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House Price Responses to Monetary Policy Surprises: Evidence from the U.S. Listings Data*

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Abstract

Evidence on the contemporaneous effects of interest rates on house prices has been elusive. We present direct evidence of the high-frequency causal relationship between interest rates and house prices in the United States. We exploit information contained in listings for residential properties for sale in the United States between 2001 and 2019 from the CoreLogic Multiple Listing Service Dataset. Using high-frequency instruments for monetary policy shocks, we estimate that a contractionary monetary policy surprise that raises average 30-year mortgage rates by 0.25 percentage points lowers housing list prices by 1 percent within two weeks. House prices respond to surprises to the expected path of future rates and are insensitive to the federal funds rate surprises. The initial response of list prices is almost entirely passed through to sale prices and persists for at least a year after the announcement.

Keywords: House prices. Monetary policy. Transmission of monetary policy. List and sales prices.
JEL codes: E52, R21, R31.

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1 Introduction

House price growth is fairly smooth and appears to be insensitive to changes in real or nominal interest rates (Case and Shiller, 1989). Summarizing the existing literature, Kuttner (2013) and Williams (2015) conclude that the effects of interest rate changes on house prices materialize only gradually, after two years or so, similar to their effects on prices of consumer goods and services. Such sluggishness is difficult to account in theory without assuming strong inefficiencies in housing markets due to search costs, transaction and carrying costs, tax considerations, or non-rational behavior and animal spirits (see Guren (2018) and references therein). Without considerable market frictions and limits on arbitrage, house prices are expected to respond quickly to changes in interest rates, akin to prices of financial assets (Bernanke and Kuttner, 2005) rather than prices of consumer goods and services. Yet, evidence on the contemporaneous effects of interest rates on house prices has been elusive, due to lack of detailed data and inadequate methods.

In this paper, we provide the first direct evidence of the high-frequency causal relationship between interest rates and house prices in the United States. We use detailed micro data on house listings and document a prompt response of house prices to interest rate changes. Using external high-frequency instruments for monetary policy shocks, we estimate that a contractionary monetary policy surprise that raises 30-year mortgage rates by 0.25 percentage points (ppt) lowers housing list prices by 1 percent within two weeks following a monetary policy announcement. New list prices, in turn, determine prices at which houses are eventually sold. Most of the response is the reaction to changes in expected future interest rates, and there is no sensitivity to surprises in the federal funds rate.

Our house price data come from the CoreLogic Multiple Listing Service Dataset, which contains property-level data on listings and sales of residential properties in the United States. Our sample covers the majority of residential property listings across 43 states and the District of Columbia (about 11,000 zip codes) from 2001 to 2019, at a daily frequency. We study the responses of house list prices, sale prices, and time-on-market to monetary policy surprises using the local projections method of Jordà (2005). We use external instruments for monetary policy surprises associated with Federal Open Market Committee (FOMC) announcements and identified by high-frequency methods in Nakamura and Steinsson (2018), Swanson (2021), and Bauer and Swanson (2022). We use Swanson (2021)'s instruments to distinguish between unanticipated changes in short-term interest rates and surprises to the expected future interest rates.

We first estimate impulse responses using surprise measures as structural shocks to interest rates. House list prices move quickly after monetary policy announcements, responding mainly to surprises about future interest rates. A one-standard-deviation contractionary surprise to future interest rates—–measured by Swanson (2021)'s factors for forward guidance (FG) and large-scale asset purchases (LSAP)—–lowers list prices by roughly 0.2 and 0.3 percent, respectively, within 2 to 3 weeks after the shock. These responses are similar in magnitude to responses of financial assets on the day of an FOMC announcement, derived using the same surprise measures. House prices are insensitive to the surprise changes in the federal funds rate. We obtain similar results to the measures of monetary surprises that combine information from a range of short-term interest rates up to one-year maturity (Nakamura and Steinsson, 2018; Bauer and Swanson, 2022) .

We extend the analysis to address concerns that the surprise measures may capture only part of the structural shock to monetary policy and may also contain measurement error. We estimate impulse responses by local projections using Swanson's monetary policy surprises as external instruments for the unobserved structural interest rate shock. A contractionary shock that raises average 30-year fixed-rate mortgage rates by 0.25 ppt lowers list prices within just two weeks since the announcement, by 1.2 percent in week 2 and by 1.4 percent in week 3 after the announcement. The magnitude of the response is economically significant: it is comparable to the response of stock prices on the day of the announcement, around 1 percent (Bernanke and Kuttner, 2005). The implied semi-elasticity of house prices to interest rates is around 5 or 6 (in absolute value) which is in the middle of the range between 3 and 8 for medium- and long-run semi-elasticities of house prices to interest rates documented in the empirical literature (Kuttner, 2013).

The results are robust to a variety of specifications. Adding controls for local and national business cycles and for financial market conditions raises economic and statistical significance of estimated responses, suggesting such controls are crucial for the direct estimation of impulse responses using local projections, as emphasized by Ramey (2016) and Stock and Watson (2018). Estimates are robust to allowing non-linear and asymmetric responses, or to using orthogonalized surprise measures (Bauer and Swanson, 2022). Importantly, the results are not sensitive to the choice of the variable representing the endogenous interest rate, as long as it captures future interest rates. For example, the responses are similar or larger when instead of average mortgage rates we use daily yields for 4- and 8-quarter Eurodollar futures or 5-year U.S. Treasury notes on the day of the announcement.

Several results provide indirect evidence that changes in expected future interest rates influence house prices via the house financing channel.[1] First, mortgage rates respond almost immediately to monetary policy surprises, providing contemporaneous market guidance for house buyers and sellers (or their brokers). Second, list prices in zip codes with lower household incomes or lower house values are more sensitive to interest rate surprises than prices in high-income or high-value zip codes. Zip codes with lower incomes or lower house values have a higher fraction of financially constrained buyers and sellers, who are more sensitive to interest rate changes. Third, list prices exhibit a larger fall after a contractionary interest rate surprise in zip codes with fewer bank branches. Such a response may reflect a larger contraction of bank lending in locations with weaker competition among banks (Drechsler, Savov, and Schnabl, 2017). Fourth, high-frequency list price responses do not depend on location's long-run housing supply elasticity, since housing supply is essentially fixed at weekly frequency. Lastly, the responses are stronger for expansionary monetary policy shocks, in line with the mortgage refinancing channel (Berger, Milbradt, Tourre, and Vavra, 2021; Eichenbaum, Rebelo, and Wong, 2022).

We emphasize two practical implications of our findings for policy analysis. First, prices of new listings provide more accurate information about contemporaneous house price responses to monetary policy shocks than sale prices. We show that the adjustment of list prices to monetary surprises is almost entirely passed through to sale prices. This implies that standard closing-date price indexes mix sale prices for houses listed before and houses listed after the announcement, thus introducing measurement error. Such measurement error obfuscates estimation of the dynamic effects of interest rates on house prices. Anenberg and Laufer (2017) provide evidence that house list prices exhibit stronger contemporaneous correlations with equity prices and macroeconomic news shocks than conventional closing-date prices.

Second, we find that the contemporaneous responses of house prices to interest rate surprises persist for at least a year after the announcement. Therefore, even at quarterly frequency there is a negative relationship between interest rates and house prices, in line with two existing strands of literature documenting gradual responses of house prices to interest rate shocks (Kuttner, 2013; Williams, 2015) and strong serial correlation in house price growth at quarterly and annual frequencies (Case and Shiller, 1989; Cutler, Poterba, and Summers, 1991). Hence, another practical implication of our findings is that

[1]Rising mortgage rates make house financing more expensive by tightening debt-to-income or loan-to-value constraints and lead to lower demand for housing (Anenberg and Kung, 2017; Favilukis, Ludvigson, and Van Nieuwerburgh, 2017; Greenwald, 2018; Garriga, Kydland, and Šustek, 2017; Bhutta and Ringo, 2021). In anticipation of the imminent fall in demand, home sellers lower their list prices. Furthermore, sellers may wish to sell their houses sooner than later while mortgage rates are still rising. Garriga, Manuelli, and Peralta-Alva (2019) show that prices respond not only to changes in interest rates, but also to changes in expected future financial conditions.

the contemporaneous adjustment of list prices may be useful for forecasting house price dynamics over longer horizons.

The rest of the paper is structured as follows. Section 2 describes our property-level data, and how we construct the zip-code-week level house price indexes. Section 3 provides a theoretical primer on the impact of monetary policy shocks on house prices, discusses measures of monetary policy shocks, and describes the local projections estimation method. Section 4 presents the estimated dynamic responses of list prices. Section 5 provides the responses of other house market variables, explores heterogeneity across zip codes, and presents evidence on the asymmetry of list price responses and on responses at longer horizons. Section 6 concludes and lays out avenues for future research.

2 Data and Construction of House Price Indexes

2.1 Property-level house price data

We use data on home listings and sales from the CoreLogic Multiple Listing Service Dataset. The dataset contains detailed information on the universe of all housing units, commercial properties, rentals, and land plots listed for sale or for rent on the Multiple Listing Service (MLS) platforms across 43 states and the District of Columbia in the United States.[2] The starting date for the MLS data varies by state, with many states reporting consistently since the late 1980s. To include as many locations as possible, we use data from 2001 to 2019 in our analysis.

The unit of observation in the data is a property listing, which comes at a daily frequency. For each listed property, we observe the list price, the date at which this property was listed, and all the characteristics of the property that the owner and the real estate broker used to describe the listing (e.g., address, property type, number of bedrooms and bathrooms, year built, living area). We also observe the dates at which the property was sold and the sale price. Our raw dataset contains about 115 million listings.

We focus on the listings of single-family homes and apartments and exclude listings of rentals, land parcels, mobile homes, or commercial properties. We restrict our sample to properties that have a non-missing and non-zero list price and drop listings that have no information on the city where the property is located. We drop listings for properties that do not sell during our sample period so that we have both list and sale price observations for each listing. Applying these filters reduces observations by about 17 percent.

[2] Some states have very few observations in the Corelogic data or are not reported at all: Alaska, Maine, North Dakota, South Dakota, Utah, Vermont, Wyoming.

Listings of rentals, land parcels, mobile homes, and commercial properties account for the majority of observations that are filtered out. To ensure that our results are not driven by outliers, we winsorize the top and bottom 0.1 percent of list and sale prices by zip code in our sample. We also drop properties that are listed or sold in location-weeks that have fewer than 5 observations per location-week. Lastly, we drop zip codes that have fewer than 50 observations across all weeks in our sample.

Table 1 provides some summary statistics. Our cleaned data comprise a total of 92,064,327 listings, on average over 760 weeks per zip code, and 121,101 listings per week across zip codes. The data represent 10,958 zip codes across 43 U.S. states and D.C., with a median of 8 new listings per week per zip code. A typical house is listed at around 229 thousand 2010 dollars, and after spending a median of 110 days on the market, it is sold at a slightly lower price of 212 thousand dollars. There is substantial heterogeneity in prices and time-on-market both within and across zip codes.

	Median	Inter-quartile range	
		within zip	across zip
List price, in 2010 dollars	228,965	127,749	188,771
Sale price, in 2010 dollars	212,492	94,608	172,784
Time-on-market, days	110	93	46
Number of listings per week	8		7
Total zip codes = 10,958			
Total listings/week = 121,101			
Total listings = 92,064,327			

Table 1. Summary Statistics for House Listings across U.S. Zip Codes

Notes: Table provides statistics at zip code level from 2001 to 2019. List price and sale price (by list date) are provided in 2010 dollars. Column "Median" provides a weighted median across zip-level medians, where the weights are the number of listings in a zip code in a given week. Column "Inter-quartile range, within zip" provides weighted median across zip-level inter-quartile ranges. Column "Inter-quartile range, across zip" provides weighted inter-quartile range across zip-level medians.

2.2 Construction of weekly house price indexes by zip code

In the first stage of our empirical analysis, we estimate real house price indexes by zip code using hedonic regressions. We deflate house prices using the Consumer Price Index for All Urban Consumers that is based on all items in the United States.

Let $\phi^L_{il,w}$ denote the real list price for property i in zip code l listed on week $w =$

$1, ..., 988$ between 2001 and 2019. For each location l we estimate

$$\ln \phi^{L}_{il,w} = \chi_l + p^{L}_{l,w} + \mathbb{X}_{il} + \tau_{l,woy} + \varepsilon_{il,w} \,, \tag{1}$$

where χ_l is a constant; $p^{L}_{l,w}$ is the time fixed effect (at weekly frequency); $\mathbb{X}_{il}$ is a set of housing characteristics for property i that includes the construction year of the property, total number of bedrooms, classification of land-use (e.g., apartment, townhouse, single-family residence), and the size of the living area in square feet; $\tau_{l,woy}$ is the week-of-year (woy) effect to capture seasonality in the housing markets across the 52 weeks of a year; and $\varepsilon_{il,w}$ is the error term. The weekly log list price index for zip code l is given by the estimates of the weekly time effects, $p^{L}_{l,w}$. We estimate a similar regression to construct weekly log time-on-market by list date indexes, $tom_{l,w}$.

For sale prices, we construct two indexes—one defined by listing date and one defined by closing date. The listing-date sale index uses the date of the listing, i.e., the same date for which we construct the list price index. Denoting by $\phi^{S}_{il,w}$ the real sale price for property i in zip code l *listed* on week w, we estimate for each zip code l a specification similar to the one in (1):

$$\ln \phi^{S}_{il,w} = \chi_l + p^{SL}_{l,w} + \mathbb{X}_{il} + \tau_{l,woy} + \varepsilon_{il,w} \,. \tag{2}$$

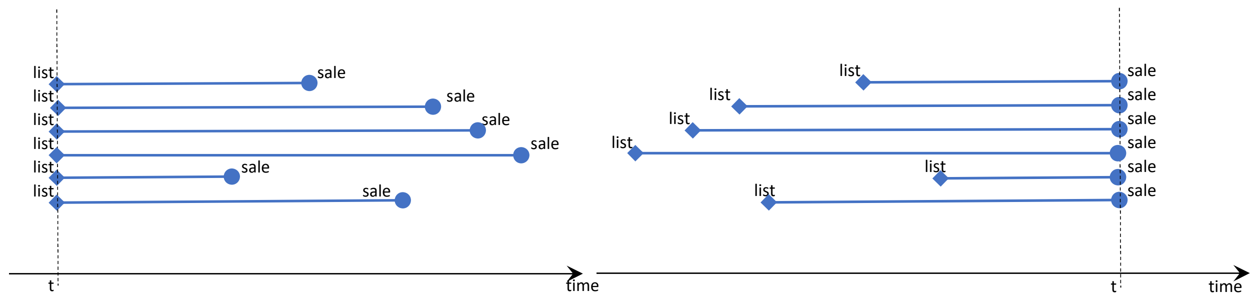
The weekly log listing-date sale price index for zip code l is given by the estimated location-week time effects, $p^{SL}_{l,w}$.

Denote by $\phi^{S}_{il,\widetilde{w}}$ the sale price for property i in zip code l *sold* in week $\widetilde{w} = 1, ..., 988$. We estimate for each location l:

$$\ln \phi^{S}_{il,\widetilde{w}} = \chi_l + p^{SS}_{l,\widetilde{w}} + \mathbb{X}_{il} + \tau_{l,woy} + \varepsilon_{il,\widetilde{w}} \,. \tag{3}$$

The weekly log closing-date sale price index for zip code l is given by the estimated location-week time effects, $p^{SS}_{l,\widetilde{w}}$.

The listing-date sale price index, $p^{SL}_{l,w}$, is constructed using data for the same set of properties as the list price index $p^{L}_{l,w}$. Therefore, the listing-date sale price index provides the average price (conditional on other regressors in 2) at which houses listed in week w are eventually sold at some point later (Figure 1a). The closing-date price index $p^{SS}_{l,\widetilde{w}}$ provides the average sale price of all houses sold in week $\widetilde{w}$ for the set of houses listed on various dates earlier (Figure 1b). In the analysis, we show that distinguishing price indexes for properties *sold* after the shock and indexes for properties *listed* after the shock influences the measurement of sale price responses to monetary policy surprises.



(a) Timing for listing-date index **(b)** Timing for closing-date index

Figure 1. Differences in sale price indexes based on listing and closing dates

3 Methodology of Estimating the Effect of Monetary Surprises on House Prices

In this Section, we provide a theoretical primer on the impact of monetary policy shocks on house prices. We then explain the measures of monetary policy surprises and describe the estimation method.

3.1 Theoretical primer

The basic mechanism linking unexpected changes in nominal interest rates to house prices can be explained using a standard business cycle model with households deriving utility from non-durable and housing consumption. For brevity, we only mention the key equations (details can be found, for example, in Barsky, House, and Kimball (2007)).

When a central bank raises interest rates and the raise is unanticipated, the demand shifts from current consumption to future consumption. This can be illustrated via a standard Euler equation:

$$U_t^c = \beta(1 + i_t)E_t[U_{t+1}^c P_t^c / P_{t+1}^c],$$

where U_t^c is the marginal utility of non-durable consumption, P_t^c is its price, and i_t is the risk-free rate. The unexpected increase in the interest rate in period t is met with higher marginal utility (lower consumption) and lower prices in period t.

The effect on house prices depends on how interest rates affect the real value of housing γ_t^h, given by the present value of marginal utilities of the service flow of the house,

$\{U^h_{t+\tau}\}$, discounted by the rate of time preference β and depreciation rate δ:

$$\gamma^h_t = E_t \sum_{\tau=0}^{\infty} [\beta^\tau (1-\delta)^\tau U^h_{t+\tau}]. \tag{4}$$

Because houses are illiquid long-lived durables, variation in the marginal utility of the service flow $\{U^h_{t+\tau}\}$ has little effect on the real value of housing, i.e., $\gamma^h_t \approx \gamma^h$. This property has direct implication for how house prices respond to interest rate shocks. Households allocate their non-durable consumption and housing to equate the marginal values of an additional dollar spent so that $U^c_t / P^c_t = \gamma^h / P^h_t$. Since the nominal interest rate increase raises U^c_t / P^c_t, it also lowers house prices P^h_t. Combining the Euler equation with constant value of housing, we can obtain a relationship between the risk-free rate and housing prices:

$$(1 + i_t) \approx \beta^{-1} E_t [P^h_{t+1} / P^h_t].$$

In this frictionless setting, the nominal interest rate approximately equals the expected inflation in the price of houses. If the interest rate hike is unanticipated, the expected value of house price $E_t[P^h_{t+1}]$ is zero, and therefore, current house price P^h_t must fall.

Introducing market inefficiencies creates additional mechanisms for house price fluctuations. A large literature studies the role of housing finance on the transmission of interest rate changes to housing markets.[3] Because buying or selling a house often involves financing, interest rates may also influence house prices via the cost of housing debt. Higher interest rates raise mortgage rates and reduce availability of credit, cooling housing demand, especially from financially constrained households.

Besides cooling the demand for houses, higher current and future interest rates also reflect the risk premium associated with owning a house (Campbell, Davis, Gallin, and Martin, 2009; Favilukis, Ludvigson, and Van Nieuwerburgh, 2017). In addition, higher interest rates can increase the user cost of housing indirectly by raising the expectation of house price depreciation (Glaeser, Gottlieb, and Gyourko, 2013; Kuchler, Piazzesi, and Stroebel, 2022) or changing property or income tax obligations across different homeowners (Poterba, 1984). An extensive review of the literature on housing in macroeconomics is provided by Piazzesi and Schneider (2016).

[3] Davis and Van Nieuwerburgh (2015) provide a review of the macroeconomic aspects of the housing finance literature. Contributions include Iacoviello (2005); Favara and Imbs (2015); Anenberg and Kung (2017); Garriga, Kydland, and Šustek (2017); Greenwald (2018); Garriga, Manuelli, and Peralta-Alva (2019); Bhutta and Ringo (2021); Berger et al. (2021); Wong (2021); Eichenbaum, Rebelo, and Wong (2022).

3.2 Measures of monetary policy surprises

We use measures of high-frequency monetary policy surprises from the existing literature. High-frequency identification of unanticipated monetary policy actions is based on the discrete adjustments of financial futures prices within a narrow window around scheduled Federal Open Market Committee (FOMC) announcements.[4] This approach produces reasonably good proxies for exogenous monetary policy shocks (Ramey, 2016).

In our baseline analysis, we use monetary policy surprises from Swanson (2021). Swanson applies a factor model to assets with maturities below 1 year and 2-, 5-, and 10-year Treasury yields. He uses the top three factors of his model to characterize the shocks to monetary policy in the U.S. The top three factors explain 94 percent of the changes in Treasury yields within a 30-minute window around scheduled FOMC announcements between 1991 and 2019. Swanson shows that under additional restrictions, the first factor can be related to unexpected changes in the federal funds rate; the second factor to the Federal Reserve's forward guidance; and the third factor to large-scale asset purchases (LSAPs). Distinguishing surprises to the current and future interest rates turns out to be crucial for understanding the mechanisms driving house price responses.[5]

We broaden our set of measures of monetary policy shocks by including the series from Nakamura and Steinsson (2018) and Bauer and Swanson (2022). Nakamura and Steinsson (2018) measure the monetary policy shock as the first principal component of the unanticipated change in five short-term interest rates within a narrow 30-minute window around scheduled FOMC announcements. Because this measure uses interest rates at maturities within one year, it captures the effects of changes in both the current federal funds rate and expected future federal funds rates. The latter, captured by the "policy news shock", is influenced by the Federal Reserve's forward guidance and balance sheet policies. Nakamura and Steinsson (2018) construct the shocks from February 2000 to March 2014. In the analysis, we use the policy news shock series from Acosta and Saia (2022), who extend Nakamura and Steinsson's shocks through 2019. Bauer and Swanson (2022), like Nakamura and Steinsson (2018), use a range of Federal funds futures and Eurodollar futures to construct high-frequency measures of monetary policy shocks.

[4] Early studies include Cook and Hahn (1989); Kuttner (2001); Cochrane and Piazzesi (2002); Gürkaynak, Sack, and Swanson (2005). Recent studies using high-frequency identification of monetary shocks include Hanson and Stein (2015); Gertler and Karadi (2015); Nakamura and Steinsson (2018); Altavilla, Brugnolini, Gürkaynak, Motto, and Ragusa (2019); Cieslak and Schrimpf (2019); Gurkaynak, Kara, Kısacıkoğlu, and Lee (2021); Swanson (2021); Andrade and Ferroni (2021).

[5] Swanson normalizes the federal funds rate factor to have a unit standard deviation from July 1991 to December 2008, the LSAP factor to have a unit standard deviation over the ZLB period from January 2009 to October 2015, and the forward guidance factor to have a unit standard deviation from July 1991 to June 2019.

Bauer and Swanson refine their measure along two dimensions. They add information from the Federal Reserve Chair's speeches and testimonies and purge their measure of the component predicted by macroeconomic and financial data preceding the policy announcements.

3.3 Estimation by local projections

We employ Jordà (2005)'s local projections (LP) method to estimate the average effect of a surprise associated with a monetary policy announcement. Let $\mathrm{P}_{l,t}$ denote a house market index of list price, listing-date or closing-date sale price, or time-on-market, in zip code l on week t. Let S_t denote a measure of an identified monetary policy surprise in week t. In our baseline specification, S_t is a vector of Swanson (2021)'s three factors—FFR_t, FG_t, LSAP_t—which capture the surprise changes in the federal funds rate, forward guidance, and large-scale asset purchases, respectively.

The impulse response of a house market index to a monetary surprise at horizon $h = 0, ..., H$ weeks is estimated by the following panel regression:

$$\ln P_{l,t+h} - \ln P_{l,t-1} = \beta^{(h)}\mathrm{S}_t + \sum_{q=1}^{52} \theta_q^{(h)}(\ln P_{l,t-q} - \ln P_{l,t-q-1}) + \chi_l^{(h)} + \varepsilon_{l,t}^{(h)}, \tag{5}$$

where $\ln P_{l,t+h} - \ln P_{l,t-1}$ is the change in a house market index over h weeks after the shock in week t, and $\ln P_{l,t}$ is one of $p^L_{l,w(d)}$, $p^{SL}_{l,w(d)}$, $p^{SS}_{l,w(x)}$, or $tom_{l,w(d)}$ constructed in Section 2.2. Controls are 52 lags of the weekly change in the index variable. $\chi_l^{(h)}$ denotes zip code fixed effects. $\varepsilon_{l,t}^{(h)}$ is the error term, assumed to be heteroskedastic, independent across localities l, and serially correlated. Note that all coefficients are h-horizon-specific. We estimate equation (5) by fixed-effects panel regression method with Driscoll and Kraay (1998) standard errors which incorporate corrections for serial correlation of the error term in local projections (Ramey, 2016) and are robust to cross-sectional dependence in house price data (Oikarinen, Bourassa, Hoesli, and Engblom, 2018). In the estimation, we weigh each observation by the number of listings in a given week in each zip code.[6] Coefficients $\beta^{(h)}$ measure the response of a housing market index h weeks after the monetary policy surprise.

Local projections are well-suited for estimating dynamic causal effects of interest rates on house prices. They can exploit state-of-the-art external instruments that provide plausibly exogenous variation for identification of these dynamic effects (Stock and Watson,

[6] Allowing time variation in the weights does not affect the results, see Appendix.

2018). Because such instruments are obtained by high-frequency methods, they are useful for estimating the responses over daily and weekly horizons. Local projections also require fewer restrictions than vector-autoregressions. For example, we need not incorporate other endogenous variables that may influence the transmission to house prices, as long as surprise measures S_t are orthogonal to those variables (Ramey, 2016).[7] Flexibility of local projections is convenient for capturing the complexity of time-series variation of house prices in decentralized housing markets.

The implementation of equation (5) assumes that the surprise S_t represents a structural shock, i.e., "a primitive, unanticipated economic force, or driving impulse, that is unforecastable and uncorrelated with other shocks" (Stock and Watson, 2018). Like most of the macroeconomic literature using local projections, we adopt this assumption in the initial analysis. We then extend local projections to address several potential concerns with implementation of equation (5). First, the surprise measure S_t may capture only part of the structural shock to monetary policy, and may also contain measurement error. A related issue, emphasized by Nakamura and Steinsson (2018), is that the estimated surprise measures are small, which introduces a "power problem" for estimating the dynamic effects. To address these issues, in Section 4.2, we estimate impulse responses by local projections using Swanson's monetary policy surprises as *external instruments* for the unobserved structural interest rate shock. We refer to the local projections in equation (5) as LP-OLS and to the local projections with instrumental variables as LP-IV.

Second, the surprise measures may not be exogenous to other related variables in the transmission mechanism or may correlate with other shocks. We analyze the robustness of the baseline specification in equation (5) to using orthogonalized surprises (Section 4.3) and to including additional controls (Section 5.4).

Third, the influence of monetary policy surprises on house prices may be state- and time-dependent, and vary with the size of the surprise. We address these issues by estimating extensions of equation (5) that allow for non-linear and asymmetric responses, presented in Sections 4.3 and 5.5.

[7] Structural vector-autoregressions (SVAR) can use external instruments for identification of the impulse reponses (Gertler and Karadi, 2015). Plagborg-Møller and Wolf (2021) show that LP and VAR methods are equivalent with infinite lag lengths, but may produce substantially different results with finite lag lengths, especially at long horizons. Ramey (2016) and Stock and Watson (2018) discuss the differences between LP-IV and SVAR-IV methods.

4 List Price Responses to Monetary Policy Shocks

4.1 LP-OLS responses

Figure 2 shows the estimated responses of list prices to contractionary one-standard-deviation impulses for three monetary policy shocks estimated by Swanson (2021).[8] The responses to factors associated with surprises to future interest rates—FG and LSAP factors—are negative and significant: house prices fall by more than 0.2 and 0.3 percent respectively within 2 to 3 weeks after the shock. By contrast, the responses to the surprise change in the federal funds rate—FFR factor—is positive and mostly not statistically significant.

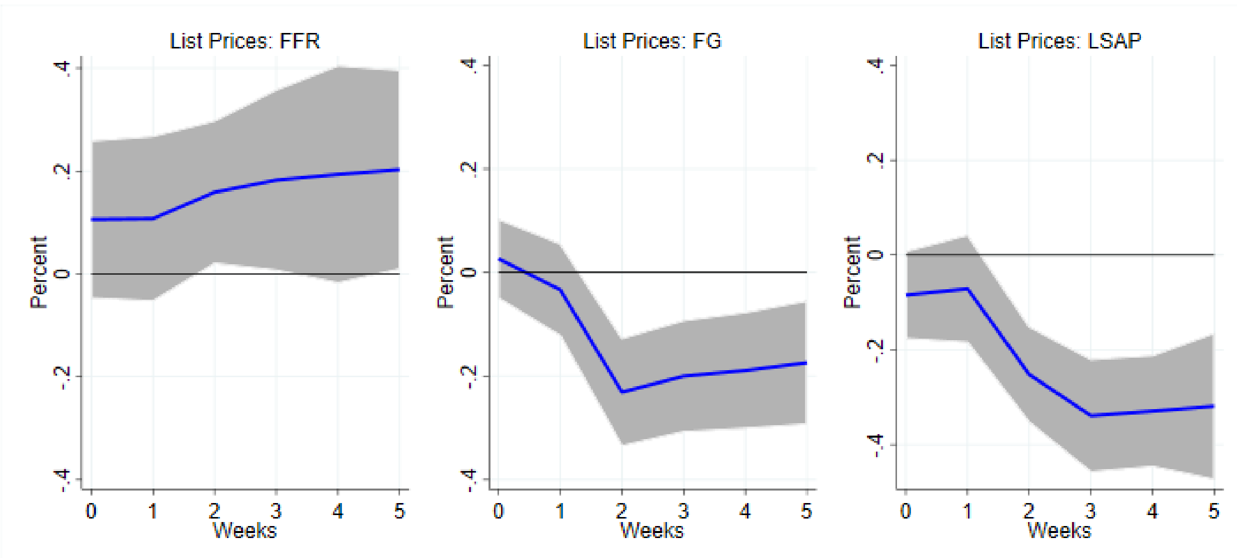


Figure 2. Responses of Housing List Prices to Contractionary Monetary Policy Surprises

Notes: The figure shows responses of the list price index to a one-standard-deviation increase in Swanson (2021)'s federal funds rate factor (left), forward guidance factor (middle), and (negative of) LSAP factor (right). Responses are estimated using specification in (5). Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

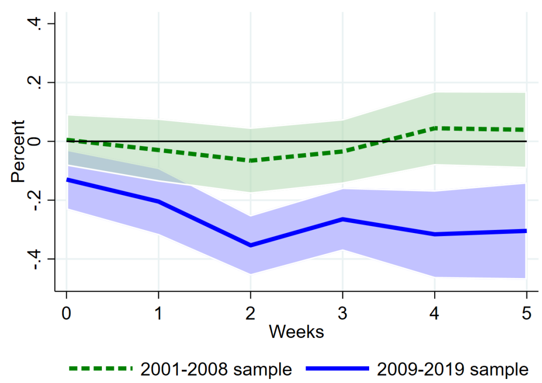
The magnitudes of the list price responses are comparable to the responses of financial assets on the day of announcement (see Tables 5 and 6 in Swanson, 2021). The key difference is that financial assets tend to respond strongly on the day of the announcement, and their responses tend to be larger to the level surprise than to the forward guidance or LSAP surprises. For example, Swanson reports that the S&P 500 stock index responds by –0.37, –0.14, and 0.03 percent to FFR, FG, and LSAP shocks, respectively, and the first two responses are statistically significant. By contrast, house price responses take a couple

[8]The contractionary impulse is an increase in the FFR and FG factors and a decrease in the LSAP factor.

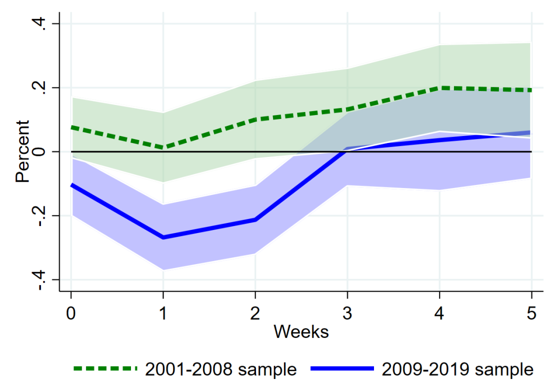
of weeks to reach similar magnitudes, and the responses to slope factors are statistically significant, whereas the response to the level surprise is at best weakly significant.

This evidence provides two main results that we reinforce throughout the paper. 1) House prices respond to monetary policy announcements much faster than previously thought, and these responses are roughly on par in terms of magnitudes with responses of financial assets on the day of announcement. 2) House prices respond significantly to surprises to expected future rates and are insensitive to surprise changes in the federal funds rate.

Insensitivity of house prices to surprises in the short-term policy rate may also, in part, reflect the influence of the 2001–2007 housing market boom. In the Appendix, we show that the responses to FFR factor are zero for pre-2008 sample, but are negative and significant for post-2008 sample, whereas the responses to FG factor are negative for both samples. Credit market conditions were considerably slack during the housing boom, counteracting the effect of rising interest rates by the Fed (Favilukis, Ludvigson, and Van Nieuwerburgh, 2017; Drechsler, Savov, and Schnabl, 2022). Moreover, during the housing boom in mid 2000s, house prices may have been influenced by non-fundamental forces, such as spurious expectations of house price appreciation, adding a considerable momentum to house price growth and desensitizing it to monetary policy surprises (Kuchler, Piazzesi, and Stroebel, 2022).



(a) Bauer-Swanson impulse



(b) Nakamura-Steinsson impulse

Figure 3. Responses of Housing List Prices to Contractionary Monetary Policy Surprises, Bauer and Swanson (2022) and Nakamura and Steinsson (2018) Shocks

Notes: The figure shows list price responses to a positive one-standard-deviation shock by Bauer and Swanson (2022) and Nakamura and Steinsson (2018). Responses are estimated using specification in (5), separately for two sub-samples: from 2001 to 2008 (green dashed line) and from 2009 to 2019 (blue solid line). Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

Our findings remain robust to using alternative monetary policy shock measures. We estimate specification (5) using two alternative measures—by Bauer and Swanson (2022) and Nakamura and Steinsson (2018). We standardize both shocks to our sample and split the responses by two sub-periods, before and after 2008. Because both shock measures do not distinguish between surprises to interest rates at different horizons, the results are somewhat weaker than in Figure 2: the responses are insignificant for the 2001–2008 period (Figure 3). Nonetheless, for the 2009–2019 period the responses are negative and similar in magnitude to the responses in Figure 2.

4.2 LP-IV responses

The estimation of equation (5) is implemented under the assumption that shocks S_t capture the structural shocks to interest rate. We relax this assumption and assume instead that they represent only part of the unobserved structural shocks to interest rates, and may also be measured with error. In such a case, impulse responses can be estimated with local projections that use constructed surprise measures as external instruments (Stock and Watson, 2018). We implement this approach by using the following specification:

$$\ln P_{l,t+h} - \ln P_{l,t-1} = \beta^{(h)} i_t^u + \chi_l^{(h)} + \text{CONTROLS}_{l,t}^{(h)} + \varepsilon_{l,t}^{(h)}, \tag{6}$$

where $\ln P_{l,t+h} - \ln P_{l,t-1}$ is the cumulative change in log list price index over h weeks after the shock in week t, and i_t^u is an exogenous variation in the interest rate variable i_t in week t, $\chi_l^{(h)}$ are zip code fixed effects, and $\text{CONTROLS}_{l,t}^{(h)}$ are control variables.

Stock and Watson (2018) explain that adding control variables can help the instruments satisfy the LP-IV conditions that the instrument: (i) is correlated with the endogenous variable of interest i_t, (ii) does not have a direct influence on the dependent variable, and (iii) is uncorrelated with all structural shocks at all leads and lags. Furthermore, adding control variables can reduce variance of the error term $\varepsilon_{l,t}^{(h)}$ and narrow the confidence intervals. Therefore, the set of $\text{CONTROLS}_{l,t}^{(h)}$ includes: 52 lags of the weekly change in the list price index in zip code l, the change of the endogenous interest rate i_t between week 13 and week 1 prior to the week of announcement, the change in the unemployment rate over the three months preceding week t in the county containing zip code l[9], and six macroeconomic controls from Bauer and Swanson (2022)[10]. These variables help controlling for the influence of house price growth momentum, local business cycles conditions, and macroeconomic and financial market conditions.

For each horizon h, we estimate (6) using two-stage least squares with fixed effects and the three Swanson (2021) factors as instruments. An additional advantage of using LP-IV over using LP-OLS is that the responses are normalized to units of the observed regressor i_t^u, which are more intuitive than having results in terms of standard deviations of the underlying factors. The estimated coefficients $\beta^{(h)}$ (divided by 4) provide responses of the log list price index to an unanticipated 0.25 ppt increase in the interest rate i_t. To represent the interest rate variable i_t, we choose the mean weekly 30-year fixed-rate mortgage rates in the United States.[11] Long-term fixed-rate mortgage rates are the most relevant interest rates for homeowners in the U.S. as most mortgages still have a 30-year tenor and a fixed rate. We show in the Appendix that these mortgage rates respond promptly to FG and LSAP surprises. In any case, we show below that our results are not sensitive to the choice of the interest rate variable.

Figure 4 shows that a 0.25 ppt exogenous increase in mortgage rates lowers list prices within weeks after the announcement, by 1.2 percent in week 2 and 1.4 percent in week 3 after the announcement.[12] These estimates imply a semi-elasticity of house prices of around 5 or 6 (in absolute value) which is in the middle of the range between 3 and 8 for medium- and long-run semi-elasticities estimated in the empirical literature on house price responses to changes in interest rates (Kuttner, 2013). The magnitude of house price responses is also comparable to responses of stock prices on the day of the announcement, around 1 percent (Bernanke and Kuttner, 2005). These LP-IV results, therefore, support the LP-OLS evidence that house list prices respond quickly to interest rate shocks by economically significant magnitudes.

Figure 4 provides two additional insights into this empirical evidence. First, excluding additional controls from LP-IV (i.e., county-specific unemployment rates and Bauer and Swanson's macroeconomic and financial market variables) reduces the estimated fall in

[9]County-specific monthly unemployment rates are obtained from the U.S. Bureau of Labor Statistics.

[10]Bauer and Swanson's controls include the recent surprise component and the 12-month log change in nonfarm payrolls, the log change in S&P 500 between 13 weeks and one day before the FOMC announcement, the change in the yield curve between 13 weeks and one day before the announcement, the log change in the Bloomberg BCOM commodity price index between 13 weeks and one day before the FOMC announcement, and the implied skewness of the 10-year Treasury yield the day before the announcement.

[11]The weekly mortgage rate data are from the Primary Mortgage Market Survey. The Survey rates represent rates charged between Monday and Wednesday of the corresponding week.

[12]The first-stage F-statistic is far above the threshold value for all horizons (Stock, Yogo, and Wright, 2002), rejecting the null of weak instruments. p-values for Hansen's J-statistic are well above 10 percent for all horizons, implying that the model is correctly specified. R^2 is 0.37 or higher for all horizons.

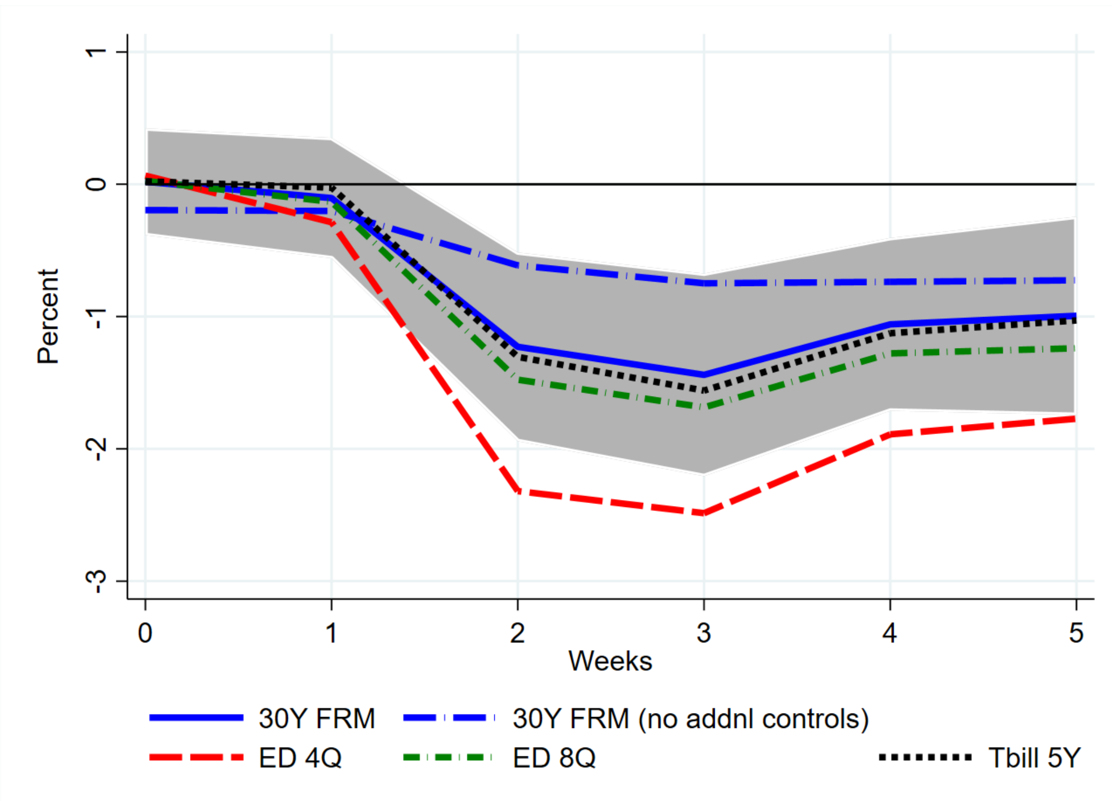


Figure 4. Responses of List Prices to an Exogenous +0.25 ppt Change in Interest Rates

Notes: The figure shows responses of the log list price index to an exogenous +0.25 ppt increase in the interest rate estimated by the two-stage least squares with fixed effects using specification (6) with Swanson (2021) factors as instruments. The endogenous policy variables include: mean weekly 30-year fixed-rate mortgage rates from the Primary Mortgage Market Survey (with and without additional controls, "30Y FRM" and "30Y FRM (no addnl controls"), 4- and 8-quarter Eurodollar futures ("ED 4Q" and "ED 8Q"), and 5-Year U.S. Treasury note ("Tbill 5Y"). Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors for 30Y FRM as endogenous policy variable.

house prices by almost one half, although those responses remain statistically significant. This suggests that the local and national business cycles and financial market conditions have some influence on the transmission of interest rates to house prices. As emphasized by Ramey (2016) and Stock and Watson (2018), including controls for such conditions is crucial for the direct estimation of impulse responses using local projections.

Second, the results are not sensitive to the choice of the variable representing the endogenous interest rate i_t on the right-hand side of LP-IV in equation (6). The responses are similar, if not somewhat larger, in magnitude when instead of mortgage rates we use daily yields for 4- and 8-quarter Eurodollar futures or 5-year U.S. Treasury on the day of the announcement. This result is consistent with the baseline LP-OLS result that house prices respond to FG and LSAP surprises, i.e., to future interest rate surprises. As long as the endogenous variable representing the interest rate in LP-IV captures future interest rates, we obtain a quick and significant response of house prices. To bring this point home, in the Appendix, we show that if we drop the FFR factor from the list of instruments, we obtain virtually the same responses; and if we use FG or LSAP separately as the only instrument, the responses remain statistically significant in both cases. When we use Bauer and Swanson (2022) and Nakamura and Steinsson (2018) surprises as instruments, the responses are no longer statistically significant, suggesting that these shock series are mostly capturing surprises to current interest rates.

As we discussed in the Section 3.1, there are several channels through which changes in expected future interest rates may influence the housing market and house prices. The most relevant is the house financing or mortgage financing channel, well documented in the literature. Rising mortgage rates make house financing more expensive by tightening debt-to-income or loan-to-value constraints and lead to lower demand for housing (Anenberg and Kung, 2017; Favilukis, Ludvigson, and Van Nieuwerburgh, 2017; Greenwald, 2018; Garriga, Kydland, and Šustek, 2017; Bhutta and Ringo, 2021). In anticipation of the imminent fall in demand for housing, home sellers lower their list prices. Furthermore, sellers may wish to sell their houses sooner than later while mortgage rates are still rising. Garriga, Manuelli, and Peralta-Alva (2019) show that prices respond not only to changes in interest rates, but also to changes in expected future financial conditions. In sum, we provide evidence of a strong contemporaneous effect of interest rate surprises, more precisely, surprises to expected future interest rates, on desired house prices.

4.3 Robustness

The results are similar for extensions of the LP-OLS specification (5) that allow for non-linear responses and use orthogonalized monetary surprise measures. We summarize them here, relegating details to the Appendix.

To test for non-linearity in the relationship between monetary policy surprises and house prices, we conduct two complementary exercises. First, we repeat the estimation of equation (5) using only large shock values. Large values are defined as those above the median of all positive values or those below the median of negative values. Second, we estimate the modified version of equation (5) that explicitly includes non-linear terms. In both cases, the estimates for the non-linear terms are small at best.

We also verify whether the shock measures are unforecastable and uncorrelated with other relevant variables, as required by local projections. To this end, we regress the Swanson factors on 52 lags of average list price weekly changes, on the macroeconomic and financial market variables from Bauer and Swanson (2022), and on the change in 30-

year mortgage rates between week 13 and week 1 prior to the FOMC announcements. We find that these controls account for a small portion of the variation in the Swanson factors. Their correlation may reflect adjustments by the financial markets to information asymmetries between the central bank and the public (Nakamura and Steinsson, 2018; Miranda-Agrippino and Ricco, 2021; Karnaukh and Vokata, 2022) or to economic news omitted in the construction of high-frequency measures of monetary surprises (Bauer and Swanson, 2021, 2022). We therefore take the residuals of these regressions as the orthogonalized Swanson factors and use them to re-estimate LP-OLS impulse responses for list prices. The responses to FG and LSAP factors remain mostly negative, losing their statistical significance in some cases or horizons. The next Section also shows that our results are generally robust to adding additional controls and allowing for asymmetric responses.

5 Additional Results

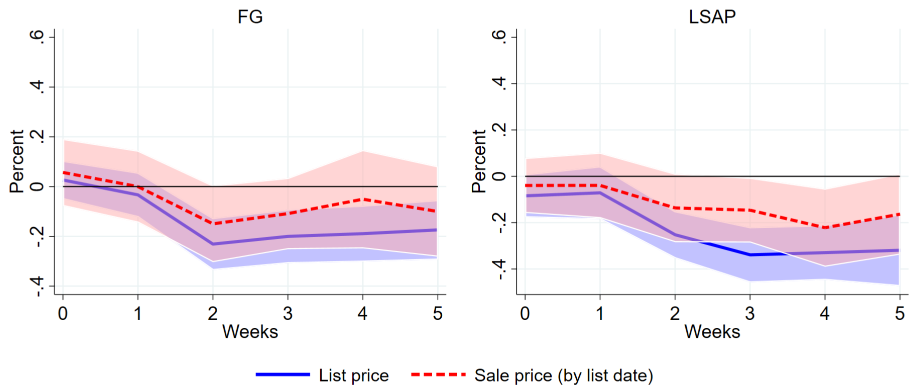
In this Section, we present the estimated responses for other house market variables: sale prices, time-on-market, and the number of listings. We then exploit differences across geographic locations to furnish further evidence on the mechanisms underlying the impulse responses we estimate. To cast our results in the context of the price growth momentum literature, we expand the horizon for the estimation of impulse responses. Lastly, we analyze the asymmetry of house price responses to changes in monetary policy.

5.1 Sale prices

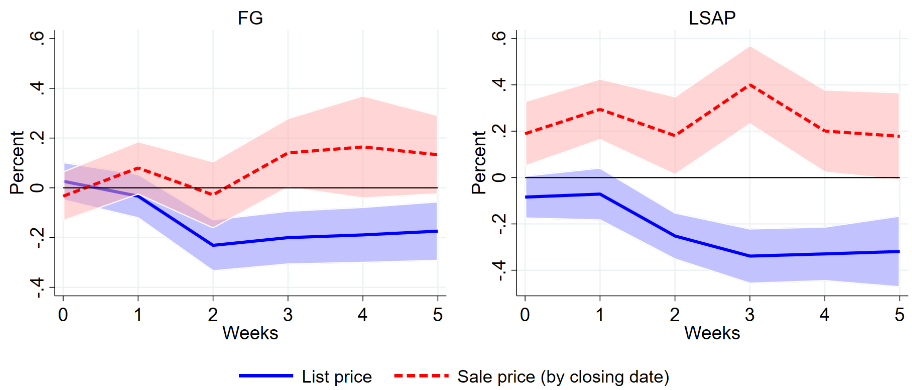
Our baseline results show that home sellers lower their listing prices within a couple of weeks after monetary policy announcements in response to a suprise monetary tightening. Do sale prices respond to monetary surprises above and beyond the response already built into list prices?

To answer this question, we estimate the LP-OLS in equation (5) with the sale price index as the dependent variable. Figure 5 provides the responses of sale prices. The top panel shows the responses of listing-date sale prices and, for comparison, the responses of list prices from Figure 2: both indexes are constructed using the same set of housing properties. The responses of listing-date sale prices closely follow the responses of list prices, suggesting that the responses of sale prices mostly reflect the list price adjustments already made by sellers in response to the monetary policy surprise.

The bottom panel in Figure 5 shows the responses of the closing-date sale price index.



(a) List price vs Sale price (by listing date)



(b) List price vs Sale price (by closing date)

Figure 5. Responses of Sale Prices

Notes: The figure provides responses of the list price index from Figure 2 (blue line) and sale price indexes (red dashed line) to a positive one-standard-deviation impulse to Swanson (2021)'s forward guidance factor (left), and (negative of) LSAP factor (right). Responses are estimated using specification (5) for the sale price index by list date (top) and by closing date (bottom). Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

The responses of this sale price index are positive for FG and LSAP factors, and significant only for the LSAP factor. The closing-date index includes properties listed at different times: some are sold quickly and others may have sat on the market for a while. Since on average houses take almost four months to sell (as we report in Section 2.2), the responses of the closing-date index reflect many of the prices for houses listed before the policy announcement. As illustrated in Figure 6, their list prices and subsequent sale prices tend to be higher than prices for houses listed after a contractionary surprise, as list prices for the latter drop following a monetary tightening according to our earlier results. Hence, this mix of listings used for constructing the closing-date index implies an upward bias

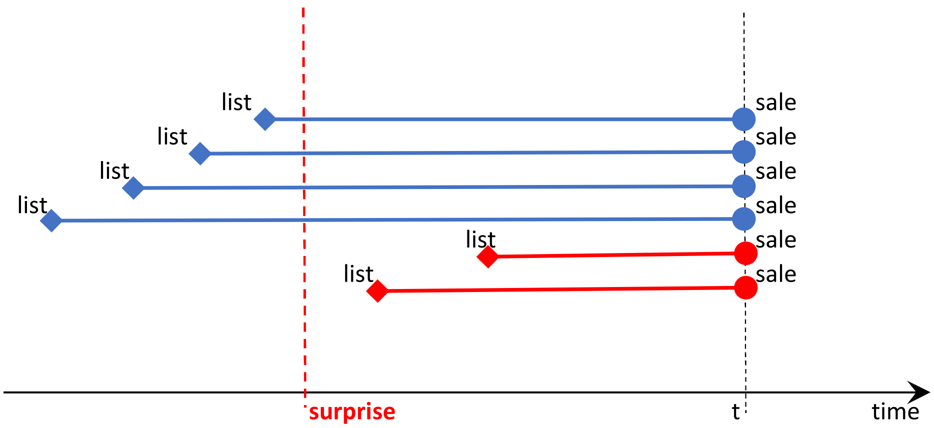


Figure 6. Upward bias in the response of closing-date price index to a contractionary monetary surprise

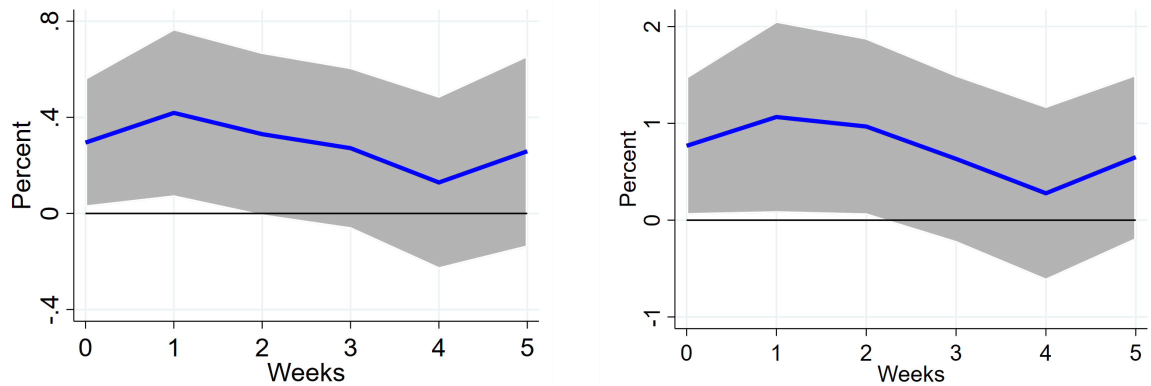
in its response to a contractionary monetary surprise.

These findings suggest that listing-date price indexes are more accurate than traditional closing-date indexes at capturing the immediate reaction of house prices to monetary policy changes. Indeed, Anenberg and Laufer (2017) use listings data for nine major U.S. metro areas from 2008 to 2012 to construct a Case-Schiller-style list price index. They show that their list price index implies a stronger contemporaneous correlation with equity prices and macroeconomic news shocks, whereas the conventional closing-dated index does not. Our evidence indicates that Anenberg and Laufer's findings can be explained by a tighter link of list prices to monetary surprises. Hence, complementing traditional indexes with weekly list-date indexes would allow policy-makers to gauge the responses of house prices within weeks of a monetary policy announcement.

5.2 Time on market and the number of listings

Besides lowering house prices, a contractionary monetary shock is expected to curtail the overall activity in the housing market , lengthen the time houses spend on the market and reduce the number of new listings. We find that this is indeed the case, although the effects are economically small at horizons we study.

The responses of the time-on-market index, shown in Figure 7, are positive but small and short-lived. In response to a +.25 ppt impulse to the 30-year average mortgage rate, time-on-market increases by about 1 percent, i.e., roughly 1 extra day on the market, and the responses get closer to zero after 3 weeks from the announcement. Most of the response is due to the forward guidance surprise as the LP-OLS responses to FFR and LSAP factors are not statistically different from zero. Since the time-on-market index applies to



(a) +1std FG impulse (LP-OLS) **(b)** +0.25 ppt 30Y FRM impulse (LP-IV)

Figure 7. Responses of Time-on-Market to Contractionary Monetary Policy Surprises

Notes: The figure shows responses of the time-on-market index to: (a) a positive one-standard-deviation impulse to Swanson (2021)'s fed funds factor (left), estimated using LP-OLS specification (5); (b) a +0.25 ppt increase in the interest rate estimated by the two-stage least squares with fixed effects using specification (6) with Swanson (2021) factors as instruments. Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

properties listed after the announcement date, its response reflects the trade-off between two opposing forces faced by the sellers in decentralized housing markets (Guren, 2018; Anenberg and Ringo, Forthcoming). A contractionary monetary policy shock cools housing demand and lengthens time-on-market. On the other hand, a lower list price helps houses sell and shortens time-on-market. A small response of time-on-market suggests that the fall in list prices offsets almost all of the cooling influence of the contractionary shock on time-on-market.

Furthermore, there are marginal sellers who, instead of listing a house at a lower price, can decide not to list. In the Appendix, we show that the number of listings goes down after the FG surprise, especially for 2009–2019 period, falling by 3 percent. Surprisingly, this response is offset by the *increase* in the number of listings after a contractionary LSAP surprise. Correspondingly, the LP-IV response of the number of listings is about zero over the month following the announcement. We conjecture that the marginal seller's listing decision is sensitive to the information around the policy announcement; we leave further clarification for future research.

5.3 Cross-sectional evidence

Rich variation of macroeconomic and house market outcomes across locations provides another avenue for evidence on the mechanisms behind price responses. We examine how the responses differ across zip codes along four dimensions: household income, house value, density of local bank branches, and housing supply elasticity. We summarize the data and results here, relegating the details to the Appendix.

Household income and house values across zip codes are obtained from the U.S. Census Bureau, 2016-2020 American Community Survey. House income is the median household income in the past 12 months, in 2020 inflation-adjusted dollars. House values are median dollar values. Total population is obtained at zip-code level from the U.S. Census Bureau, 2010 Census. Branch density is the number of bank branches per 1000 people. The number of bank branches includes branches of state-chartered banks (obtained from the Federal Deposit Insurance Corporation) and credit unions (from the National Credit Union Administration). House supply elasticities are obtained from Baum-Snow and Han (2021), who estimate elasticities using repeat sales price indexes and the fraction of the U.S. Census tract developed from 2001 or 2011. We use their quadratic finite mixture model estimates for supply elasticities of residential housing units for 2011.

Table 2 provides summary statistics for the distribution of household income, house value, branch density, and housing supply elasticity across zip codes. All variables exhibit significant dispersion across almost 11,000 zip codes.

Statistic	p25	Median	p75	# Zip codes
Median income, 2020 dollars	56,025	72,402	93,108	10,778
Median value, dollars	182,600	270,700	413,100	10,767
Num branches/1000 people	0.14	0.23	0.36	9,181
Housing supply elasticity	0.09	0.17	0.30	8,929

Table 2. Statistics for Auxiliary Variables, by U.S. Zip Codes

Notes: Statistics are weighted by the number of listings. "p25" and "p75" refer to 25th and 75th percentiles.

To assess how price responses to monetary shocks differ across zip codes, we re-estimate local projections separately for zip codes in the top and bottom quartiles of income, value, branch density, and house supply elasticity. Figure 8 provides the LP-IV responses, which are similar to LP-OLS responses provided in the Appendix.[13]

List prices in zip codes with lower average household incomes and house values are more sensitive to interest rate surprises than those in high-income and high-value zip codes. This evidence is consistent with the financing mechanism driving house price re-

[13]Since income and house values are strongly correlated across zip codes (correlation 0.68), the responses by house value are similar to those by household income, so we do not report the former here. House elasticities are negatively correlated with incomes (correlation –0.09) and with house values (correlation –0.30). Branch density is uncorrelated with income and house values.

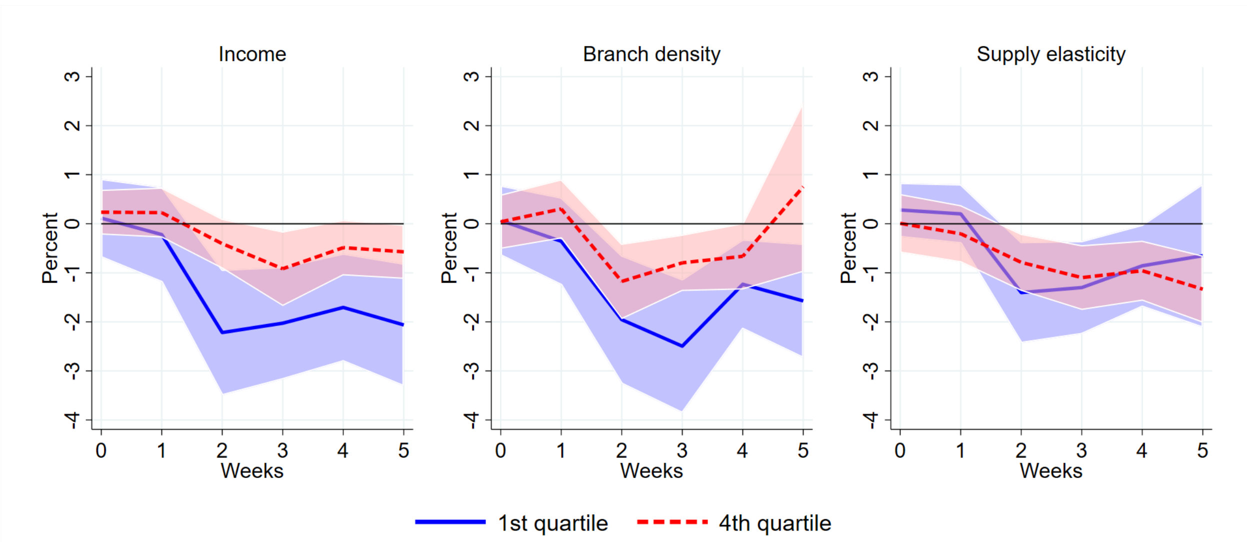


Figure 8. Responses of List Prices for Zip Codes in the Top and Bottom Quartiles of the Distribution of Household Income, Branch Density and Supply Elasticity

Notes: The figure shows responses of the log list price index to an exogenous +0.25 ppt increase in the mean weekly 30-year fixed-rate mortgage rate estimated by the two-stage least squares with fixed effects using specification (6) with Swanson (2021) factors as instruments. Responses are estimated separately for top and bottom quartiles of the distribution of median household income across zip codes. Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

sponses. Zip codes with lower household income or lower house values have a higher fraction of financially constrained buyers and sellers, multiplying the impact of monetary shocks on house prices. Indeed, Ringo (2023) documents that low- and moderate-income households are less likely to buy a house after a policy-induced increase in mortgage rates. Adelino, Schoar, and Severino (2012) estimate local elasticity of house prices to interest rates using exogenous variation in conforming loan limit to instrument for lower cost of house financing. They report stronger elasticities for zip codes in the lowest income quartile and zip codes with low income growth. Furthermore, we report in the Appendix that differences in responses across house value quartiles are somewhat smaller than differences across income quartiles, suggesting a more influential role of payment-to-income constraints than loan-to-value constraints in determining how house prices respond to changes in interest rates. (Garriga, Kydland, and Šustek, 2017; Greenwald, 2018).

List prices exhibit a larger fall after a contractionary interest rate surprise in zip codes with fewer bank branches. Such a response may reflect a larger contraction of bank lending in locations with weaker competition among banks. Drechsler, Savov, and Schnabl (2017) show that in response to Fed's interest rate hikes, commercial banks in concentrated markets curb their lending by more than other banks in less concentrated markets.

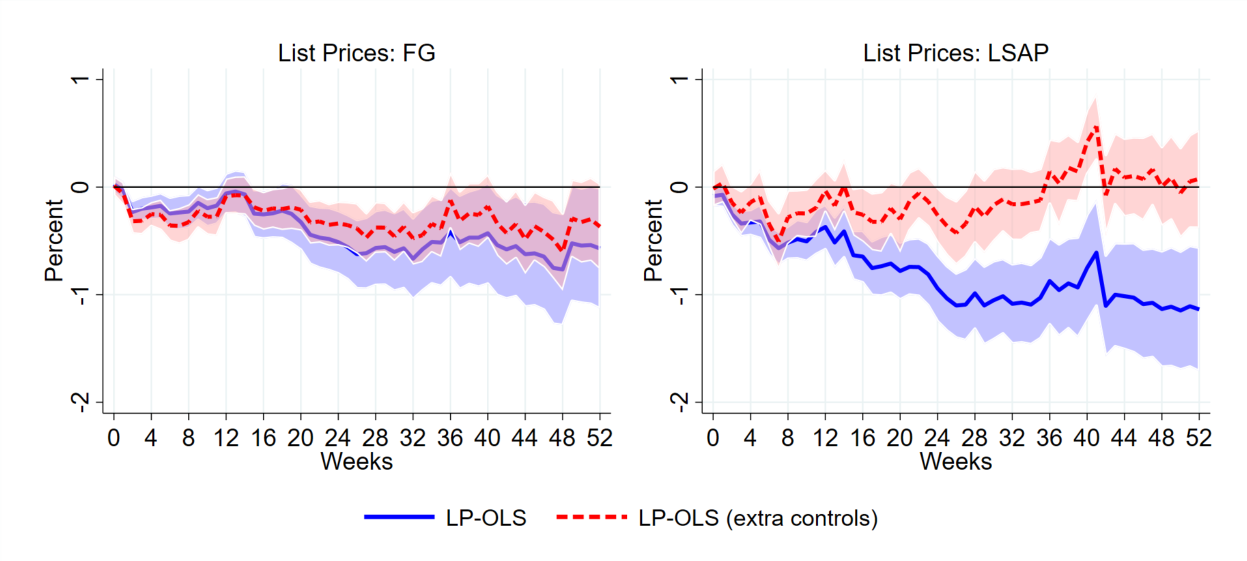
Lastly, list price responses do not vary with housing supply elasticities. Housing supply elasticities are important for long-run house market outcomes (Glaeser and Gyourko, 2018) and medium-run responses of house prices to changes in interest rates (Aastveit and Anundsen, 2022). Since at weekly horizons housing supply is effectively inelastic, housing supply elasticities are unlikely to be crucial for the contemporaneous responses of house prices to monetary policy shocks. Rather, the transmission of such shocks operates via financial markets, which react almost immediately to what the Fed does. In this respect, house prices behave more like prices of financial assets than prices of consumption goods.

5.4 Long-horizon responses

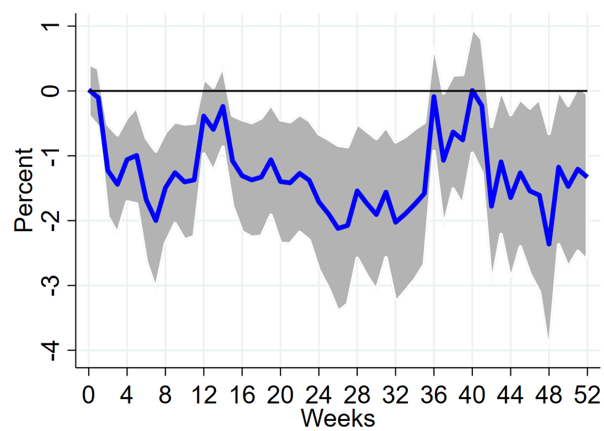
While we focus on house price responses over the horizon of several weeks, most of the empirical literature uses quarterly or annual data to study horizons of many quarters and years. Two most prominent strands of the literature document significant but gradual responses of house prices to interest rate shocks (Kuttner, 2013; Williams, 2015) and strong serial correlation in house price growth at quarterly and annual frequencies (Case and Shiller, 1989; Cutler, Poterba, and Summers, 1991).

To place our results in the context of these strands of the literature, we conduct LP-OLS and LP-IV estimations of list price index responses for horizons up to 52 weeks after an FOMC announcement. Panel (a) in Figure 9 shows extended responses to FG and LSAP suprises from the LP-OLS specification in equation (5) that includes lags of the change in the dependent variable as control variables (solid blue line). Ramey (2016) suggests also adding lags of other variables that may be relevant when estimating shock transmission using local projections. We therefore also provide impulse responses from the LP-OLS that includes additional controls already used in the LP-IV estimation in Section 4.2 (dashed red line): the change in county-specific unemployment rate over the three months preceding the announcement week, and six macroeconomic and financial market control variables from Bauer and Swanson (2022). These additional controls capture the influence of local business cycles conditions, as well as that of macroeconomic and financial market conditions on estimated LP-OLS responses. The extended LP-IV responses are shown in Panel (b) of Figure 9.

The responses to contractionary shocks are negative and significant for almost the entire year after the shock. The LP-IV response stays between –1 and –2 percent from the second week after the shock, corresponding to semi-elasticity between 4 and 8 in absolute value. The LP-OLS responses to FG impulse are also negative and significant, and



(a) +1std FG or LSAP impulse (LP-OLS)



(b) +0.25 ppt 30Y FRM impulse (LP-IV)

Figure 9. Responses of List Prices to Contractionary Monetary Policy Surprises, Long Horizons

Notes: The figure shows responses of list price index to: (a) a positive one-standard-deviation impulses to Swanson (2021)'s FG and LSAP factors (left and right), estimated using LP-OLS specification (5) (blue) and (5) with additional controls (red); (b) a +0.25 ppt increase in the interest rate estimated by the two-stage least squares with fixed effects using specification (6) with Swanson (2021) factors as instruments. Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

not sensitive to additional controls. By contrast, LP-OLS responses to LSAP impulse are smaller when additional controls are included, although they are still negative and significant for most of the first half of the year after the shock. The difference in responses is mainly due to including Bauer and Swanson (2022) macroeconomic and financial market controls. Hence, these controls become important for estimating house price responses to expected long-term interest rate surprises over horizons above one quarter. At the same time, for horizons within one quarter all responses in Figure 9 are negative and significant. The extended responses to the FFR factor remain not significantly different from zero during the entire year after the shock.

These additional results complement existing studies of house price dynamics along three dimensions. First, the causal effects of interest rate surprises on house prices persist for at least a year after the announcement. Therefore, even at quarterly or annual frequency there is a negative relationship between interest rates and house prices, in line with existing literature. Our contribution is to show that this relationship exists at high frequency.

Second, the implementation of the estimation matters for the results. We show that the estimated responses are sensitive to identified surprises to future interest rates rather than current rate surprises. Furthermore, incorporating macroeconomic and financial market controls may influence the results for medium- and long-run horizons. In light of these findings, future research should re-visit estimation of medium- and long-run effects of interest rates on house prices using external instruments that distinguish between surprises to future versus current interest rates and additional controls for local house market and business cycle conditions.

Third, house price momentum depends on the degree of frictions in the housing market which deter the quick adjustment of house prices in response to changes in fundamentals. Guren (2018) explains that such frictions (e.g., search frictions, behavioral biases, learning and heterogeneity in beliefs, and price adjustment costs) preclude sellers from charging a price that is too far from the average market price, reinforcing momentum. Results in this section corroborate previous findings that such frictions can generate significant momentum for house price responses to monetary shocks at quarterly and annual frequencies. On the other hand, quick responses at higher frequencies are in line with forward-looking behavior and quick nominal house price changes. Future applied research will need to reassess the magnitude and type of frictions necessary to account for both high-frequency dynamics and price growth momentum in response to monetary shocks or changes in other fundamentals.

5.5 Asymmetry of responses

Local projections in equation (5) do not differentiate the responses to positive and negative surprises. To test for the asymmetry in the responses, we estimate a specification that allows the responses to differ with the sign of the surprise:

$$\ln P_{l,t+h} - \ln P_{l,t-1} = \left(\beta^{+(h)} D_t^+ + \beta^{-(h)} D_t^-\right) \mathrm{S}_t + \sum_{q=1}^{52} \theta_q^{(h)} (\ln P_{l,t-q} - \ln P_{l,t-q-1}) + \chi_l^{(h)} + \varepsilon_{l,t}^{(h)}, \tag{7}$$

The impulse response at horizon h is now $\beta^{+(h)} D_t^+ + \beta^{-(h)} D_t^-$, where D_t^+ (D_t^-) is equal to 1 if the value of the surprise measure S_t is positive (negative), and zero otherwise. Responses are asymmetric if $\beta^{+(h)} \neq \beta^{-(h)}$.

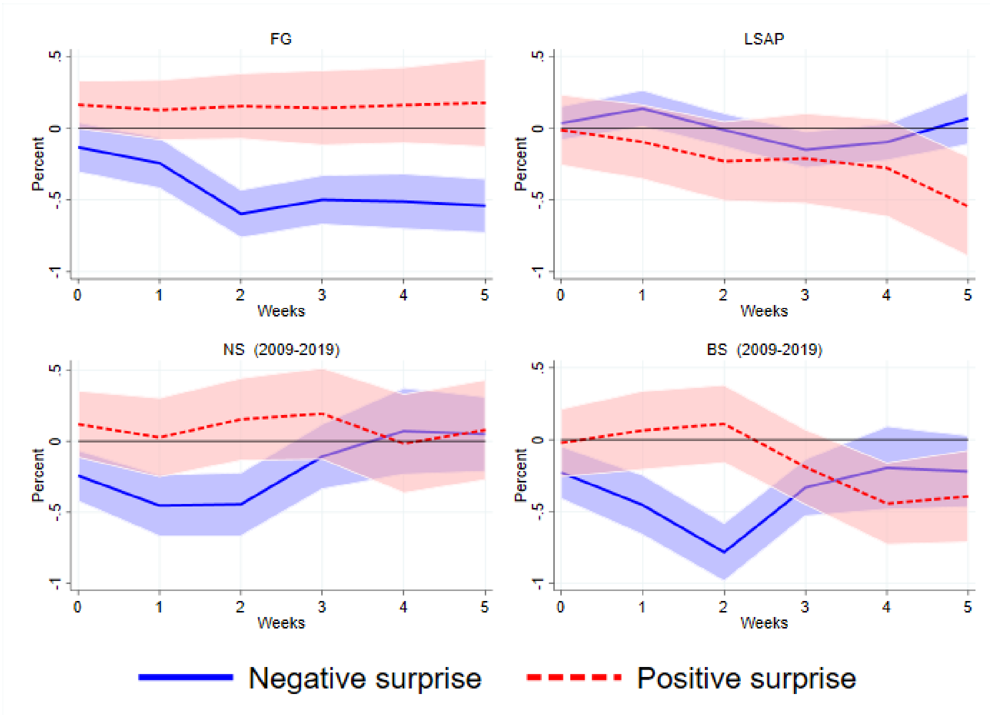


Figure 10. Response coefficients for Positive/Negative Monetary Policy Surprises, List Prices

Notes: The figure provides the estimated coefficients $\beta^{+(h)}$ (in red) and $\beta^{-(h)}$ (in blue) from specification (7) for the list price index. $\beta^{+(h)}$ (in red) are interpreted as responses to a contractionary impulse. $\beta^{-(h)}$ (in blue) are interpreted as (the negative of the) responses of the expansionary impulse. Surprises: a one-standard-deviation impulse to Swanson (2021)'s forward guidance factor and (negative of) LSAP factor (top left and right), Nakamura and Steinsson (2018) (bottom left, 2009–2019 sample), and Bauer and Swanson (2022) (bottom right, 2009–2019 sample). Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

Figure 10 plots $\beta^{+(h)}$ (in red) versus $\beta^{-(h)}$ (in blue) for FG and LSAP shocks. The symmetry is clearly rejected for FG surprises: list prices rise after expansionary surprises but are insensitive to contractionary surprises. The symmetry cannot be rejected for the first four weeks following an LSAP surprise. The bottom panels of Figure 10 provides the estimates for Nakamura and Steinsson (2018) and Bauer and Swanson (2022) shocks using

2009–2019 sample. The symmetry again is rejected with significant responses to expansionary surprises and close-to-zero responses to contractionary surprises. The symmetry cannot be rejected for 2001–2008 sample.

The asymmetry in favor of stronger responses to expansionary monetary policy shocks is in line with Berger et al. (2021) and Eichenbaum, Rebelo, and Wong (2022) who attribute it to the mortgage refinancing channel. When interest rates decrease, households refinance their mortgages to lock in low rates, and they hold on to low rates when interest rates go up. This makes expansionary monetary policy more potent than contractionary policy. Another mechanism consistent with such asymmetry is due to sellers' aversion to cutting list prices and potentially realizing a nominal loss (Genesove and Mayer, 2001). Aastveit and Anundsen (2022) show that the asymmetry for medium- and long-run responses tends be strong in areas with inelastic housing supply. Our results in Section 5.3 indicate supply elasticity is not important for higher-frequency house price responses.

6 Conclusions

The contemporaneous relationship between interest rates and house prices has been elusive to analysis due to lack of detailed data and inadequate identification. We fill these gaps and provide the first direct estimates of the dynamic causal effects of interest rate surprises on house prices in the United States. Contractionary surprises lead to a fall of list prices within two weeks after an FOMC announcement. Such responses are driven primarily by unexpected changes in future interest rates, and we present indirect evidence that the house financing channel plays a role in the transmission of monetary policy.

The magnitude of house price responses is comparable to the responses of stock prices on the day of the announcement. Even though the U.S. equity and residential real estate holdings of households are comparable in size[14], the short-run influence of monetary policy on the housing market has by far more significant economic implications than its effect on the stock market. Unlike equity wealth, housing wealth is more evenly distributed across households, and mortgage debt is the largest component of household debt. Therefore, monetary policy may influence consumption via the housing wealth and house financing channels (Mian, Rao, and Sufi, 2013; Auclert, 2019). Unlike the equity market responses, the responses of house prices persist far beyond the first few weeks af-

[14]The overall value of real estate held by U.S. households and nonprofit organizations stood at $43.5 trillion at the end of 2022 according to the Financial Accounts of the United States (Z1 tables, B.101), while the market value of their equity in corporate and noncorporate businesses stood at $43.4 trillion.

ter monetary policy surprises. Future research should focus on obtaining direct evidence linking housing wealth and mortgage debt with house market outcomes in the wake of interest rate changes and over longer horizons.

Measurement of contemporaneous house price responses to interest rates requires combining detailed micro data with state-of-the-art identification of external instruments for monetary policy shocks. We show that it is crucial for micro data to contain list prices at daily or weekly frequency, be long enough to distill business cycle and financial market fluctuations, and include a broad cross-sectional coverage for capturing local house market dynamics. Local projections are well-suited for using such data for estimating the dynamic causal effects of interest rate shocks thanks to recently developed external high-frequency measures of these shocks. Further applications of local projection methods to rich micro data provides an exciting agenda for empirical research.

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House Price Responses to Monetary Policy Surprises: Evidence from the U.S. Listings Data

— APPENDIX —

A Responses before and after 2008

Impulse responses to the FFR factor reflect, in part, variation of house price dynamics over time. To see this, we estimate equation (5) in the main text separately for two sub-samples: from 2001 to 2008, and from 2009 to 2019. Figure A.1 shows the responses to the FFR and FG factors. (We omit responses to the LSAP factor because the factor and its variation were negligible for the 2001–2008 period.)

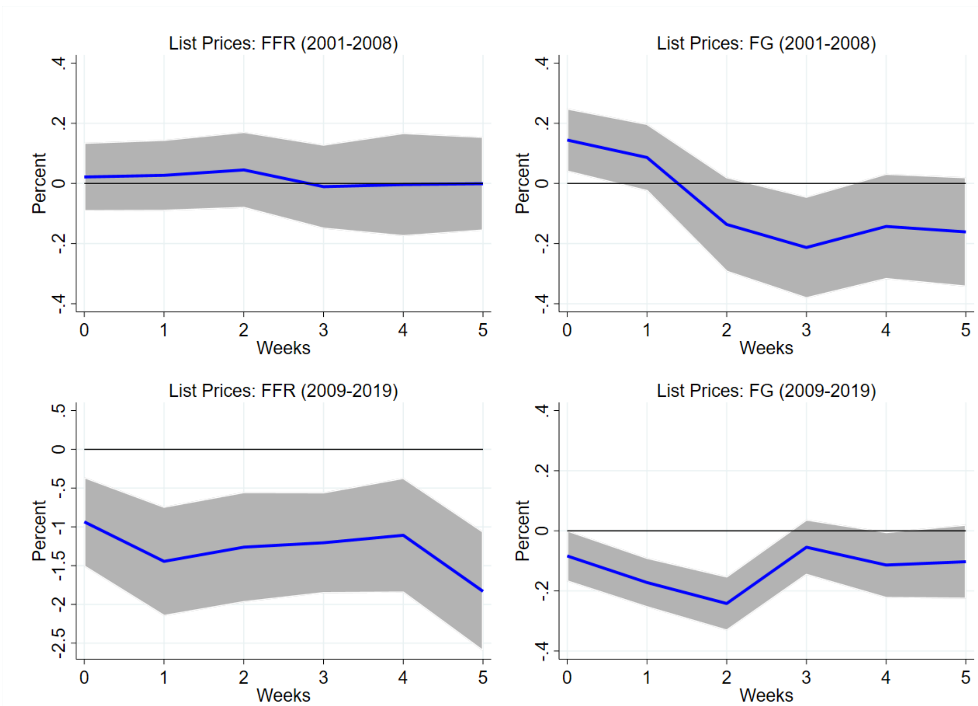


Figure A.1. Responses of Housing List Prices to Contractionary Monetary Policy Surprises, by Sub-Period

Notes: The figure shows responses of the list price index to a positive one-standard-deviation impulse to Swanson (2021)'s federal funds rate factor (left) and forward guidance factor (right). Responses are estimated using specification in (5) in the main text separately for two sub-samples: from 2001 to 2008 (top) and from 2009 to 2019 (bottom). Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

While the responses to the FG factor are negative and significant for both sub-periods, the responses to the FFR factor during the two periods differ. The response during the 2009–2019 period is negative and significant. By contrast, the response during the 2001–2008 period is positive and not statistically significant.

Insensitivity of house prices to surprises in the short-term policy rate during 2001–2008 can be associated with the concurrent housing market boom. Credit market conditions were considerably slack during that period, counteracting the effect of rising interest rates by the Fed (Favilukis, Ludvigson, and Van Nieuwerburgh, 2017; Vojtech, Kay, and Driscoll, 2018; Drechsler, Savov, and Schnabl, 2022). Moreover, during a housing boom, house prices may be influenced by non-fundamental forces, such as expectations of house price appreciation, adding a considerable momentum to house price growth and desensitizing it to monetary policy surprises (Kuchler, Piazzesi, and Stroebel, 2022).

These results illustrate why it may have been difficult to detect high-frequency house price responses so far in the literature (Williams, 2015). Much of the 2001–2008 data are dominated by the housing boom, which tends to blunt the effect of interest rates on house prices. Our long sample helps circumvent this issue. Furthermore, it might be difficult to measure a house price response using broader measures of monetary policy shocks, because house prices are more responsive to surprises in the slope of the yield curve and not the level. Recent advances in the high-frequency identification of monetary policy shocks have brought about measures that distinguish between current and future interest rate surprises.

B The response of mortgage rates to monetary surprises

Figure B.1 shows the estimated responses to monetary policy surprises of the mean weekly 30-year fixed-rate mortgage rates in the United States. The weekly mortgage rate data are from the Primary Mortgage Market Survey.[15] In response to a surprise about future interest rates, captured by the FG or LSAP factors, mortgage rates increase by around 4 basis points within a month. By contrast, the response of mortgage rates to the level of surprise is close to zero. Based on data through 2006, Hamilton (2008) demonstrates that changes in information about the level and slope of the federal funds rate are positively correlated with 30-year mortgage rates, with slope effects 2.6 times stronger than level effects. Hamilton argues that the mortgage rate response materializes as soon as markets realize the changes in the path of the federal funds rate. Our results in Figure B.1 suggest

[15]See `https://www.freddiemac.com/pmms/pmms_archives`. The Survey rates represent rates charged between Monday and Wednesday of the corresponding week. We estimate the responses using linear projections on Swanson (2021) factors and four lags of the weekly change in the dependent variable.

that it takes only a few weeks for monetary surprises to be reflected in mortgage rates.

Fast responses of mortgage rates to monetary surprises align with our baseline results, where list prices react strongly to surprises about future interest rates and are insensitive to current rate shocks.

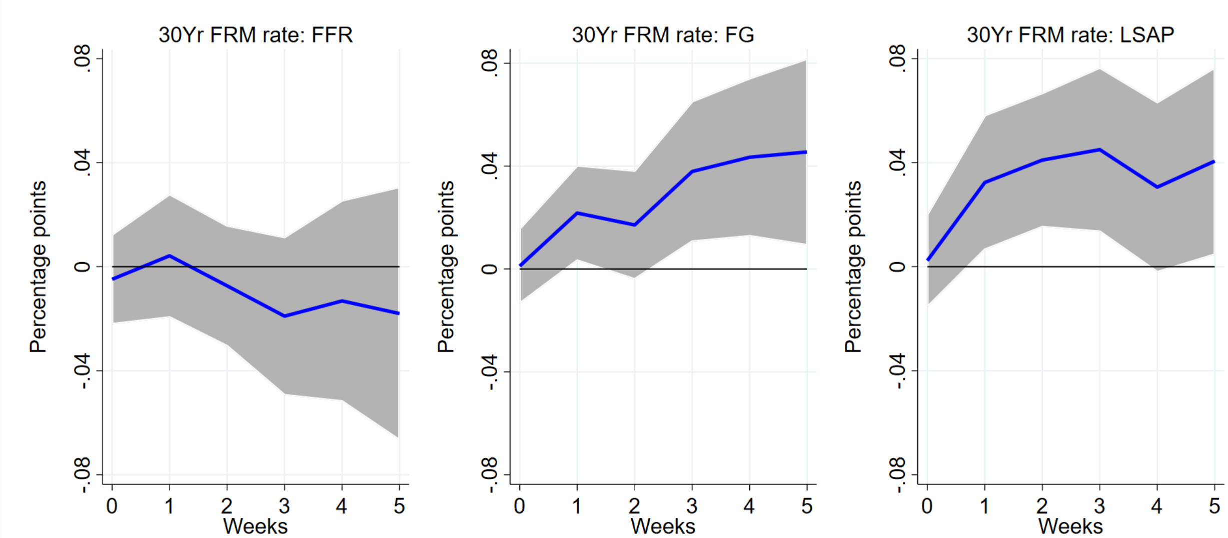


Figure B.1. Responses of Mortgage Rates to Contractionary Monetary Policy Surprises

Notes: The figure shows responses of the mean weekly 30-year fixed-rate mortgage rates to a positive one-standard-deviation impulse to Swanson (2021)'s federal funds rate factor (left), forward guidance factor (middle), and (negative of) LSAP factor (right). Mortgage rate data are from the Primary Mortgage Market Survey, https://www.freddiemac.com/pmms/pmms_archives. The responses are estimated using linear projections on Swanson factors and four lags of the weekly change in the dependent variable. Shaded areas represent the 90 percent confidence intervals based on robust standard errors.

Figure B.2 shows that if we drop FFR factor from the list of instruments, we obtain virtually the same responses as responses based on all three instruments, used in the main text (Figure 4). And if we use FG or LSAP as the only instrument, the responses remain statistically significant in both cases. Figure B.3 shows that when we use Bauer and Swanson (2022) and Nakamura and Steinsson (2018) surprises as instruments, the responses are no longer statistically significant.

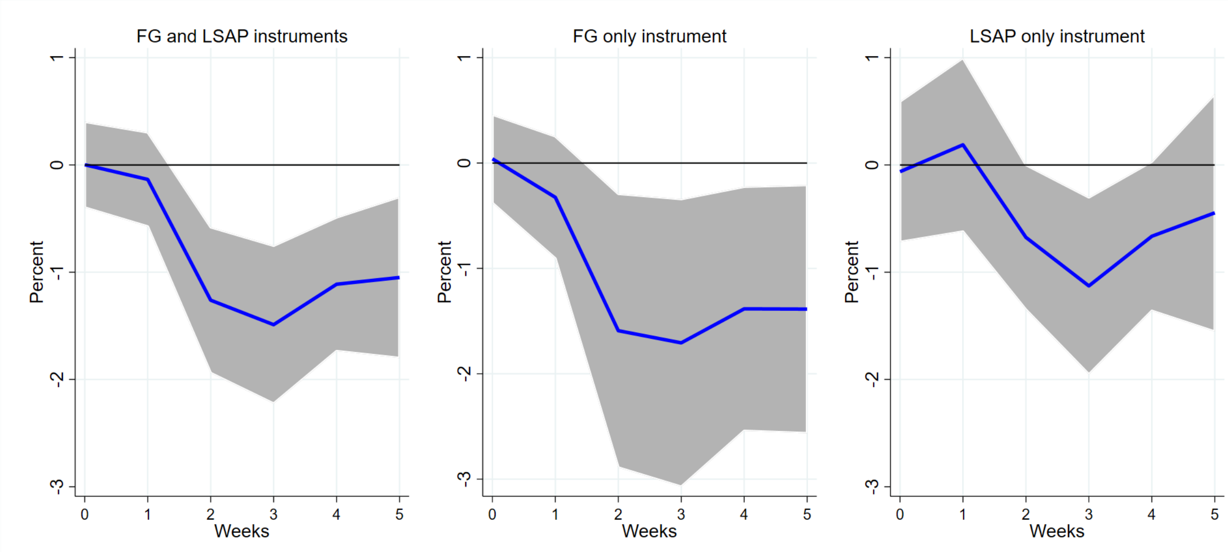


Figure B.2. LP-IV Responses for FG and LSAP instruments

Notes: The figure shows responses of the log list price index to an exogenous +0.25 ppt increase in the mean weekly 30-year fixed-rate mortgage rate estimated by the two-stage least squares with fixed effects using specification (6) with Swanson (2021) factors as instruments: FG and LSAP factors (left), only FG factor (middle), only LSAP factor (right). Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

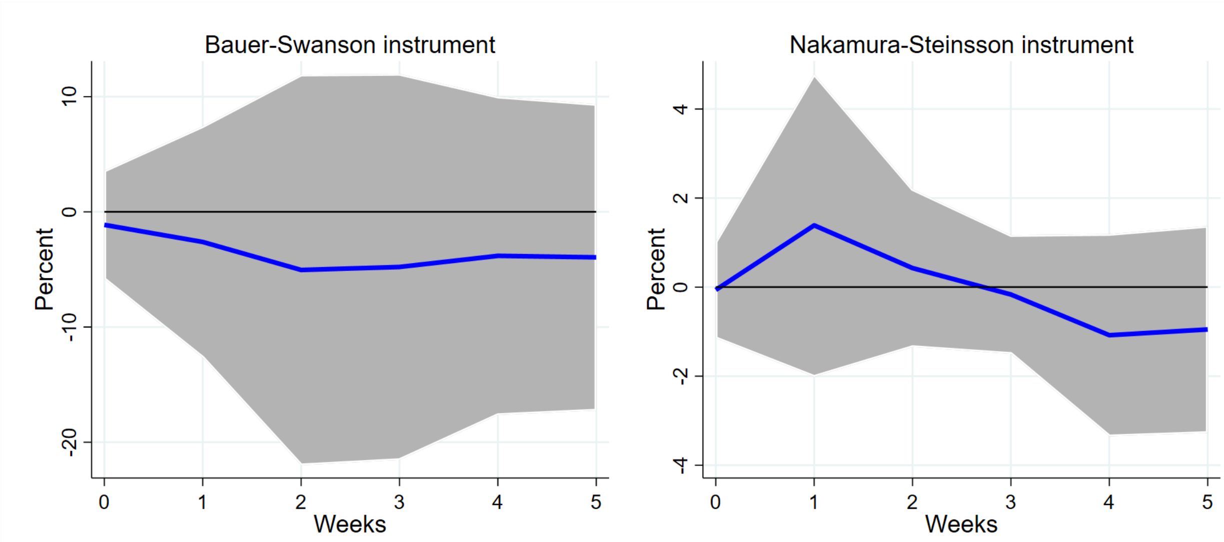


Figure B.3. LP-IV Responses for Bauer and Swanson (2022) and Nakamura and Steinsson (2018) instruments

Notes: The figure shows responses of the log list price index to an exogenous +0.25 ppt increase in the mean weekly 30-year fixed-rate mortgage rate estimated by the two-stage least squares with fixed effects using specification (6) with Swanson (2021) factors as instruments: Bauer and Swanson (2022) surprises (left), Nakamura and Steinsson (2018) surprises (right). Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

C Varying the number of listings

In our estimation of house price responses by LP-OLS (5) and in other estimations in the main text, we use the number of listings in each week and zip code as the weights, i.e., the weights are allowed to vary from week to week. We re-estimate (5) using the mean number of listings in each zip code as weights. Figure C.1 shows that the estimated list price responses are virtually the same as in the baseline with varying weights reported in Figure 2 in the main text.

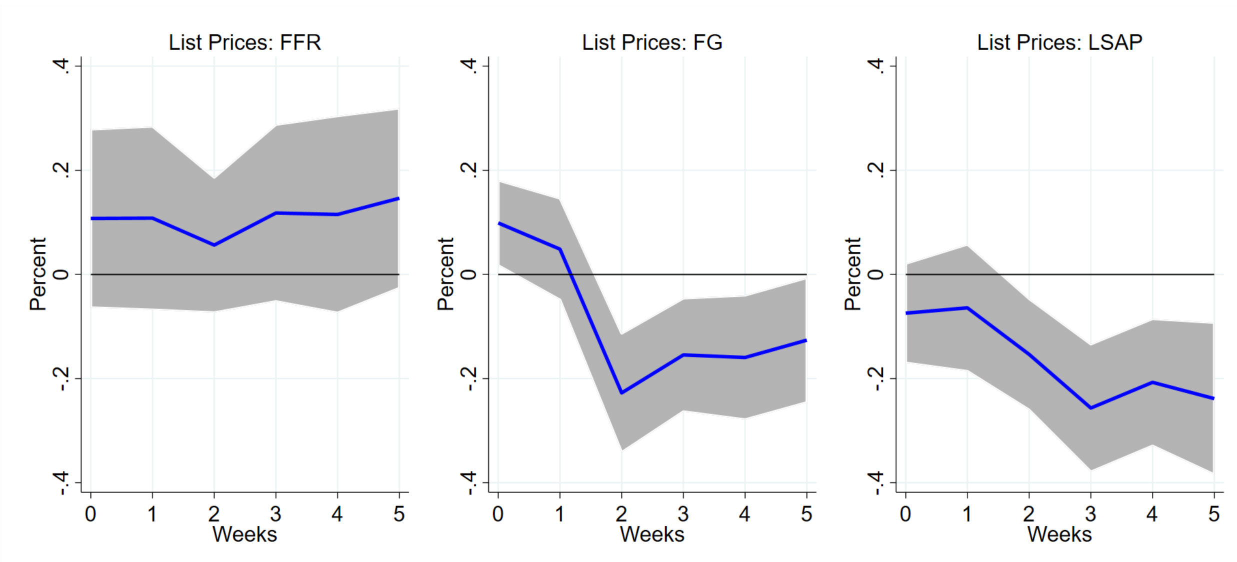
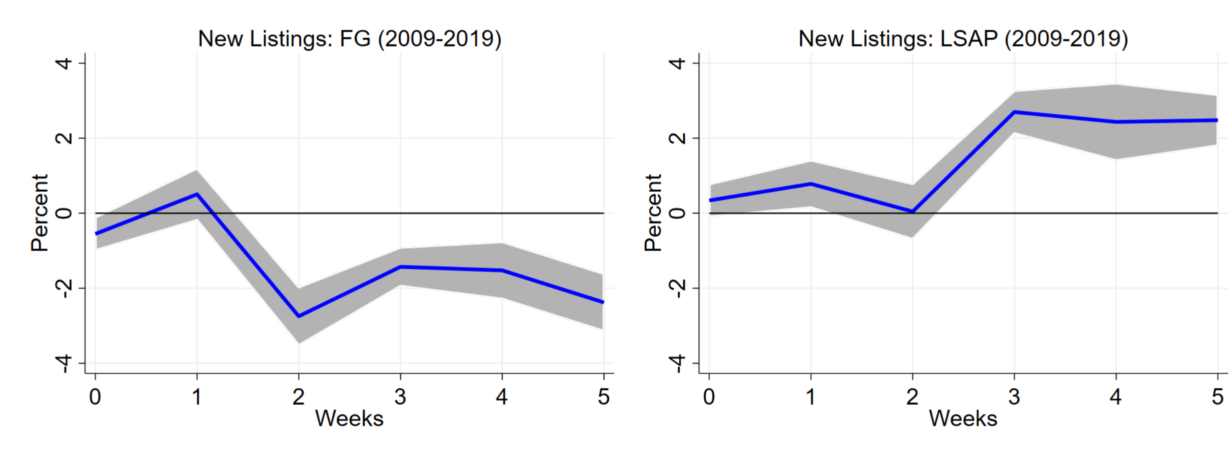


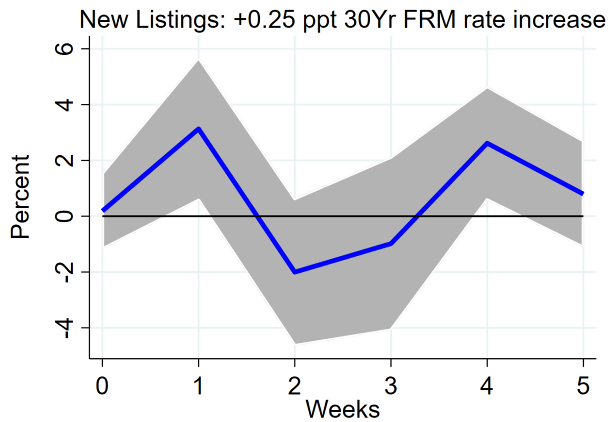
Figure C.1. Responses of Housing List Prices to Contractionary Monetary Policy Surprises, constant weights

Notes: The figure shows responses of the list price index to a one-standard-deviation increase in Swanson (2021)'s federal funds rate factor (left), forward guidance factor (middle), and (negative of) LSAP factor (right). Responses are estimated using specification in (5) using the mean number of listings in each zip code as weights. Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

Figure C.2 shows that the number of listings goes down after the FG surprise, especially for 2009–2019 period, falling by 3 percent. Surprisingly, this response is offset by the *increase* in the number of listings after a contractionary LSAP surprise. Correspondingly, the LP-IV response of the number of listings is about zero over the month following the announcement.



(a) +1std FG or LSAP impulse (LP-OLS)



(b) +0.25 ppt 30Y FRM impulse (LP-IV)

Figure C.2. Responses of the Number of Listings to Contractionary Monetary Policy Surprises

Notes: The figure shows responses of the number of new listings index to: (a) a positive one-standard-deviation impulses to Swanson (2021)'s FG and LSAP factors (left and right), estimated using LP-OLS specification (5), using 2009–2019 sample and average number of listings as weights; (b) a +0.25 ppt increase in the interest rate estimated by the two-stage least squares with fixed effects using LP-IV specification (6) with Swanson (2021) factors as instruments. Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

D Non-linear responses

The estimation of house price responses uses linear LP-OLS specification (5). To test for non-linearity in the relationship between monetary policy surprises and house prices, we conduct two complementary exercises.

First, we repeat estimation of (5) using only large shock values. Large values are defined as those above the median of all positive values or those below the median of negative values. Figure D.1 shows that the estimated list price responses are qualitatively similar to the baseline responses reported in Figure 2 in the main text. This suggests that non-linear effects are likely to be modest.

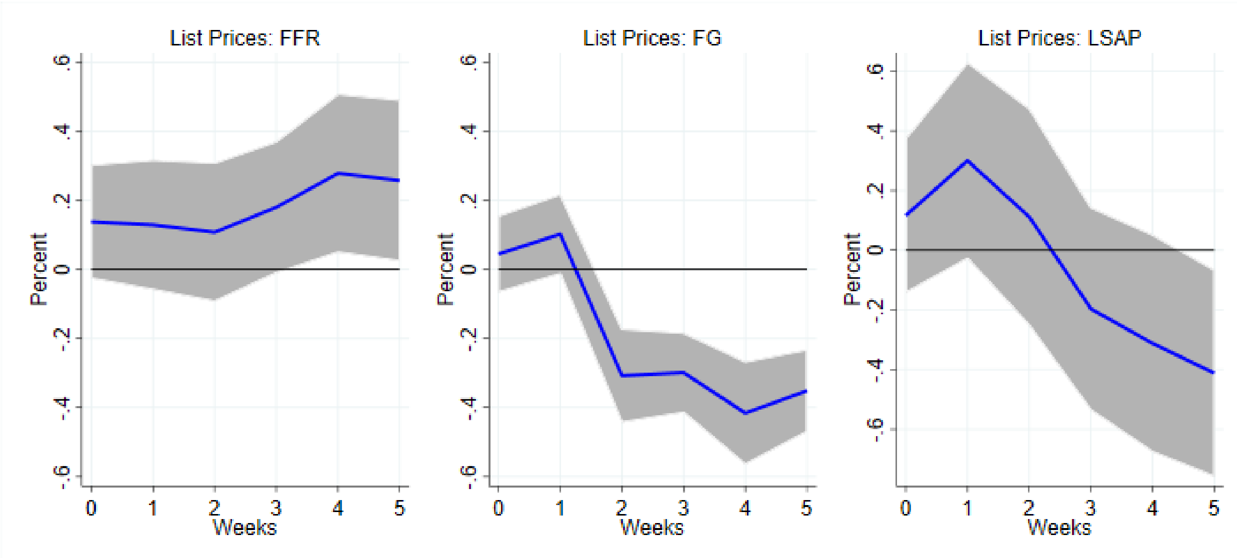


Figure D.1. Responses of Housing List Prices to Contractionary Monetary Policy Surprises, large shock values

Notes: The figure shows responses of the list price index to a one-standard-deviation increase in Swanson (2021)'s federal funds rate factor (left), forward guidance factor (middle), and (negative of) LSAP factor (right). For each factor, above-median positive values and below-median negative values are used. Responses are estimated using specification in (5). Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

In the second exercise, we establish statistical significance of non-linear effects by estimating the modified specification that explicitly includes non-linear terms:

$$\ln P_{l,t+h} - \ln P_{l,t-1} = \chi_l^{(h)} + \beta^{(h)} \mathrm{S}_t + \gamma^{(h)} \mathrm{S}_t \, |\mathrm{S}_t| + \sum_{q=1}^{52} \theta_q^{(h)} (\ln P_{l,t-q} - \ln P_{l,t-q-1}) + \varepsilon_{l,t}^{(h)}, \quad (8)$$

LP-OLS specification (8) is the same as (5) in the main text with an additional term $\gamma^{(h)} \mathrm{S}_t \, |\mathrm{S}_t|$ that would capture the non-linear effects. It turns out that the estimated coefficients $\gamma^{(h)}$ are not statistically different from zero for all three surprise measures and all horizons $h = 0, ..., 5$. We conclude that non-linear effects of monetary policy surprises on list prices are unlikely to be important.

E Cross-sectional evidence

We merge price data by zip codes with cross-sectional data for household income, house value, density of local bank branches, and housing supply elasticity.

E.1 Data

Household income is obtained at zip5 level from the U.S. Census Bureau, 2016-2020 American Community Survey (ACS) 5-Year Estimates, series B19013_001E "MEDIAN HOUSEHOLD INCOME IN THE PAST 12 MONTHS (IN 2020 INFLATION-ADJUSTED DOLLARS)".

House values are obtained at zip5 level from the U.S. Census Bureau, 2016-2020 American Community Survey (ACS) 5-Year Estimates, series B25077_001E "MEDIAN VALUE (DOLLARS)".

Total population is obtained at zip5 level from the U.S. Census Bureau, 2010 Census.

Number of bank branches includes branches of state-chartered banks that are not members of the Federal Reserve System and State-chartered savings associations and federal and state-chartered credit unions. The number of state bank branches is obtained at zip5 from the Federal Deposit Insurance Corporation (FDIC) website. The number of credit union branches is obtained at zip5 level from the National Credit Union Administration. We define **branch density** by the number of branches per 1000 people.

House supply elasticities are obtained from Baum-Snow and Han (2021), who estimate elasticities using repeat sales price index and fraction tract developed from 2001 or 2011. We use their quadratic finite mixture model (FMM) estimates for supply elasticities of housing units for 2011, "gamma11b_unit_FMM". The elasticities are estimated at Census tract level. The tract to zip crosswalk is downloaded from HUD's Office of Policy Development and Research website at https://www.huduser.gov/portal/datasets/usps_crosswalk.html#codebook.

E.2 Evidence

To assess how price responses to monetary shocks differ across zip codes, we re-estimate LP-OLS specification (5) in the main text separately for zip codes in the top/bottom quartiles of income, value, branch density, and house supply elasticity. Figure 8 in the main text compares the LP-IV responses for top/bottom quartiles. Figure E.1 here provides the LP-OLS results.

	Median income	Median value	Branch density
Median value	**0.68**		
	0.00		
Branch density	**0.01**	**0.00**	
	0.22	*0.91*	
Supply elasticity	**-0.09**	**-0.30**	**-0.02**
	0.00	*0.00*	*0.0086*

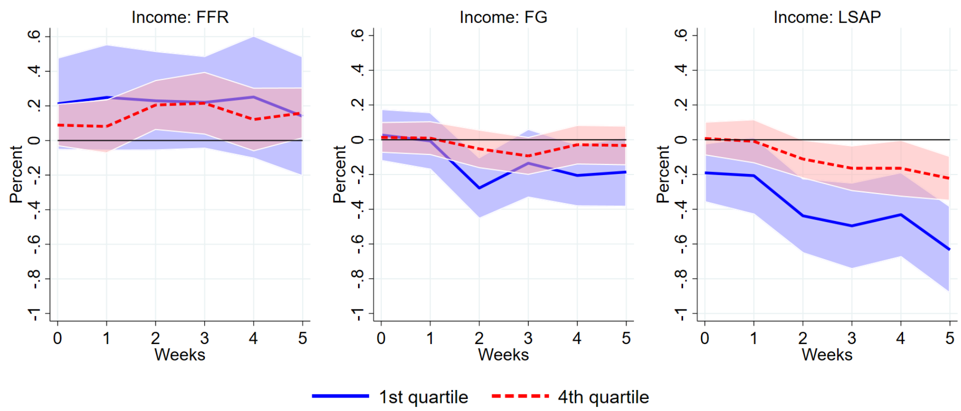
Table E.1. Correlations across U.S. Zip Codes

Notes: Statistics are unweighted. p-values are provided in italics.

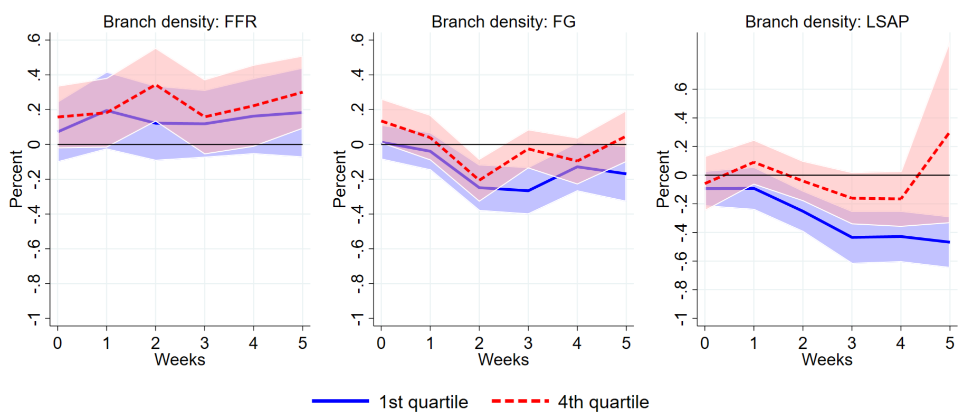
Response differentials across zip codes reported here and in the main text are not influenced by mutual correlations reported in Table E.1. To this end, we standardize log income, density, and elasticity variables across zip codes by subtracting weighted median and dividing by weighted inter-quartile range. For example, standardized log income for zip code l is $\widehat{INC}_l = \frac{\ln INC_l - median(\ln INC_l)}{iqr(\ln INC_l)}$, and we apply similar definitions branch density $\widehat{BRA}_l$, and housing supply elasticity $\widehat{ELA}_l$. We then run baseline regression (5) with 9 additional interaction terms with three Swanson factors:

$$\begin{aligned}\ln P_{l,t+h} - \ln P_{l,t-1} = {} & \alpha^{(h)} + \beta^{(h)}_{FFR} \cdot FFR_t + \beta^{(h)}_{FG} \cdot FG_t + \beta^{(h)}_{LSAP} \cdot LSAP_t \\ & + \beta^{(h)}_{INC-FFR} \cdot \widehat{INC}_l \cdot FFR_t + \beta^{(h)}_{INC-FG} \cdot \widehat{INC}_l \cdot FG_t + \beta^{(h)}_{INC-LSAP} \cdot \widehat{INC}_l \cdot LSAP_t \\ & + \beta^{(h)}_{BRA-FFR} \cdot \widehat{BRA}_l \cdot FFR_t + \beta^{(h)}_{BRA-FG} \cdot \widehat{BRA}_l \cdot FG_t + \beta^{(h)}_{BRA-LSAP} \cdot \widehat{ELA}_l \cdot LSAP_t \\ & + \beta^{(h)}_{ELA-FFR} \cdot \widehat{ELA}_l \cdot FFR_t + \beta^{(h)}_{ELA-FG} \cdot \widehat{ELA}_l \cdot FG_t + \beta^{(h)}_{ELA-LSAP} \cdot \widehat{ELA}_l \cdot LSAP_t \\ & + \sum_{q=1}^{52} \theta^{(h)}_q (\ln P_{l,t-q} - \ln P_{l,t-q-1}) + \chi^{(h)}_l + \varepsilon^{(h)}_{l,t},\end{aligned} \tag{9}$$

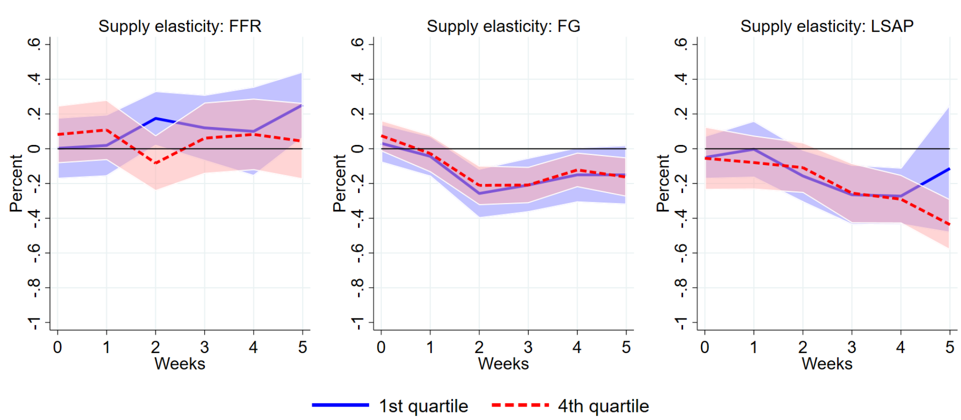
where $\beta^{(h)}_{INC-FFR}, \beta^{(h)}_{INC-FG}, \beta^{(h)}_{INC-LSAP}, \ldots$ estimated coefficients for 9 interactions of log income, branch density, supply elasticity with three Swanson factors at horizon h. We did not include interactions with house value as it is highly correlated with household income. The estimated coefficients, depicted in Figure E.2, yield results similar to those reported for each of these variables separately.



(a) Responses by household income



(b) Responses by the number of branches per 1000 people



(c) Responses by house supply elasticity

Figure E.1. Responses across Zip Codes

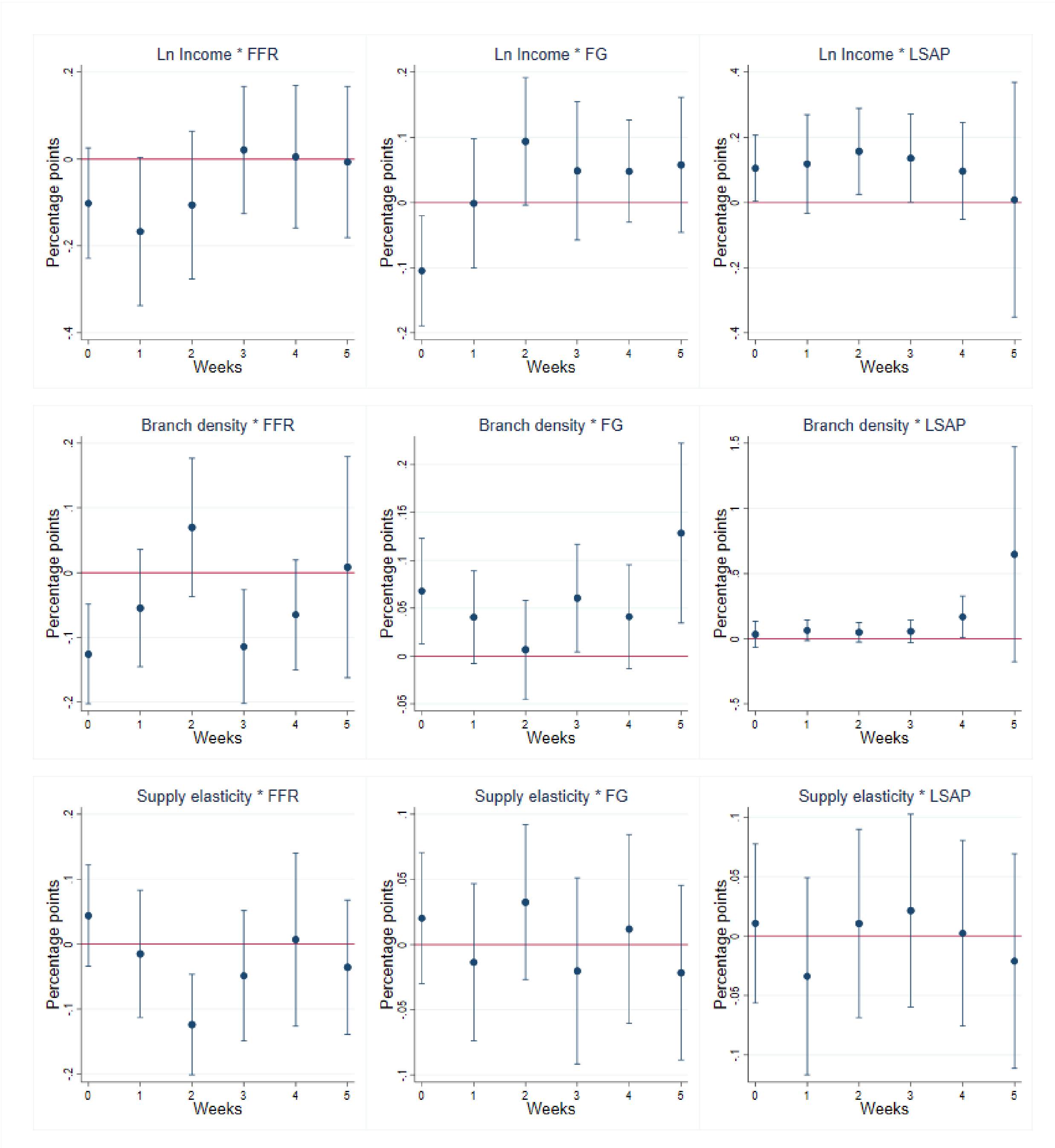


Figure E.2. Estimated Coefficients for Interaction Terms

Notes: The figure shows estimate coefficients for interaction terms in regression (9) estimating responses of the list price index to a one-standard-deviation increase in Swanson (2021)'s federal funds rate factor (left), forward guidance factor (middle), and (negative of) LSAP factor (right). Interaction terms are for log income (top), branch density (middle), housing supply elasticity (bottom). Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

F Orthogonalized Swanson (2021) factors

We verify whether the shock measures are unforecastable and uncorrelated with other relevant variables, as required by local projections. We regressed Swanson factors on 52 lags of average list price weekly changes, on Bauer and Swanson (2022) macroeconomic and financial market variables, and on the change in 30-year mortgage rates between week 13 and week 1 prior to FOMC announcement. Indeed, these controls account for a small portion of variation of Swanson factors. We take the residuals of these regressions as orthogonalized Swanson factors and use them to estimate LP-OLS impulse responses for list prices. Figure F.1 shows that the responses to orthogonalzied FG and LSAP factors remain negative. For FG filtered with all controls and for LSAP filtered with macroeconomic and financial controls the responses are less significant for some horizons.

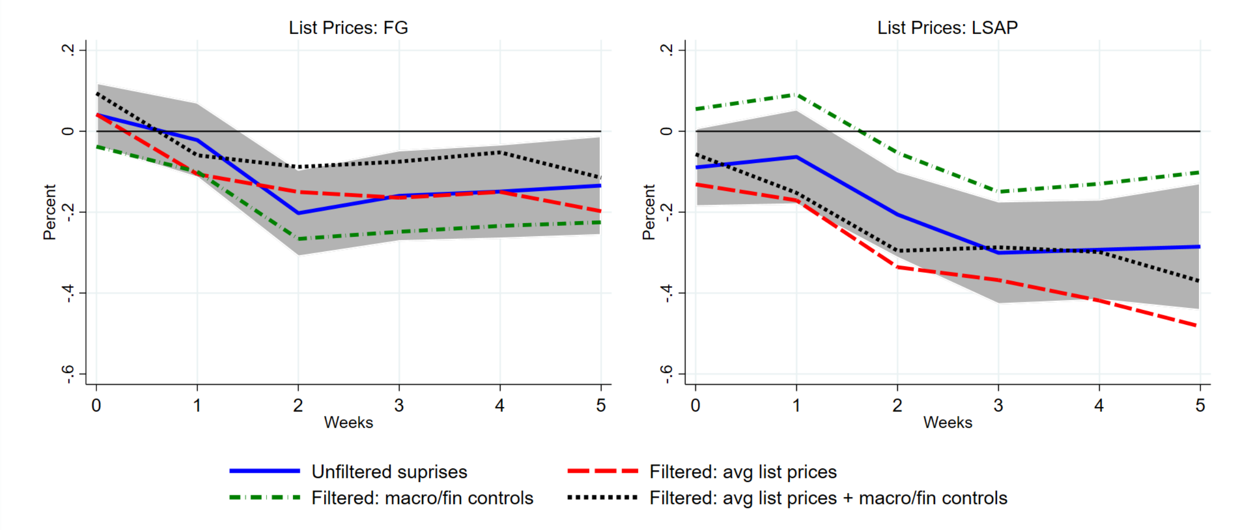


Figure F.1. Responses of Housing List Prices to Contractionary Monetary Policy Surprises, Orthogonalized Swanson (2021) factors

Notes: The figure shows responses of the list price index to a one-standard-deviation increase in Swanson (2021)'s forward guidance factor (left), and (negative of) LSAP factor (right). Responses are estimated using specification (5). Factors are orthogonalized by OLS regression on 52 lags of (mean of weekly change in) list price index, Bauer and Swanson (2022) control variables together with change in 30-year FRM rate between weeks 13 and 1 before the FOMC announcement. Shaded areas represent the 90 percent confidence intervals based on Driscoll-Kraay standard errors.

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