CHAPTER 2

FEELING THE PINCH? TRACING THE EFFECTS OF MONETARY POLICY THROUGH HOUSING MARKETS

Online Annexes

Online Annexes 2.1–2.7 provide details regarding the data sources, variable transformations, analytical approaches (empirical and model-based), and additional analyses of the findings presented in the Chapter. Selected additional and complementary findings are also included.

Online Annex 2.1. Data Sources, Sample Coverage, and Variable Definitions

This section presents a detailed description of the data comprising the two main datasets used in the Chapter, along with information on their sources and variable transformations.

2.1.1. Country-level panel dataset

The variables that make up the aggregate panel dataset and their data sources are listed in Online Annex Table 2.1.1. The empirical analysis is performed at the quarterly frequency. Data transformations are explained below. Online Annex Table 2.1.2 lists the full sample of countries, split in subgroups of advanced economies (AE) and emerging market economies (EM).

- Monetary Policy Shocks (MPS): The construction of *Monetary Policy Shocks* and *Orthogonalized Monetary Policy Shocks* is documented in section 2.3 of this Annex. The data series are constructed at the monthly frequency, and then transformed to quarterly by summing the shocks within each quarter.
- Housing and credit variables: Four different sources are combined to get the best data coverage for *Total homeownership rate* and *Average mortgage lending rate* as documented in Online Annex Table 2.2.1. *Share of fixed rate mortgages* combines information from various sources and is defined as the share of outstanding mortgages with rates that are fixed for at least 12 months (i.e., there is no rate-reset in the following 12 months) as a proportion of total outstanding mortgages. Details on the data sources and variable construction are provided in Annex Table 2.2.2.
- Policy interest rate: Policy rates are retrieved from Bloomberg for each monetary policy announcement, at the monthly frequency.[1] Monthly series are averaged to create quarterly data.
- Temporal transformations: Annual data is converted into quarterly by assigning the annual value to each quarter in a given calendar year; monthly data is converted into quarterly by assigning the value from the third month of each quarter.

[1] Policy rates are averaged in months with more than one announcement (less than 2 percent of the sample).

Online Annex Table 2.1.1. Country-level Panel Dataset Variables and Sources

Variable	Sources
Monetary Policy Shocks	
Monetary Policy Shocks	Bloomberg
Orthogonalized Monetary Policy Shocks	Bloomberg
Housing Variables	
Residential House Price	Bank of International Settlements (BIS)
Commercial House Price	Morgan Stanley Capital International (MSCI)
House Sales	Haver Analytics
House Starts	Haver Analytics
House Rents	Organisation for Economic Co-operation and Development (OECD)
Price-to-Rent Ratio	Organisation for Economic Co-operation and Development (OECD)
Price-to-Income Ratio	Organisation for Economic Co-operation and Development (OECD)
Asset Value Growth Index: Office	Morgan Stanley Capital International (MSCI)
Asset Value Growth Index: Retail	Morgan Stanley Capital International (MSCI)
Credit Variables	
Household Credit to GDP	Bank of International Settlements (BIS)
Total Household Credit (NCU)	Bank of International Settlements (BIS)
Share of Fixed Rate Mortgages in Stock	European Central Bank (ECB), national Central Banks
Regulatory Loan-to-Value Limits (Average)	Integrated Macroprudential Policy (iMaPP) Database
Effective Rates on Outstanding Mortgage Loans	European Central Bank (ECB); Federal Reserve Board
Other General Economic Indicators	
GDP (Constant and Current Prices)	World Economic Outlook database
Headline CPI	World Economic Outlook database
GDP per Capita (Constant Prices)	World Economic Outlook database
Private Consumption (Constant Prices)	World Economic Outlook database
Gross Fixed Capital Formation (Constant Prices)	World Economic Outlook database
Policy Interest Rate	Bloomberg

Online Annex Table 2.1.2. Country Groups Composition for Advanced and Emerging Markets

Advanced Economies	Emerging Markets
Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, United Kingdom, United States	Chile, Colombia, Hungary, Indonesia, Malaysia, Mexico, Poland, Russia, South Africa, Thailand

2.1.2. Regional-level panel dataset

The regional dataset consists of a panel of regions in 9 different countries: Belgium (11 regions), Denmark (5), Finland (4), France (26), Hungary (8), Mexico (32), Netherlands (12), Spain (19), United Kingdom (35) and United States (51). The regions are defined at the *NUTS2* level. The full list of the regions is shown in Online Annex Table 2.1.3. The main variables of the dataset and their sources are listed in Online Annex Table 2.1.4. The main series transformations are described below.

- Monetary policy shocks: The national MPS are imputed to all regions in each country. See section 2.3 for sources and transformations of these variables.
- House Price Index: Available regional House Price Index data are used for Mexico, United Kingdom, and United States. For United Kingdom, as the regional data is at a lower level of regional disaggregation than NUTS2, the index is computed as the sales-weighted mean price by NUTS2 region-day, and then aggregated as the sales-weighted mean price by NUTS2 region-quarter. For Finland, Netherlands, and Belgium, median house price for "all dwellings" or "all houses" is used. House price series for these three countries is smoothed using a 4-quarter moving average by region. House price data for Spain is only transformed by smoothing the house price series using a 4-quarter moving average by region. House price data for Hungary are computed as the mean price of all dwelling types within each region-quarter. Countries where available data is at the transaction level require additional transformations. For France, house price series is computed as the median sales price by region-quarter, and then the series are smoothed using a 4-quarter moving average. For Denmark, properties classified as a "Holiday home" are dropped, and the mean house price by region-quarter across all dwelling types is calculated. The series are smoothed using a 4-quarter moving average by region. For countries where House Price Index is already available, no further changes to the series are made (Mexico, United Kingdom, and United States). All house price series are normalized by setting the value in 2018 to 100.
- CPI: For United States, the state-level price level is obtained using nominal and real GDP from the Bureau of Economic Analysis (BEA) and is computed as a GDP deflator: CPI = 100 * (nominal GDP / real GDP). This is then rebased to the value in 2018 being set to 100.
- GDP: GDP series in national currencies are converted into USD using PPP-adjusted exchange rates for each country (GDP data for the US and Mexico is already in PPP-adjusted USD). The data for the UK is in Pounds, and the data for all other countries is in PPP-adjusted Euros. Exchange rates from local currency to PPP-adjusted for all countries are retrieved from WEO database, except for Denmark and Hungary where it is equal to the market exchange rate from euros to USD (because the series for these countries are already given in PPP-adjusted euros).

- Housing supply constraints: For the United States, housing supply constraints are measured using the Wharton Residential Land Use Regulation Index (WRLURI) compiled by Gyourko and others, 2021.
- Regional data transformations: all variables are given at the *NUTS2* level for all countries but United Kingdom and France, where the level of aggregation is *Local Authority District* and *NUTS3* region, respectively. The series are then aggregated to the *NUTS2*. For United States, the WRLURI is aggregated from the county to the state level as the population-weighted average of the county-level index.
- Temporal transformations: annual data series have been assigned to the fourth quarter of their respective year, then interpolated to obtain quarterly values.

Online Annex Table 2.1.3. List of Countries for the Regional-Level Panel Dataset

Country	Sources
Belgium	Anvers; Brabant Flamand; Brabant Wallon; Bruxelles-Capitale; Flandre Occidentale; Flandre Orientale; Hainaut; Liege; Limbourg; Luxembourg; Namur
Denmark	Hovedstaden; Midtjylland; Nordjylland; Sjælland; Syddanmark
Finland	Eastern Finland; Greater Helsinki; Southern Finland; Western Finland
France	Alsace; Aquitaine; Auvergne; Bourgogne; Brittany; Centre-Val de Loire; Champagne-Ardenne; Corsica; Franche-Comté; French Guiana; Guadeloupe (including Collectivity of Saint Martin); La Réunion; Languedoc-Roussillon; Limousin; Lorraine; Lower Normandy; Martinique; Midi-Pyrénées; Nord-Pas-de-Calais; Pays de la Loire; Picardy; Poitou-Charentes; Provence-Alpes-Côte d'Azur; Rhône-Alpes; Upper Normandy; Île de France
Hungary	Budapest; Central Transdanubia; Northern Great Plain; Northern Hungary; Pest; Southern Great Plain; Southern Transdanubia; Western Transdanubia
Mexico	Aguascalientes; Baja California; Baja California Sur; Campeche; Chiapas; Chihuahua; Ciudad de México; Coahuila; Colima; Durango; Guanajuato; Guerrero; Hidalgo; Jalisco; Michoacán; Morelos; México; Nayarit; Nuevo León; Oaxaca; Puebla; Querétaro; Quintana Roo; San Luis Potosí; Sinaloa; Sonora; Tabasco; Tamaulipas; Tlaxcala; Veracruz; Yucatán; Zacatecas
Netherlands	Drenthe; Flevoland; Friesland; Gelderland; Groningen; Limburg; North Brabant; North Holland; Overijssel; South Holland; Utrecht; Zeeland
Spain	Andalucía; Aragón; Canarias; Cantabria; Castilla y León; Castilla-la Mancha; Cataluña; Ciudad de Ceuta; Ciudad de Melilla; Comunidad Forel de Navarra; Comunidad de Madrid; Comunitat Valenciana; Extremadura; Galicia; Illes Balears; La Rioja; País Vasco; Principado de Asturias; Región de Murcia
United Kingdom	Bedfordshire and Hertfordshire; Berkshire, Buckinghamshire and Oxfordshire; Cheshire; Cornwall and Isles of Scilly; Cumbria; Derbyshire and Nottinghamshire; Devon; Dorset and Somerset; East Anglia; East Wales; East Yorkshire and Northern Lincolnshire; Essex; Gloucestershire, Wiltshire and Bath/Bristol area; Greater Manchester; Hampshire and Isle of Wight; Herefordshire, Worcestershire and Warwickshire; Inner London - East; Inner London - West; Kent; Lancashire; Leicestershire, Rutland and Northamptonshire; Lincolnshire; Merseyside; North Yorkshire; Northumberland and Tyne and Wear; Outer London - East and North East; Outer London - South; Outer London - West and North West; Shropshire and Staffordshire; South Yorkshire; Surrey, East and West Sussex; Tees Valley and Durham; West Midlands; West Wales and The Valleys; West Yorkshire
United States	Alabama; Alaska; Arizona; Arkansas; California; Colorado; Connecticut; Delaware; District of Columbia; Florida; Georgia; Hawaii; Idaho; Illinois; Indiana; Iowa; Kansas; Kentucky; Louisiana; Maine; Maryland; Massachusetts; Michigan; Minnesota; Mississippi; Missouri; Montana; Nebraska; Nevada; New Hampshire; New Jersey; New Mexico; New York; North Carolina; North Dakota; Ohio; Oklahoma; Oregon; Pennsylvania; Rhode Island; South Carolina; South Dakota; Tennessee; Texas; Utah; Vermont; Virginia; Washington; West Virginia; Wisconsin; Wyoming

Online Table 2.1.4. Regional-Level Panel Dataset Variables

Variable	Sources
Monetary Policy Shocks	
Monetary Policy Shocks	Bloomberg
Orthogonalized Monetary Policy Shocks	Bloomberg
Economic and Housing variables	
House Price Index	Belgium (STATBEL), Denmark (Statistics Denmark), France (INSEE), Finland (StatFin), Hungary (Hungarian Central Statistical Office), Mexico (Sociedad Hipotecaria Federal), Netherlands (CBS Open Data), Spain (CEIC), United Kingdom (Local Authority District), United States (Federal Housing Finance Agency, FHFA)
Consumer Price Index (CPI)	World Economic Outlook database, Bureau of Economic Analysis (United States)
GDP	Belgium (Eurostat), Denmark (Eurostat), France (Eurostat), Finland (Eurostat), Hungary (Eurostat), Mexico (OECD), Netherlands (Eurostat), Spain (Eurostat), United Kingdom (Office of National Statistics (ONS)), United States (Bureau of Economic Analysis (BEA))
GDP per capita	Belgium (Eurostat), Denmark (Eurostat), France (Eurostat), Finland (Eurostat), Hungary (Eurostat), Mexico (OECD), Netherlands (Eurostat), Spain (Eurostat), United Kingdom (Office of National Statistics (ONS)), United States (OECD)
Population	Belgium (Eurostat), Denmark (Eurostat), France (Eurostat), Finland (Eurostat), Hungary (Eurostat), Mexico (OECD), Netherlands (Eurostat), Spain (Eurostat), United Kingdom (Office of National Statistics (ONS)), United States (US Census Bureau)
Population density	Belgium (Eurostat), Denmark (Eurostat), France (Eurostat), Finland (Eurostat), Hungary (Eurostat), Mexico (OECD), Netherlands (Eurostat), Spain (Eurostat), United Kingdom (OECD), United States (OECD)
Exchange rate	World Economic Outlook database
Office capital value	Morgan Stanley Capital International (MSCI)
Retail capital value	Morgan Stanley Capital International (MSCI)
Land use regulation index	Wharton Residential Land Use Regulation Index (WRLURI) (only US)

Online Annex 2.2. Additional Statistics and Stylized Facts

This section provides additional statistics and data descriptives on housing market and housing finance developments.

2.2.1. Additional Statistics

Online Annex Table 2.2.1 includes country level information on housing finance characteristics for the widest of major economies for which data are available. Online Annex Table 2.2.2 provides details on coverage, sources, and definitions for data on the share of fixed-rate mortgages in stock.

Online Annex Table 2.2.1. Housing Finance Characteristics

	Share of Households (Owner with Mortgage)[1]	Share of Households (Owner without Mortgage)[1]	Share of Fixed rate Mortgages[2]	Average of Regulatory LTV Limits[3]	Typical Term to Maturity[4]	Availability of Full Recourse[4]	Housing Finance: Retail Funding[4]
Argentina	–	–	–	100	20	No	Retail Deposit
Australia	32	31	C	100	25	Yes	Other
Austria	19	29	51	100	25	Yes	Retail Deposit
Belgium	33	33	92	100	20	Yes	Retail Deposit
Brazil	–	–	–	77	25	No	Retail Deposit
Bulgaria	2	83	–	100	15	Yes	Retail Deposit
Canada	39[6]	30[6]	67	79	25	Yes	Retail Deposit
China	–	–	0	62	15	No	Retail Deposit
Colombia	5	32	83	75	15	Yes	Other
Croatia	6	85	–	75	30	Yes	Retail Deposit
Cyprus	15	47	11	67	30	No	Retail Deposit
Czech Republic	17	59	–	75	20	Yes	Retail Deposit
Denmark	36	15	40	61	30	Yes	Other
Estonia	19	58	8	88	30	Yes	Retail Deposit
Finland	30	33	9	90	20	Yes	Retail Deposit
France	23	39	92	100	20	Yes	Retail Deposit
Germany	18[7]	26[7]	92	100	15	Yes	Retail Deposit
Greece	9	64	30	100	15	Yes	Retail Deposit
Hungary	12	79	–	55	20	Yes	Other
Iceland	49[6]	19[6]	–	85	40	Yes	Retail Deposit
India	–	–	–	84	20	No	Retail Deposit
Ireland	29	41	55	80	40	Yes	Retail Deposit
Israel	–	–	26	72	20	Yes	Retail Deposit
Italy	11[7]	61[7]	61	100	22	Yes	Retail Deposit
Japan	–	–	26[9]	100	30	Yes	Retail Deposit
Korea	14[5]	59	40	44	20	No	Retail Deposit
Latvia	9	70	–	89	30	Yes	Retail Deposit
Lithuania	8	84	11	85	25	Yes	Retail Deposit
Luxembourg	35	30	71	90	25	Yes	Retail Deposit
Malaysia	–	–	–	87	35	No	Retail Deposit
Malta	22	57	16	83	30	Yes	Retail Deposit
Mexico	8	62	100	100	25	No	Other
Netherlands	49	9	92	100	30	Yes	Retail Deposit
New Zealand	34[8]	31[8]	38	70	30	Yes	Retail Deposit
Norway	51	22	5	72	20	Yes	Retail Deposit
Philippines	–	–	–	75	30	Yes	Other
Poland	12	71	3[8]	79	33	Yes	Retail Deposit
Portugal	32	43	22	90	30	No	Retail Deposit
Singapore	–	–	–	38	35	Yes	Other
Slovenia	10	64	69	80	10	Yes	Retail Deposit
South Africa	–	–	2	100	30	Yes	Other
Spain	26	49	39	100	20	Yes	Retail Deposit
Sweden	44	15	42	85	45	Yes	Other
Switzerland	33	4	77[9]	100	20	Yes	Other
Thailand	–	–	–	87	20	Yes	Retail Deposit
Türkiye	–	56	–	89	8	Yes	Retail Deposit
United Kingdom	28	39	85[9]	100	25	Yes	Retail Deposit
United States	40	26	95	100	30	No	Other

Sources: Bank for international settlements; country authorities; Haver; OECD; iMAPP, Cerutti, E., J. Dagher and G. Dell'Ariccia (2017), and IMF staff calculations.
Note: The letter C refers to data points that are not published in this table for confidentiality reasons.
[1]Data is collected for 2020 unless otherwise specified;
[2]Data is collected for 2023 unless otherwise specified;
[3]Data is collected for 2021 unless otherwise specified;
[4]Data corresponds to 2015 and is collected from Cerutti, Dagher, and Dell'Ariccia (2017);
[5]2017;
[6]2018;
[7]2019;
[8]2021;
[9]2022. Fixed rate mortgages exclude mortgages that adjust to inflation (like in Chile and Israel).

Online Annex Table 2.2.2. Fixed Rate Mortgages in Outstanding Stock: Coverage and Definitions

Country	Coverage	FRM if residual fixation	Source
Australia	2019:Q3–2022:Q4	> 12 months	Reserve Bank of Australia
Austria	2010:Q2–2022:Q4	> 12 months	ECB
Belgium	2010:Q2–2022:Q4	> 12 months	ECB
Canada	2016:Q3–2022:Q4	> 12 months	Bank of Canada
Chile	2002:Q4–2022:Q4	Duration of contract	Banco Central de Chile
Colombia	2008:Q2–2022:Q4	Duration of contract	Superintendencia Financiera de Colombia
Denmark	2013:Q4–2022:Q4	> 12 months	Danmarks Nationalbank
Finland	2010:Q2–2022:Q4	> 12 months	ECB
France	2010:Q2–2022:Q1	> 12 months	ECB
Germany	2010:Q2–2022:Q2	> 12 months	ECB
Greece	2010:Q2–2022:Q3	> 12 months	ECB
Ireland	2010:Q2–2022:Q4	> 12 months	ECB
Israel	2011:Q2–2022:Q4	Duration of contract	Bank of Israel
Italy	2010:Q2–2022:Q4	> 12 months	ECB
Japan	2016:Q1–2022:Q1	> 12 months	Bank of Japan
Korea	2013:Q1–2022:Q4	Duration of contract	Bank of Korea
Luxembourg	2010:Q2–2022:Q4	> 12 months	ECB
Mexico	2016:Q2–2022:Q4	Duration of contract	Banco de Mexico
Netherlands	2010:Q2–2022:Q4	> 12 months	ECB
New Zealand	2016:Q4–2022:Q4	> 12 months	Reserve Bank of New Zealand
Norway	2013:Q4–2022:Q4	> 3 months	Statistics Norway
Poland	2018:Q1–2021:Q4	Duration of contract	Financial Supervision Authority (KNF)
Portugal	2010:Q2–2022:Q4	> 12 months	ECB
South Africa	2008:Q1–2022:Q4	Duration of contract	South African Reserve Bank
Spain	2010:Q2–2022:Q4	> 12 months	ECB
Sweden	2003:Q4–2022:Q4	> 12 months	Haver Analytics
United Kingdom	2007:Q1–2022:Q4	> 12 months	Financial Conduct Authority
United States	2013:Q1–2022:Q4	Duration of contract	Federal Housing Finance Agency

Note: Unless otherwise specified, loan classification is based on current fixed/floating status, rather than status at origination. Countries for which residual fixation is denoted by "duration of contract" are countries for which a breakdown of the outstanding stock by 12 months residual fixation is not currently available. In these cases, FRMs are all those loans which are not floating at any given quarter, irrespectively of residual fixation. Rate resets of floating rate loans may be subject to contracted limits and gradual phasing-in. ECB: proportion of total outstanding loans to households (including, but not limited to, mortgages). Chile: all mortgages are inflation indexed and are thus classified as floating. Denmark: loans from domestic mortgage banks, market value. Israel: classification based on characteristics at origination; mortgages which are inflation–adjusted are classified as floating irrespectively of fixation period. Spain: comparisons across time use 2012Q1 at the request of authorities. United Kindom: Residential loans to individuals: percent floating in outstanding. ECB = European Central Bank; FRM = fix-rate mortgages.

2.2.2. Additional Stylized Facts

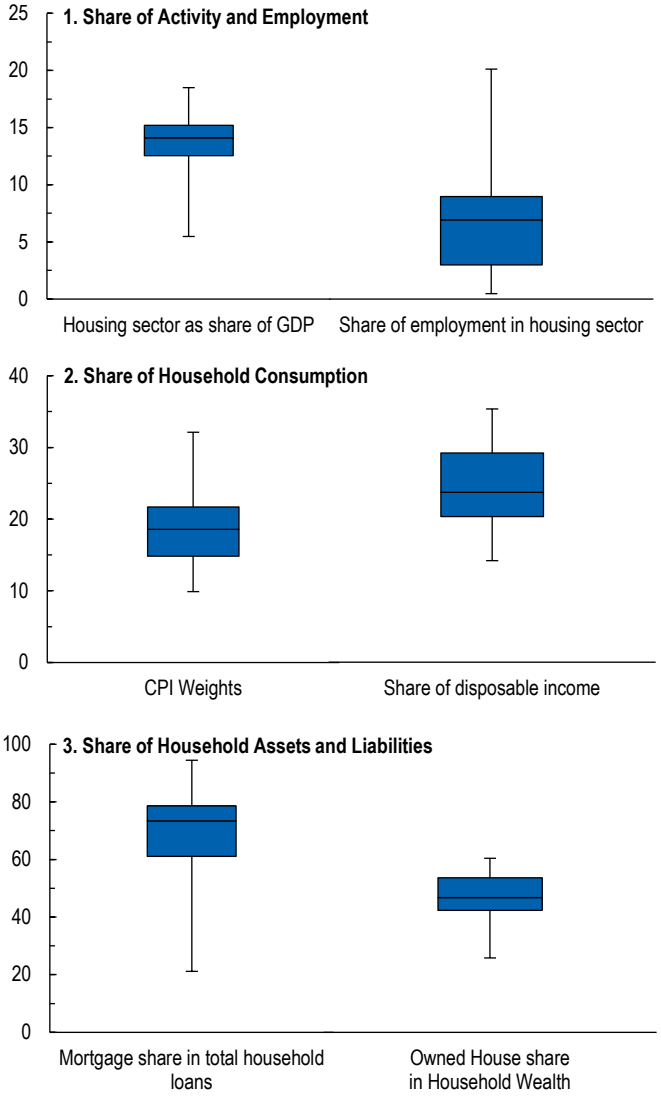
Online Annex Figure 2.2.1 displays cross-country distributions of key variables showing that housing is a critical sector with macroeconomic implications. Activities related to housing account for about 15 percent of a country GDP on average, and to about 7 percent of employment (panel 1). Housing also constitutes a large share of household spending and consumption baskets (panel 2). Finally, mortgages are the largest liabilities of households while houses constitute an overwhelming share of household wealth (panel 3).

Online Annex Figure 2.2.2 displays key housing affordability metrics: both price-to-rent and price-to-income ratios have experienced a boom and bust around the GFC. The pandemic period led to an increase in both ratios, which reached and surpassed pre-GFC levels in many countries.

Online Annex Figure 2.2.3 displays key high frequency measures of housing market activity: the number of new housing constructions (starts) and the number of housing transactions (sales). Following the GFC, both starts and sales dropped by about 30 percent compared to pre-GFC levels, and remained low for most of the 2010s, suggesting that supply was depressed. The pandemic saw a surge in transactions, as households looked for bigger space and took advantage of the low-rate environment to contract mortgages. Following the beginning of rate hikes in 2022, which led to an increase in capital costs for developers, the number of new constructions fell sharply across countries. This was accompanied by a drop in sales.

The recent drop-in housing activity is also illustrated by the drop in the number of new loans extended to households, as Online Annex Figure 2.2.4 shows for countries in the euro area, where data is available.

Online Annex Figure 2.2.1. Housing is Macro-Critical
(Percent)



Sources: International Labor Organization (ILO); Organisation for Economic Co-operation and Development (OECD); and IMF staff calculations.
Note: Whiskers indicate the minimum and the maximum; the bars show the 25th and the 75th percentiles; and the horizontal line inside each box represents the median.

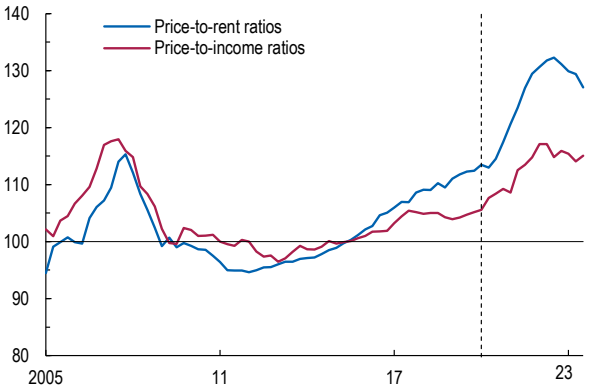
Finally, inflation conspired with the rise in capital costs to push developers costs up, particularly as key material inputs saw their costs increased significantly (Online Annex Figure 2.2.5).

Online Annex Figure 2.2.6 and 2.2.7 show the changes in regulatory LTV ratios and household credit-to-GDP ratios between 2022:Q4 (or latest available) and 2011:Q1.

Online Annex Figure 2.2.8.1 shows the differences in the population growth differential between areas with high and low population density, from 2019:Q4 to 2022:Q4 (or latest available).

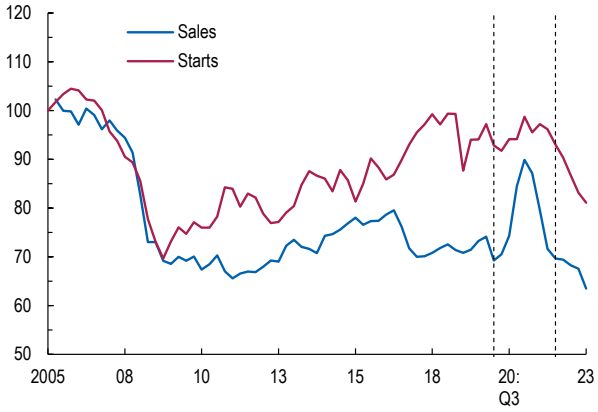
Online Annex Figure 2.2.8.2 shows the median price-to-income ratio (PIR) growth differential between overvalued and non-overvalued areas, from 2019:Q4 to 2022:Q4 (or latest available).

Online Annex Figure 2.2.2. Price-to-Rent and Price-to-Income Ratios
(Median index, 2005 = 100)



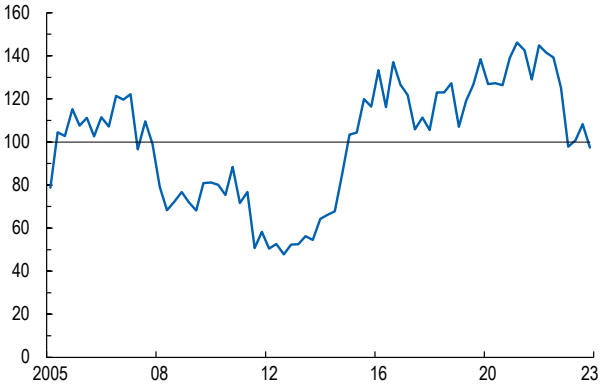
Sources: Organisation for Economic Co-operation and Development (OECD); and IMF staff calculations.
Note: The dotted vertical line corresponds to 2020:Q1, the start of the pandemic. The median calculation for price-to-rent ratio include data for Australia, Austria, Belgium, Bulgaria, Canada, Chile, Colombia, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, South Africa, Spain, Sweden, Switzerland, United Kingdom,and United States. The median calculation for price-to-income ratio include data for Australia, Austria, Belgium, Bulgaria, Canada, Chile, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, South Africa, Spain, Sweden, Switzerland, United Kingdom,and United States.

Online Annex Figure 2.2.3. Housing Starts and Sales
(Median index, 2005 = 100)



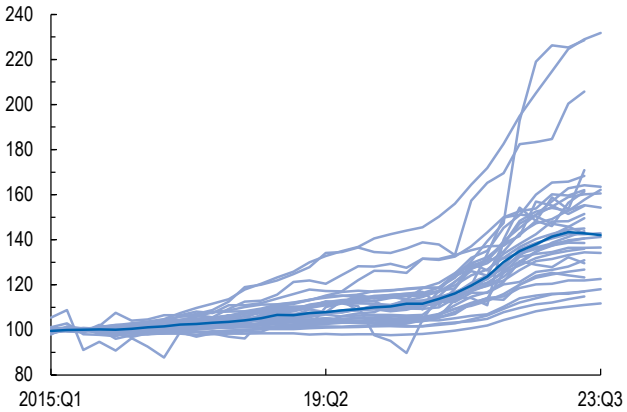
Sources: Haver Analytics; and IMF staff calculations.
Note: Series depict cross-country medians for indices of housing sales and housing starts. Median calculations use data for the following countries: Australia, Belgium, Canada, Chile, Czech Republic, Estonia, France, Germany, Hong Kong SAR, Ireland, Israel, Italy, Japan, Malaysia, Netherlands, New Zealand, Norway, Philippines, Poland, Romania, Slovak Republic, South Africa, Spain, Sweden, Türkiye, United Kingdom, and United States. The vertical lines correspond to 2020:Q1, the start of the pandemic; and 2022:Q1, the beginning of the synchronous hiking cycle.

Online Annex Figure 2.2.4. Volume of New Loans to Households
(Median index, 2005 = 100)



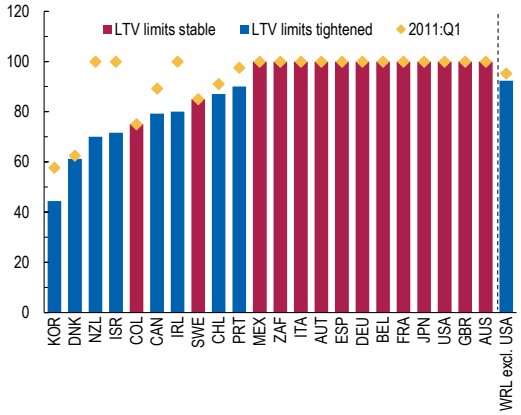
Sources: European Central Bank; and IMF staff calculations.
Note: Median calculations use country level data for Austria, Belgium, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Netherlands, Portugal, Slovenia, and Spain.

Online Annex Figure 2.2.5. Construction: Surging Input Costs
(Median index, 2015 = 100)



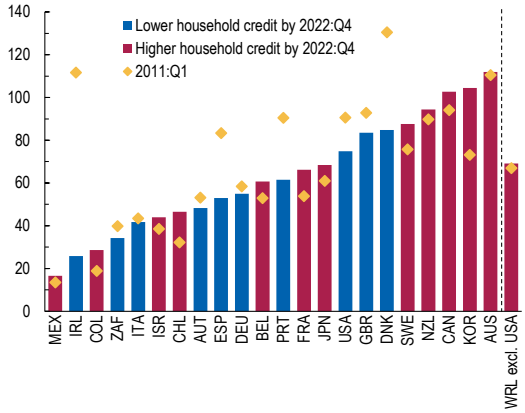
Sources: EuroStat; and IMF staff calculations.
Note: The dark blue line corresponds to cross-country median. Each light blue line depicts the time series for each of the following countries: Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye, and the United Kingdom.

Online Annex Figure 2.2.6. Changes in Regulatory LTV Ratios
(Percent of total)



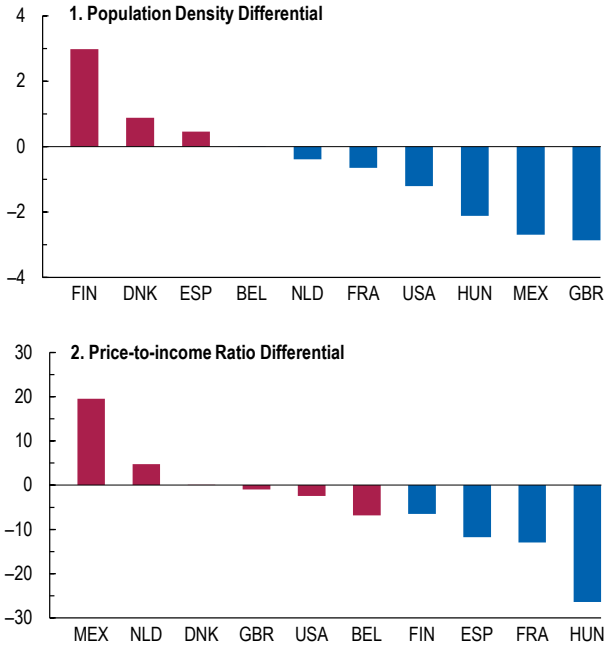
Sources: IMF integrated Macroprudential Policy (iMaPP) database; and IMF staff calculations.
Note: LTV limits = regulatory threshold for maximum loan-to-value ratio across all mortgage typologies. Diamonds denote maximum LTV limits in 2011:Q1; bars denote maximum LTV limits allowed in 2021:Q4. Grey bars denote countries in which LTV limits remain unchanged; blue bars denote countries in which limits were lowered between the two periods. Data labels use International Organization for Standardization (ISO) country codes. WRL = world; excl. = excluding.

Online Annex Figure 2.2.7. Changes in Household Credit-to-GDP Ratios
(Ratio)



Sources: Bank of International Settlements; and IMF staff calculations.
Note: Diamonds denote ratios in 2011:Q1; bars denote ratios in 2022:Q4; red bars denote countries in which the share of household debt-to-GDP declined between the two period; blue bars denote countries in which the share increased. Data labels use International Organization for Standardization (ISO) country codes. WRL = world; excl. = excluding.

Online Annex Figure 2.2.8. Changes in Housing Market Characteristics
(Percentage points)



Sources: Bureau of Economic Analysis (BEA); CBS Open Data; CEIC Data Company Limited; Eurostat; Hungarian Central Statistical Office; National Institute of Statistics and Economic Studies (INSEE); Organisation for Economic Co-operation and Development (OECD); Sociedad Hipotecaria Federal; STATBEL; Statistics Denmark; Statistics Finland; UK Local Authority District; UK Office of National Statistics; US Bureau of labor statistics; US Census Bureau; US Federal Housing Finance Agency (FHFA); and IMF staff calculations.
Note: In panel 1, the population growth differential compares the growth between 2019:Q4 to 2022:Q4 (or latest available) in areas with high and low population density in 2019. Blue shades denote a negative differential between high and low population density areas. A high population density area is one exceeding the 90th percentile in 2019 in a given country. For the US, metropolitan statistical areas (MSA) level data is used, limited to the top 100 largest by population in 2022. Autonomous cities and overseas territories are excluded from the sample. In panel 2, the price-to-income (PIR) growth differential compares the growth between 2019:Q4 and 2022:Q4 (or latest available) in areas that had a housing boom in 2019 with those that did not. Blue shading indicates either negative or zero growth in the PIR in regions with a housing boom. A housing boom area is defined as having a PIR that exceeded the 75th percentile of regional PIR values during any quarter of 2019.

Online Annex 2.3. Construction of Monetary Policy Shocks

This section describes the sources and construction of the two monetary policy shocks used both in the Medium-term Panel Dataset and in the Regional Dataset: *Monetary Policy Shocks* and *Orthogonal Monetary Policy Shocks*.

Monetary Policy Shocks

Monetary Policy Shocks (MPS) are measured as the difference between actual monetary policy announcements and professional analyst forecasts submitted to Bloomberg up to the day prior

to the corresponding announcement. MPS are constructed at the monthly frequency.[2,3] The dataset includes an unbalanced panel of 30 countries and monetary unions, starting from as early as 1998 and covering over 4,600 months of announcements. Finally, the monthly MPS are transformed to quarterly by summing the shocks within each quarter.

As a second step, countries that are pegged to the currencies for which MPS information is available are added to the dataset. In particular, the relevant countries that are pegged to the European Currency Unit/Euro or the Dollar and have been included in the dataset, as well as the date from which they are pegged (if after 1998), are included in Online Annex Table 2.3.1.

Online Table 2.3.1. List of Countries Pegged to the Euro or the Dollar

Currency	Country (date of peg)
European Currency Unit/Euro	Austria; Belgium; Bulgaria (1999); Croatia (2020); Cyprus (2005); Denmark; Estonia (2004); Finland; France; Germany; Greece (1999); Ireland; Italy; Latvia (2005); Lithuania (2002); Luxembourg; Malta (2005); Netherlands; Portugal; Slovak Republic (2005); Slovenia (2004); Spain
Dollar	Hong Kong SAR; Saudi Arabia; United Arab Emirates
Euro-Dollar	Morocco (2001–2015, basket of 80% Euro–20% Dollar), Morocco (2015–, basket of 60% Euro–40% Dollar)

Orthogonal Monetary Policy Shocks

To account for "the central bank reacting to information" channel (Bauer and Swanson, 2023), an orthogonalized measure of the MPS is constructed. The orthogonalized MPS are obtained as the residual of regressing each MPS on two lags of GDP surprises, 6 lags of inflation surprises and the change in the national stock price index over the previous 6 months to the shock.

- GDP surprises comprise the difference between the actual release value for GDP and the mean of analyst forecasts available from Bloomberg. Different Bloomberg Indexes are used. For Euro Area, South Korea, and Norway, Advanced Stage of the GDP actual release are used, while for the rest of the countries, Final Stage of the GDP actual release are used. To improve coverage, different GDP series are combined for two countries. For Colombia, the indexes COCIPIBY and COGNPIBY are combined; for India, the indexes IGQREGDY and INQGGDPY are combined. For each monetary policy announcement, 2 lags of GDP surprises are taken within a backward-looking window of 11 months up to the day prior of the monetary policy announcement.

- Inflation surprises, similarly, to GDP surprises, comprise the difference between the actual release value for inflation and the mean of analyst forecasts available from Bloomberg. For each monetary policy announcement, 6 lags of inflation surprises are taken within a

[2] Series for EMs were kindly shared by Ariadne Checo De Los Santos, Francesco Grigoli, and Damiano Sandri.

[3] In rare cases where there was more than one announcement per month – less than 2 percent of the sample – policy rates and forecasts are averaged at the monthly level.

backward-looking window of 330 days up to the day prior to the monetary policy announcement.

- Stock price changes, derived from Bloomberg, comprise the change in the domestic stock market price index on the day prior to each policy announcement relative to its value 180 days earlier. The stock price series refer to the performance of the largest Exchange-Traded Funds (ETFs), listed on each country's stock exchange, capturing the evolution of stock prices of the largest companies in terms of capital valuation.

The orthogonalized MPS dataset is then transformed to include pegged countries, following the same methodology as in the previous section, and aggregated at the quarterly level by summing the value of the shocks within each quarter.

Online Annex 2.4. Transmission of Monetary Policy to House Prices and Real Economic Activity

This section describes the methodology used to assess how monetary policy affects house prices and other macroeconomic outcomes, using an unbalanced country-level panel dataset covering 33 AEs and EMEs between 1998:Q4 and 2022:Q4 described in Online Annex Table 2.1.2.

Empirical Methodology

The analysis is based on instrumental variables local projections (LP-IV) as in Stock and Watson (2018). The specification follows the application to a panel dataset described in Jordà and others (2015). Average effects are estimated through the following LP-IV equation:

$$y_{c,t+h} - y_{c,t-1} = a^h + \beta_1^h \widehat{DeltaRate}_{c,t-1} + \sum_{l=1}^{8} \beta_2^h X_{c,t-l} + \mu_c^h + \tau_t^h + \varepsilon_{c,t+h}, \quad (1)$$

$$for\ h = 0, \ldots, 8,$$

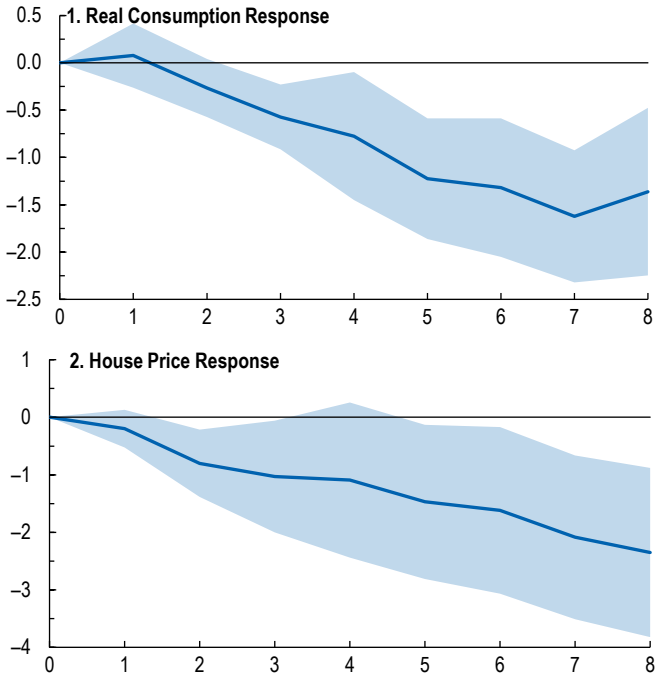
where c is country and t is quarter. $y_{c,t+h} - y_{c,t-1}$ denotes the cumulative percentage change (log difference) in house prices, consumption, or other macroeconomic outcomes after h quarters, and $\widehat{DeltaRate}_{c,t-1}$ is the 2SLS estimate of the effect of a 100bpp change in the policy rates over a given quarter. This is the result of a system of equations where the change in policy rates is instrumented with surprises around monetary policy announcements among Bloomberg professional forecasters described in section 2.3 above. The projection period h goes up to 8 quarters ahead; the vector of controls $X_{c,t-l}$ includes 8 lags of the growth rate in the dependent variable; as well as 8 lags of the growth rate in real GDP; headline CPI inflation; nominal house prices; and outstanding household credit in national currency. Country and time fixed effects are captured by μ_c^h and τ_t^h, respectively. All specifications use Driscoll and Kraay (1998) standard

errors with three lags, which are robust to heteroskedasticity, autocorrelation, and cross-sectional dependence.[4] Charts report 90 percent confidence intervals based on these standard errors.[5]

Additional Results

Online Annex Figure 2.4.1 presents estimates of β_1^h in equation (1), using real private consumption and nominal house prices as outcome variables. The blue lines represent the cumulative percentage point response to a 100bpp change in policy rates, instrumented with monetary policy shocks described in section 2.3. Y-axes represent percentage points and X-axis represents quarters after the monetary policy action. Shaded areas represent 90 percent confidence intervals.

Online Annex Figure 2.4.1. Average Effects of Monetary Policy
(Percentage points)



Sources: Bank for International Settlements; Bloomberg Finance L.P.; and IMF staff calculations.
Note: Numbers on the horizontal axes in the panels represent quarters. Charts present the average response of nominal house prices and real private consumption to a 100 basis points change in policy rates, instrumented with the quarterly sum of the average policy rate forecast errors among professional forecasters, sourced from Bloomberg. Shaded areas represent 90 percent confidence intervals.

Online Annex 2.5. Heterogeneity Due to Mortgage Finance Characteristics

This section describes the methodology used to assess how the transmission of monetary policy to various macroeconomic outcomes (including house prices and private consumption) depends on three key mortgage market characteristics: relative leverage ratio (proxied by outstanding household credit-to-GDP); maximum regulatory LTV limits; and the share of fixed-rate mortgages (FRMs) in stock. These estimations are produced using the same unbalanced country-level panel dataset described in section 2.1.

Empirical Methodology

The estimation analysis is based on LP-IV, which is identical to the model described in section 2.4, only augmented with interaction terms meant to capture the differential effects of monetary

[4] Reported t-statistics thus correct for serial correlation within a given country over time (e.g., US 2023:Q1 and 2022:Q4 are not statistically independent), contemporaneous correlation across countries at any given quarter (e.g., US 2023:Q1 and Canada 2023:Q1 are not statistically independent), as well as cross-autocorrelation (e.g., US 2023:Q1 and Canada 2022:Q4 are not independent).

[5] Detailed regression output for all analyses presented in the Chapter and the Online Annex are available upon request from the authors.

policy at different levels of a given state variable of mortgage finance characteristics. The LP-IV equation is altered as follows:

$$y_{c,t+h} - y_{c,t-1} = a^h + \beta_1^h \widehat{DeltaRate}_{c,t-1} + \beta_2^h (\widehat{DeltaRate}_{c,t-1} \times \boldsymbol{H_{c,t-1}}) + \beta_3^h \boldsymbol{H_{c,t-1}} + \sum_{l=1}^{8} \beta_4^h X_{c,t-l} + \mu_c^h + \tau_t^h + \varepsilon_{c,t+h}, for\ h = 0, \dots, 8, \quad (2)$$

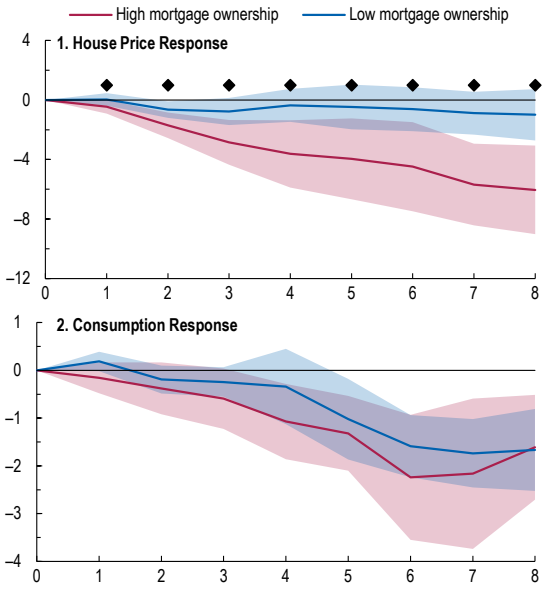
where notation, set of fixed effects, controls, lag structure and standard errors are identical to the model presented in section 2.4. The only difference is in the addition of variable $\boldsymbol{H_{c,t-1}}$, which denotes the (lagged) value of each of the three mortgage finance characteristics (regulatory LTV limits, household debt-to-GDP ratio, share of FRMs in stock) for each country/quarter. Panel 2.7 in the main text displays the results of equation 2 using these three variables as interaction terms. For ease of interpretation, the models depicted in Panel Figure 2.7 interact the monetary policy shock with a dummy, denoting when a given country/quarter is above or below sample median for two out of three characteristics (household debt-to-GDP; share of FRMs in stock). The dummy variable in LTVs takes value 1 when the regulatory limit is below 100 percent, 0 otherwise. The coefficient $\boldsymbol{\beta_2^h}$ thus captures the differential effects of a given change in policy rates for a different level of the state variable $\boldsymbol{H_{c,t-1}}$, thus providing an estimate of the heterogeneity in monetary policy transmission.

Equation (3) below modifies equation (2) to assess whether the role of state variables depends on the sign of the monetary policy impulse (i.e., tightening vs. loosening). Due to the loss in power in the instrumental variable model, stemming from multiple interaction terms, this equation is also expressed in reduced form (i.e., outcomes are regressed directly on the monetary policy shocks, rather than instrumenting the change in rates with shocks).

$$\begin{aligned} y_{c,t+h} - y_{c,t-1} = {} & a^h + \beta_1^h abs(MP_{c,t-1}) \times Tightening_{c,t-1} \times \boldsymbol{H_{c,t-1}} \\ & + \beta_2^h abs(MP_{c,t-1}) \times Loosening_{c,t-1} \times \boldsymbol{H_{c,t-1}} \\ & + \beta_3^h abs(MP_{c,t-1}) \times Loosening_{c,t-1} \\ & + \beta_4^h abs(MP_{c,t-1}) \times Tightening_{c,t-1} + \beta_5^h \boldsymbol{H_{c,t-1}} + \sum_{l=1}^{8} \beta_6^h X_{c,t-l} \\ & + \mu_c^h + \tau_t^h + \varepsilon_{c,t+h}, \qquad for\ h = 0, \dots, 8, \end{aligned} \quad (3)$$

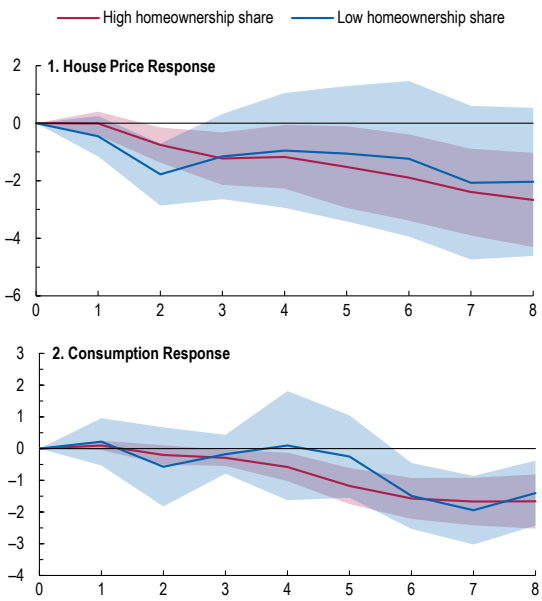
where $abs(MP_{c,t-1})$ is the absolute value of the monetary policy shock at any given quarter. These absolute values are interacted simultaneously with two different dummies: a dummy ($Tightening_{c,t-1}$) which takes value 1 if the shock has positive value, and 0 otherwise; and the dummy $Loosening_{c,t-1}$ which takes value 1 if the shock has negative value, and 0 otherwise.

Online Annex Figure 2.5.1. Differential Effects of Monetary Policy: Mortgage Ownership
(Percentage points)



Sources: Bank for International Settlements, Bloomberg Finance L.P., and IMF staff calculations.
Note: Numbers on the horizontal axes in the panels represent quarters. The charts plot the differential response of house prices and real private consumption to a 100 basis points change in policy rates between the sample where mortgage ownership rates are above the median (red) and the sample where homeownership rates are below the median (blue). Shaded areas represent 90 percent confidence intervals. Diamonds represent statistical significance, p value < 0.1.

Online Annex Figure 2.5.2. Differential Effects of Monetary Policy: Homeownership Rates
(Percentage points)



Sources: Bank for International Settlements; Bloomberg Finance L.P.; and IMF staff calculations.
Note: Numbers on the horizontal axes in the panels represent quarters. The charts plot the differential response of house prices and real private consumption to a 100 basis points change in policy rates between the sample where homeownership rates are above the median (red) and the sample where homeownership rates are below the median (blue). Shaded areas represent 90 percent confidence intervals.

The coefficients β_1^h and β_2^h capture the differential response to a tightening and loosening shock, respectively, at different values of the state variable $\boldsymbol{H_{c,t-1}}$. The general effects of the state variables, of tightening/loosening episodes, and of the magnitude of the monetary policy shock itself are captured by coefficients β_3^h through β_5^h. The set of coefficients β_6^h captures the same controls as in equation (2).

Additional Results

This section provides additional results that are either discussed in the main text or provide robustness checks.

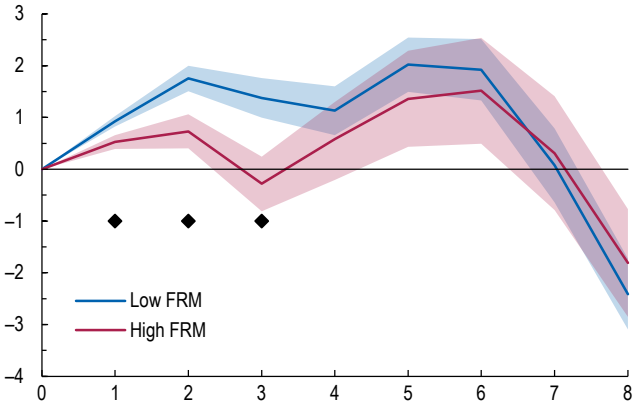
Online Annex Figure 2.5.1 depict the results of equation (2), using the share of households with and without mortgages as state variable $\boldsymbol{H_{c,t-1}}$. Results are comparable to those obtained when using household-debt-to-GDP ratios as an interaction (see text figure 2.7.5 and 2.7.6). House prices respond significantly more the more households have mortgages; and consumption appears to respond more slowly to a rate change (albeit differences in consumption are not significant).

Online Annex Figure 2.5.2 depicts the differential response of house prices and consumption depending on the simple share of homeowners. Effects are not statistically different between the

two groups, either on house prices or consumption, suggesting that homeownership rates in isolation do not determine the degree of response to monetary policy shocks.

Online Annex Figure 2.5.3 plots the responses of effective rates (rates on all outstanding mortgages) to a monetary policy shock depending on the prevalence of FRMs in a given country / quarter. The red (blue) line plots the response to a 100bpp monetary policy shock for the portion of the sample where FRMs are above (below) the median. Due to the reduced sample size and consequent loss of first-stage power in the instrumental variable estimation, equation (2) is here expressed in reduced-form (i.e., outcomes are regressed directly on the monetary policy shock, rather than on changes in policy rates instrumented with the shock).

Online Annex Figure 2.5.3. Effective Mortgage Rates: Average Change for High and Low FRM Sample
(Percentage points)



Sources: Bloomberg Finance L.P.; Federal Reserve Board; Eurostat; national authorities' data; and IMF staff calculations.
Note: Numbers on the horizontal axes in the figure represent quarters. Sample includes selected Eurozone economies and the US. FRM is a dummy taking value 1 if the outstanding share of FRM mortgages the quarter is above sample median; 0 otherwise. FRMs are defined as all mortgages for which rates do not reset in the following 12 months., Diamonds* denote pvalue<0.1. FRM = Share of fixed-rate mortgages.

Online Annex 2.6. Heterogeneity Due to Housing Market Characteristics

This section describes the methodology and presents additional results used to assess how regional housing market characteristics affect the transmission of monetary policy conditional on two key regional housing market characteristics, including population density, serving as a proxy of housing supply constraints, and house price overvaluations, measured by deviations of the regional price-to-income ratio (PIR) from its long-term average. The dataset comprises of an unbalanced region-level panel dataset covering 192 regions in 9 countries between 2005:Q1 and 2022:Q4 described in 2.1.2.

Empirical Methodology

The estimation analysis is similarly as before based on LP-IV, augmented with interaction terms and country-time fixed effects, and follows closely Aastveit and Anundsen, 2022:

$$y_{c,j,t+h} - y_{c,j,t-1} = \beta_1^h(\widehat{DeltaRate}_{c,t} \times \boldsymbol{H_{c,j,t-4}}) + \beta_2^h \boldsymbol{H_{c,j,t-4}} + \sum_{l=1}^{12} \beta_3^h X_{c,j,t-l} + \mu_{c,j}^h + \theta_{c,t}^h + \varepsilon_{c,j,t+h}, for\ h = 0, \dots, 8 \quad (3)$$

where *c* is country, *j* is region, and *t* is time. $y_{c,j,t+h} - y_{c,j,t-1}$ is the cumulative log change in house prices and GDP per capita after *h* quarters, $\widehat{DeltaRate}_{c,t}$ is the 2SLS estimate of the change in the policy rates as described earlier in section 2.4. $\boldsymbol{H_{c,j,t-4}}$ is a regional dummy indicator, denoting past values of high population density or past values of high levels of house price overvaluations; $X_{c,j,t-l}$ is a vector of controls, including 12 lags of changes in log house prices, GDP per capita, CPI inflation, and population. $\mu_{c,j}^{h}$ are region fixed effects and $\theta_{c,t}^{h}$ are country-time fixed effects. Standard errors are clustered at the regional level. Charts report 90 percent confidence intervals based on these standard errors.

The regression specification includes the interactions of instrumented policy changes with the regional dummy indicator, $\widehat{DeltaRate}_{c,t} \times H_{c,j,t-4}$. In the regressions when population density is the conditioning variable, $\boldsymbol{H_{c,j,t-4}}$ takes the value of 1 if a region's density is in the top 10th percentile within its respective country and year; and 0 otherwise. When house price overvaluation is the conditioning variable, $\boldsymbol{H_{c,j,t-4}}$ is set to 1 when the regional PIR deviations from its long-term average ranks in the top 25th percentile. The main coefficient of interest on the interaction term, β_1^h, which reveals the responses of monetary policy on the outcome variables in regions where population density is high, or house prices are overvalued. Panel 2.10 in the main text of the chapter shows the results of equation (4), using high population density and house price overvaluations as dummy interaction terms.

To test for asymmetric effects of monetary policy, equation (4) above is modified and takes the following form:

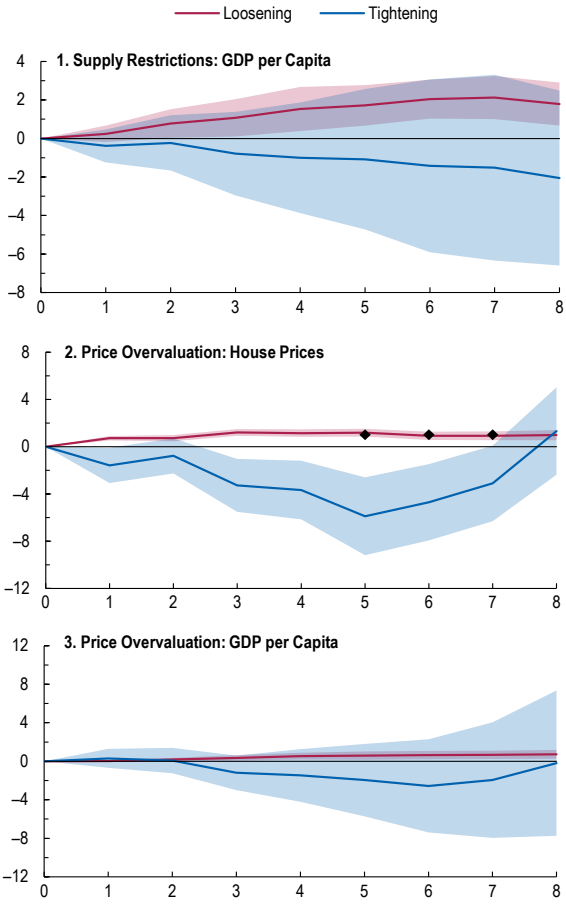
$$\begin{aligned} y_{c,j,t+h} - y_{c,j,t-1} &= \beta_1^h abs(\widehat{DeltaRate}_{c,t}) \times Tightening_{c,t} \times \boldsymbol{H_{c,j,t-4}} \\ &+ \beta_2^h abs(\widehat{DeltaRate}_{c,t}) \times Loosening_{c,t} \times \boldsymbol{H_{c,j,t-4}} + \beta_3^h \boldsymbol{H_{c,j,t-4}} \\ &+ \sum_{l=1}^{12} \beta_4^h X_{c,j,t-l} + \mu_{c,j}^h + \theta_{c,t}^h + \varepsilon_{c,j,t+h}, for\ h = 0, \dots, 8, \end{aligned} \quad (4)$$

where $abs(\widehat{DeltaRate}_{c,t})$, $Loosening_{c,t}$, and $Tightening_{c,t}$ are defined exactly as in equation (3). The lag structure, set of controls, and fixed effects as identical as in equation (4). This model captures how a change in policy rates of similar magnitude, but opposite sign affects macroeconomic outcomes.

Additional Results

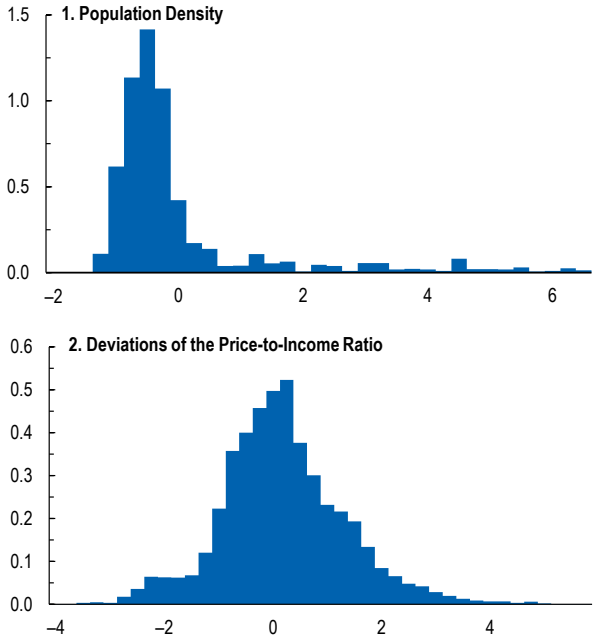
This section provides figures with additional results that are discussed in the main text of the chapter and provides additional robustness checks.

Online Annex Figure 2.6.1. Asymmetric Differential Effects of Housing Market Characteristics
(Percentage points)



Sources: STATBEL; Statistics Denmark; National Institute of Statistics and Economic Studies (INSEE); StatFin; Hungarian Central Statistical Office; Sociedad Hipotecaria Federal; CBS Open Data; CEIC; UK Local Authority District; Federal Housing Finance Agency (FHFA); Eurostat; Organisation for Economic Co-operation and Development (OECD); UK Office of National Statistics; Bureau of Economic Analysis (BEA); US Census Bureau; and IMF staff calculations.
Note: Numbers on the horizontal axes in the panels represent quarters. Lines represent the cumulative response to a 100bpp tightening or loosening in the policy rate at any given quarter. Shaded areas indicate the 90th percentile confidence intervals. High population density, indicating housing supply constraints, is a dummy variable: 1 if a region is in the top 10th percentile of the country-year distribution, 0 otherwise. High house price overvaluation area is similarly denoted by a dummy variable: 1 if the deviation from the long-term price-to-income ratio falls within the top 25th percentile of the region's distribution, 0 otherwise.

Online Annex Figure 2.6.2. Distribution of population density and house price overvaluations
(Density)



Sources: Eurostat; Organization for Economic Co-operation and Development (OECD); US Federal Housing Finance Agency (FHFA); US Bureau of labor statistics; and IMF staff calculations.
Note: The panels shows the distribution of population density and house price overvaluations, standardized with mean 0 and standard deviation of 1 at the country level.

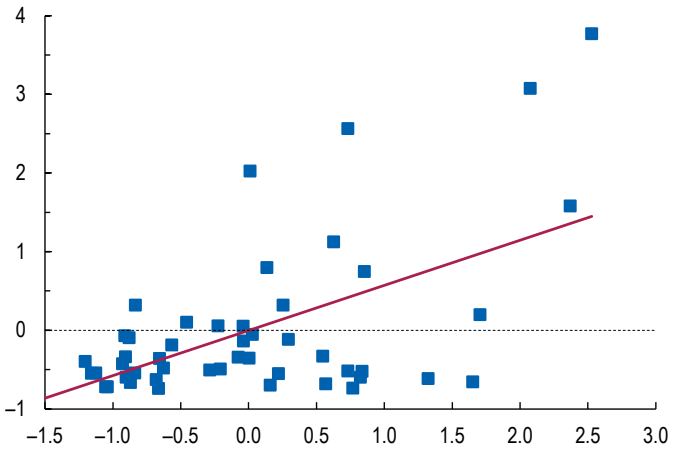
Online Annex Figure 2.6.1 shows the differential responses of house prices and real GDP-per-capita to monetary policy tightening (blue) and loosening (red) in areas that are housing supply constrained, as proxied by population density, or have experienced house price overvaluations.

Figure 2.6.1 shows the distribution of both population density and house price overvaluations across the sample period, with each variable standardized at the country level to have a mean of 0 and a standard deviation of 1.

To show that population density could serve as a reasonable proxy for housing supply constraints, Figure 2.6.3 shows the correlation between population density in 2019 and the

Wharton residential land use regulatory index (WRLURI) from a 2018 survey in the US.[6] The correlation coefficient is approximately 0.6, indicating a significant positive relationship between these two variables. This finding supports the external validity of using population density as a reasonable proxy for housing supply constraints given the limited availability of regional-level data for housing constraints.

Online Annex Figure 2.6.3. United States: Population Density versus Housing Supply Constraints (Wharton Index)
(Population density)



Sources: Organisation for Economic Co-operation and Development (OECD); Wharton Residential Land Use Regulation Index (2018); and IMF staff calculations.
Note: Numbers on the horizontal axes in the figure refer to the Wharton residential land use regulatory index (WRLURI). Both variables have been standardized, with a mean of 0 and a standard deviation of 1.

Online Annex 2.7. Model-based Analysis

The chapter employs a two-agent New Keynesian (TANK) model based on Chen and others (2023). It extends the TANK model of Iacoviello and Neri (2010) with housing and collateral constraints by introducing illiquid housing, long-term debt, and macroprudential tools such as LTV ratios. The economy consists of households and firms. Households, characterized by heterogeneous discount rates, consume both housing and non-housing goods while providing labor to both sectors. Patient and impatient households act as savers and borrowers, respectively. Housing and consumption goods are produced using different technologies, generating endogenous dynamics both in residential and business investment, as well as in housing prices. The latter further impacts the borrowing capacity of households and the relative profitability of new home production.

The model used in the chapter is calibrated following Chen and others (2023) with a few adjustments. The adapted model considers a changing between more and less restrictive LTV limits, and high and low share of fixed rate mortgages. The following changes to the model calibration are introduced. First, following the "low debt" scenario in Chen and others (2023), the share of a home's value available for an equity withdrawal and inflation target are fixed at 1.5 percent and 2 percent, respectively. Differently from Chen and others (2023), household preferences for housing services are set to 0.19 for all households to raise the steady state level of debt in percent of GDP to better match the levels observed in our sample. Finally, monetary policy is modeled by a Taylor Rule with a smoothness parameter set at 0.95 to roughly mimic the peak response of consumption observed in Figure 2.9 in the main text. The recalibrated model

[6] Population density is measured in 2019 to abstract from migration patterns that took place during the pandemic and that have likely influenced population density.

exhibits standard-sized impulse responses for main aggregate variables, like GDP, consumption and inflation.

The model assesses how LTV limits and share of FRMs jointly impact changes in monetary policy transmission. Initial simulations with less restrictive LTV and low FRM analyze the consumption response to a monetary policy tightening, representing the highest degree of transmission. Subsequent simulations explore consumption responses under high FRM and high LTV scenarios, indicating a lower degree of transmission. These simulations adhere to specific assumption definitions below:

1. Restricted vs. not restricted LTV: LTV changes from 0.75 to 0.9 as percentage of housing investments.

2. High vs. low FRM: Share of outstanding loans with a fixed-rate mortgage change from 95% to 70%.

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