House prices, monetary policy and regional heterogeneity∗

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Abstract

The effectiveness of monetary policy in affecting house prices depend both on the nature of the shock; expansionary versus contractionary, and on local housing market characteristics. In particular, our results suggest that monetary policy is more effective when it is expansionary and in markets with low housing supply elasticities. While expansionary and contractionary shocks have similar impacts on house prices in markets with an elastic housing supply, the effect of expansionary shocks are markedly larger than the impact of contractionary shocks in supply inelastic areas. These conclusions are drawn based on an empirical examination of the effects of exogenous monetary policy shocks on house prices using local projection methods on a panel of the 100 largest metro areas in the US over the period 1980Q1–2008Q4.

Keywords: House prices; Heterogeneity; Monetary policy; Non-linearity; Supply elasticities;

JEL classification: E32, E43, E52, R21, R31

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1 Introduction

We study the asymmetric effect of exogenous monetary policy shocks on house prices using a panel of 100 US MSAs over the period 1980Q1-2007Q4. In our baseline exercise, we measure the monetary policy shock, using an updated version of the Romer and Romer (2004) narrative shock series, provided by Wieland and Yang (2016) and estimate impulse responses using panel data and local projection methods as in Jordà (2005). We ask the following two questions: (i) Is the effect of monetary policy dependent on local housing market conditions? (ii) Is the impact of monetary policy asymmetric?

We start by documenting a strong role of monetary policy in influencing aggregate house prices in the US. Following a one percentage point contractionary monetary policy shock aggregate house prices decrease with about 8 percent after three to four years. These estimates are in line with the rapidly growing literature investigating the nexus between monetary policy and house prices (see e.g., Del Negro and Otrok (2007), Glaeser et al. (2012), Goodhart and Hofmann (2008), Iacoviello (2005), Jarocinski and Smets (2008), Jordà et al. (2015) and Williams (2011, 2015)). That said, an aggregate investigation masks the major heterogeneities existing across regional US housing markets and national house price cycles are often driven by developments in certain regional markets, see e.g., Capozza et al. (2004), Glaeser et al. (2008) and Malpezzi and Wachter (2005) and Saiz (2010). For instance, while house prices increased by more than 160% in some coastal areas of Florida and California from 2000 to 2006, they increased by less than 20% in inland open space areas of the Midwest.

The presence of heterogeneous regional shocks within a country may pose a challenge to monetary policy making. A key question is whether monetary policy should pay attention to these regional disparities? The fact that monetary policy is common across regional markets may suggest that changes in monetary policy could have similar effects across member regions. However, on the other side, differences in regional economic conditions could impact the transmission of monetary policy, potentially amplifying regional
heterogeneity. Many have for instance wondered whether the low interest rate environment that prevailed in the years before the 2008 crisis contributed to the house price booms experienced in many Western economies before the recent crash. Others, such as Mian and Sufi (2009) and Favara and Imbs (2015) have emphasized the role of lax lending standards associated with securitization.

A branch of the literature have attributed regional variations in house price dynamics to heterogeneous supply side restrictions see e.g., Malpezzi (1996), Green et al. (2005), Saiz (2010), Gyourko et al. (2008), Glaeser (2009), and Anundsen and Heebøll (2016), Huang and Tang (2012) and Glaeser et al. (2008) show that house price booms tend to be larger in markets with an inelastic housing supply. By adding MSA-dependent housing supply elasticities, as calculated by Saiz (2010), as an interacting variable in our model, we still find a strong role of monetary policy in affecting house prices. However, consistent with the cross section studies alluded to above, the heterogeneity in the transmission of monetary policy is considerable. For instance, whereas the cumulative drop in house prices following a one percentage point contractionary monetary policy shock is estimated to be more 11 percent in Miami (FL) after four years, house prices in Dayton (OH) are predicted to fall less than three percent over the same period.

Motivated by recent findings of an asymmetric effect on output from contractionary and expansionary fiscal policy shocks (see Auerbach and Gorodnichenko (2012) and Owyang et al. (2013)) and monetary policy shocks (see Angrist et al. (2013) and Tenreyro and Thwaites (2016)), our final exercise is to explore asymmetric effects on house prices of contractionary and expansionary shocks. We find evidence that expansionary shocks have a greater impact on house prices than contractionary shocks, which could pose a challenge from a financial stability point of view. There are nuances to this finding, however. We find that the increase in house prices following an expansionary shock is twice as high (in absolute value) as the fall in prices following a contractionary shock in Miami (FL) and San Francisco (CA) – both markets with an inelastic housing supply. For Dayton (OH), an area with an elastic housing supply, the effect of contractionary shocks
are stronger. Thus, unless the housing supply elasticity is very high, monetary policy has a far larger impact on fueling than taming house price growth, which may be particularly important to keep in mind when then there are trade-offs between developments in economic activity, inflation and house prices.

Our investigation of the asymmetric transmission of monetary policy shocks to house prices continue as follows. The next section sketches a simple skeleton model that gives a theoretical foundation for our empirical investigation. Section 3 presents the data we utilize. Section 4 documents our empirical findings on the heterogenous and asymmetric effects of monetary policy. The final section concludes.

2 Theoretical motivation

Following Glaeser et al. (2008), we consider an economy consisting of several heterogeneous housing markets with different supply elasticities. Specifically, some regions are open space areas with no regulations on building permits, while other regions are naturally restricted, e.g. by mountains or water, or by the local regulatory framework. In particular, we will shed light on possible heterogeneities and asymmetries in the response to expansionary and contractionary monetary policy shocks.

In each period, the law of motion of capital accumulation for area \(i\) is given as:

\[
H_{i,t} = H_{i,t-1} + I_{i,t}
\]  

(1)

where \(H_{i,t}\) is the housing stock at time \(t\), while \(I_{i,t}\) represents new investments in housing capital. We assume that investments are determined according to Tobin’s Q theory (Tobin, 1969), i.e. new construction projects are initiated as long as the market price, \(P_{H_{i,t}}\), exceeds the marginal cost of construction, \(M_{C_{i,t}}\).

When considering heterogeneous areas of different sizes, the number of new construction projects initiated in each period will naturally depend on the size of the market in

\footnote{For now, we abstract from depreciation of the existing stock.}
question. To take account of this, we assume that the marginal cost of investments is inversely proportional to the existing housing stock, i.e. there is a larger construction capacity in bigger markets. The marginal cost function for area $i$ takes the following form:

$$MC_{i,t}(I_{i,t}) = C_{0,i} \left( \frac{I_{i,t}}{H_{i,t-1}} + 1 \right)^{1/\varphi_i}, \quad \varphi_i > 0 \quad \forall \ i$$

where $\varphi_i$ is the time invariant area specific supply elasticity, while $C_{0,i}$ is a positive variable measuring fixed costs of housing construction (we disregard time varying construction costs for now). Setting the price equal to the marginal cost, we get the following investment function:

$$I_{i,t} = H_{i,t-1} \cdot \max \left\{ 0, \left( \frac{PH_{i,t}}{C_{0,i}} \right)^{\varphi_i} - 1 \right\} \quad (2)$$

Given a non-zero supply elasticity, it follows from (2) that there will be positive investments if and only if prices exceed the fixed costs of construction. Moreover, the size of the investment response depends on both the size of the market (as measured by $H_{i,t-1}$) and the supply elasticity. The two extreme cases are interesting: In a completely supply elastic market ($\varphi_i \rightarrow \infty$), a positive price-to-cost ratio implies that investments become infinite, while in a market where supply is completely inelastic ($\varphi_i \rightarrow 0$), investments will be zero and independent of house prices. From (1) and (2), we find that a log transformation (lower case letters) of the supply equation yields:  

$$h_{i,t} = h_{i,t-1} + \max \left\{ 0, \varphi_i (ph_{i,t} - c_{0,i}) \right\} \quad (3)$$

It follows that the log supply curve will be piecewise linear and kinked; only if the price exceeds the fixed cost of construction will supply increase as a function of the supply elasticity, $\varphi_i$, and the price-to-cost ratio (Tobin’s Q). Hence, supply is assumed completely

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2This is seen by rewriting (1) using (2): $H_{i,t} = H_{i,t-1} \cdot \max \left\{ 1, \left( \frac{PH_{i,t}}{C_{0,i}} \right)^{\varphi_i} \right\}$ and then taking logs.
rigid downwards, motivated by the fact that housing is usually neither demolished nor dismantled (see also the discussion in Glaeser and Gyourko (2005)).

We follow custom when it comes to the modelling of the demand side. For each area, it is assumed that demand is determined in accordance with the life cycle model of housing, see e.g. Meen (1990, 2001) and Muellbauer and Murphy (1997), and the references therein. For area $i$, a logarithmic representation of the inverted demand function is given as:

$$p_{hi,t} = v_{0,t} + v_{1,i,t} + v_{2}h_{i,t}, \quad v_0, v_2 < 0$$ (4)

where the $v_0$ is the semi-elasticity of house prices with respect to the interest rate, $v_{1,i,t}$ measures other demand shifters, such as income and migration. The parameter $v_2$ measures the price elasticity of an increase in the number of houses (the inverse demand elasticity).

Let us assume that market $i$ initially is in equilibrium ($p_{hi,t} = c_{0,i}$), which also implies that $I_{i,t} = 0$ and hence that $H_{i,t} = H_{i,t-1}$. Then, market $i$ is hit by an expansionary monetary policy shock. This will lead to a greater increase in house prices in more inelastic markets. Figure 1 illustrates this results for the case of two markets with different supply elasticities (elastic and inelastic). In this figure, the short-run supply curve at time $t$ is drawn as a vertical line due to the fact that increasing the housing stock is not done over night. The original long-run supply curve has a kink at point A – the market equilibrium. This is to capture the implication implied by our stylized model, namely that houses are durable and that once they are built, they are usually not destroyed.

As seen, a positive demand shock ($D_t$ to $D_{t+1}$) primarily leads to quantity adjustments in supply elastic markets, while the shock is mostly absorbed in terms of higher prices in inelastic markets. To ensure market clearing, the part of the adjustments that has to be made in the form of higher prices will be larger the lower the supply elasticity. Thus, as expected, the conjecture of a standard supply-demand story is that expansionary shock
has a greater impact on house prices the lower is the elasticity of supply. At the same time, the new short run supply curve will shift, leading to a new kink in the long-run supply curve at point B. Thus, the dotted part of the old long-run supply curve is no longer relevant, since we assume that the new houses that are built will not be destroyed. Thus, a negative shock would lead to an adjustment along the vertical part of the supply curve.

Figure 1: Expansionary monetary policy in supply-elastic vs. - inelastic markets

In Figure 2, we consider a contractionary monetary policy shock. Since supply is rigid downwards, this means that the demand curve shifts along a vertical supply curve, independent of the supply elasticity. The conjecture is therefore that the drop in house prices following a contractionary monetary policy shock is independent of the supply elasticity. Furthermore, the drop in prices following the contractionary shock will always be greater (in absolute value) than the increase in house prices following a similar sized expansionary shock – at least as long as supply is not completely inelastic, in which the supply curve would always be vertical.
Figure 2: Contractionary monetary policy in supply-elastic vs. - inelastic markets

Market 1: Elastic supply

Market 2: Inelastic supply

Note: $D_t$ is the original demand curve, while $D_{t+1}$ is the demand curve after the expansionary monetary policy shock. $SSR_t$ is the original short-run supply curve and $SSR_{t+1}$ is the short-run supply curve after the shock materializes. The long-run supply curve is given by $SLR$.

Notes to self: Section is incomplete, but we should:

1. Extend the model to allow for endogenous acceleration in demand in upturns (expectations and credit availability) \(\Rightarrow\) Can explain why expansionary shocks have a greater impact than contractionary shock in inelastic markets

2. Consider modeling flow of supply instead of the housing stock, i.e. what is available for sale at any point in time is the sum of new investments and a fraction of the existing stock. Mechanisms will be similar, but this is more in line the approach taken in e.g., Glaeser et al. (2008)

3. Derive results analytically in addition to the figures

4. Consider dropping the figures
3 Data and descriptive statistics

3.1 Data

Our data set includes the 100 largest Metropolitan Statistical Areas (MSAs) in the United States, covering about 60 percent of the entire US population and all but four of the 50 US states. Following the Census Bureau, the US may be split into four distinct regions: West, South, Midwest and Northeast, confer Figure 3. With reference to those regions,

![Main geographical regions in the US](image)

Figure 3: Main geographical regions in the US

our data set includes 25 areas in the West and the Midwest regions, while we have 20 MSAs situated in the Northeast and 30 in the South. In addition to having a rich cross-sectional dimension, we also have a fairly long time series dimension for each of these areas. The sample runs through the period from 1980q1 to 2010q2 \((T = 122)\) for 82 of the areas, while the shortest samples (Fargo (ND-MN) and Sioux Falls (SD)) contain 95 observations. Thus, the sample covers both the recent housing cycle and the previous boom-bust cycle in the period 1982–1996 for a majority of the areas considered.

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3. Note that some of the MSAs belong to multiple states.

4. Here, we rely on the boom-bust cycle classification provided by Glaeser et al. (2008).
The house price data have been gathered from the Federal Housing Finance Agency (FHFA), while households’ disposable income, the housing stock and the CPI index – used for the nominal-to-real transformations – have been supplied by Moody’s Analytics.

We combine the MSA specific data with the Romer and Romer (2004) narrative monetary policy shock series. Romer and Romer propose a novel procedure to identify monetary policy shocks. First, they use the narrative approach to extract measures of the change in the Fed’s target interest rate at each meeting of the Federal Open Market Committee (FOMC) between 1969 and 1996. They then regress this measure of policy changes on the Fed’s real-time forecasts of past, current, and future inflation, output growth, and unemployment. The residuals from this regression constitute their measure of monetary policy shocks. The Romer and Romer shock series has gained acceptance as an exogenous indicator of monetary policy shocks and has been widely used to study the transmission of monetary policy shocks, see e.g. Coibion (2012), Ramey (2016). We use an updated version of the Romer and Romer (2004) narrative shock series, provided by Wieland and Yang (2016).

To account for regional heterogeneities, we use the MSA specific supply elasticities calculated by Saiz (2010) based on topographic measures of undevelopable land.

4 Monetary policy shocks and house prices

4.1 Monetary policy shocks and house prices

The starting point for our empirical analysis is to encompass the findings of a strong effect of monetary policy on house prices, as documented in the literature. Our modus operandi is the local projection framework suggested in Jordà (2005). We use this framework to estimate the cumulative percentage response to house prices h quarters after a monetary policy shock, letting h run from 0 to 20. The advantage of using the local projection approach is that it allows us to study the various non-linearities we are interested in, which would be vastly complicated – and maybe even infeasible – in a standard VAR
framework. In addition, our parameters of interest (the response in house prices to a monetary policy shock) are confined to one equation in the underlying VAR system, i.e., the house price equation. We start by considering a dynamic fixed effects model with no heterogeneity or asymmetries:

$$ ph_{i,t+h} - ph_{i,t-1} = \alpha_{h,i} + \beta_h RR_t + \Gamma_h' Z_{i,t-1} + \epsilon_{i,t+h} $$

(5)

where $ph_{i,t+h} - ph_{i,t-1}$ is the cumulative change in log house prices after $h$-horizons, $RR$ is the Romer and Romer (2004) shock, while $Z$ is a vector of control variables, including lagged changes in log house prices, lagged values of the log change in disposable income per capita, lagged changes in net migration rates and lagged changes in the log of the housing stock. For all variables, we include four lags. $\beta_h$ measures the cumulative change in house prices $h$ quarters after the monetary policy shock. Cumulative responses at $h = 2, 4, 8, 12, 16$ are reported in Table 1 for a monetary policy shock that raises the interest rate by one percentage point. In the same table, we report cumulative effects on house prices for the same horizons following a shock to disposable income per capita of one percent.

It is evident that an exogenous increase in the Fed funds rate has a negative effect on house prices. While house prices are predicted to fall by a little more than one percent after 2 quarters, the fall is substantial – just below 8 percent – after four years. While sizeable, the effects we find are very much in line with estimates documented in the literature on international and US data (see Williams (2015) for an excellent overview).

We also see that our results imply that house prices increase by close to one percent when income increases by unity – implying a constant price-to-income ratio four years after income is permanently increased by one percent.

In Figure 4, we plot the cumulative effect on house prices for all horizons running from 0 to 20. The figure show the same picture as we can read from the table, namely that an
Table 1: Effect of monetary policy shock on house prices, symmetric and homogenous response.

<table>
<thead>
<tr>
<th></th>
<th>h=2</th>
<th>h=4</th>
<th>h=8</th>
<th>h=12</th>
<th>h=16</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP shock</td>
<td>-1.23***</td>
<td>-1.42***</td>
<td>-4.28***</td>
<td>-6.17***</td>
<td>-7.78***</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(0.20)</td>
<td>(0.36)</td>
<td>(0.56)</td>
<td>(0.74)</td>
</tr>
<tr>
<td>Income per cap.</td>
<td>0.23***</td>
<td>0.29***</td>
<td>0.56***</td>
<td>0.72***</td>
<td>0.92***</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.05)</td>
<td>(0.08)</td>
<td>(0.11)</td>
<td>(0.15)</td>
</tr>
<tr>
<td>MSA fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>8872</td>
<td>8872</td>
<td>8872</td>
<td>8872</td>
<td>8872</td>
</tr>
<tr>
<td>MSAs</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Within R2</td>
<td>0.25</td>
<td>0.31</td>
<td>0.30</td>
<td>0.26</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Notes: The dependent variable are the cumulative log changes in the FHFA house price index at horizon $h = 2, 4, 8, 12$ and 16. Results are based on estimating equation 5 using a fixed effect estimator and the data set cover a panel of 100 US MSA’s countries over the period 1980q1–2007q4. Standard errors are clustered by MSA and reported in absolute value in parenthesis below the point estimates. The asterisks denote significance levels: * = 10%, ** = 5% and *** = 1%.

An exogenous contractionary monetary policy shock has a sizeable and negative impact on house prices.
4.2 Asymmetric effects of monetary policy

The durability of housing implies that the responses to contractionary and expansionary shocks may differ. In particular, if the demand responses to a contractionary and an expansionary monetary policy shock are equal (in absolute value), the simple demand-supply framework described in Section 2 suggests that the change in house prices will be larger for the contractionary shock. To investigate the relevance of this conjecture, we consider a modified version of (5):

\[
p h_{i,t+h} - p h_{i,t-1} = \alpha_{h,i} + \beta_{h}^{Exp} RR_{t}^+ + \beta_{h}^{Cont} RR_{t}^- + \Gamma_{h} Z_{i,t-1} + \varepsilon_{i,t+h} \quad (6)
\]

where \( RR_{t}^+ \) is a variable measuring expansionary shocks and is calculated as \( RR_{t}^+ = RR_{t} \times I(RR_{t} \geq 0) \), where \( I(RR_{t} \geq 0) \) is an indicator variable taking the value one for expansionary shock and a value of zero otherwise. Contractionary shocks are measured
by $RR_t = R R_t \times (1 - I(RR_t \geq 0))$. Thus, $-\beta_h^{\text{Exp.}}$ is the cumulative effect on house prices after $h$ quarters following an expansionary monetary policy shock, while $\beta_h^{\text{Cont.}}$ measures the effect of a contractionary monetary policy shock. Estimating 6 for $h = 2, 4, 8, 12$ and 16, we obtain the results reported in the Table 2.\(^5\)

The contractionary shock has an expected negative impact on house prices, while the expansionary shock exercises a positive impact on house prices. More intriguing, and in contrast to the simple demand-supply framework, we find that expansionary shocks have a greater impact on house prices than contractionary shocks. In particular, while an expansionary shock immediately leads an increase in house prices, it takes about a year before a contractionary shock materializes into a drop in house prices. We will later investigate possible explanations of this, but one obvious explanation is that the demand response to an interest rate increase differ from that of a reduction in the interest rate.

Figure 5 summarizes the the cumulative responses for all horizons from zero to 20 following an expansionary and a contractionary shock, and – unsurprisingly – the figure mirrors the results reported in Table 2.

Table 2: Effects of contractionary and expansionary monetary policy shocks on house prices.

<table>
<thead>
<tr>
<th></th>
<th>h=2</th>
<th>h=4</th>
<th>h=8</th>
<th>h=12</th>
<th>h=16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contr. MP shock</td>
<td>-0.12</td>
<td>0.21</td>
<td>-3.16***</td>
<td>-5.39***</td>
<td>-5.44***</td>
</tr>
<tr>
<td></td>
<td>(0.25)</td>
<td>(0.29)</td>
<td>(0.45)</td>
<td>(0.62)</td>
<td>(0.75)</td>
</tr>
<tr>
<td>Exp. MP shock</td>
<td>2.15***</td>
<td>2.81***</td>
<td>5.35***</td>
<td>6.82***</td>
<td>9.51***</td>
</tr>
<tr>
<td></td>
<td>(0.23)</td>
<td>(0.35)</td>
<td>(0.54)</td>
<td>(0.79)</td>
<td>(1.06)</td>
</tr>
<tr>
<td>Income per cap.</td>
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<td>0.26***</td>
<td>0.59***</td>
<td>0.80***</td>
<td>1.00***</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.05)</td>
<td>(0.09)</td>
<td>(0.12)</td>
<td>(0.16)</td>
</tr>
<tr>
<td>MSA fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MSAs</td>
<td>100</td>
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<td>0.25</td>
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</table>

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\(^5\)Note that the effect of the expansionary shock is normalized to be $-\beta_h^{\text{Exp.}}$, such that it picks up the effect of a reduction in the interest rate of 1 percentage point.
Figure 5: Asymmetric effect on the aggregate house price from a 1 percentage point monetary policy shock. The first subfigure, labeled Expansionary, shows the response on aggregate house prices of a monetary policy shock that decrease the interest rate. The second subfigure, labeled Negative, refers to a monetary policy shock that decrease the interest rate.
4.3 Regional variations in effectiveness of monetary policy

While our results are consistent with the literature documenting a strong role of monetary policy in affecting house prices, it is well known that the evolution of house prices differ substantially across US MSAs (see e.g., (Glaeser et al., 2008; Capozza et al., 2004; Malpezzi and Wachter, 2005)). Figure 6 displays the evolution of real house prices for four of the MSAs contained in our data set. The areas were chosen to illustrate four different types of housing markets, located in different regions of the US. Real house prices have moved quite differently in the four different areas, with a much more pronounced run-up (and subsequent bust) in San Francisco and Boston than in Houston and Wichita over the previous decade.

![Figure 6: Log of real house prices, 1980q1-2010q2.](image)

Our theory discussion suggested that local variations in housing supply elasticities may lead to different house price responses following a demand shock. To investigate whether the supply elasticity has an impact on how monetary policy shocks are absorbed, we
consider an equation of the following form:

\[ ph_{i,t+h} - ph_{i,t-1} = \alpha_{h,i} + \beta_{h} \times RR_{t} + \beta_{h}^{El} Elasticity_{i} \times RR_{t} + \Gamma'W_{i,t-1} + \varepsilon_{i,t+h} \]  

(7)

where \( Elasticity_{i} \) is the time-invariant supply elasticities calculated in Saiz (2010), with a higher value indicating a more elastic housing supply. For a particular area, \( i \), the cumulated response to house prices in period \( h \) following a monetary policy shock is given as \( \beta_{h} + \beta_{h}^{El} Elasticity_{i} \). The vector of controls include the same set of controls as previously, but also interactions of the other demand shifters (migration and income) and the supply elasticity. This is because theory also suggests that the reaction to other demand shifters should be lower the lower is the elasticity of supply. Table 3 summarizes results from estimating (7).

We find that an exogenous increase in the policy rate has a smaller negative effect on house prices at all horizons the higher is the elasticity of supply, which is in line with the theory model. Consistent with this, we also find a smaller effect on house prices following an increase in per capita disposable income in more supply elastic areas.

We have calculated the response for 5 different MSAs with very different supply elasticities; Dayton, Kansas City, Scranton, San Francisco and Miami. While house prices are predicted to fall by less than 3 percent in Dayton 4 years after a contractionary monetary policy shock, house prices in Miami are predicted to fall by more than 11 percent over the same horizon. Our results therefore suggest a substantial difference in house price responses for areas with different supply elasticities.

To shed some more light on this, Figure 7 display the response in house prices for areas with low, normal and high supply elasticities. An area is classified as having a low elasticity of supply if it is at least one standard deviation below the mean. Similarly, the elasticity is high if it is at least one standard deviation above the mean. All other areas
Table 3: Effect of contractionary monetary policy shock with different supply elasticities.

<table>
<thead>
<tr>
<th></th>
<th>h=2</th>
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<th>h=12</th>
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</tr>
</thead>
<tbody>
<tr>
<td>MP shock</td>
<td>-1.53***</td>
<td>-2.66***</td>
<td>-6.98***</td>
<td>-10.43***</td>
<td>-13.13***</td>
</tr>
<tr>
<td></td>
<td>(0.23)</td>
<td>(0.39)</td>
<td>(0.64)</td>
<td>(0.96)</td>
<td>(1.22)</td>
</tr>
<tr>
<td>MP shock × Elasticity</td>
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<td>0.69***</td>
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Effects of contractionary monetary policy shock for five different MSAs:

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<td>0.34</td>
<td>0.33</td>
<td>0.29</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Notes: The dependent variable are the cumulative log changes in the FHFA house price index at horizon $h = 2, 4, 8, 12$ and $16$. Results are based on estimating equation 7 using a fixed effect estimator and the data set cover a panel of 100 US MSA’s countries over the period 1980q1–2007q4. The specification allows the response in house prices to differ depending on the elasticity of supply, as calculated in Saiz (2010). Standard errors are clustered by MSA and reported in absolute value in parenthesis below the point estimates. The asterisks denote significance levels: * = 10%, ** = 5% and *** = 1%.
are classified as having a normal elasticity.\(^6\) Responses are remarkably different. While the most inelastic areas experience a large drop in house prices following a contractionary monetary policy shock, the most elastic areas see only a modest fall in house prices.

\(^6\)To compute the cumulative responses for the low, normal and high elasticity areas, we estimated an auxiliary regression of the following form:

\[ ph_{i,t+h} - ph_{i,t-1} = \alpha_{h,i} + \beta_{h}^{\text{Low}} El_{i}^{\text{Low}} \times RR_t + \beta_{h}^{\text{Normal}} El_{i}^{\text{Normal}} \times RR_t + \beta_{h}^{\text{High}} El_{i}^{\text{High}} \times RR_t + \Gamma' W_{i,t-1} + \varepsilon_{i,t+h} \]

where  \( El_{i}^{\text{Low}} = El_{i} \times I(El_{i} < \bar{El} - \sigma_{El}) \), with \( \bar{El} \) signifying the mean elasticity and \( \sigma_{El} \) being the standard deviation of the elasticity measure. Likewise,  \( El_{i}^{\text{High}} = El_{i} \times I(El_{i} > \bar{El} + \sigma_{El}) \) and  \( El_{i}^{\text{Normal}} = El_{i} \times I(\bar{El} - \sigma_{El} \geq El_{i} \leq \bar{El} + \sigma_{El}) \).
Figure 7: Effect on house price from a 1 percentage point monetary policy shock for MSA’s with different housing supply elasticity, as measured by Saiz (2010). Low elasticity refers to the lower decile of elasticity, i.e., the most inelastic markets, while High elasticity refers to the decile with the most elastic supply. Normal refers to rest.
4.4 Asymmetric effects of monetary policy with different supply elasticities

The final prediction of the theory model is that while an expansionary monetary policy shock have a greater impact on house prices in areas with an inelastic housing supply, the response to a contractionary shock should be similar across areas, due to the downward rigidity of housing supply. We investigate this by allowing expansionary and contractionary shocks have different effects for different supply elasticities. We consider a specification of the following form:

\[ ph_{i,t+h} - ph_{i,t-1} = \alpha_i + \beta_h^{\text{Exp.}} RR_t^+ + \beta_h^{\text{Exp., El.}} \times \text{Elasticity}_i \times RR_t^+ \]
\[ + \beta_h^{\text{Cont.}} RR_t^- + \beta_h^{\text{Cont., El.}} \times \text{Elasticity}_i \times RR_t^- + \Gamma W_{i,t-1} + \varepsilon_{i,t} \]  

With this specification, the cumulative response to house prices in area \( i \) after \( h \) quarters following an expansionary monetary policy shock is given by \( \beta_h^{\text{Exp.}} + \beta_h^{\text{Exp., El.}} \times \text{Elasticity}_i \), which clearly varies by the supply elasticity as long as \( \beta_h^{\text{Exp., El.}} \) is different from zero. The following a contractionary shock is given by \( \beta_h^{\text{Cont.}} + \beta_h^{\text{Cont., El.}} \times \text{Elasticity}_i \). Regression results are displayed in Table 4.

While we find that both contractionary and expansionary shocks have a greater effect on house prices in inelastic areas, there are nuances to these results. If we consider a very inelastic market, such as San Francisco or Miami, the expansionary shock has twice the impact on house prices as the contractionary shock, which is at odds with the simple demand-supply story. However, considering an area with very elastic housing supply, Dayton (OH), the effect of the expansionary shock is smaller than the contractionary shock. This can be due to expansionary shocks leading to expectations of substantial future price increases in a market with a low elasticity of supply, since people may understand that a high demand pressure in an inelastic market will lead to higher prices in the future, leading them to increase demand today in anticipation of future price increases. Thus,
households that are eager to enter the market may increase their demand today in expectation of increasing prices in the future. At the same time, banks may be willing to extend more credit, since the value of their housing portfolio has increased. If price increases lead to expectations of further price increases, or to a relaxation of credit constraints, this can have a strong amplifying effect on demand (Glaeser et al., 2008; Bernanke and Gertler, 1989; Kiyotaki and Moore, 1997; Aoki et al., 2004; Iacoviello, 2005), resulting in large price increases in inelastic markets. On the other hand, an increase in the interest rate may have a relatively smaller impact on demand. These mechanisms will be less relevant in markets with a high supply elasticity, since people know that even in the face of an increase in house prices, there is still plenty of land to build on at a relatively low cost.

Figure 8 show the cumulative response in house prices following an expansionary (upper panels) and contractionary (lower panels) monetary policy shocks for markets with an elasticity below average (left panels) and for markets with an elasticity above average (right panels).
Notes to self: Incomplete and needs to be elaborated. Some ideas:

1. Endogenizing expectations in the theory part, so that expected house price appreciation depends on past price changes ⇒ Relatively stronger acceleration in inelastic markets

2. Genesove and Mayer (2001) QJE piece on loss aversion may explain smaller drop in demand when prices are falling. Possible to link to our story?

3. What about local differences in credit market institutions? Combination of lax lending standards and low supply elasticities contributing to magnify demand shocks?
Table 4: Effect of contractionary monetary policy shock with different supply elasticities.

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<td>× Elasticity</td>
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<td>(0.33)</td>
<td>(0.48)</td>
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<td>(0.16)</td>
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<td>(0.29)</td>
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<td>Income per cap. × Elasticity</td>
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Effects of contractionary monetary policy shock for five different MSAs:

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Effects of expansionary monetary policy shock for five different MSAs:

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| Observations     | 8781              | 8781              | 8781               | 8781                  | 8781             |
| MSAs             | 99                | 99                | 99                 | 99                    | 99               |
| Within R2        | 0.29              | 0.35              | 0.33               | 0.30                  | 0.25             |

Notes: The dependent variable are the cumulative log changes in the FHFA house price index at horizon \( h = 2, 4, 8, 12 \) and 16. Results are based on estimating equation 8 using a fixed effect estimator and the data set cover a panel of 100 US MSA’s countries over the period 1980q1–2007q4. The specification allows the response in house prices to differ depending on the elasticity of supply, as calculated in Saiz (2010), and whether the monetary policy shock is expansionary or contractionary. Standard errors are clustered by MSA and reported in absolute value in parenthesis below the point estimates. The asterisks denote significance levels: * = 10%, ** = 5% and *** = 1%.
Figure 8: Asymmetric effect on house price from a 1 percentage point monetary policy shock for MSA’s with different housing supply elasticity, as measured by Saiz (2010). Expansionary, Low refers to the effect of an expansionary monetary policy shock for MSA’s with low supply elasticity, while Expansionary, High refers to the effect of an expansionary monetary policy shock for MSA’s with high supply elasticity. Likewise, Contractionary, Low refers to the effect of an contractionary monetary policy shock for MSA’s with low supply elasticity, while Contractionary, High refers to the effect of an contractionary monetary policy shock for MSA’s with high supply elasticity.

5 Conclusion
References


