The unequal impacts of monetary policies on regional housing markets*

Kevin P. Boge[a,*], Konstantin A. Kholodilin[b], Malte Rieth[a,b]

[a] *Martin-Luther-Universität Halle-Wittenberg, Germany*
[b] *DIW Berlin, Mohrenstraße 58, 10117, Berlin, Germany*

Abstract

We study the dynamic distributional effects of monetary policies on regional housing markets, using a unique dataset of transaction prices in Germany covering all residential market segments, over 200 regions, and 50 years. We document three stylized facts. First, the adjustment size and speed differ significantly across segments: land and property prices respond more than rents. Second, regional differences amplify these disparities: rural areas are significantly more affected than larger cities. Third, unconventional monetary policy has stronger impacts than conventional policy and particularly on urban house prices. The results imply that monetary policy affects spatial housing polarization.

Key words: House prices, rents, European Central Bank, distribution, asset pricing, regional data, local projections, Germany.

JEL codes: E52, R12, R31

1. Introduction

Real house prices doubled in Germany from 2010 to 2022, while land prices tripled. Both halved from 2022 to 2024. In contrast, rents increased by only one-fourth since 2010 and remain stable. As rural areas have double the homeownership rate of major cities, households there are more vulnerable to house price fluctuations. Over the past 15 years, rural discontent with the democratic process has grown. There is a perception that urban bureaucrats dictate policy, neglecting rural needs. This, among others, led to the rise of the Alternative for Germany, an extreme-right populist party, in 2013. Their vote share in national polls exceeds 20% in 2024. Rural areas show the highest support, sometimes

*We thank for useful comments and suggestions participants of the DIW Berlin Seminar.
*kevin.boge@wiwi.uni-halle.de

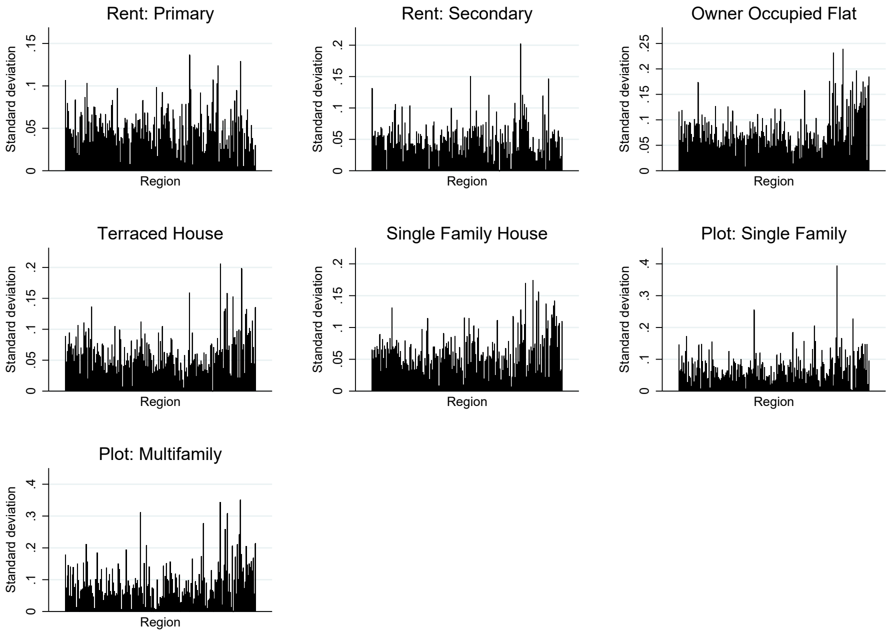
surpassing majority. This phenomenon extends beyond Germany. In France, Gilets jaunes protested violently against centralist policies. In the UK, dissatisfaction with London's policies drove many Brexit votes. In the US, rural voters tend to support populist policies more than urban voters.

Is housing important for households? Certainly. The market plays a central role in every economy. In Germany, as in many other countries, households spend about one-third of their income on housing, while properties and land account for roughly two-thirds of total household wealth. In addition to its economic significance, housing serves as the most important status symbol of the middle class, with the fear of losing status closely linked to the predisposition to populist arguments. Are house prices important for central banks? Absolutely. The housing market serves as a primary transmission channel of monetary policy (Beraja et al., 2019; Corsetti et al., 2022). Furthermore, crashes in housing markets have led to some of the largest financial crises in recent history, such as the Japanese housing crash, the Asian crisis, the global financial crisis, and the European debt crisis. Are house prices in Germany important for the European Central Bank? Indeed. A founding principle of the Alternative for Germany is to leave the euro, which could potentially lead to the end of the common currency.

In this paper, we investigate the granular impacts of monetary policy shocks on housing markets in Germany. We use a unique regional dataset of housing transaction prices at a NUTS-3 level. This dataset offers two crucial dimensions of disaggregation. Firstly, it encompasses the universe of residential housing segments, including rents (primary and secondary), property prices (different types of houses and owner-occupied flats), and land prices (single and multifamily). Secondly, it covers more than 200 regions, providing representation for the entire country while also distinguishing between more rural areas, small, medium, and large cities.

Figure 1 introduces both of these dimensions of disaggregation, and highlights the importance of an analysis of housing markets at these levels. Specifically, it shows the regional heterogeneity of historical housing price volatility, measured by the standard deviation of an AR(1) process residual calculated for each region. We observe that the volatility of housing prices varies considerably across regions, where, within segments, the volatility of housing prices in the most volatile region is up to 5 times higher than the average.

Figure 1: Regional heterogeneity of housing prices volatilities in Germany



Notes: The figure shows the regional heterogeneity of the volatility of seven housing prices in Germany between 1975 and 2021. The volatility is measured as the standard deviation of an AR(1) process residual estimated for each region. Each bar is the estimated volatility for a region. The order of the bars is determined by the numerical order of the official municipality code.

Despite the high granularity of the data, the dataset has two main advantages over alternative datasets. First, it provides prices and rents of realized transactions. Other datasets are often based on offered prices, which can deviate substantially from realized prices, particularly during periods of strong price dynamics. Second, the sample begins in 1975, thus spanning nearly 50 years of house price fluctuations. This extensive timeframe is crucial as housing cycles tend to be much longer than business cycles.

We augment the dataset with comprehensive regional socio-economic data and a measure of monetary policy shocks. For the latter, we construct a monetary policy shock series using high-frequency monetary surprises. We are the first (to the best of our knowledge) to construct a measure of high-frequency monetary surprises for policy conducted by the Bundesbank. We employ instrumental variable local projections to trace out the distributional effects of monetary shocks across housing segments and regions.

We document that monetary policy shocks have strong but heterogeneous effects along three dimensions. First, we highlight significant differences in the size and speed of price adjustments across housing segments. Monetary shocks affect real land prices the most strongly and persistently, followed by property prices, and then rents. In response to a contractionary 1 percentage point (pp) monetary policy shock, primary market rents reach their bottom after just 3 years, declining by –7%, while multifamily plot prices hit their trough only after 7 years, decreasing by –12%. Second, we show that rural areas with small cities are significantly more affected than metropolitan areas. The gap between small and large cities in the response of primary rents is 2pp, it widens to 14pp for terraced house prices. These numbers imply that homeowners (representing 50% of the population in rural areas with small cities) experience the shocks several times more than renters (constituting 75% of the population in large cities).[1] Third, we find that unconventional monetary policy shocks have fundamentally different effects on housing markets than conventional monetary policy shocks. The impact of unconventional shocks is greater on all segments, particularly on property and land prices in larger cities. In other words, unconventional monetary policy narrows the exposure gap between rural areas and large cities, but this comes at the expense of magnifying price fluctuations in larger cities. Furthermore, we observe that unconventional monetary policy shocks are the main driver of housing prices fluctuations since 2010.

While the main aim of the paper is to document the distributional effects of monetary policies on housing markets, we provide two tentative explanations for the mechanisms underlying the heterogeneities. First, the differential responses of housing market segments can be rationalized by a standard cash-flow asset pricing model. As land prices reflect future property prices and property prices reflect future rents, and because higher (risk-free) interest rates imply higher discounting, land and property prices decline more and more persistently than rents, where the effect on land prices is the most persistent. Second, the small-large city exposure gap to monetary policy shocks is in line with a liquidity mechanism whereby rural housing markets are less liquid than metropolitan markets, with thinner markets and a more difficult matching process between buyers and sellers, or tenants and landlords. An alternative explanation for the regional exposure gap lies in the differences in banking sector concentration, which affect the transmission of monetary policy through the deposit channel. Given that in rural areas, banks have more market power than in urban areas, they will widen their deposit spread more. Consequently, a higher outflow of deposits in rural areas means that lending is dampened further and the negative effects

[1] Recent work shows large consumption responses to house price fluctuations (Berger et al., 2018).

on mortgages, homebuying demand and house prices are exacerbated in rural compared to metropolitan regions. Other explanations are less likely. We show that economic activity in rural areas is not more affected than in large cities. Unemployment, insolvency rates, and household income all respond similarly across regions, and GDP per capita reacts less.

Overall, the findings suggest unequal effects of monetary policies across housing segments and regions. The stronger effects on prices than on rents have two implications. First, monetary policy can affect the price-rent ratio, a standard predictor of housing bubbles. Second, the rural population is more affected by monetary interventions than urban households because both rents and prices respond more and since the ownership rate is twice as high in rural areas as in large cities and prices react more than rents. The typical middle-class house price in a small city reacts two times as much to monetary shocks as the price of the same object in one of the country's largest cities. Finally, the intended asset price inflation of unconventional monetary policies closes, or even reverses in some cases, the small-large city exposure gap by inflating house prices, especially in large cities, undermining the support for monetary policy also in these regions.

Are policy makers helpless against these disparities? No. Monetary policy can monitor disaggregated house prices and respond to sectoral or regional imbalances. For example, it could give more weight to specific developments that are not visible in aggregate data. It could also try to target imbalances directly through specific tools, such as collateral requirements or balance sheet policies. Local public policy can try to enhance regional market liquidity, for example, through reductions in real estate taxes or local subsidies. In addition, more public housing in non-metropolitan areas would increase renting shares and reduce the exposure to house and land price fluctuations. Finally, regulators could try to limit the access of financial investors to urban housing markets in a search for yield in response to large-scale asset purchases.

Relation to literature. The paper relates to several literature strands. The first strand examines the distributional effects of monetary policy on income and wealth. Coibion et al. (2017) find that contractionary monetary policy shocks increase consumption and income inequality. Amberg et al. (2022) observe that high and low-income households are more affected than middle-income classes. Holm et al. (2021) estimate the transmission of monetary policy along the liquid asset distribution and find that low-liquidity and high-liquidity households respond most. We complement these studies by investigating the diverse effects of monetary policy on housing, a crucial asset for households, from a sectoral and geographical perspective. We identify the housing segments and regions most exposed to monetary policy shocks.

Another strand examines the effects of monetary policy on housing prices at the country level. Many articles find a negative effect of contractionary monetary policy shocks on house prices. However, fewer studies examine rents or land prices. The majority of them find that rents drop after contractionary shocks, while a few detect an increase (Dias and Duarte, 2019). We contribute detailed evidence on the response of rents and prices in different segments of the housing market.

Some studies consider the heterogeneity of regional housing markets. Del Negro and Otrok (2007) employ a dynamic factor model to determine the importance of local and common shocks across U.S. states and of monetary policy for house prices. They find that local shocks historically dominated, common shocks increased in importance, and the contribution of monetary policy to the house price boom in the early 2000s is modest. Aastveit and Anundsen (2022) and Fischer et al. (2021) examine regional heterogeneity in the sensitivity of house prices to monetary policy by differentiating regions based on housing supply elasticity. Both papers find an overall higher sensitivity in supply inelastic regions. Conversely, Amaral et al. (2021) investigate differences in the returns on residential housing investment between the biggest agglomerations of a country and other cities. They find that returns are higher in the latter group due to higher risk and lower liquidity.

The aforementioned articles focus on conventional monetary policy. Only a few papers consider the effects of unconventional monetary policy, although a main aim of that policy is to create asset price inflation. Huber and Punzi (2020); Rahal (2016); Rosenberg (2020) all find that unconventional monetary policy has larger effects than conventional interest rate policy. We find that unconventional policy is also qualitatively different, having as much (or more) impact in urban regions as in rural ones.

Lastly, this paper contributes to the identification of monetary policy shocks. To the best of our knowledge, we are the first to construct high-frequency monetary surprises for policy conducted by the Bundesbank, although this identification approach has become the standard in the literature (Gertler and Karadi, 2015; Amberg et al., 2022; Altavilla et al., 2019). Thereby, we complement the analysis of Cloyne et al. (2022), who use the more traditional narrative approach of Romer and Romer (2004) to construct a shock series for the Bundesbank era.

2. Data and estimation strategy

2.1. Regional housing data

We use regional annual data at the level of German districts (*Kreise*). The districts are NUTS-3 regions which represent a level of administrative division below federal states (*Länder*, NUTS-1) and government regions (*Regierungsbezirke*, NUTS-2). Berlin and Hamburg are both states and districts because they are city states. Table A1 defines the data, lists their sources, and provides some descriptive statistics. Most series stretch between 1975 and 2021. However, due to some missing observations at the beginning of the sample for others, we have an unbalanced panel.

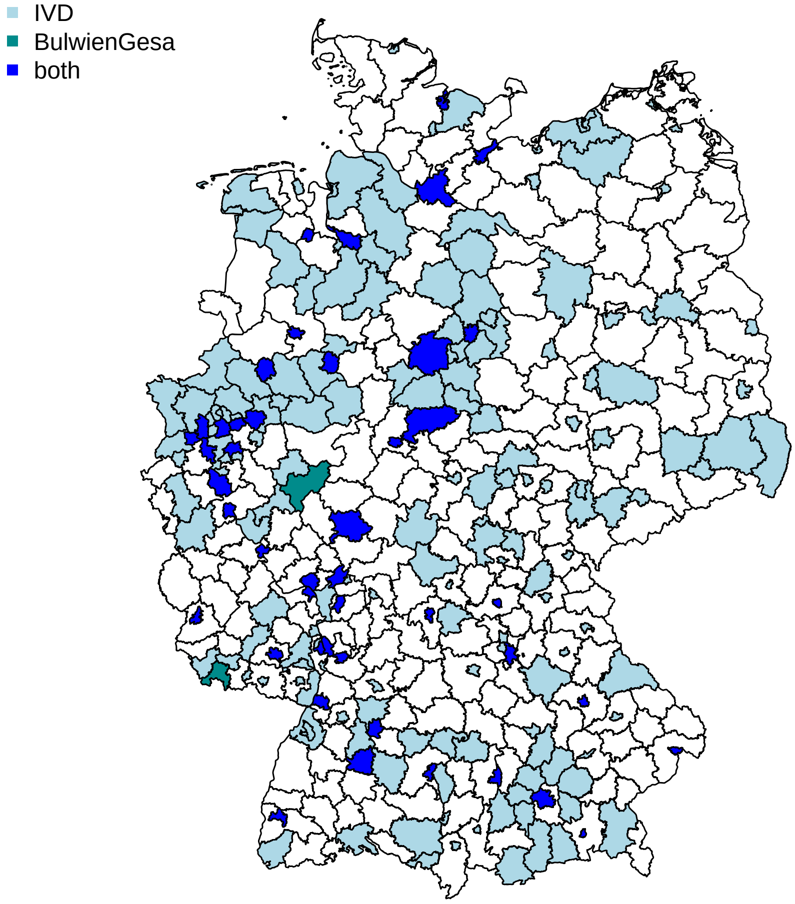
The primary source of regional housing price data is IVD, which stands for *Immobilienverband Deutschland*. It is an association of real estate consultants, agents, managers, and appraisers.[2] The association collects and provides real estate data on realized, that is, transaction prices and indices on the universe of real estate market segments since 1975. The data collection contains average purchase prices and rents for different sorts of flats, houses, and plots in up to 685 German municipalities from 1975 to 2022, making it a unique source of information in terms of geographic and temporal coverage of the market. We use a subset of these data, focusing on residential markets.

The second source of regional housing price data is BulwienGesa AG.[3] The company provides real estate data and indices on individual real estate segments for nearly 50 years. Among other things, these are used by the Deutsche Bundesbank to monitor developments on the real estate market. In addition, they are used by the Organization for Economic Cooperation and Development (OECD) as the basis for a Germany-wide house price index that is embedded in its international database. From this dataset, we use average purchase prices and rents for apartments in 49 major German cities from 1975 to 2021.

[2] *IVD Bundesverband der Immobilienberater, Makler, Verwalter und Sachverständigen e.V.*; `https://ivd.net/`.

[3] `https://bulwiengesa.de/de`.

Figure 2: Coverage of regional housing data



Notes: The figure shows the availability of housing price data for German NUTS-3 level regions from the Immobilienverband Deutschland (IVD) and BulwienGesa AG. The regions where only data from the IVD is available are shaded in light blue. The regions where only data from BulwienGesa AG are available are shaded in teal. The regions where data from both sources is available are shaded in dark blue.

Table 1: Descriptive statistics for IVD regional housing price data

Variable	N	Price for	Mean	Std. dev.
Rent: primary	4851	Square meter	6.97	2.3
Rent: secondary	4875	Square meter	5.63	1.5
Owner occupied flat	5096	Square meter	1398.68	554.3
Terraced house	5082	Full object	195,682	83,088
Single family house	5189	Full object	265,914	121,058
Plot: single family	5151	Square meter	202.04	158.96
Plot: multifamily	4614	Square meter	293.56	220.37

Figure 2 shows the availability of the housing price data from both sources. Overall, the data are available for 207 out of 401 districts. Among these, for 160 only data of IVD are available, for 2 only of BulwienGesa, and for the remaining 45 districts we have data from both sources. The coverage is evenly distributed across the country. Only for the sparsely populated regions in Mecklenburg-Western Pomerania the coverage is a bit lower.

Apart from its granularity, the dataset has the main advantage that the prices and rents are based on realized transactions. Other regional datasets are often obtained from web scrapping or online platforms. Therefore, they contain only the initial display price and not on the final transaction price. The offered price can deviate from the realized prices. Especially, during periods of booms and crashes the spread between offered and realized price can be substantial. Thus, the dataset used in this in this paper measures regional housing prices in Germany more accurately than previous analyses.

We use the IVD data for seven housing segments. These can be separated into three types: land prices (single family house and multifamily house plots), property prices (single family houses, terraced houses, and owner occupied flats), and rent prices (secondary and primary). The primary market are new rental units and the secondary market contains existing rental units. Table 5 presents descriptive statistics for the segments. Primary rents are higher on average than secondary rents. Single family houses are more expensive than terraced houses. Land for multifamily houses is more expensive than land for single family houses. The prices also vary substantially within segments. For example, a one standard deviation drop for the average terraced house implies that the price nearly halves, whereas a one standard deviation increase implies a 40% higher price. For all segments, the price fluctuations reflect variation over both time and space, as we will show.

To analyze the regional heterogeneity in housing price responses to monetary policy

Table 2: Region categories based on largest city

Region category	Min. pop.	Max. pop.	N
Largest city is mid-small	20,000	50,000	1,064
Largest city is mid-big	50,000	100,000	1,321
Largest city is big-small	100,000	500,000	2,346
Largest city is big-big	500,000		556

shocks, we use a variable that classifies regions by the population of their biggest city. This variable is provided by IVD and based on their expert knowledge about the size-related structural characteristics of real estate markets. Table 2 shows the categories we use. We focus on the categories with a sufficient data coverage, which are the four region types with the largest city having at least 20,000 inhabitants.[4] Out of these, the most rural areas are those where the largest city has 20,000-50,000 inhabitants. The most urban areas are defined as having a city with more than 500,000 people. For each category, we have a sufficient number of observations to estimate impulse responses reliably over several years. Importantly, the prices within each category do not only reflect those of the largest city but also the prices outside the local centers. Figure A2 shows that the categorization is related to other structural economic and housing characteristics of the regions—such as GDP per capita, unemployment rate, homeownership rate, or household size—but not the same. In fact, we show that it is the size of the housing market that shapes the response of housing prices to monetary policy shocks, and not these alternative structural features.

Figure 3 brings together the two dataset dimensions that we use in the empirical analysis. It plots the evolution of real residential housing prices in Germany between 1975 and 2021 by market segment and region type. For each segment, it also shows the average price across regions. We deflate the nominal prices with the national consumer price index as regional consumer price indices are not available and state indices start only in the 1990s. The figure shows considerable heterogeneity in the price dynamics across both segments and region types.

To test whether monetary policy affects housing boom-bust cycles, we construct two standard metrics. First, we compute price-rent ratios. Second, we construct a binary

[4]The IVD data contain three more categories for smaller city sizes (small, very small, and no city) but these categories start only halfway through the sample and have a very low number of observations such that we cannot estimate consistent impulse response functions. Therefore, we do not use these in the analysis.

Figure 3: Real house prices by segment and region 1975–2021 (Index=100 in year 2000)

Notes: The figure shows the evolution of real house prices by segment and region type between 1975 and 2021. Each graph contains five lines, one for the country average (black dashed) and one for each region type. For easier comparison, for each segment, the country's average housing price is set to 100 in the year 2000, and all other values for all regions are compared accordingly.

indicator of house price booms, following Goodhart and Hofmann (2008). The approach uses as input the real house price indices and takes the following three steps. First, we apply the Hodrick-Prescott filter with λ =25,000 to to decompose prices into trend and cycle. Second, we identify potential booms as periods when the relative deviation of the cycle from the trend exceeds 5%. Third, we impose a minimum duration of booms of 3 years. This approach is less demanding and more robust than the explosiveness test of Phillips et al. (2015), which requires many observations. Finally, we complement the housing data with a rich set of socio-economic variables for the regional level, and we add some standard macroeconomic variables for the country level. These are listed and defined in Table A1.

2.2. Construction of monetary policy shocks

We construct a monetary policy shock series for Germany for the 1975-2021 period. The monetary authority changed in 1999 from the Bundesbank to the European Central Bank (ECB). Within the latter period, we distinguish between two policies: conventional policy between 1999-2009 and unconventional policy between 2010-2021. To take the changes into account, we construct monetary policy shocks for the corresponding three subsamples separately and then combine them into one single full sample shock series.

Within each subsample, we follow the methodology of Amberg et al. (2022). First, we use high frequency identification to obtain the policy surprises on central bank meeting days. Specifically, we calculate the variation in financial market interest rates from the day of the central bank meeting to the next day. This frequency is the highest for which Germany interest rate data since the 1970s are available. Then, we use poor man's sign restrictions (Jarociński and Karadi, 2020) by assuming that every observation is either a regular monetary policy surprise or a central bank information shock. To obtain the regular policy surprises, we select the meeting days on which the German stock market index co-moves negatively with the interest rate and disregard the others. Then, we perform the following regression:

$$\Delta i_m^{PR} = \alpha + \beta \Delta i_m^{MR} + \epsilon_m, \tag{1}$$

where Δi_m^{PR} and Δi_m^{MR} are daily changes in the policy rate and market rate, respectively, associated to meeting day m, and ϵ_m is an iid error term. We compute the fitted values $\widehat{\Delta i_m^{PR}}$ which give the exogenous changes in the policy rate at each meeting.

To account for the transition in the monetary authority and type of policy, we use different combinations of policy rates and market rates for each subsample. Table 3 summarizes the combinations. Section 4 shows that the main results are robust to alternative choices.

Table 3: Sample, data, and construction of monetary policy shocks

Sample	Authority	Policy type	Policy rate	Market rate	Sign restrictions
1975–1998	Bundesbank	conventional	Lombard	3m interbank	No
1999–2009	ECB	conventional	MRO	3m interbank	Yes
2010–2021	ECB	unconventional	–	2y bond rate	Yes

For the Bundesbank subsample, we use the Lombard rate as the policy rate because Bernanke and Mihov (1997) show that it is the preferred monetary policy indicator for most of the Bundesbank area and since the repurchase rate is available only since 1990.[5] For the conventional ECB policy subsample, we use the main refinancing operations (MRO) rate as the policy rate. In the unconventional ECB policy subsample, we do not use a policy rate as monetary policy was barely conducted through policy rate changes. Instead, we use shifts in the two-year rate on government bonds directly.

[5]The Lombard rate determined the interest rate on loans granted by the central bank to its customers

To capture policy surprises from conventional monetary policy, we use the 3-month interbank rate as a measure of short term interest rates. To capture the surprises from unconventional monetary policy, we use the 2-year government bond rate as an approximation of risk-free medium term interest rates. We make this distinction because conventional monetary policy focuses on affecting short term rates, whereas unconventional monetary policy (like forward guidance and quantitative easing) affects medium and long-term rates (Hachula et al., 2020).

As we use market rates of different maturity in the two ECB subsamples, we take into account the difference in the variation of the 3-month rate and the 2-year rate to ensure the quantitative comparability of the surprises across the two subsamples. For the meeting days of the 1999-2009, we regress the daily changes in the 2-year rate on the fitted policy rate changes. The estimated coefficient is 0.48. We divide all surprises in the second ECB subsample by this coefficient.

We do not employ the sign restrictions on the observations in the first subsample. The Bundesbank conducted policy differently than the ECB. Meetings were held more frequently (every two weeks) and changes in the repurchase rate were often done in weeks between meetings. With this abundance of meetings, and therefore signals, the information component on meeting days is small. Kaen et al. (1997) analyze the reaction of a bank stock index to Bundesbank meetings and they observe that the stock index does not respond much to Bundesbank meetings. For example, the authors find that when there was a change in the repurchase rate the week before a meeting, but this was not followed by a Lombard (or discount) rate change at the meeting itself, a not untypical scenario, the stock index had no significant reaction to the meeting.

To assess the relevance of the subsample instruments, Table 4 reports the F-statistic for the first stage regressions (Equation 1) of the first two subsamples using different estimators. Rows 1, 2, and 3 report F-stats for the first stage regression for the Bundesbank subsample instrument, and rows 4, 5, and 6 for the ECB conventional subsample instrument. All F-statistics surpass the value 10, thus proving the relevance of the high frequency instruments used.

We aggregate the daily surprises to the annual frequency to match the housing market data. To make sure that surprises at the beginning of the year have more weight than

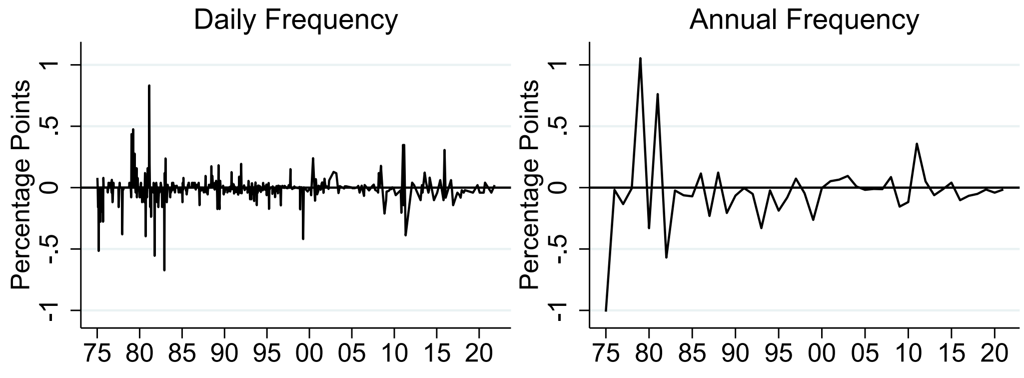
Table 4: Tests on relevance of first stage regression of monetary policy shock instrument

	Coefficient	Standard error	Obs	R2	F test
(1)	0.79	0.06	579	0.21	153.4
(2)	0.79	0.19	579	0.21	17.00
(3)	0.79	0.20	579	0.21	15.90
(4)	1.78	0.47	70	0.17	14.25
(5)	1.78	0.56	70	0.17	10.10
(6)	1.78	0.52	70	0.17	11.89

Notes: The table shows results for various F-statistic tests on the relevance of the subsample instruments. The regressions are based on Equation 1. Rows 1, 2, and 3 are tests on the Bundesbank subsample instrument, and rows 4, 5, and 6 are tests on the ECB conventional subsample instrument. Three estimators are used on both subsamples, OLS (rows 1 and 4), OLS with robust errors (rows 2 and 5) and a Newey-West estimator (rows 3 and 6).

surprises at the end of the year, as the latter have had less time to have an effect on the real economy, we use quarter weights: $S_t = \sum_{m \in t}(\widehat{\Delta i_m^{PR}} / q_m)$, where S_t is the monetary policy shock in year t and q_m is the quarter of the meeting. For the baseline estimates, we combine the three subsample series into one shock series and in extended analysis look at the period of unconventional monetary policy shocks only. Figure 4 shows the shocks at the daily and yearly frequency.

Figure 4: Monetary policy shock series 1975–2021



Notes: The figure shows the constructed monetary policy shock series from 1975 to 2021. The left panel shows the daily frequency shock series ($\widehat{\Delta i_m^{PR}}$). The right panel shows the aggregated annual frequency shock series (S_t).

Furthermore, we test for possible autocorrelation and predictability of the aggregated monetary policy shock instrument. Table 5 provides the results of the tests. Rows 1 and 3 pertain to tests on the whole sample, rows 2 and 4 to tests on the unconventional monetary policy sample. In rows 1 and 2 we test for autocorrelation. We find some autocorrelation for the whole sample instrument, which likely comes from the aggregation of daily shocks to annual frequency. Rows 3 and 4 present predictability tests, where we test if the monetary policy shock instrument can be predicted by past macroeconomic data. We find that neither the whole sample nor the unconventional monetary policy sample instrument can be predicted by past macroeconomic data.

Table 5: Autocorrelation and predictability of monetary policy shock instrument

	L.S_t	L2.S_t	L.gdp	L2.gdp	L.cpi	L2.cpi	L.ur	L2.ur	t	Constant	Obs	R2	F Test
(1)	-0.32	0.18								-0.01	45	0.19	5.13
	(0.10)	(0.16)								(0.04)			
(2)	-0.11									0.01	11	0.01	0.11
	(0.33)									(0.03)			
(3)			0.95	0.86	-5.75	3.24	0.01	0.02	0.01	2.08	45	0.11	0.36
			(2.69)	(2.75)	(6.49)	(5.30)	(0.03)	(0.03)	(0.02)	(3.80)			
(4)			2.99		-7.51		0.05		0.05	17.39	11	0.57	0.88
			(3.48)		(7.16)		(0.04)		(0.08)	(32.07)			

Notes: The table presents results from autocorelation and predictability tests of the annual frequency full sample (rows 1 and 3) and ECB unconventional subsample (rows 2 and 4) monetary policy shock instruments. Rows 1 and 2 are regressions on lagged values of the instrument. Rows 3 and 4 are regressions of the monetary policy shock instruments on aggregate variables including GDP, CPI, unemployment rate, and a time trend. Given that there are only 11 observations for the ECB unconventional subsample, only one lag of every regressor is included in the relevant regressions. Robust standard errors are reported in parenthesis below the coefficients.

2.3. Estimation

We estimate the dynamic impacts of monetary policy shocks on housing markets via local projections. We run the following regressions for horizons $h = 1, ..., H$ for either segments or regions:

$$y_{i,t+h} = \alpha_i^h + \sum_{j=0}^{J} \beta_j^h S_{t-j} + \sum_{k=1}^{K} \gamma_k^h y_{i,t-k} + \sum_{l=1}^{L} \Theta_l^h X_{i,t-l} + \epsilon_{i,t+h}, \quad (2)$$

where $y_{i,t}$ is the dependent variable for sector i or region i in year t and in (log) level, α_i^h a sector-specific or region-specific constant, $S_{i,t}$ the monetary policy shock, $X_{i,t}$ a control vector containing lags of country-specific and region-specific controls, and $\epsilon_{i,t}$ an error term. J, K, and L are the number of lags of the shock, dependent variable, and controls, respectively. We include log GDP, log consumer price index, and the unemployment rate as control variables. Typically, we set $J = K = L = 2$.[6] We cluster standard errors at the regional level. [7]

To see whether our new measure of monetary policy shocks for Germany performs well, we estimate the macroeconomic effects of the shocks before looking at the granular housing market responses. Figure 5 focuses on country-level effects. It shows the point estimates of the impulse responses as well as their one and two standard-error confidence bands. We look at a contractionary shock that increases the 3-month rate by 1 percentage point in the first year. All other responses are scaled accordingly.[8] The estimated effects are as expected, in both shape and magnitude. GDP, prices, investment, consumption, and national house prices decrease, while unemployment increases. The estimates coincide with standard theory and are mostly statistically significant. The short lag in the fall of the price levels has been documented previously for Germany Cloyne et al. (2022). Figure A1 provides a similar picture using quarterly data.

As a validation of the regional socio-economic data that we use and to obtain an impression of the housing market effects of the monetary policy shocks, Figure 6 shows average impulse responses for regional-specific variables.[9] Given the large number of observations, the estimation precision is high. The 1pp contractionary monetary policy shock slows down the regional economies, decreasing GDP per capita and increasing the unemployment rate as well as the insolvency rate. Household income falls. The monetary policy shock also ripples through the housing market. It dampens housing investment and fewer dwellings are completed. The stock of housing falls. As the economic outlook deteriorates and income decreases, household size increases while the population falls.

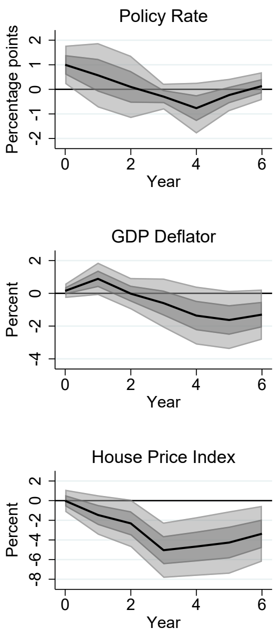
[6]For estimations with shorter samples, we use fewer lags and/or variables to prevent overparametrization. For example, some variables start only 2005, or unconventional monetary policy shocks in 2010.

[7]In the sensitivity analysis, we try out different clustering methods and observe that results are qualitatively and quantitatively similar

[8]We do not include lagged shocks when estimating the response of the interest rate, following Holm et al. (2021). Moreover, we account for autocorrelation by using the Newey-West estimator as we have pure time series data in these regressions.

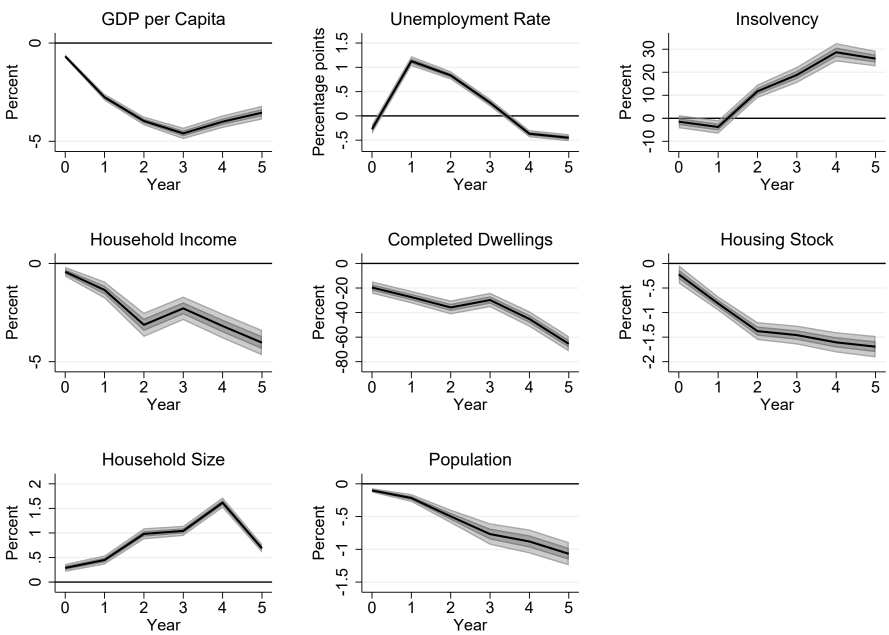
[9]The estimation samples depend on the variables included, the earliest starting in 1975 and the latest in 2007.

Figure 5: Macroeconomic responses to new measure of monetary policy shocks for Germany



Notes: The figure shows the responses of various aggregate variables to a monetary policy shock that causes a 1pp increase in the monetary policy rate. The darker shaded area presents the 68% confidence band, and the lighter shaded area the 95% confidence band.

Figure 6: Average responses to monetary policy shocks at the regional level



Notes: The figure shows the responses of regional variables to a monetary policy shock that causes a 1pp increase in the monetary policy rate. The darker shaded area presents the 68% confidence band, and the lighter shaded area the 95% confidence band.

3. Main results

In this section, we first measure the responses of different housing segment prices to a monetary policy shock. Then, we analyze how the responses vary across region types and explore possible reasons for the observed heterogeneity. Finally, we investigate the effects of unconventional monetary policy. All responses reflect a contractionary shock that provokes a 1pp increase in the policy rate and are reported with 68% and 95% confidence bands.

3.1. Heterogeneity across housing segments

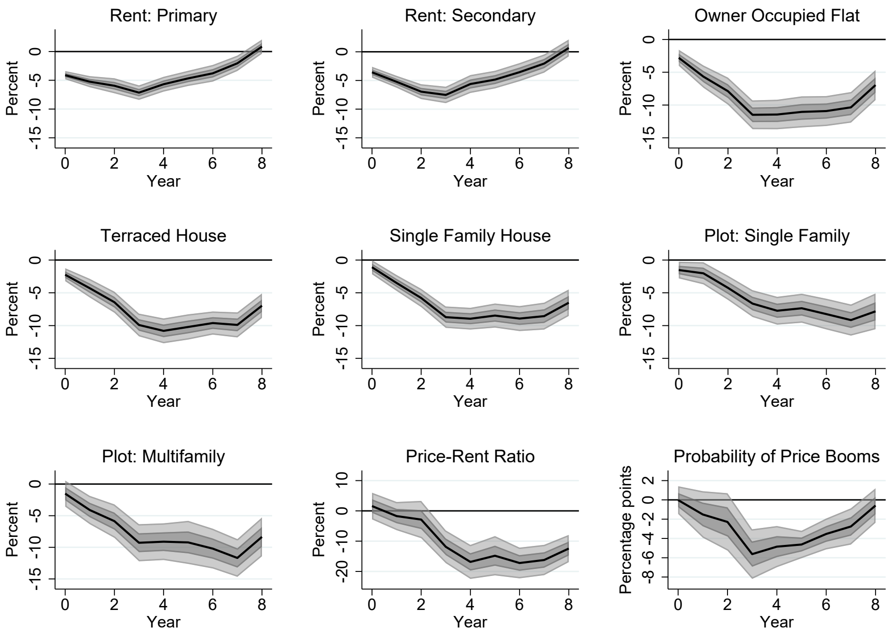
To analyze the heterogeneity in housing prices across segments, we estimate impulse responses for each segment at the country level. In addition, we estimate impulse responses for two variables that measure the propensity for housing price boom-bust cycles. Figure 7 presents the results. Prices in all segments fall. The drop is both statistically and economically significant. It is also long-lasting, underscoring the need for a long sample to capture the average cyclical properties of housing markets accurately. For many segments, the downturn lasts for more than 5, often up to ten years.

Despite this common pattern, the responses are heterogeneous across segments. The effects on land and property prices are stronger and more persistent than on rent prices. Rent prices peak within the first three years, whilst property and land prices need up to 7 years to bottom. Moreover, rent prices respond strongly upon impact, whereas the instant effect on property and land prices is small, especially for land prices. Overall, the effects on rent prices are weaker and more short-lived than the effect on prices of land or property. Within segments, rents and prices tend to respond similarly, with some nuances.

The negative responses of prices coincide with previous evidence. An interest rate increase leads to a flow of capital towards bonds and other interest yielding assets, i.e. away from housing, an increase in homeownership costs due to higher mortgage rates to be paid by potential homeowners, and a decrease in lending activity by banks. These cause demand for property, and consequently prices, to fall.

On the other hand, the effects of monetary policy on rents are less clear in the literature. Monetary theory predicts rents to fall as housing is considered a service, but, empirical literature on this is still lagging behind. Still, Koeniger et al. (2022) find evidence of this in Germany, observing that both rents and house prices increase after an interest rate cut. Other recent empirical works find that in other countries, rents and house prices move in

Figure 7: Responses of housing segments to contractionary monetary policy shock



Notes: The figure shows the responses of seven housing price variables and two variables measuring the propensity of housing prices to boom to a monetary policy shock that causes a 1pp increase in the monetary policy rate. The darker shaded area presents the 68% confidence band, and the lighter shaded area the 95% confidence band.

opposing directions after a monetary policy shock. Dias and Duarte (2019) attribute this to a substitution decision between owning and renting, whereby increased homeownership costs lead to a higher demand for renting. The results in Figure 7 show that the substitution effect between buying and renting in the housing market caused by monetary policy shocks is not strong in Germany: prices and rents both fall. These findings are in line with Koeniger et al. (2022) who observe that the pass-through of monetary policy shocks to rents is lower than in other countries and that changes in housing tenure are not significant. The authors partially attribute this to a relatively large share of public owned housing, which curbs the effect substitution from owning to renting has on prices.

The price decline is good news for renters but bad news for land and property owners. Renters now have lower housing costs, but property and land owners see the value of their assets decline significantly.

As renters are on average less wealthy than owners, the restrictive monetary policy shock may have positive distributive effects but lead to dissatisfaction of the owners.

As prices respond significantly more than rents, contractionary monetary policy shocks reduce the likelihood of housing boom-bust cycles significantly. One way to measure the fundamental value of houses is the sum of rent returns that the buyer can obtain from the housing object. Therefore, the price-rent ratio is a simple way to measure the relationship between property prices and their fundamental value.[10] The final panel shows that a contractionary monetary policy shock significantly decreases the likelihood of a housing price boom. For the first two years, the responses of both variables are not significant. But then they fall significantly below trend. The price-rent ratio decreases by more than 15% and the probability of housing price booms by 6pp. Hence, monetary policy seems effective at curbing boom-bust cycles in housing markets.

The distinguishing characteristics of the responses across segment types become clearer in Figure 8. The left panel shows the year of the lowest point of response of each segment price. The pattern is clear. Both renting prices bottom first, after 3 years. Thereafter, the three property prices bottom in years 3-4. Finally, land prices reach their trough after 7 years. The right panel depicts the trough size of each segment. The order is similar. Rent prices decline the least, by on average 7%. The average fall in property and land prices is similar, both being around 10%

Figure 8: Years and sizes of troughs of housing segments

Notes: The figure shows the trough responses and years of trough responses of seven housing price variables to a monetary policy shock that causes a 1pp increase in the monetary policy rate. The left panel presents the year of the troughs, and the right panel is the size of the troughs.

These patterns are in line with a standard cash-flow asset pricing model of real estate. The fundamental value of residential land prices is determined by the value of future properties on the land. The value of the properties, in turn, is determined by the future rents.

[10] We construct the price-rent ratio with owner-occupied flat prices and secondary market rents to measure prices for the same type of housing object.

Thus, as rents fall persistently, the decline in the future cash-flow accumulates over time and property prices fall. These effects are accentuated by higher interest rates used for discounting future cash-flows due to the contractionary monetary shock.

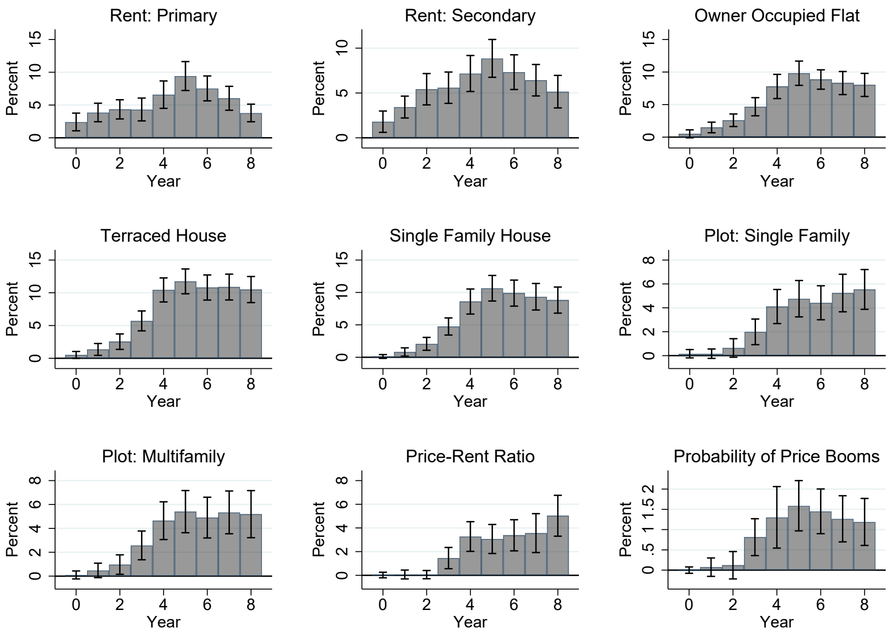
The stronger response of terraced house prices in comparison to single family house prices may be explained by preferences. For most households, buying a house is the most important investment of their lives. This decision does not only have a financial perspective but a psychological one, too. Buyers want their house to be special and unique to them, which per definition terraced housing is not. Therefore, the demand for single family houses tends to be less elastic than for terraced houses, which have a higher elasticity of substitution with flats.

The yet strong response of owner occupied flats can be explained by a similar substitution effect. The renting market is mostly composed of flats. Therefore, a shift of demand from owner occupied flats to renting a flat is more likely than from buying a single family house to renting a flat. In the first case, the objects are similar but the ownership is different (renting versus buying). In the second case, both the object and the ownership differ. As a result, there is a higher degree of substitutability between renting segments and owner occupied flats than with other housing segments.

The figures above document the impact a monetary policy shock has on housing prices. To determine its importance as a factor explaining the overall variance of prices, we compute the forecast error variance decomposition in the style of Gorodnichenko and Lee (2020). A detailed explanation of the application can be found in Appendix 5

Figure 9 depicts the variance of housing prices explained by monetary policy shocks over an 8 year horizon. Firstly, we see that monetary policy shocks significantly explain part of the variance of all housing prices. Secondly, we see that the maximum variance of housing prices explained by monetary policy shocks is around 10% for rent and property segments, whereas in land segments monetary policy shocks only explain around 6% of the price variance. In other words, even though monetary policy shocks cause a stronger fall in land prices than in rents, they explain less of the overall land price volatility than they do for rents. Furthermore, Figure 9 shows that monetary policy shocks explain barely 1.5% of the overall variance of probability of housing price booms, meaning that monetary policy shocks are not a key driver of housing price booms.

Figure 9: Forecast error variance decomposition by housing segments



Notes: The figure shows the forecast error variance decomposition for the seven housing segments and the two propensity of housing prices to boom variables. The bars denote the percentage of the total variance of the housing price explained by monetary policy shocks at different horizons. The range lines show the bootstrap estimated 95% confidence bands

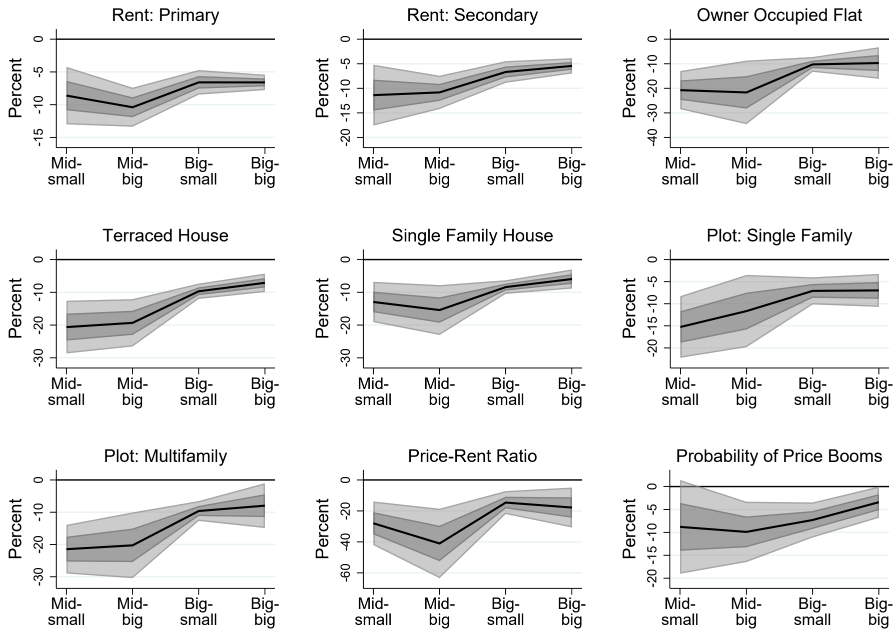
To sum up, rent prices respond the least and the quickest to monetary policy shocks, whereas land and property prices respond the strongest. Further, land prices respond the slowest, while property prices lie in-between. These patterns imply that monetary policy shocks also affect the boom-bust cycles in housing markets, measured either through a price-rent ratio or an exuberance indicator. Still, even though the effects of monetary policy shocks on prices and boom-bust cycles are considerable, they explain only a smaller percentage of overall fluctuation in price and exuberance. Furthermore, as the effect varies across segments, monetary policy shocks produce winners and losers among the households.

As the homeownership rate is twice a high in rural areas than in the largest cities, the lower responsiveness of rents compared to house and land prices implies that the households outside the large cities are more affected by monetary interventions than the citizens in metropolitan areas. We continue by looking at the geographical consequences of the shocks for regional housing markets in the next section.

3.2. Heterogeneity across housing regions

Housing markets are not only segmented but also regional and potentially heterogeneous at that level. Within segments, we differentiate further by using the classification of regions according to their largest city (Section 2.1). We estimate impulse response for each class of regions. We extract the point estimates and confidence bands of the trough responses and plot them ordered from rural to urban areas.

Figure 10: Trough responses of housing prices and rents by segment and region type

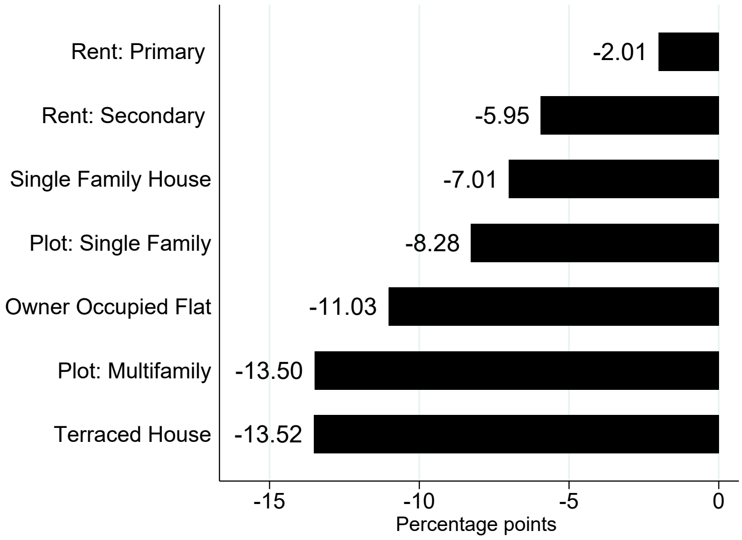


Notes: The figure shows the trough responses by region of seven housing prices and two propensity of housing prices to boom variables to a monetary policy shock that causes a 1pp increase in the monetary policy rate. For each segment and region, an impulse response is calculated. Then, the trough response point estimate and confidence bands of 68% and 95% are extracted and plotted from least to most urban region type.

Figure 10 presents the results. The troughs of rents and prices are all negative and statistically significant. However, all trough response curves are upward sloping across all segments. Prices and rents in regions with smaller cities respond stronger than in regions with larger cities. The increase is nearly monotonic for all segments and the positive slope is steep for many segments. The largest jump is between regions with a mid-big city (population of 50,000-100,000) and a big-small city (population of 100,000-500,000). The positive slope pattern also holds for the price-rent ratio and the probability of house price booms. The confidence intervals are wider for more rural regions, reflecting larger variation within this category.

To quantify the regional heterogeneity, Figure 11 shows the difference between the price trough of the most urban region category and of the least urban category, that is, the difference between regions with big-big cities and regions with medium-small cities. The order of the segments according to the differential is similar to the order of the country-level trough responses of rents and prices (Figure 8). Prices in segments that generally respond less also show smaller differentials across regions. For rents, the difference is 4pp on average across primary and secondary market rents. For single family plots and houses, the difference is 7.7pp. For owner-occupied flats, plots for multifamily houses, and terraced houses, the price differential is between 11pp and 13.5pp.

Figure 11: Difference between trough price response of metropolitan and rural areas

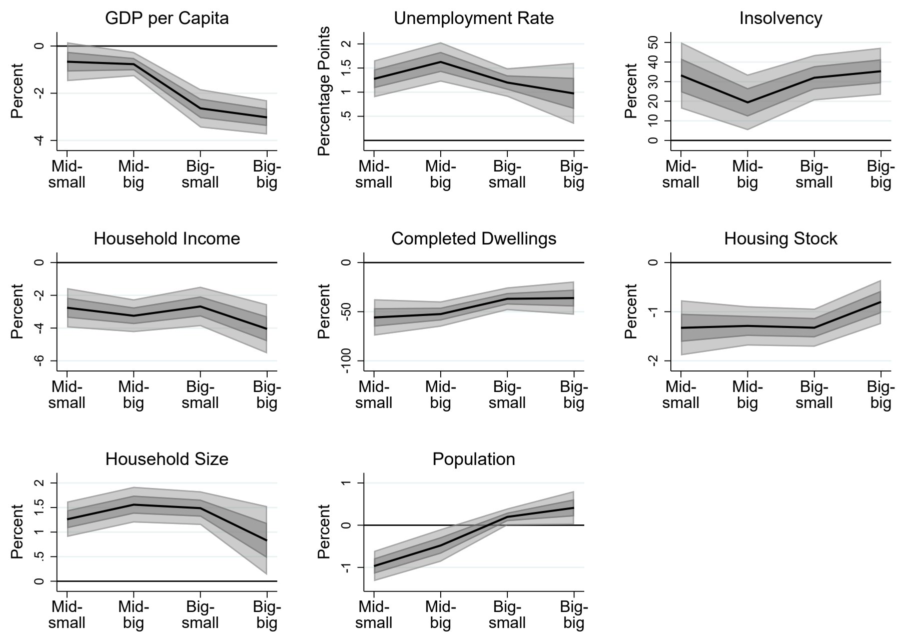


Notes: The figure shows the differential in the trough responses of seven housing prices to a monetary policy shock that causes a 1pp increase in the monetary policy rate between the most and least urban regions. A negative value signifies that prices in the least urban regions react more than prices in the most urban regions.

The differential responses are economically important given that housing costs account for about one-third of household expenditures in Germany and real estate assets for two-thirds of household wealth. Both renters and owners in rural areas are more affected by monetary policy shocks. The divide is accentuated by the fact that the differences are largest for house and land prices and that the ownership rate in rural areas is double that of urban areas.

To understand the sources of these price differentials, we investigate whether other variables show similar response patterns. We estimate the peak responses of regional economic and housing market variables and show them along the region category distribution in Figure 12. With the exception of population, none of the variables shows a pattern that would induce the upward slope of the peak price responses across the region type distribution document in Figure 10. Reversely, GDP per capita is more sensitive to monetary policy shocks in more urban districts than in rural areas. The peak responses of the unemployment rate, the insolvency rate, household income, and household size have mostly a flat slope with little differences across region types. The unemployment and insolvency rate increase by similar amounts and household income drops by roughly 5% across the region distribution. In the second row, the housing supply (completed dwellings and housing stock) is more sensitive to monetary policy shocks in more rural regions, which should potentially offset the stronger price decline there. Of course, the larger fall in housing supply could also reflect lower prices as the estimates measure general equilibrium outcomes.

Figure 12: Peak responses of socio-economic and housing variables by region type



Notes: The figure shows the peak responses by region of various socio-economic and housing market related variables to a monetary policy shock that causes a 1pp increase in the monetary policy rate. For each variable and region, an impulse response is calculated. Then, the trough response point estimate and confidence bands of 68% and 95% are extracted and plotted from least to most urban region type.

The only variable offering an explanation for the stronger price responses in rural areas is population. It falls in regions with smaller cities, whilst it increases in regions with bigger cities. This hints towards migration from rural to metropolitan areas and corresponding inter-regional shifts in demand for residential housing that offset some of the price fall in the metropolitan areas and accentuate the one in non-metropolitan areas. If the migration is into jobs and not into unemployment that would explain why the unemployment rate does not increase more in the metropolitan areas than in rural. The migration would also explain why GDP per capita may fall more in metropolitan districts if the newcomers accept jobs that are less productive than the average jobs in the urban areas to avoid being unemployed in their rural district of origin.

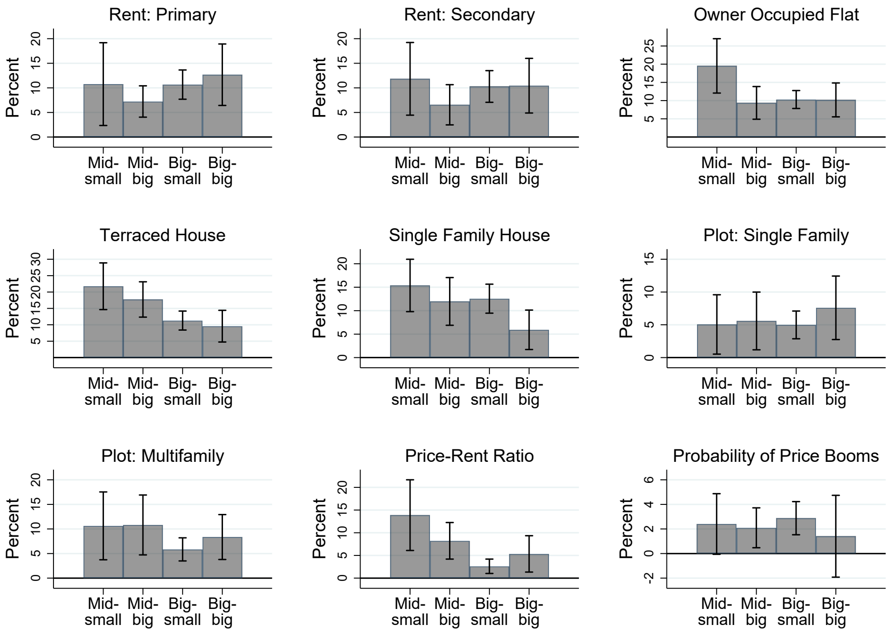
Other explanations can be derived from existing market frictions. On such friction is market liquidity. Amaral et al. (2021) investigate the unconditional returns on residential investments in superstar cities and in regions outside big agglomerations. They find that due to lower liquidity and higher risk, returns are significantly higher in regions outside big agglomerations. Compared to other assets, such as stocks or bonds, houses are indivisible and transactions are slow. The time to sell or rent out housing can be long and the associated frictions high. In particular, matching seller (landlord) and buyer (tenant) can be difficult. Even within housing segments, markets are strongly subdivided according to housing characteristics, such as number of bedrooms, bathrooms, floor area, and specific location. Therefore, the matching process depends on the thickness of the market and the bigger the market, the more likely it is to match, as there will be a higher demand for each subdivision of the segment.

In response to a contractionary monetary policy shock, demand will decrease in all regions. Thin markets will become even thinner, or in extreme cases dry out, and matching seller and buyer becomes more complicated. In contrast, thick markets will become thinner as well, but will still be thick. The liquidity effect would also explain why the rent differentials are smaller than the house and land price differentials across the regional distribution as flats are more homogeneous than houses and land.

A second friction that could explain the regional exposure gap of housing prices to monetary policy is banking sector concentration. Drechsler et al. (2017) present a new channel of transmission of monetary policy, the deposit channel. The authors find that in response to an increase in the monetary policy rate, banks widen the deposit spread and consequently, there is an outflow of deposits. Given that banks rely on deposits as a funding source for lending and investments, after a fall in deposits, banks reduce their lending. This includes mortgage lending, hence, decreasing households´ access to homebuying and dampening housing market demand. Drechsler et al. (2017) also find, that the deposit channel effects are intensified in regions with higher banking concentration, i.e. where individual banks have higher market power. In regions with higher banking concentration, banks increase the deposit spread more than in lower concentration regions, escalating the transmission of the shock through the deposit channel. Furthermore, they observe that higher banking concentration can be found in areas with lower populations. In other words, the effect of monetary policy shocks on the lending behavior of banks is exacerbated the more rural a region is. Consequently, through the deposit channel, a contractionary monetary policy shock will lead to lower access to mortgages, a steeper fall in homebuying demand, and hence, to a stronger decrease in housing prices in rural regions compared to urban regions.

Lastly, we assess if we find similar patterns in the share of housing price variance explained by monetary policy shocks. For this purpose Figure 13 depicts the maximum value of a forecast error variance decomposition for each region type. Interestingly, even though we find a clear regional pattern in the response of housing prices to monetary policy shocks, we do not observe such a pattern in the relevance of monetary policy in overall housing price fluctuations.

Figure 13: Forecast error variance decomposition by region type



Notes: The figure shows the peak value of the forecast error variance decomposition for seven housing segments and two propensity of housing prices to boom variables by region type. For each segment and region type, a forecast error variance decomposition is calculated. The bars denote the peak value of the percentage of the total variance of housing prices explained by monetary policy shocks from least to most urban regions. The range lines show the relevant estimated 95% confidence bands

3.3. Heterogeneity across monetary policies

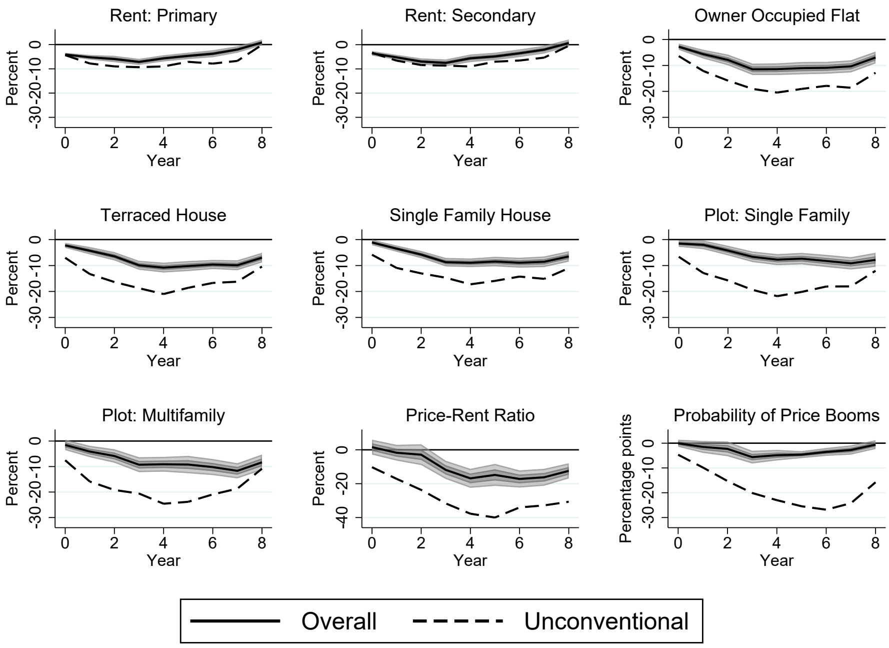
Given the prominence of unconventional monetary policy in the euro area since 2010 and the controversial discussion about its effects and side effects, we now estimate the impact of unconventional monetary policy shocks on housing prices. For this, we restrict the sample to the 2010-2021 period, which encompasses all types of unconventional policy conducted by the ECB. The sample starts in 2010, which is the year of the first announcement of the ECB to purchase sovereign debt in secondary markets, and ends in 2021, when the Pandemic Emergency Purchasing Program was still in force.[11] As we use surprises in the 2-year sovereign rate to construct the shocks, the estimates reflect the impact of both forward guidance and quantitative easing.

First, we estimate the effects on housing segment prices at the national level. Figure 14 shows the responses to unconventional monetary policy shocks as dashed lines. For ease of comparison, it also contains the baseline estimates for the full sample (containing both conventional and unconventional shocks) as solid lines and the corresponding confidence intervals. The responses to unconventional monetary policy shocks are stronger. This observation holds across all segments and all horizons. The point estimates typically lie outside the confidence bands of the baseline, suggesting that the differences are statistically significant. They are also economically significant. The difference is particularly large for house and land prices. At trough, the prices respond often twice as much, or more, to unvonventional shocks than on average. For example, the trough of single family houses is nearly −20%, compared to 9% in the baseline. These findings are in line with Rosenberg (2019) who finds that the effect of unconventional monetary policy on house prices in Scandinavia peaks higher and is more persistent than the impact of conventional policy shocks.

As the difference for prices is larger than for rents, the price-rent ratio is substantially more affected by unconventional shocks than on overage. It drops by 40% after five years. Similarly, the probability of a price boom decreases by nearly 30pp after six years. The two estimates suggest that unconventional monetary policy has strong effects on boom-bust cycles in housing markets.

[11] Because of the short sample, we reduce the number of variables in the control vector to avoid over-parametrization. We include one lag of both the policy shock and the dependent variable.

Figure 14: Effects of unconventional monetary policy shocks on housing segments

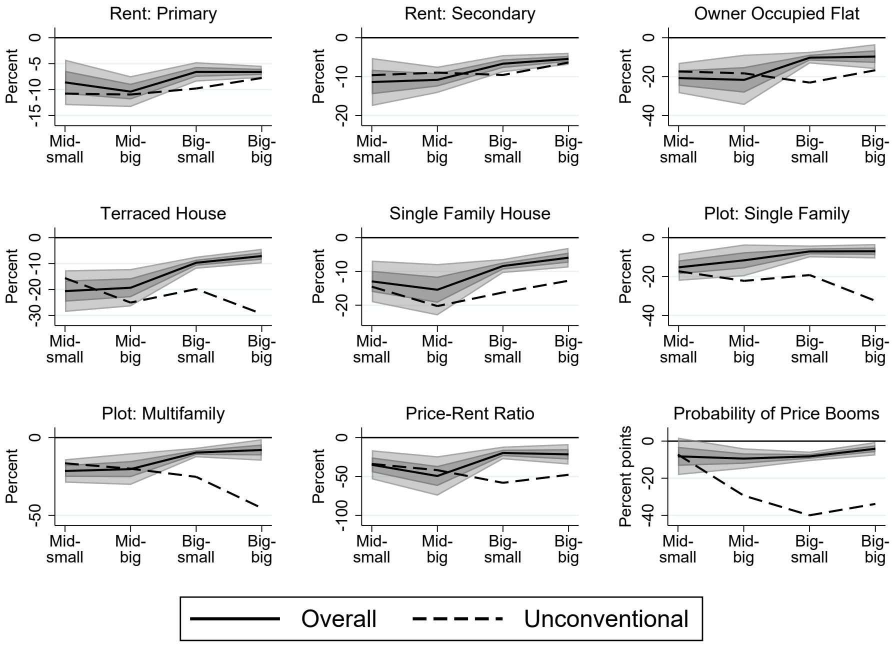


Notes: The figure shows the responses of seven housing price variables and two variables measuring the propensity of housing prices to boom to two types of monetary policy shocks that cause a 1pp increase in the monetary policy rate. The full black line shows the response to a general monetary policy shock. The dotted line shows the response to an unconventional monetary policy shock. The shaded areas present the 68% and 95% confidence bands of the response to a general monetary policy shock.

Second, we study how unconventional monetary policy shocks affect prices and rents across the region type distribution. Figure 15 shows the trough response curves of unconventional monetary policy shocks as dashed lines. For comparison, it also includes the baseline point estimates and confidence intervals. Across all segments, the peak response curves for unconventional policy are less upward sloping than for the full sample. For rents, they are only mildly positive across the region type distribution. For property prices, they are either flat or downward sloping. This change in slope is primarily driven by stronger price responses in urban regions than during the full sample. Terraced house prices in metropolitan areas now react twice as much as in rural areas. For land prices, the trough response curves are steeply falling along the regional distribution. Now, the sensitivity of plot prices for multifamily houses is more than twice as high in the most metropolitan regions than in least metropolitan regions. This is a clear reversal of the peak response curves of regional housing prices.

The qualitative differences carry over to the boom-bust indicators. The price-rent ratio and the likelihood of a boom in urban areas respond stronger than in rural areas, whereas

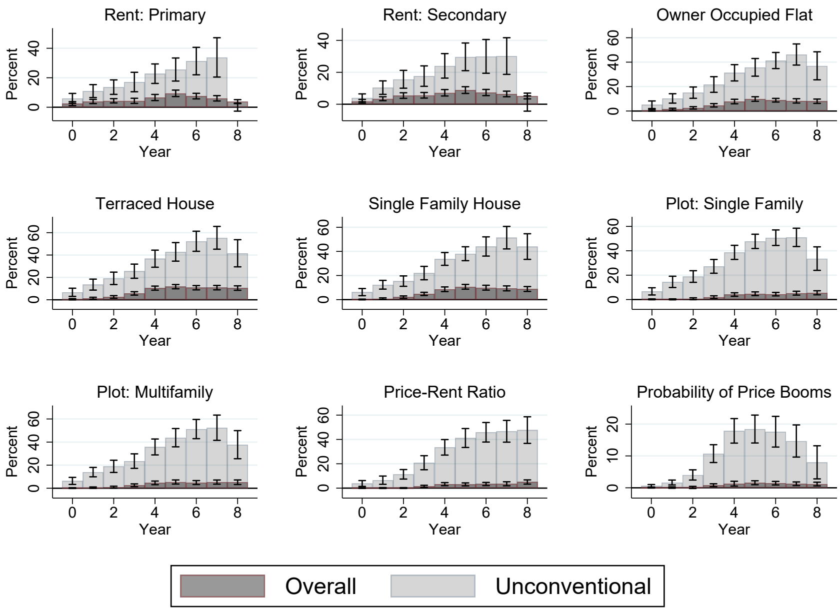
Figure 15: Trough response of housing prices to unconventional monetary policy shocks across region type distribution



Notes: The figure shows the trough responses by region of seven housing price and two propensity of housing prices to boom variables to two types of monetary policy shocks that cause a 1pp increase in the monetary policy rate. For each segment and region, an impulse response is calculated. Then, the trough response point estimate and confidence bans of 68% and 95% are extracted and plotted by segment from least to most urban region type. The full black line presents trough responses to a general monetary policy shock. The dotted line presents trough responses to an unconventional monetary policy shock. The shaded areas present the 68% and 95% confidence bands of the response to a general monetary policy shock.

for the full sample we observed the opposite. Overall, Figure 15 suggests that the stronger aggregate responses to unconventional monetary shocks in Figure 14 are driven by an increased sensitivity of housing prices in regions with bigger cities.

Figure 16: Forecast error variance decomposition by monetary policy type



Notes: The figure shows the forecast error variance decomposition for seven housing segments and two propensity of housing prices to boom variables when considering two types of monetary policy shocks. The bars denote the percentage of the total variance of the housing price explained by monetary policy shocks at different horizons. The darker gray bars reflect the total variance explained by general monetary policy shocks. The lighter gray bars reflect the total variance explained by unconventional monetary policy shocks. The range lines show the bootstrap estimated 95% confidence bands

Furthermore, we evaluate if, compared to general monetary policy shocks, unconventional monetary policy shocks are a larger factor explaining housing price volatilities. Figure 16 compares the percentage of housing price variance explained by general and unconventional monetary policy shocks. We see that, whilst the general monetary policy shocks at most explain 10-12% of housing price variance, unconventional monetary policy shocks explain up to half of the price variance. In addition, unconventional monetary policy shocks are essential drivers of housing booms and busts, explaining around half of the price-rent ratio changes and 20% of variation in the probability of booms. In conclusion, general monetary policy shocks affect housing prices but are not the main driver of price fluctuations. On the other hand, unconventional monetary policy shocks both, cause strong falls in housing prices and explain most of their variance.

It is beyond the scope of this paper to discern a reason for the different responses of housing prices to unconventional monetary policy shocks. Huber and Punzi (2020) argue that the transmission mechanism of conventional and unconventional monetary policy is the same. The results in Figure 15 suggest this might be true for smaller regions, but not for large agglomerations. One explanation for this qualitative difference is that unconventional monetary policy affects long term interest rates more than conventional monetary policy. This can lead institutional investors to search for yield in real estate markets. But there, they might prefer more liquid urban markets relative to less liquid rural markets where large in and outflows of financial capital would induce even stronger price movements.

In summary, the results suggest that the reactions of housing prices and boom-bust cylces to unconventional monetary policy are stronger than the reactions to general monetary policy. This difference is more pronounced in property and land prices than in rent prices. The stronger response to unconventional monetary policy seems to be driven by stronger responses in regions with larger cities. This increased response in regions with bigger cities is so large, that the differential across regions evens out or reverses, where now prices in bigger cities respond stronger than prices in rural areas. This pattern also transgresses into the price-rent ratio and the probability of house price booms.

4. Sensitivity analysis

We assess the sensitivity of the main results. Here, we summarize the tests and defer the detailed description and the results to Appendix 5. First, we assess the robustness to changing the specification. We use different numbers of lags (Figures A3 and A4) and we alter the control variables (Figures A5 and A6). Second, we change the construction of the monetary policy shock (Figures A7 and A8). Furthermore, we account for the reunification of Germany and the COVID-19 pandemic (Figures A9 and A10). Lastly, we focus on the robustness of standard errors by, amongst other, channging the clustering level (Figures A11 and A12) In all cases, the results remain qualitatively and often quantitatively similar to the baseline.

Alternatively, we use the BulwienGesa dataset on housing prices as an out-of-sample test. It covers the 49 biggest cities, and the prices refer to a somewhat different classification of segments, thus the results are not directly comparable. Still, we find that the effect of monetary policy shocks on housing prices increases along the region type distribution (Figures A13 and A14). We also use another variable in the dataset that characterizes regional markets. It classifies types of cities/regions by their importance internationally, nationally, and regionally. We estimate maximum response curves with this alternative structural variable and obtain similar results: the smaller/less important the region, the stronger the reaction of prices (Figure A15). In summary, the main findings are robust to using an alternative dataset.

5. Conclusions

In this paper, we analyze the heterogeneous responses of housing prices to monetary policy shocks. We use a unique dataset of transaction prices for the universe of residential housing market segments, covering more than 200 German regions, and nearly 50 years. We find that, across segments, monetary policy shocks cause stronger and more persistent responses of land and property prices than of rents. Furthermore, we document that, across regions, rents and prices are more sensitive to monetary policy shocks in rural areas than in metropolitan areas. Finally, we estimate that the effects of unconventional monetary policy shocks are yet stronger across the board, especially on metropolitan prices, and that they have been the main driver of housing price variance since 2010.

The paper contributes to a literature that emphasizes the distributional effects of monetary policy. While several articles focus on differences in the income and wealth of households (Coibion et al., 2017; Amberg et al., 2022; Holm et al., 2021), we study two differences in the housing of households: between renters and owners and between rural regions and urban regions. Thereby, we complement two recent articles that look at the spatial heterogeneity in housing markets. Aastveit and Anundsen (2022) estimate the nonlinear effects of monetary policy according to the housing supply elasticity of regions and find that regions with more elastic supply experience lower price responses. This finding suggests that prices in rural regions, with typically more space and higher supply elasticity, are less price responsive than in urban regions. In contrast, Amaral et al. (2021) document that unconditional returns on residential investment are higher outside superstar cities because of higher risk premia. Our results add particularly to this evidence and suggest one reason for the higher risk premia: prices are more volatile in response to monetary policy shocks.

References

Aastveit, K. A. and A. K. Anundsen (2022). Asymmetric effects of monetary policy in regional housing markets. *American Economic Journal: Macroeconomics 14*(4), 499–529.

Altavilla, C., L. Brugnolini, R. S. Gürkaynak, R. Motto, and G. Ragusa (2019). Measuring euro area monetary policy. *Journal of Monetary Economics 108*, 162–179.

Amaral, F., M. Dohmen, S. Kohl, and M. Schularick (2021). Superstar returns. CEPR Discussion Paper No. DP16806.

Amberg, N., T. Jansson, M. Klein, and A. R. Picco (2022). Five facts about the distributional income effects of monetary policy shocks. *American Economic Review: Insights 4*(3), 289–304.

Bartels, C., J. König, and C. Schröder (2021). Born in the land of milk and honey: The impact of economic growth on individual wealth accumulation. Kiel, Hamburg: ZBW-Leibniz Information Centre for Economics.

Beraja, M., A. Fuster, E. Hurst, and J. Vavra (2019). Regional heterogeneity and the refinancing channel of monetary policy. *Quarterly Journal of Economics 134*(1), 109–183.

Berger, D., V. Guerrieri, G. Lorenzoni, and J. Vavra (2018). House prices and consumer spending. *The Review of Economic Studies 85*(3), 1502–1542.

Bernanke, B. S. and I. Mihov (1997). What does the Bundesbank target? *European Economic Review 41*(6), 1025–1053.

Cloyne, J. S., P. Hürtgen, and A. M. Taylor (2022). Global monetary and financial spillovers: Evidence from a new measure of Bundesbank policy shocks. NBER Working Paper No. 30485.

Coibion, O., Y. Gorodnichenko, L. Kueng, and J. Silvia (2017). Innocent bystanders? Monetary policy and inequality. *Journal of Monetary Economics 88*, 70–89.

Corsetti, G., J. B. Duarte, and S. Mann (2022). One money, many markets. *Journal of the European Economic Association 20*(1), 513–548.

Del Negro, M. and C. Otrok (2007). 99 Luftballons: Monetary policy and the house price boom across US states. *Journal of Monetary Economics 54*(7), 1962–1985.

Dias, D. A. and J. B. Duarte (2019). Monetary policy, housing rents, and inflation dynamics. *Journal of Applied Econometrics 34*(5), 673–687.

Drechsler, I., A. Savov, and P. Schnabl (2017). The deposits channel of monetary policy. *The Quarterly Journal of Economics 132*(4), 1819–1876.

Fischer, M. M., F. Huber, M. Pfarrhofer, and P. Staufer-Steinnocher (2021). The dynamic impact of monetary policy on regional housing prices in the United States. *Real Estate Economics 49*(4), 1039–1068.

Gertler, M. and P. Karadi (2015). Monetary policy surprises, credit costs, and economic activity. *American Economic Journal: Macroeconomics 7*(1), 44–76.

Goodhart, C. and B. Hofmann (2008). House prices, money, credit, and the macroeconomy. *Oxford Review of Economic Policy 24*(1), 180–205.

Gorodnichenko, Y. and B. Lee (2020). Forecast error variance decompositions with local projections. *Journal of Business & Economic Statistics 38*(4), 921–933.

Hachula, M., M. Piffer, and M. Rieth (2020). Unconventional monetary policy, fiscal side effects, and euro area (im)balances. *Journal of the European Economic Association 18*(1), 202–231.

Holm, M. B., P. Paul, and A. Tischbirek (2021). The transmission of monetary policy under the microscope. *Journal of Political Economy 129*(10), 2861–2904.

Huber, F. and M. T. Punzi (2020). International housing markets, unconventional monetary policy, and the zero lower bound. *Macroeconomic Dynamics 24*(4), 774–806.

Jarociński, M. and P. Karadi (2020). Deconstructing monetary policy surprises — the role of information shocks. *American Economic Journal: Macroeconomics 12*(2), 1–43.

Kaen, F. R., H. C. Sherman, and H. Tehranian (1997). The effects of Bundesbank discount and lombard rate changes on German bank stocks. *Journal of Multinational Financial Management 7*(1), 1–25.

Koeniger, W., B. Lennartz, and M.-A. Ramelet (2022). On the transmission of monetary policy to the housing market. *European Economic Review 145*, 104107.

Phillips, P. C., S. Shi, and J. Yu (2015). Testing for multiple bubbles: Historical episodes of exuberance and collapse in the S&P 500. *International Economic Review 56*(4), 1043–1078.

Rahal, C. (2016). Housing markets and unconventional monetary policy. *Journal of Housing Economics 32*, 67–80.

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

Rosenberg, S. (2019). The effects of conventional and unconventional monetary policy on house prices in the Scandinavian countries. *Journal of Housing Economics 46*, 101659.

Rosenberg, S. (2020). Conventional and unconventional monetary policies: effects on the Finnish housing market. *Baltic Journal of Economics 20*(2), 170–186.

Appendix

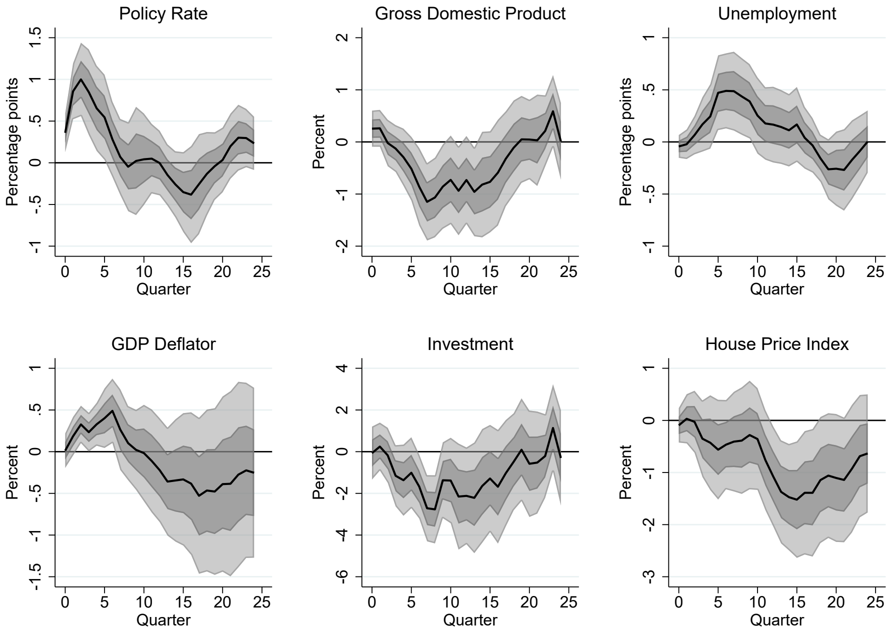
Data description

Table A1: Data description

Variable	Description	Source	Begin	End	Number of observations
3-month interbank	3-month interbank rate	Macrobond	1975	2021	
Two-year German bond	Two-year German bond rate	Macrobond	1975	2021	
Lombard	Lombard rate	Macrobond	1975	2021	
Main refinancing operations	Main refinancing operations rate	Macrobond	1975	2021	
German stock market index	Equity indices, MSCI, price return, index	Macrobond	1975	2021	
GDP	Gross domestic product, total, calendar adjusted	Macrobond	1975	2021	
Consumer Price Index	Consumer price index, total calendar adjusted	Macrobond	1975	2021	
Unemployment Rate	Unemployment rate, as a percent of civilian labor force, West Germany, seasonally adjusted	Macrobond	1975	2021	
Consumption	Private final consumption expenditure, seasonally adjusted	Macrobond	1975	2021	
Gross Fixed Capital Formation	Gross fixed capital formation, seasonally adjusted	Macrobond	1975	2021	
House Price Index	Real residential property prices for Germany	FRED	1975	2021	
Deflator	GDP deflator for Germany, seasonally adjusted	FRED	1975	2022	22848
Long Term Interest Rate	Long term interest rate	IMF, Macrohistory, OECD	1975	2022	22848
Plot: Single Family	Price for building plots for one- and two-family houses, euro	IVD	1975	2022	5293
Plot: Multifamily	Price for building plots for multifamily houses, euro	IVD	1975	2022	4744
Single Family House	Price for one family houses, euro	IVD	1975	2022	5331
Terraced House	Price for terraced houses, euro	IVD	1975	2022	5221
Owner Occupied Flat	Price for owner-occupied flats, secondary market, euro	IVD	1975	2022	5237
Rent: Secondary	Rent for dwellings, secondary market, euro/month	IVD	1975	2022	5012
Rent: Primary	Rent for dwellings, primary market, euro/month	IVD	1975	2022	4979
Price-Rent Ratio	Price-rent ratio, secondary market	own calculations	1975	2022	
Probability of Price Booms	Chronology of speculative price bubbles, obtained using the methodology of Goodhart and Hofmann (2008) for logarithm of RHPrice	own calculations	1975	2022	5437
City-type	Type of city according to its size	IVD	1975	2022	5407
Household size	Persons per household, regional	empirica regio	2005	2020	6400
Household income	Disposable income of private household, including private non-profit organization, euro per person, regional	Arbeitskreis VGR der Länder	1995	2020	10034
GDP per capita (Kreis)	Nominal GDP per capita, euro, regional	Bartels et al. (2021)	1975	2019	17651
GDP (Kreis)	Nominal GDP per capita, euro, regional	Bartels et al. (2021)	1975	2019	17651
Housing stock	Housing stock, dwellings in residential and non-residential buildings, regional	Destatis	1995	2020	11159
Completed dwellings	Completed dwellings in residential and non-residential buildings, regional	Destatis	1995	2020	11202
Insolvency	Insolvency (consumers and self employed), regional	empirica regio	2007	2020	5600
Vacancy rate	Market active housing vacancy rate, regional	empirica regio	2005	2020	6400
Unemployment rate (Kreis)	Unemployment rate, regional %	empirica regio	2005	2021	6800
Home ownership rate	Home ownership rate, regional %	empirica regio	2005	2021	6800
RETT	Real estate transfer tax rate, regional %	own collection	1975	2022	22848
New Dwelling (BG)	Price for new dwellings, euros/square meter	BulwienGesa	1975	2021	2303
Rent: New	Rent (BG) for new dwellings, euros/square meter	BulwienGesa	1975	2021	2303
Rent: Used (BG)	Rent for used dwellings, euros/square meter	BulwienGesa	1975	2021	2303
Terraced Housing (BG)	Price for terraced houses, euro	BulwienGesa	1975	2021	2303
Plot: Single Family (BG)	Price for building plot for single family houses, euro	BulwienGesa	1975	2021	
Market-type_RIWIS	The RIWIS locations were divided by bulwiengesa AG into 4 classes according to their functional importance for the international, national, regional or local real estate market: A, B, C and D.	BulwienGesa	1975	2022	4637

Quarterly responses of macroeconomic variables

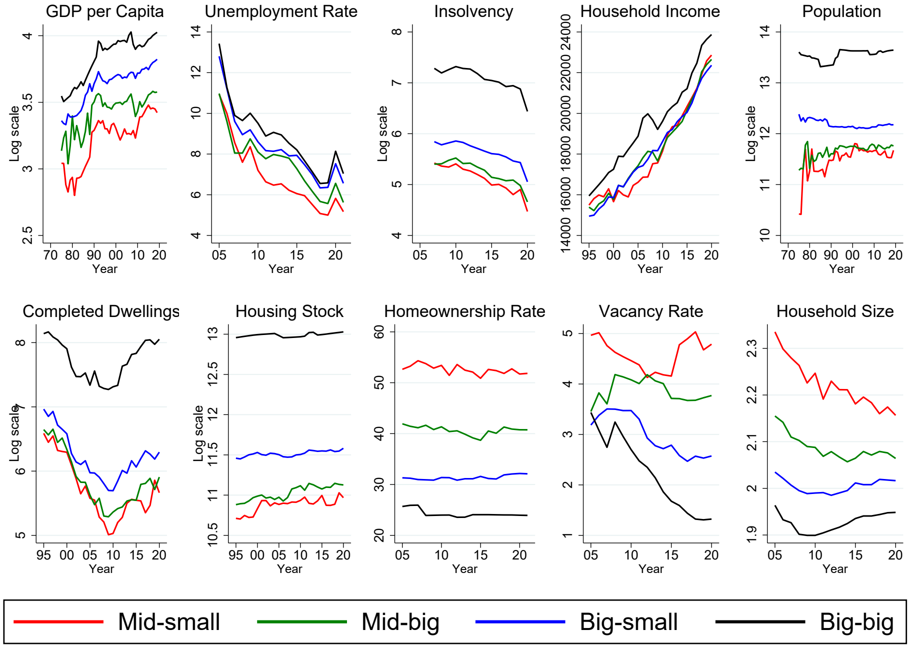
Figure A1: Impulse responses of various macroeconomic variables, quarterly frequency



Notes: The figure shows the responses of various aggregate variables to a monetary policy shock that causes a 1pp increase in the monetary policy rate using quarterly data. The darker shaded area presents the 68% confidence band, and the lighter shaded area the 95% confidence band.

Descriptive evidence

Figure A2: Socio-economic variables in Germany 1975-2022



Notes: The figure shows the average value by region type of various socio-economic variables in Germany from 1975 to 2021.

Forecast error variance decomposition

We compute the forecast error variance decomposition in the style of Gorodnichenko and Lee (2020). First, we obtain an estimated forecast error by regressing the $y_{i,t+h}$ on an information set in $t-1$ as in Equation 3:

$$y_{i,t+h} = \alpha_i^h + \sum_{j=1}^{J} \beta_j^h S_{t-j} + \sum_{k=1}^{K} \gamma_k^h Z_{i,t-l} + f_{i,t+h|t-1}, \tag{3}$$

where $y_{i,t+h}$ is the dependent variable, S_{t-j} are past monetary policy shocks, $Z_{i,t-j}$ is the information set in t-1 and $\hat{f}_{i,t+h|t-1}$ will be the estimated forecast error.

Then, as depicted in Equation 4, we regress the estimated forecast error in $t+h$ on all monetary policy shocks between, and including, t and $t+h$. The R-squared calculated in each regression measures the variation of the monetary policy shocks that explains the total variation of the forecast error.

$$\hat{f}_{i,t+h|t-1} = \alpha_{i,0} S_{t+h} + ... + \alpha_{i,h} S_t + \tilde{v}_{t+h}, \tag{4}$$

We then bootstrap the regression 200 times to estimate the standard error of the forecast error variance decomposition.

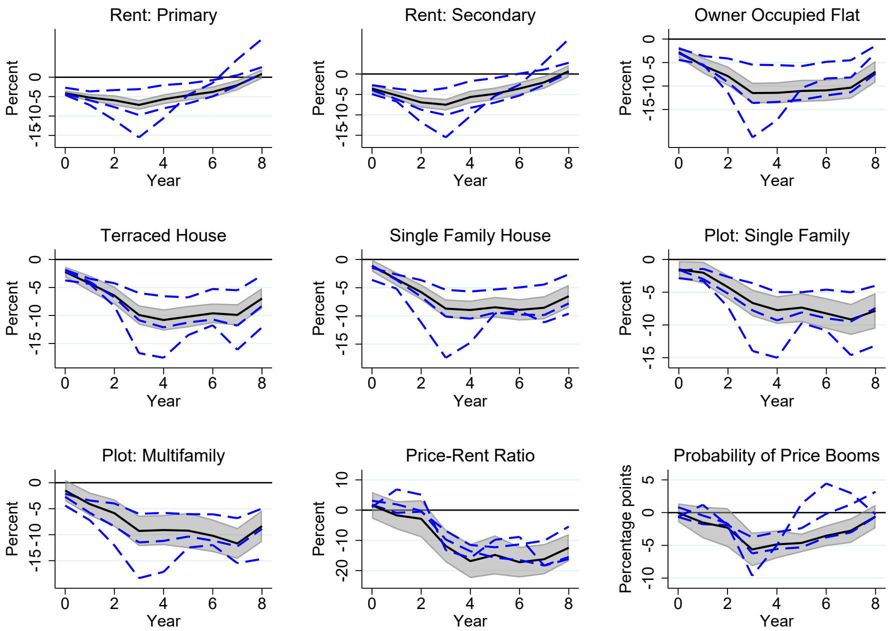
Note, that we define the information set in $t-1$ as close as possible to the control variables used in the local projections. In other words, we include lags of the monetary policy shock, the dependent variable, and macroeconomic variables (GDP, CPI and the unemployment rate). Furthermore, we set $J = K = 2$ when using the full sample, but $J = K = 1$ when only considering unconventional monetary policy due to the short time sample.

Sensitivity

We perform various sensitivity tests to see how changes in the model specification affect the main results. The following figures present the results obtained with the baseline specification (black line) and with sensitivity changes (blue dashed lines). The gray shaded area shows the 95% confidence interval of the baseline specification.

Figures A3 and A4 show the sensitivity of the results to changes in the number of lags. In the baseline specification, we include two lags of various control variables, in the sensitivity tests we include one, three, and four lags.

Figure A3: Impulse responses of housing prices with varying number of lags in specification

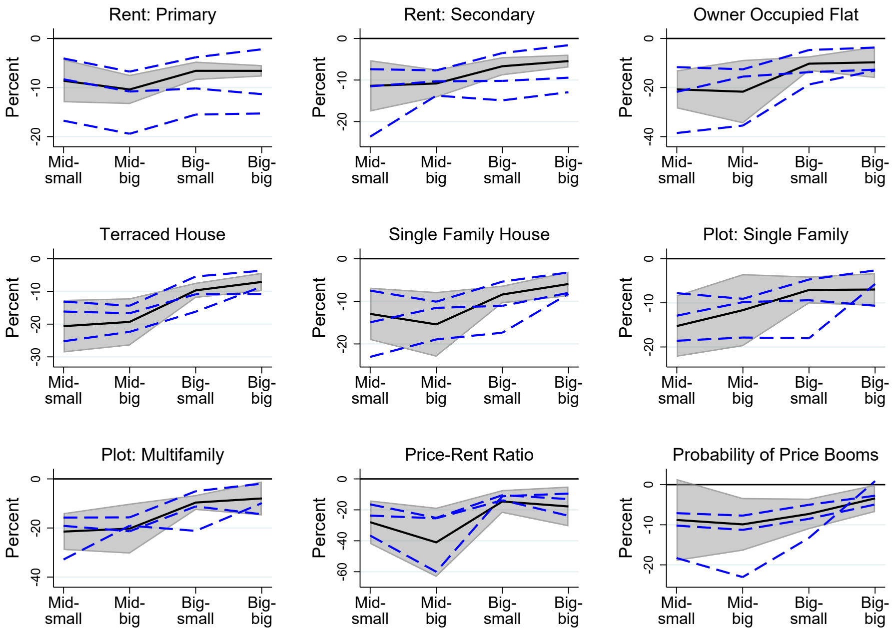


Notes: The figure shows the baseline specification responses of housing prices to a monetary policy shock as in Figure 7. The added dashed blue lines are the estimated responses when changing the number of lags of control variables included in the estimation from 2 to 1, 3, and 4.

Figures A5 and A6 show the sensitivity of the results to changes in the control variables. In the baseline specification, we include GDP, the consumer price index, and the unemployment rate as control variables. In the sensitivity tests, we estimate seven specifications with varying combinations of control variables. In these, we drop variables and/or include new ones. For each of the baseline specification control variables, there is at least one sensitivity specification where it is not included. The new variables incorporated in the sensitivity tests include a quadratic trend, gross fixed capital formation, long term interest rate, regional population, and the regional real estate transfer tax rate.

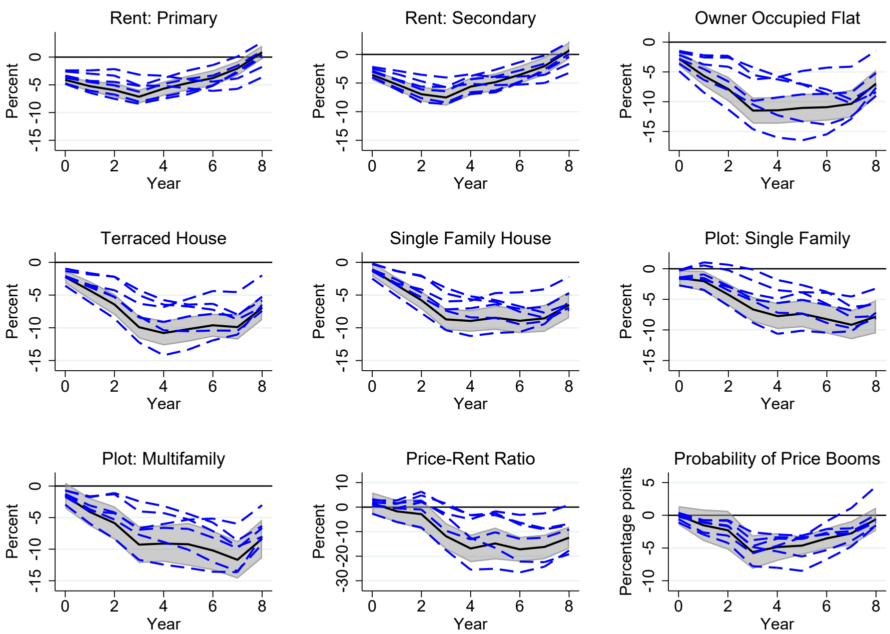
Figures A7 and A8 show the sensitivity of the results to changes in the construction of the monetary policy shock instrument. We test the following changes in the policy rates: 1-month interbank rate instead of 3-month interbank rate and one (or five) year German bond rate instead of two year bond rates; discount rate instead of Lombard rate and marginal lending facility rate instead of main refinancing operations rate. Moreover, we implemented the poor man's sign restriction either in all samples or in none. We also change the aggregation method, using semiannual and monthly weights as well as an alternative quarterly weighting scheme.

Figure A4: Trough responses of housing prices by region with varying number of lags in the specification



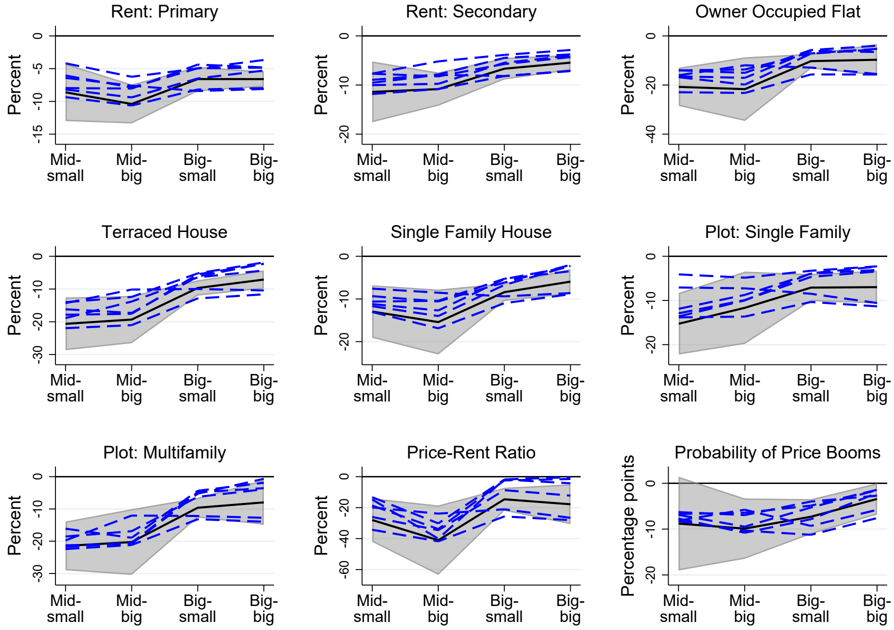
Notes: The figure shows the baseline specification trough responses of housing prices by region type as in Figure 10. The added dashed blue lines are the estimated trough responses by region when changing the number of lags of control variables included in the estimation from 2 to 1, 3, and 4.

Figure A5: Impulse responses of housing prices to monetary policy shock with varying combinations of control variables included in the specification



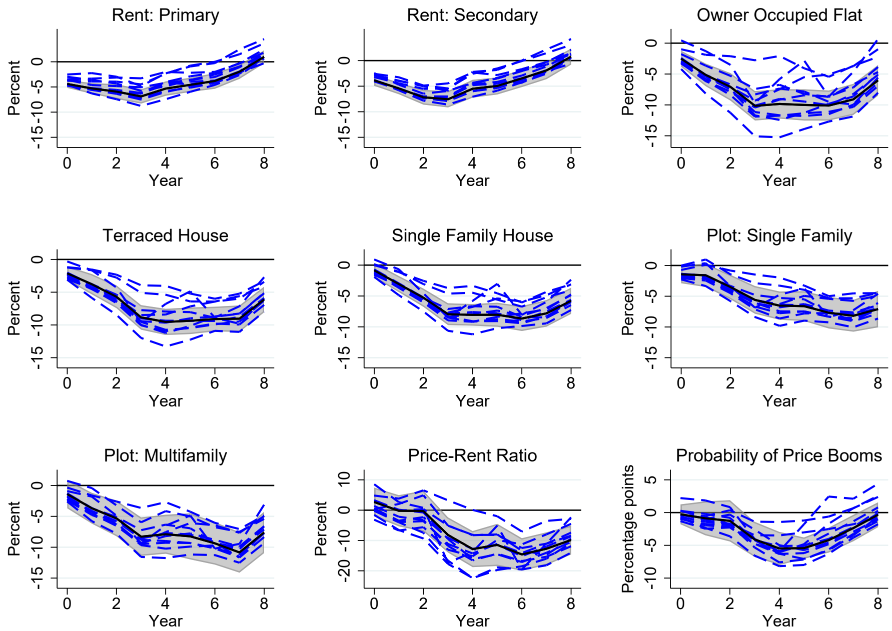
Notes: The figure shows the baseline specification responses of housing prices to a monetary policy shock as in Figure 7. The added dashed blue lines are the estimated responses using specifications with alternative combinations of control variables included in the estimation. These alternative combinations include complementing or substituting the variables used in the baseline specification with new variables.

Figure A6: Trough responses of housing prices to a monetary policy shock with varying combinations of control variables included in the specification



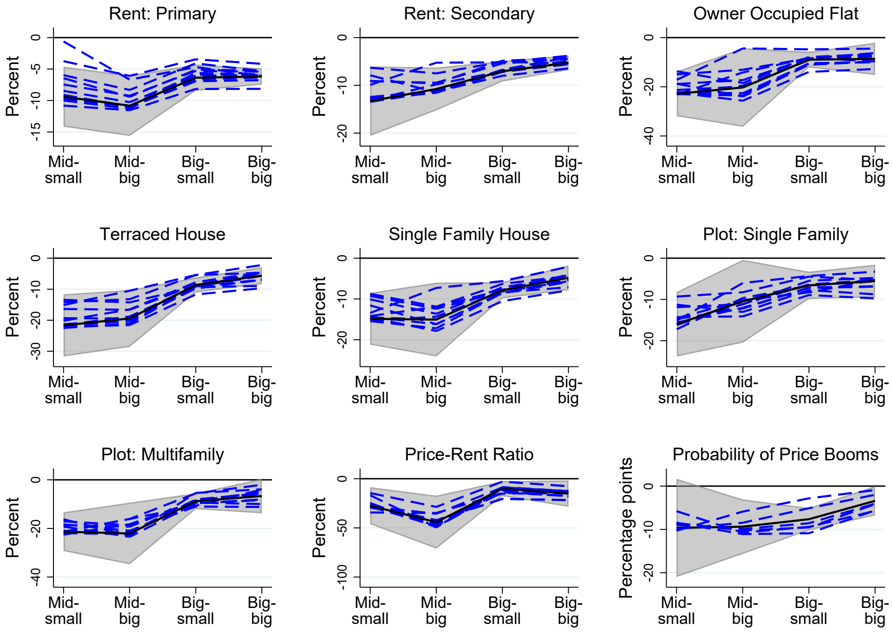
Notes: The figure shows the baseline specification trough responses of housing prices by region type as in Figure 10. The added dashed blue lines are the estimated responses using specifications with alternative combinations of control variables included in the estimation. These alternative combinations include complementing or substituting the variables used in the baseline specification with new variables.

Figure A7: Impulse responses of housing prices to alternative monetary policy shock instruments



Notes: The figure shows the baseline specification responses of housing prices to a monetary policy shock as in Figure 7. The added dashed blue lines are the estimated responses using alternative constructions of the monetary policy shock instrument.

Figure A8: Trough responses of housing prices to alternative monetary policy shock instruments



Notes: The figure shows the baseline specification trough responses by region of housing prices as in Figure 10. The added dashed blue lines are the estimated responses using alternative constructions of the monetary policy shock instrument.

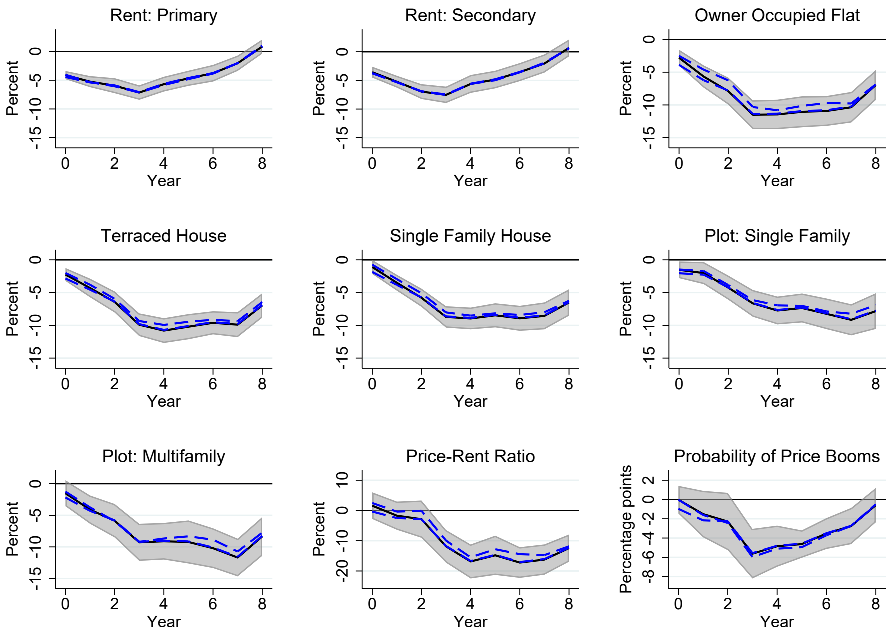
Figures A9 and A10 show the sensitivity of the results to the exclusion of observations related to the reunification of Germany in 1989 and to the COVID-19 pandemic in 2020. We exclude once all the observations of regions that were part of the former German Democratic Republic and once all observations from the period of the COVID-19 pandemic.

Figures A11 and A12 show the sensitivity of the significance of the main results to changes in the estimation of the standard errors. Specifically, we estimate the standard errors by clustering at Kreis level (shaded area) and Bundesland (state) level (blue dashed lines), without clustering (green dashed lines), with robust errors (brown dashed lines) and by bootstrapping them (red dashed lines). The short dashed lines are the 68% confidence intervals and the longer dashed lines the 95% confidence intervals.

Figures A13 and A14 show the effect of a monetary policy shock on a different set of housing prices. These housing prices are made available by BulwienGesa and contain housing price information for the biggest 49 cities in Germany. Therefore, no observations for the mid-small city type category are available.

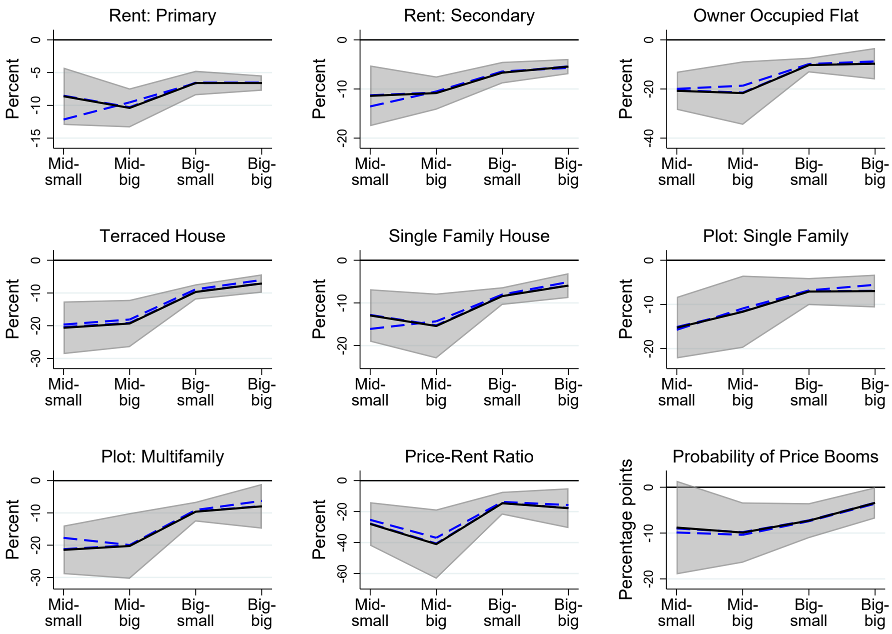
Figure A15 shows the maximum responses of housing prices to monetary policy shocks, where regions are categorized by the market type of their biggest city. Market type is a variable provided by BulwienGesa which classifies cities by their regional, national, and international importance, where A are cities that reach international importance, and D are cities that only have a limited regional importance. As the dataset covers only the 49 largest cities, the cross-sectional heterogeneity in region type is considerably smaller than in the IVD data.

Figure A9: Impulse responses of housing prices to a monetary policy shock, excluding certain observations



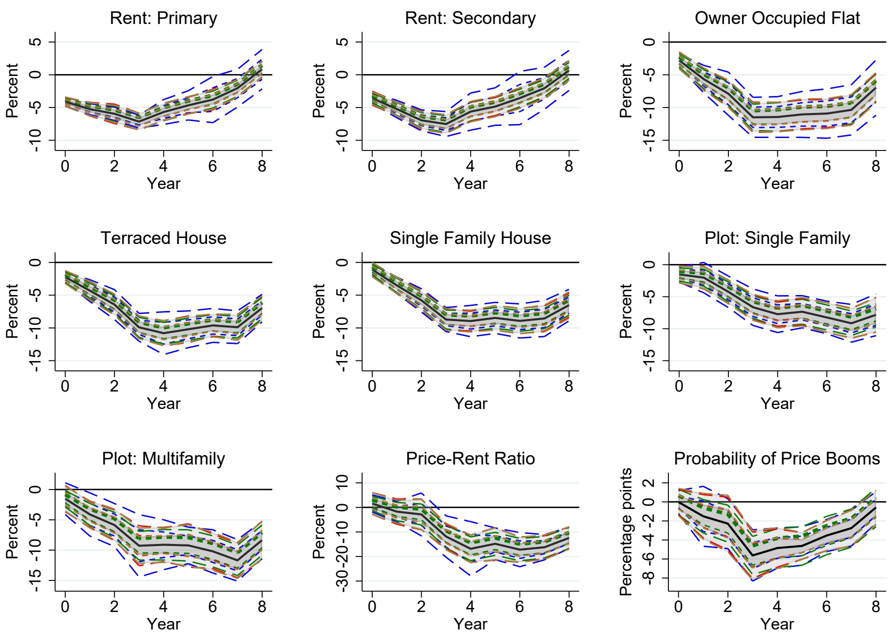
Notes: The figure shows the baseline specification responses of housing prices to a monetary policy shock as in Figure 7. The added dashed blue lines are the estimated responses using time samples excluding observations relating to the reunification of Germany or the COVID-19 pandemic.

Figure A10: Maximum responses of housing prices to a monetary policy shock, excluding certain observations



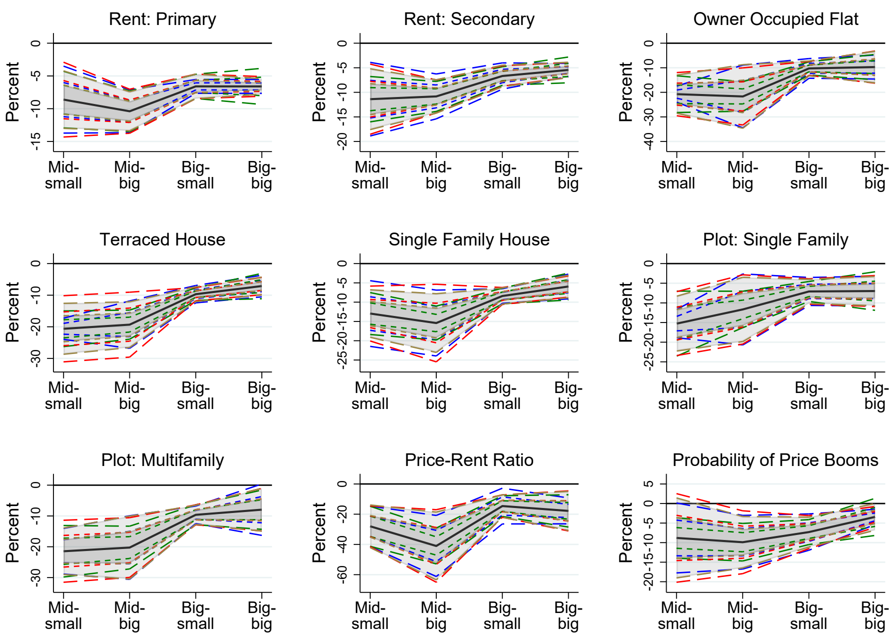
Notes: The figure shows the baseline specification trough responses of housing prices by region type as in Figure 10. The added dashed blue lines are the estimated responses using time samples excluding observations relating to the reunification of Germany or the COVID-19 pandemic.

Figure A11: Impulse responses of housing prices to a monetary policy shock, with alternative estimations of standard errors



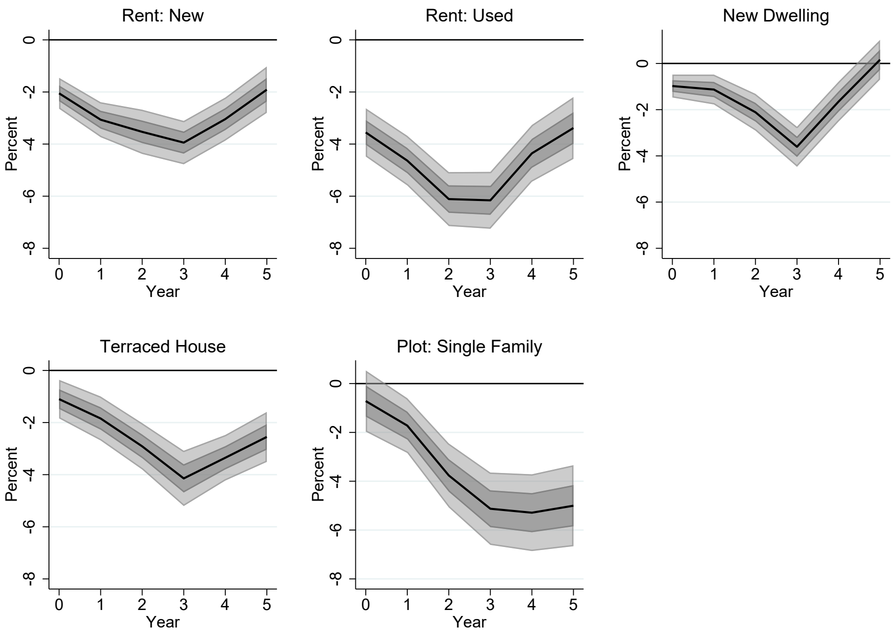
Notes: The figure shows the baseline specification responses of housing prices to a monetary policy shock as in Figure 7. The added dashed colored lines are the confidence bands using alternative estimations of standard errors. These include bootstrapping and alternative clustering levels. Short dashed lines show the 68% confidence bands, longer dashed lines the 95% confidence bands.

Figure A12: Trough responses of housing prices to a monetary policy shock, with alternative estimations of standard errors



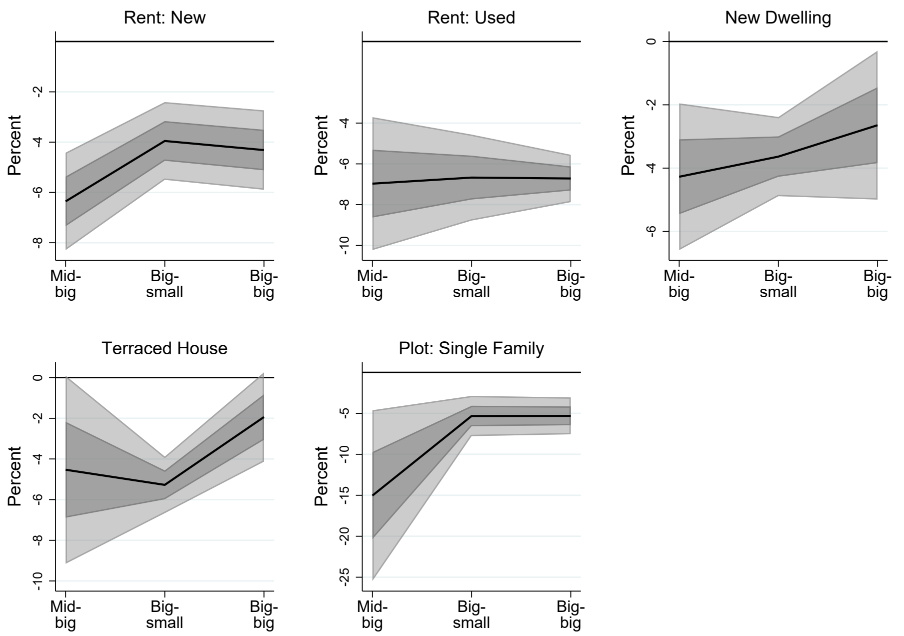
Notes: The figure shows the baseline specification trough responses of housing prices by region type as in Figure 10. The added dashed colored lines are the confidence bands using alternative estimations of standard errors. These include bootstrapping and alternative clustering levels. Short dashed lines show the 68% confidence bands, longer dashed lines the 95% confidence bands.

Figure A13: Impulse responses of housing prices to a monetary policy shock using alternative housing price data



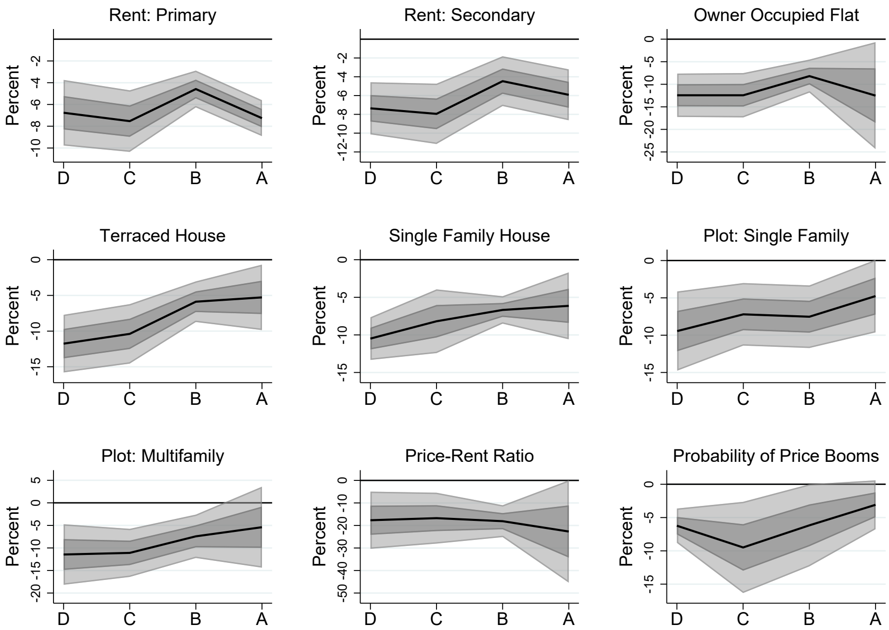
Notes: The figure shows the responses of housing price variables from an alternative data source (BulwienGesa AG) to a monetary policy shock that causes a 1pp increase in the monetary policy rate. The darker shaded area presents the 68% confidence band, and the lighter shaded area the 95% confidence band.

Figure A14: Trough responses of housing prices to a monetary policy shock using alternative housing price data



Notes: The figure shows the trough responses by region type of housing price variables from an alternative data source (BulwienGesa AG) to a monetary policy shock that causes a 1pp increase in the monetary policy rate. For each segment and region, an impulse response is calculated. Then, the trough response point estimate and confidence bans of 68% and 95% are extracted and plotted by segment from least to most urban region type.

Figure A15: Trough responses of housing prices to a monetary policy shock by region importance



Notes: The figure shows the trough responses by region of housing prices as in Figure 10, but using an alternative variable to classify regions. Specifically, the alternative variable classifies regions by their international, national, or regional importance. For each segment and region, an impulse response is calculated. Then, the trough response point estimate and confidence bans of 68% and 95% are extracted and plotted by segment from least to most important region type.