects for older household who are natural sellers of housing and have fewer years over which to smooth wealth shocks. On the other hand, young households are likely to be upsizing housing and have negative wealth effects due to rising home values.

Collateral effects give the opposite prediction. Young, credit constrained homeowners are more likely to use their homes as a source of collateral compared to older households. Agency costs between these borrowers and lenders may result in a borrowing capacity determined by the collateral held by the borrower. Rising home values provide young homeowners with additional collateral with which she may insure her creditor against her default and thereby acquire additional credit. Older homeowners, on the other hand, are unlikely to be collateral constrained as they are less likely to have rising income paths relative to consumption and have had longer to accumulate assets.[27] This implies MPC's that fall over the life-cycle.

[27] I use the term "collateral constrained" to refer to households who are able to repay debt but cannot credibly promise to repay it due to some agency cost. This may occur, for example, if a household has rising labor income over the life-cycle but cannot credibly commit to providing labor and earning this income in the future. This is distinct from a household with low income throughout its life-cycle, as even the absence agency costs cannot guarantee a higher level of spending. Collateral constraints, in this context, rely on a rising (first-best) income-to-consumption ratio and an inability to borrow against future excess income.

The estimator developed in the previous section allows for the estimation of MPC's across the life-cycle. By interacting the house price term q_{it} and instruments with age groups, I can estimate effects of house price changes on borrowing and spending at different points in the life-cycle. Table 3.6 shows results of this exercise for mortgage debt. Homeowners under 40 years old extract \$0.46-0.48 of the value of their homes in mortgage debt. On the other hands, households 55-64 years of age who are approaching retirement extract only \$0.29 with this number falling to \$0.18 for those over 65.

Allowing for income sensitivity to differ across ages has little impact on this result as evidenced by Column 2. Testing the restricted model in column (1) against a the income-interactions model fails to reject restrictions placed in column (1), suggesting that the specification in column (2) simply sacrifices efficiency with little effect on robustness. Columns (3) and (4) control for liquid asset holdings and non-housing wealth respectively. The inclusion of these variables has minimal impact on MPBs across ages.

Table 3.7 displays results for consumption across the life-cycle. MPC's once again show a clear decline with age with households under 40 years of age consuming over \$0.08 for each dollar of home value and households 55-64 years old consuming only \$0.04-0.05. As with mortgage debt, allowing income responses to differ across group has little impact on results as evident in column (2).

Column (3) includes liquid asset holdings as a control variable. This results in a notable, but insignificant, drop in MPCs for younger households, but maintains a downward pattern in MPC's over the life-cycle. Column (4) includes total non-housing wealth as a control, which results in a slight increase in MPCs for older households, but once again maintains the downward pattern in MPC's with age.

The final column links households to county-level Zillow home values and also includes renters. All MPCs from this specification are reported separately in Table 3.8 for convenience. Once again, owners have a declining MPC over the life-cycle suggesting collateral effects play a dominant role. Furthermore, renters have no significant response to changes in local home values at all ages. This is especially notable for young renters who are likely to be future home buyers. The lack of negative effects for young renters is consistent with small wealth effects. These results once again provide evidence that collateral effects play a dominant role in driving the consumption response to house price changes.

The results from Tables 3.6 and 3.7 indicate a declining propensity to use home equity and spend out of housing as the homeowner ages with no significant effect on renters. These results are inconsistent with the hypothesis that older homeowners enjoy large wealth effects as they are natural sellers of housing with fewer years over which to smooth their wealth shock. On the other hand, the results support the theory that collateral effects are the dominant force in determining MPC's out of housing.

To look at this issue more directly, I split the sample into groups based on balance sheet strength and liquidity. These variables proxy for the likelihood of binding credit constraints. If collateral effects play a significant role, rising house prices would loosen credit constraints driving large MPCs for households with high levels of debt and low liquid assets.

In the top panel of Table 3.9, I estimate MPCs for households with Loan-to-Value ratios[28] below 0.8 (unconstrained), between 0.8 and 1 (constrained), and above 1 (underwater). Constrained households with high LTVs who are not underwater have an MPC of 0.06, nearly double that of unconstrained (LTV<0.8) households. Constrained households display

[28]Loan-to-Value (LTV) = $\frac{\text{Total Mortgage Debt}}{\text{Self-reported Home Value}}$. An LTV of 80% is consistent with a standard 20% down-payment on a home. LTV's above this are likely to be denied additional credit(Hurst and Stafford, 2004).

a higher MPC over the majority of the life-cycle.

The bottom panel of Table 3.9 displays MPC estimates for households differing in liquid-wealth-to-income ratios. Households are sorted based on Liquidity ratios under 0.083 (liquid wealth less than 1 month of income), over 0.083, and zero reported liquid wealth. Households reporting zero liquid wealth are separated in an effort to reduce survey measurement error due to under-reporting or rounding of liquid wealth holdings. While MPC estimates do not show a statistically significant difference between high and low liquidity ratio households, point estimates are higher for households with lower liquidity throughout the life-cycle.

The dominance of collateral effects has strong implications for potential aggregate effects. Since wealth effects are largely transfers from buyers to sellers as home values rise, the effects are likely distributive with little impact on aggregate spending. This is especially true if older homeowners who are most likely to be net sellers of housing have lower MPC's than younger net buyers.

On the other hand, if MPC's out of housing are determined by collateral effects, aggregate impacts may be large. Rising home values provide constrained homeowners with collateral, loosening their borrowing constraints. Since these households were constrained away from their optimal spending point, their MPC's will be very large. These effects may be especially pronounced when homeowner balance sheets are especially weak, and may provide policy makers with a lever to increase output through housing market policies.

3.5 Conclusion

This paper uses a longitudinal panel of households from the PSID linked to geographic data on local housing supply elasticity to estimate consumption and borrowing responses to changes in home values. First, it uses a unique IV estimator exploiting regional heterogeneity in land availability to identify the propensity to borrow and consume out of housing. Then, it compares consumption and borrowing responses to house price changes over the life-cycle to test for the relative importance of wealth and collateral effects in driving this relationship.

The IV estimator used is based on a simple structural model of housing supply and demand. Changes in interest rates shift housing demand nationally. Cities with plentiful land and lax zoning restrictions respond to this shock with new construction, keeping house prices in check. On the other hand, prices rise in cities with limited land availability and strict zoning restrictions where housing supply is relatively inelastic. Under the assumption that household credit and consumption behavior does not respond in a systematically different way across these types of cities, comparing house prices, household debt, and consumption responses identifies marginal propensities to borrow and consume out of housing wealth.

This paper finds rather large average responses in both mortgage debt and spending due to house price changes. An increase in house prices of one dollar causes households to borrow \$0.24 and increase spending by \$0.04-0.06. Furthermore, renters are largely unaffected by house price changes. These effects arise independently of common factors that may drive consumption, credit, and housing to comove.

The literature proposes two general reasons linking house prices to spending: wealth effects and collateral effects. The main contribution of this paper is to estimate these effects over the life-cycle to provide a test of the relative importance of these two effects. This test rests on the premise that wealth effects and collateral effects cause opposing patterns in MPC's over the life-cycle. Strong wealth effects imply higher MPC's for older households who are more likely to sell their homes as their children move out and have fewer years over which to housing wealth shocks. On the other hand, strong collateral effects imply higher MPC's for younger homeowners who have fewer liquid assets and are more likely to rely on home equity-based borrowing to smooth consumption. While a formal decomposition of these effects may be difficult, comparing the slope of MPC's over the life-cycle can provide insight into the relative importance of these two effects.

Using the same IV approach, I estimate marginal propensities to borrow and consume out of housing over the life-cycle. Estimated MPC's fall with age from as high as \$0.08 for homeowners under 40 down to half as much at \$0.04-0.05 by retirement age. These responses are consistent with responses in credit, where young households extract as much as \$0.50 in equity per \$1 of home value compared to older households who extract only \$0.09-0.19. These results are consistent with collateral effects being the dominant force in determining the relationship between housing and consumption.

The distinction between thee two types of effects is important when considering the welfare implications or the potential aggregate impact of house price changes. Collateralized lending likely arises due to agency costs between borrowers and lenders. For example, young homeowners may be unable to commit to repayment despite having rising income streams since they are unable to credibly commit to providing labor in the future. Collateral provides them with a means to insure their lenders against default. Therefore rising collateral values can be welfare improving by mitigating agency costs.

Furthermore, increases in the value of this collateral may loosen borrowing constraints allowing constrained households to more easily smooth consumption. Credit constrained households are likely to have very high MPC's as loosening borrowing constraints allows them to move closer to their first-best consumption path. This can result in very large aggregate effects relative to largely redistributive wealth effects.

These results are also important for policy purposes. Wealth effects are largely distributional with net sellers of housing winning from rising house prices at the expense of buyers. In the absence of strong heterogeneity in MPC's between buyers and sellers, aggregate effects would be rather small. Given the result that older homeowners have rather small MPC's wealth effects are unlikely to result in large aggregate impacts on consumption.

On the other hand, rising house prices may put collateral in the hands of constrained households who use it to mitigate agency costs with their creditors. Namely, by posting the additional collateral, households can insure their creditors against default and increase their borrowing capacities. Those households who are constrained away from their optimal consumption path are likely to have very large consumption responses as they move closer to their first-best consumption levels. This can result in large aggregate effects on consumption.

The results of this paper point to the importance of housing wealth in determining consumption for this group of young, credit constrained homeowners. This means that policies that affect house prices can be an important tool, especially when falling asset prices have left many households with weakened balance sheets. The results also imply that volatility in housing markets, spills over to volatility in consumption for younger, credit constrained households. This can be especially pronounced in inelastic-supply markets where house prices are sensitive to demand shocks. Therefore, policies that stabilize house prices will be welfare improving as they are likely to stabilize consumption for these households.

Figures and Tables

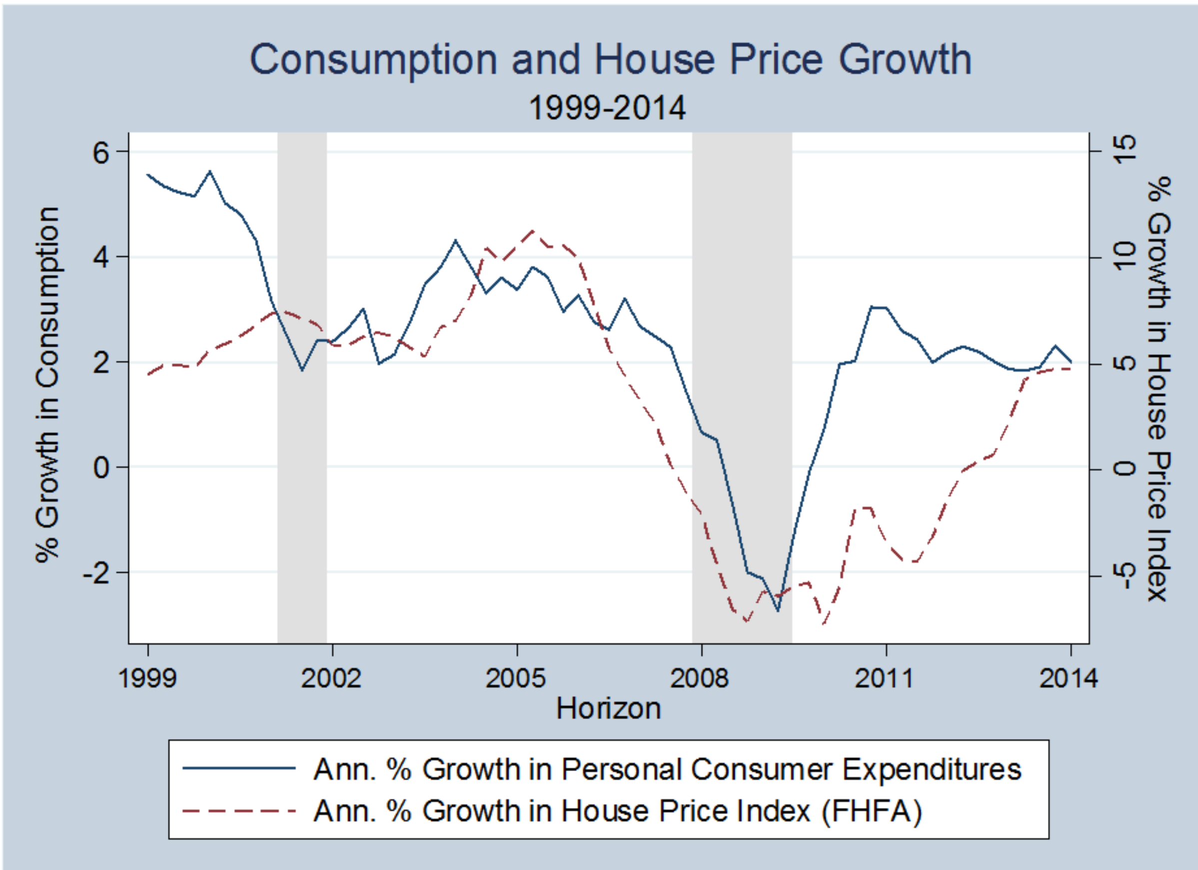

Figure 3.5.1: **Growth Rates in Personal Consumer Expenditures vs House Price Index (FHFA):** Real PCE (annual) growth on left axis and House Price (annual) growth on right axis. Covariance between the two series is evident during early-1980's recessions, 1990-1991 house price crash and recession, and is especially pronounced during the 2006-2011 period.
Source: Real PCE data from NIPA. HPI series from Federal Housing Finance Agency.

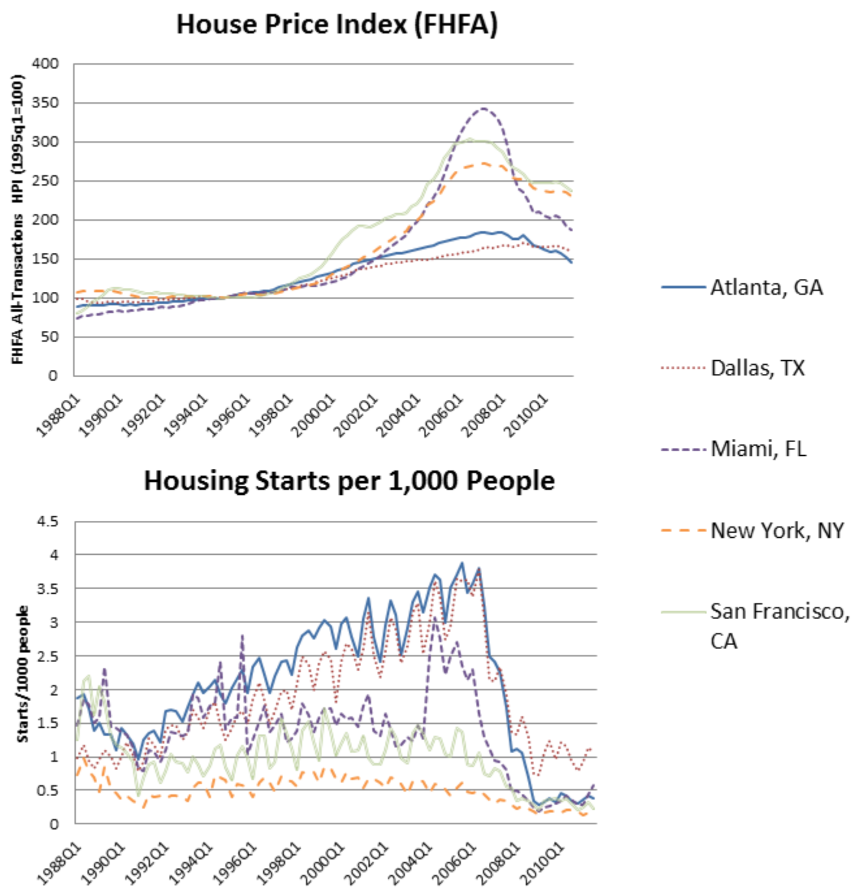

Figure 3.5.2: **House Prices and Housing Starts in Select Cities**: Top panel displays house price indices (FHFA) in several large US metropolitan areas (MSA's). Bottom panel displays housing starts per 1000 people for same cities over same time span. Flat, non-coastal cities with generally lax zoning laws such as Atlanta and Dallas see large increases in construction during housing boom, but only moderate house price appreciation. Land constrained, strictly regulated cities see more moderate construction with large swings in house prices during the same period. This heterogeneity is exploited to identify the propensity to borrow and consume out of housing wealth.

	50% Most Inelastic	50% Most Elastic	Overall
Age	46.4	43.9	44.9
	(16.34)	(15.42)	(16.3)
Family Size	2.7	2.8	2.7
	(1.48)	(1.52)	(1.48)
Income	$69,000	$60,000	$61,000
	($88,600)	($95,200)	($87,100)
Non-Housing Wealth	$172,000	$106,000	$127,000
	($1,395,000)	($688,000)	($946,000)
Home Value (if owner)	$269,000	$153,000	$195,000
	($281,000)	($127,000)	($216,000)
% Owning Homes	60.6%	60.66%	60.87%
% Owning Stocks	22.1%	16.58%	17.88%

Table 3.1: **PSID Summary Statistics**: Mean and standard deviations (in parenthesis) of demographic, income, and wealth variables for households in the sample. Columns split sample into the 50% (population-weighted) of households living in the most inelastic and elastic cities as well as an overall grouped mean. All means and standard deviations for dollar-valued variables are rounded to nearest $1000.

	(1)	(2)	(3)	(4)
Dependent Var:	Self-Reported Home value	Zillow Home value (County)	Self-Reported Home value	Zillow Home value (County)
Mortgage Debt	OLS	OLS	IV	IV
Home Value	0.203***	0.185***	0.246***	0.326***
	(0.0260)	(0.0299)	(0.0112)	(0.0656)
After Tax Income	0.000343	0.00520	8.66e-05	0.00234
	(0.000417)	(0.0203)	(0.000530)	(0.00985)
Family Size	2,556***	4,931***	2,199***	4,710***
	(485.3)	(1,156)	(242.3)	(682.8)
Age	4,305***	8,927***	4,025***	9,057***
	(358.1)	(895.3)	(191.0)	(600.3)
Age-squared	-43.21***	-77.90***	-40.90***	-79.53***
	(2.950)	(6.709)	(1.326)	(4.610)
R-squared (within)	0.287	0.102	0.280	0.094
Number of FU's	8,849	4,621	8,849	4,621
Sample	1984+, Owners Only	1999+, Owners Only	1984+, Owners Only	1999+, Owners Only

Table 3.2: **Mortgage Debt Response**: Estimates from fixed-effects OLS and IV models for mortgage debt using either self-reported home values or county-level Zillow home values as endogenous measures of home values. IV estimates use interactions between 10yr T-bill rate and Housing Supply Elasticity measures (% land availability and zoning regulations) as instruments for home values.
Robust standard errors in parenthesis. All specifications include Family Size, age/age-squared of head, and year dummies as controls. (T-bill rate excluded since collinear with year dummies).
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

	(1)	(2)	(3)	(4)
Dependent Variable:	Self-Reported	Zillow Home	Self-Reported	Zillow Home
	Home value	value (County)	Home value	value (County)
Consumption (1999 measure)	OLS	OLS	IV	IV
Renter x House Value		0.00118		0.00349
		(0.00352)		(0.0114)
Owner x House Value	0.0403***	0.0486***	0.0452**	0.0295***
	(0.00492)	(0.00478)	(0.0191)	(0.00939)
After Tax Income	0.0111	0.0192	0.0105**	0.0198***
	(0.00854)	(0.0119)	(0.00412)	(0.00324)
Family Size	2,156***	2,751***	2,110***	2,772***
	(269.7)	(185.5)	(297.9)	(162.2)
Age	2,591***	1,512***	2,560***	1,470***
	(216.7)	(131.6)	(244.3)	(121.9)
Age-squared	-21.88***	-12.91***	-21.67***	-12.42***
	(1.748)	(1.316)	(1.806)	(1.127)
Owner Dummy		-791.3		2,295
		(789.8)		(1,700)
Number of FU's	5,477	8,062	5,477	8,062
R-squared (within)	0.152	0.148	0.152	0.147
Sample	1999+, Owners Only	1999+, Owners & Renters	1999+, Owners Only	1999+, Owners & Renters

Table 3.3: **Consumption Response**: Estimates from fixed-effects OLS and IV models for consumption (sum of 1999 categories) using either self-reported home value or county-level Zillow home value index. IV estimates use interactions between 10yr T-bill rate and Housing Supply Elasticity measures (% land availability and zoning regulations) as instruments for home values. All instruments are interacted with ownership dummy when home values are interacted with ownership in (2) and (4).
Robust standard errors in parentheses. All specifications include Family Size, age/age-squared of head, and an ownership dummy when renters are included in the sample.
*** p<0.01, ** p<0.05, * p<0.1

Dependent Variable: Mortgage Debt	(1) Baseline	(2) Mortgage Age as Control	(3) Min 2yrs in House	(4) Liquid Assets as control	(5) Non-Housing Wealth as Control
House Value	0.246***	0.338***	0.228***	0.267***	0.267***
	(0.0112)	(0.0266)	(0.0112)	(0.0204)	(0.0236)
After-Tax Income	8.66e-05	-0.0263***	9.94e-05	0.00378	-0.000800
	(0.000530)	(0.00896)	(0.000527)	(0.00967)	(0.0106)
Age of Mortgage		-2,475***			
		(49.38)			
Liquid Assets				-0.0437***	
				(0.00497)	
Non-Housing Wealth					-0.00438***
					(0.000639)
Family Size	2,199***	1,610***	1,668***	2,645***	3,176***
	(242.3)	(560.7)	(242.5)	(474.0)	(529.1)
Age	4,025***	4,318***	3,909***	4,606***	4,701***
	(191.0)	(460.0)	(197.6)	(381.1)	(444.2)
Age-squared	-40.90***	-39.01***	-38.18***	-45.14***	-44.66***
	(1.326)	(3.368)	(1.326)	(2.515)	(2.788)
Number of FU's	8,849	6,441	7,955	7,610	7,084
R-squared (within)	0.280	0.303	0.243	0.259	0.266
Sample	1984+, Owners	1984+, Owners with Mortgage Origination Data	1984+, Owners in Residence for 2yrs or more	Wealth Supplement Years, Owners	Wealth Supplement Years, Owners

Table 3.4: **Mortgage Debt Response, Robustness Checks**: Estimates from fixed-effects IV models for mortgage debt using self-reported home values as endogenous measures of home values. IV estimates use interactions between 10yr T-bill rate and Housing Supply Elasticity measures (% land availability and zoning regulations) as instruments for home values.

Robust standard errors in parenthesis. All specifications include Family Size, age/age-squared of head, and year dummies as controls. (T-bill rate excluded since collinear with year dummies).

*** p<0.01, ** p<0.05, * p<0.1

Dependent Variable: Consumption (1999 measure)	(1) Baseline	(2) Mortgage Age as Control	(3) Min 2yrs in House	(4) Liquid Assets as control	(5) Non-Housing Wealth as Control
House Value	0.0452**	0.0462**	0.0565**	0.0412**	0.0663***
	(0.0191)	(0.0191)	(0.0233)	(0.0200)	(0.0226)
After-Tax Income	0.0105**	0.0100**	0.00683*	0.0108**	0.00582
	(0.00412)	(0.00412)	(0.00410)	(0.00424)	(0.00481)
Age of Mortgage		-239.2***			
		(25.57)			
Liquid Assets				0.00698***	
				(0.00257)	
Non-Housing Wealth					0.000267
					(0.000201)
Family Size	2,110***	2,048***	1,753***	2,178***	2,032***
	(297.9)	(296.4)	(323.0)	(318.8)	(336.7)
Age	2,560***	2,369***	2,503***	2,600***	2,599***
	(244.3)	(240.7)	(287.4)	(265.8)	(276.2)
Age-squared	-21.67***	-19.80***	-20.37***	-22.30***	-22.52***
	(1.806)	(1.771)	(2.041)	(1.930)	(1.981)
Number of FU's	5,477	5,440	4,876	5,332	5,025
R-squared (within)	0.152	0.157	0.132	0.151	0.156
Sample	1999+, Owners	1999+, Owners with Mortgage Origination Data	1999+, Owners in Residence for 2yrs or more	1999+, Owners w/ Valid Liquid Debt Response	1999+, Owners with Valid Wealth Responses

Table 3.5: **Consumption Responses, Robustness Checks**: Estimates from fixed-effects IV models for 1999 measure of consumption using self-reported home values as endogenous measures of home values. IV estimates use interactions between 10yr T-bill rate and Housing Supply Elasticity measures (% land availability and zoning regulations) as instruments for home values.
Robust standard errors in parenthesis. All specifications include Family Size, age/age-squared of head, and year dummies as controls. (T-bill rate excluded since collinear with year dummies).
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Dependent Variable: Mortgage Debt	(1) Baseline, IV	(2) Inc x Age Interaction	(3) Liquid Assets as Control	(4) Non-housing Wealth as Control
[Ages under 40] x House Val	0.483***	0.482***	0.460***	0.485***
	(0.0224)	(0.0224)	(0.0376)	(0.0412)
[Ages 40-54] x House Val	0.367***	0.367***	0.379***	0.394***
	(0.0139)	(0.0139)	(0.0266)	(0.0304)
[Ages 55-64] x House Val	0.290***	0.290***	0.314***	0.309***
	(0.0115)	(0.0115)	(0.0205)	(0.0231)
[Ages 65-80] x House Val	0.185***	0.185***	0.208***	0.217***
	(0.0126)	(0.0126)	(0.0199)	(0.0222)
[Ages 81+] x House Val	0.0970***	0.0972***	0.0873*	0.108*
	(0.0247)	(0.0248)	(0.0471)	(0.0563)
After tax Income	-0.000436	[by age]	-0.0116	-0.0122
	(0.000533)		(0.00965)	(0.0103)
Liquid Wealth			-0.0431***	
			(0.00494)	
Total Non-Housing Wealth				-0.00545***
				(0.000621)
Number of id	8,807	8,807	7,554	7,031
R-squared	0.318	0.318	0.309	0.325
Sample	1984+	1984+	Wealth Supplement years only.	Wealth Supplement years only.

Table 3.6: **Mortgage Debt over Life-Cycle**: Panel OLS/IV regressions for Mortgage Debt by age group. Coefficients on housing are marginal propensities to borrow for $1 of additional home equity for the given age group. IV estimates use interactions between 10yr T-bill rate and Housing Supply Elasticity measures (% land availability and zoning regulations) as instruments for home values. All instruments are interacted with age group to appropriately instrument for age interactions.

Robust standard errors in parentheses. All specifications include After-tax income, Family Size, and Age Group dummies for age of head (coefficients omitted in table).

*** p<0.01, ** p<0.05, * p<0.1

Dependent Variable: Consumption (1999 measure)	(1) Baseline, IV	(2) Inc x Age	(3) Liquid Assets as Control	(4) Non-housing as Control Wealth	(5) Zillow Home Values
Owner x [Ages <40] x House Val	0.0825***	0.0837***	0.0786***	0.0845***	0.0457***
	(0.0227)	(0.0230)	(0.0227)	(0.0239)	(0.00418)
Owner x [Ages 40-54] x House Val	0.0600***	0.0611***	0.0534***	0.0715***	0.0483***
	(0.0188)	(0.0189)	(0.0189)	(0.0217)	(0.00422)
Owner x [Ages 55-64] x House Val	0.0485***	0.0485***	0.0504***	0.0608***	0.0405***
	(0.0154)	(0.0155)	(0.0156)	(0.0169)	(0.00689)
Owner x [Ages 65-80] x House Val	0.0492***	0.0508***	0.0504***	0.0608***	0.0244***
	(0.0144)	(0.0142)	(0.0145)	(0.0151)	(0.00938)
Owner x [Ages 81+] x House Val	0.0462*	0.0471	0.0420	0.0456	0.000966
	(0.0269)	(0.0287)	(0.0307)	(0.0292)	(0.0120)
Renter x [Ages Group] x House Val					X
					(X)
After tax Income	0.00919**	[by age]	0.00930**	0.00614	0.0174***
	(0.00407)		(0.00421)	(0.00448)	(0.00329)
Liquid Wealth			0.00634**		
			(0.00268)		
Total Non-Housing Wealth				0.000268	
				(0.000227)	
R-squared	0.147	0.147	0.146	0.159	0.146
Number of id	5,457	5,457	5,307	5,004	7,991
Sample	1999+, Owners	1999+, Owners	1999+, Owners	1999+, Owners	1999+, All

Table 3.7: **Consumption over Life-Cycle**: Panel OLS/IV regressions for Consumption by age group. Coefficients on housing value are marginal propensities to consume out of an additional $1 of home equity for the given age/ownership status. IV estimates use interactions between 10yr T-bill rate and Housing Supply Elasticity measures (% land availability and zoning regulations) as instruments for home values. All instruments are interacted with age group to appropriately instrument for age interactions.

Joint test of coefficients on Renter x [Age Group] x House Value in Column 5 fail to reject the null hypothesis of zero effects on renters at all ages. Estimates MPCs for renters in column 5 are available in the next table.

Robust standard errors in parentheses. All specifications include After-tax income, Family Size, and Age Group dummies for age of head (coefficients omitted in table).

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

	Pooled	Under 40	Ages 40-54	Ages 55-64	Ages 64-80	Over 80
Owners	0.0295***	0.0457***	0.0483***	0.0405***	0.0244***	0.000966
	(0.00939)	(0.00418)	(0.00422)	(0.00689)	(0.00938)	(0.012)
Renters	0.00349	0.00969	-0.0111	-0.00555	0.0108	0.0299
	(0.0114)	(0.0132)	(0.0111)	(0.0141)	(0.0172)	(0.0225)

Table 3.8: **MPC Estimates by Age and Ownership Status**: Reported MPCs are coefficients on housing wealth from panel IV regressions for Consumption split by age group and ownership status. Interactions between 10yr T-bill rate and Housing Supply Elasticity measures (% land available and zoning regulations) are used as instruments for home values. All instruments are interacted with age and ownership dummies.
Robust standard errors in parentheses. All specifications include After-tax income, Family Size, Ownership dummies, and Age Group dummies for age of head (coefficients omitted in table).
*** p<0.01, ** p<0.05, * p<0.1

	Pooled	Under 40	Ages 40-54	Ages 55-64	Ages 65-80	Over 80
Unconstrained	0.0333	0.0523**	0.031	0.0344**	0.0381**	0.124*
(LTV<80%)	(0.0224)	(0.0228)	(0.0203)	(0.0165)	(0.0161)	(0.0695)
Constrained	0.0639**	0.0853***	0.0528*	0.0751***	0.0657*	0.119
(LTV 80% to 100%)	(0.0296)	(0.0296)	(0.0275)	(0.0235)	(0.0385)	(0.161)
Underwater	0.0567	0.0979**	0.0465	0.0442	0.0669	0.158
(LTV>100%)	(0.0417)	(0.042)	(0.0387)	(0.0434)	(0.0545)	(0.152)

	Pooled	Under 40	Ages 40-54	Ages 55-64	Ages 65-80	Over 80
Unconstr.	0.0565***	0.0899***	0.0704***	0.0567***	0.0531***	0.0464
(Cash>1mo Income)	(0.0181)	(0.02)	(0.0163)	(0.0135)	(0.0137)	(0.029)
Constrained	0.0608***	0.102***	0.0693***	0.0712***	0.0536***	0.0624**
(Cash<1mo Income)	(0.0203)	(0.0232)	(0.0183)	(0.0156)	(0.0134)	(0.0303)
No Liq Wealth Rpt.	0.0586**	0.104***	0.0642***	0.0574***	0.0536**	0.0371
	(0.0228)	(0.0276)	(0.0216)	(0.0182)	(0.0216)	(0.0462)

Table 3.9: **MPC Estimates by Age and Credit Constraint**s: Reported MPCs are coefficients on housing wealth from panel IV regressions for Consumption split by age group and credit status (Loan-to-Value (LTV) and Liquid-Wealth-to-Income ratios) for all owners. Interactions between 10yr T-bill rate and Housing Supply Elasticity measures (% land available and zoning regulations) are used as instruments for home values. All instruments are interacted with age group dummy and credit constraint dummies.
Robust standard errors in parentheses. All specifications include After-tax income, Family Size, Credit group dummies, and Age Group dummies for age of head (coefficients omitted in table).
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

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