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Working Paper

Navigating the housing channel of monetary policy across euro area regions

ECB Working Paper, No. 2752

Provided in Cooperation with:

European Central Bank (ECB)

Suggested Citation: Battistini, Niccolò; Falagiarda, Matteo; Hackmann, Angelina; Roma, Moreno (2022) : Navigating the housing channel of monetary policy across euro area regions, ECB Working Paper, No. 2752, ISBN 978-92-899-5400-6, European Central Bank (ECB), Frankfurt a. M., <https://doi.org/10.2866/439771>

This Version is available at:

<https://hdl.handle.net/10419/278227>

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EUROPEAN CENTRAL BANK

EUROSYSTEM

Working Paper Series

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Navigating the housing channel of
monetary policy across euro area
regions

No 2752 / November 2022

Disclaimer: This paper should not be reported as representing the views of the European Central Bank (ECB). The views expressed are those of the authors and do not necessarily reflect those of the ECB.

Abstract

This paper assesses the role of the housing market in the transmission of conventional and unconventional monetary policy across euro area regions. By exploiting a novel regional dataset on housing-related variables, a structural panel VAR analysis shows that monetary policy propagates effectively to economic activity and house prices, albeit in a heterogeneous fashion across regions. Although the housing channel plays a minor role in the transmission of monetary policy to the economy on average, its importance increases in the case of unconventional monetary policy. We also explore the determinants of the diverse transmission of monetary policy to economic activity across regions, finding a larger impact in areas with lower labour income and more widespread homeownership. An expansionary monetary policy can thus be effective in mitigating regional inequality via its stimulus to the economy.

JEL Classification: D31, E32, E44, E52, R31

Keywords: housing market, conventional and unconventional monetary policy, regional inequality, business cycles

Non-technical summary

Profound economic and institutional differences across regions have long challenged the effectiveness of monetary policy in the euro area. The unequal geography of the transmission of monetary policy has also stoked concerns about its possible side effects on regional inequality, especially owing to the unconventional measures conducted by the European Central Bank (ECB) over the last decade. In this context, the housing market—in light of its role in the propagation of shocks, its distributional implications and its local dimension—has often come to the front of the media and policy debate on the intended and unintended effects of monetary policy across euro area regions.

Our paper contributes to the literature on this debate by assessing empirically the role of the housing market in the conventional and unconventional transmission of monetary policy across regions in the first two decades of the euro area. We first construct a large dataset with a panel of 106 regions in eight euro area countries (Belgium, Germany, Spain, France, Ireland, Italy, the Netherlands and Portugal) covering the period 1999-2018. We compile novel indicators for regional house prices and loan-to-value (LTV) ratios based on loan-level data. We also collect regional indicators for aggregate and sectoral activity, labour market developments and housing market features.

We then consider monetary policy through its conventional and unconventional transmission mechanisms by constructing a measure of monetary policy shocks. To isolate the impact of “genuine” monetary policy shocks, we adopt a high-frequency identification and impose sign and zero restrictions on high-frequency changes in risk-free interest rates and stock prices around the ECB’s monetary policy announcements. We assume that the conventional transmission mechanism of monetary policy has mainly operated through short-term rates, whereas long-term rates were primarily related to the unconventional transmission mechanism of monetary policy enacted in the aftermath of the Global Financial Crisis.

Making use of our regional dataset and our measure of conventional and unconventional monetary policy shocks, we design a methodology to assess the role of the housing market in the transmission of monetary policy to the real economy. Using a structural panel vector autoregression (SPVAR) model with regional GDP, employment and house prices as endogenous variables, and euro area monetary policy shocks as exogenous variable, we first assess the average impact of a monetary accommodation on GDP, employment and house prices across regions.

Accounting for the endogenous reaction of GDP to employment and house prices, we further quantify the role of the employment and the housing channels in conveying monetary stimulus. We finally provide an anatomy of the long-term drivers of the diverse impact of monetary policy across euro area regions.

Our results point to an effective, yet widely heterogeneous transmission of monetary policy across the euro area, with monetary policy stimulating economic activity mainly through labour income, compared with housing wealth. Nevertheless, the housing channel becomes more relevant in the unconventional transmission of monetary policy. Moreover, as monetary policy is found to impact poorer regions the most, policy makers should carefully monitor the risks of an increase in cross-regional inequality as monetary policy normalises, especially in the case of resurgent fragmentation risks. Our findings suggest that a proper assessment of the monetary policy transmission should not neglect the housing market, with its multiple sources of propagation and its pronounced local dimension.

1 Introduction

Profound economic and institutional differences across regions have long challenged the effectiveness of monetary policy in the euro area.¹ The unequal geography of the transmission of monetary policy has also stoked concerns about its possible side effects on regional inequality, especially owing to the unconventional measures conducted by the European Central Bank (ECB) over the last decade.² The ECB's large-scale asset purchases—critics maintain—have inflated the prices of assets, such as stocks and houses, unfairly favouring rich, wealthy households.³ To the extent that similar households cluster geographically, monetary policy has, according to critics, further exacerbated regional inequality. In the transition of the ECB out of crisis-era stimulus, a crucial issue on the policy agenda has thus become the calibration of an appropriate monetary policy stance that can support the recovery while minimising economic divergence across regions. In this context, the housing market—in light of its role in the propagation of aggregate shocks, its distributional implications and its local dimension—⁴ has often come to the front of the media and policy debate on the intended and unintended effects of monetary policy.⁵

Our paper contributes to the literature on this debate by assessing empirically the role of the housing market in the conventional and unconventional transmission of monetary policy across regions in the first two decades of the euro area. Our contribution is threefold. First, we construct a large dataset with a panel of 106 (mostly) NUTS2-level regions in eight euro area countries (Belgium, Germany, Spain, France, Ireland, Italy, the Netherlands and Portugal) covering the period 1999-2018. Most notably, we compile novel indicators for regional house prices and loan-to-value (LTV) ratios based on loan-level data from the European DataWarehouse. We also collect regional indicators for aggregate and sectoral activity, labour market developments and housing market features from the ARDECO database and Eurostat. Our dataset features a high degree of within-country, besides cross-country, diversity pervading housing markets over the first twenty years of the euro area (Figure 1).⁶ This indicates that the information content

¹For a discussion of financial integration challenges in the euro area, see [European Central Bank \(2022\)](#). For the implications of regional heterogeneity for monetary policy in the euro area, see [Cœuré \(2019\)](#).

²See, for instance, [The Economist \(2016\)](#) and [Cœuré \(2018\)](#).

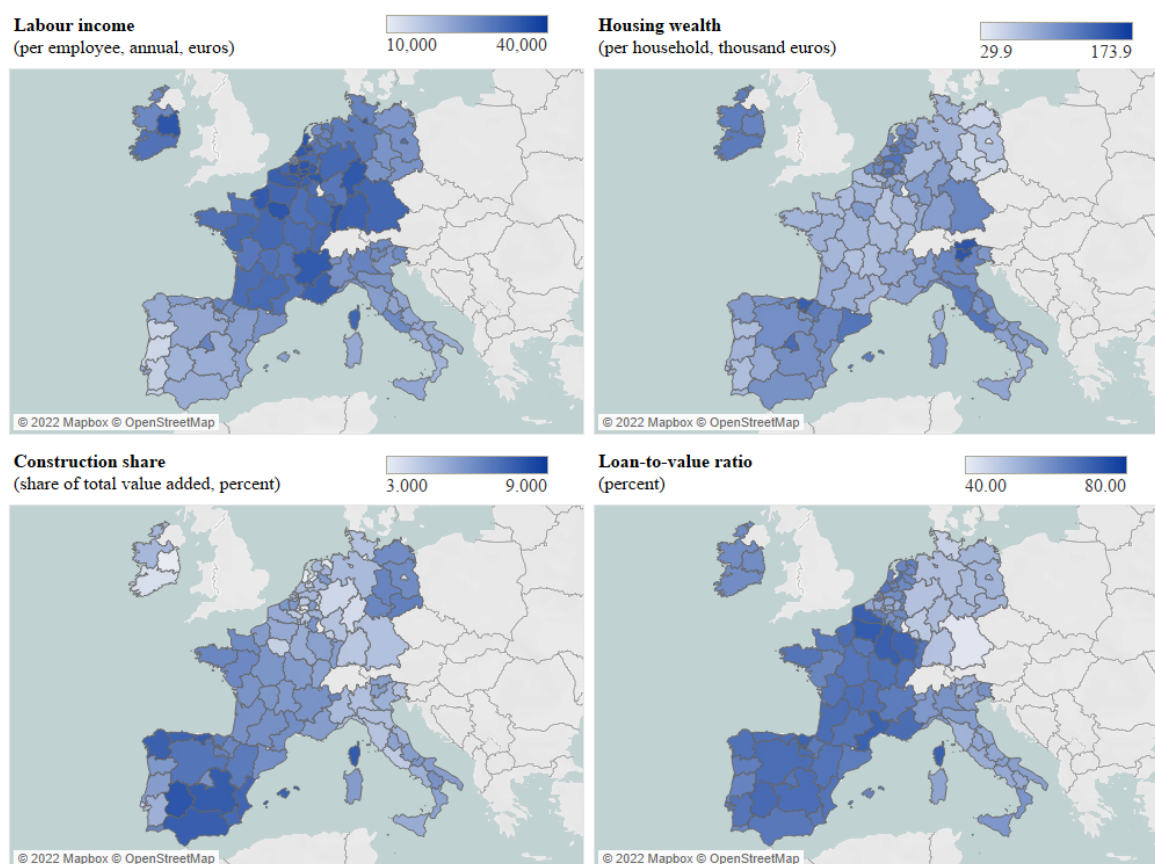
³Among the earliest concerns, see [The Economist \(2013\)](#) and [The Financial Times \(2015a\)](#).

⁴On the features of the housing market, see the comprehensive study by [Piazzesi and Schneider \(2016\)](#).

⁵To name a few recent examples, see, in the media, [The Financial Times \(2021\)](#) and, in policy circles, [OECD \(2020\)](#), [Schnabel \(2021\)](#), [Battistini et al. \(2021\)](#) and [European Commission \(2021\)](#).

⁶A simple measure of the information content specific to within-country (relative to cross-country) heterogeneity can be computed, for each variable, as the ratio of the cross-country average of the within-country standard deviations to the cross-country standard deviation of the within-country averages. All the considered variables exhibit a sizeable degree of relative within-country variation, especially construction share (85 percent), followed

Figure 1: Regional heterogeneity in euro area housing markets



Source: ARDECO, Eurostat, European DataWarehouse and authors' calculations.

Notes: Labour income is measured as compensation of employees divided by number of employees (average 1999-2018). Housing wealth is computed as house price level (average 1999-2018) multiplied by homeownership rate (share of households living in owner-occupied dwellings) in 2011. Construction share is calculated as construction value added divided by total value added (average 1999-2018). Loan-to-value ratio is computed as the amount of the mortgage loan divided by the value of the underlying property (average 1999-2018).

of our regional dataset extends beyond that of a typical cross-country panel, confirming the pronounced local dimension of housing markets.

Our second contribution is to consider monetary policy through its conventional and unconventional transmission mechanisms. To this end, we tap the Euro Area Monetary Policy Database ([Altavilla et al., 2019b](#)) to construct a measure of monetary policy surprises. To isolate the impact of “genuine” monetary policy surprises, we adopt a high-frequency identification and impose sign and zero restrictions on high-frequency changes in OIS interest rates and stock prices around the ECB’s monetary policy announcements ([Jarociński and Karadi, 2020](#)). We

by homeownership rate and labour income (both 55 percent) and LTV ratio (36 percent).

assume that the conventional transmission mechanism of monetary policy has mainly operated through short-term rates, whereas long-term rates were primarily related to the unconventional transmission mechanism of monetary policy in the aftermath of the Global Financial Crisis.

Third, using our regional dataset and our measure of conventional and unconventional monetary policy, we design a methodology to assess the role of the housing market in the transmission of monetary policy to the real economy. Using a structural panel vector autoregression (SPVAR) model with regional GDP, employment and house prices as endogenous variables, and euro area monetary policy shocks as exogenous variable, we first assess the average impact of monetary policy on GDP, employment and house prices across regions. Accounting for the endogenous reaction of GDP to employment and house prices, we further quantify the role of the employment and the housing channels in conveying monetary stimulus.

Our results show a significant, positive impact of a monetary policy easing on GDP, employment and, to a lesser extent, house prices. Further, monetary policy stimulus to the overall economy transmits mainly through the employment channel, in line with [Hauptmeier, Holm-Hadulla and Nikalexi \(2020\)](#), with a rather limited role for the housing channel, consistently with findings in [Slacalek, Tristani and Violante \(2020\)](#) and [Lenza and Slacalek \(2021\)](#). However, unconventional monetary policy is estimated to induce significantly larger responses in house prices, relative to conventional monetary policy, thereby amplifying the housing channel.

Finally, we provide an anatomy of the long-term drivers of the diverse impact of monetary policy across euro area regions. The region-specific estimates of our benchmark SPVAR model allow us to dissect the role of several housing-related economic and institutional characteristics. We find that monetary policy has a larger impact on the economy of regions with lower labour income and a higher homeownership rate. This suggests that poorer regions stand to benefit the most from expansionary monetary policy, but can also be more negatively affected from a policy tightening.

Overall, our results point to an effective, yet widely heterogeneous transmission of monetary policy across the euro area, with monetary policy stimulating economic activity mainly through labour income, compared with housing wealth. Nevertheless, the housing channel becomes more relevant in the unconventional transmission of monetary policy. Moreover, as monetary policy is found to impact poorer regions the most, policy-makers should carefully monitor the risks of an increase in cross-regional inequality as monetary policy normalises, especially in the case of resurgent fragmentation risks. Our findings suggest that a proper assessment of the monetary policy

transmission should not neglect the housing market, with its multiple sources of propagation and its pronounced local dimension.

The remainder of this paper is structured as follows. Section 2 describes the data. Section 3 lays out the theoretical and empirical frameworks. Section 4 presents a quantitative assessment of the housing channel of monetary policy. Section 5 analyses the role of economic and institutional characteristics in explaining the heterogeneous impact of monetary policy across regions. Section 6 conducts robustness tests on our main results. Section 7 draws concluding remarks.

2 Data

2.1 Regional dataset

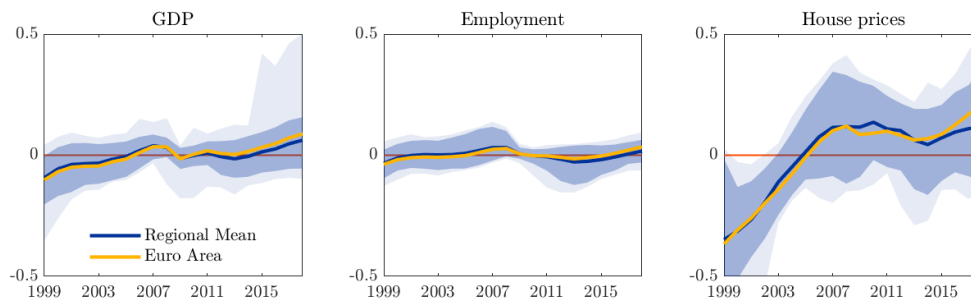
Our regional dataset has annual frequency and spans the period from 1999 to 2018. It covers 106 regions of eight euro area countries (Belgium, Germany, Spain, France, Ireland, Italy, the Netherlands and Portugal) accounting for around 90 percent of euro area gross domestic product (GDP). We consider NUTS2 regions for Belgium, Spain, France, Ireland, Italy, the Netherlands, and Portugal and NUTS1 regions for Germany.⁷ Regional data on real GDP, real gross value added (GVA) for the construction and manufacturing sectors, real compensation of employees, as well as employment and population are obtained from the ARDECO database, which is maintained and updated by the Joint Research Centre of the European Commission. Moreover, we collect regional data on homeownership rate (share of households living in owner-occupied housing) and population density (persons per square kilometre) from Eurostat.⁸

Crucial for our analysis, house price indices, loan-to-value (LTV) ratios and the share of variable-rate mortgages at the regional level are derived via loan-level data provided by the European DataWarehouse (ED). The ED is a securitisation repository that collects, validates and makes available detailed, standardised and asset class-specific loan-level data for asset-backed securities (ABS) transactions. For our purposes, only residential mortgage-backed securities

⁷Very small regions (Ceuta and Melilla in Spain; Madeira and Azores in Portugal; overseas departments in France) are excluded. In line with the Italian Constitution, we consider the provinces of Trentino and Alto Adige/Südtirol a single political region, although they are two different NUTS2 areas. Therefore, the variables available for these two provinces at the NUTS2 level are aggregated or averaged at the regional level. We consider NUTS1-level regions for Germany in order to have a number of regions (16) similar to that of France (22), Italy (20), and Spain (17). The use of NUTS2 regions for Germany (which are 38) would have led this country to be over-represented in the aggregate estimates. As regards the other countries, we consider 11 regions for Belgium, 12 for the Netherlands, 5 for Portugal and 3 for Ireland.

⁸Regional data on homeownership rates are available from Eurostat only for a few, distant years at irregular intervals. Hence, we only consider 2011 data, which broadly corresponds to the middle of our sample.

Figure 2: Key variables in our dataset



Notes: Demeaned log variables. The yellow line depicts euro area aggregate data, while the dark blue line the cross-regional mean of the variable. The dark (light) blue shading indicates 10th and 90th (1st and 99th) percentiles of the regional distribution.

(RMBS) transactions are used. Note that ED data dictate our choice on the country coverage and the level of geographical disaggregation. First, within the euro area, ED data are available only for the countries included in our sample. Second, NUTS3-level geographical units (NUTS2 in Germany) would not ensure that the sample is sufficiently representative, as only a relatively small number of loans may be recorded at such granular level in some regions. For more details on how ED data are processed, see Appendix A.

Our key variables (i.e. GDP, employment and house prices) are transformed as follows. We consider real GDP and employment in per capita terms. We do this to make our estimates comparable to other empirical studies and consistent with assessments based on standard DSGE models, where the population is typically normalised to unity and economic aggregates are thus in per capita terms. Moreover, we take the log of GDP, employment and house price indices. Finally, we demean these variables in order to remove region-specific fixed effects in the data.⁹

A closer look at our regional dataset confirms its suitability to investigate the role of the housing market in the euro area. Figure 2 shows indeed that the cross-region mean of each variable, computed across the 106 regions in the eight countries in our sample, tracks well the corresponding euro area aggregate over time. Moreover, the cross-region dispersion of house prices is significantly higher than that for the other variables, confirming that the housing market is indeed a regional phenomenon. Lastly, the dispersion across regions, especially between the 1st and 99th percentiles, seems to widen in the second half of the sample, possibly reflecting the impact of the Global Financial Crisis and the Sovereign Debt Crisis. This pattern is already

⁹Note that our methodology based on mean-group estimation deals with further potential fixed effects in the transmission of monetary policy by estimating region-specific parameters.

Table 1: Summary statistics of the key variables

		Mean	Median	Minimum	Maximum	Standard deviation
GDP	regional	29467	28052	14181	65785	9267
	national	32019	33480	17474	45529	8872
Employment	regional	43.63	43.00	31.24	65.17	6.84
	national	45.10	43.19	40.95	52.38	4.41
House prices	regional	146.01	145.84	97.68	193.39	23.23
	national	149.35	153.18	114.76	180.03	21.87

Notes: Real GDP and employment are in per capita terms. National GDP and employment are calculated as cross-regional aggregate of all regions within a country. National house prices are given by GDP-weighted cross-regional means of all regions within a country.

documented in [Hauptmeier, Holm-Hadulla and Nikalixi \(2020\)](#) for GDP, while we observe similar dynamics for house prices.

Table 1 shows descriptive statistics on the cross-region and cross-country distributions of our variables over the sample period. For all variables, we find a higher degree of heterogeneity on the regional vis-à-vis the national level. On average over the entire period, GDP per capita ranges at the national level between 17,474 EUR in Portugal and 45,529 EUR in Ireland, while the regional minimum is 14,181 EUR in Norte (Portugal) and the maximum is 65,785 EUR in Région de Bruxelles-Capitale (Belgium). Regarding house prices, we also find a large cross-regional dispersion with a minimum house price index of 97.7 in Sachsen-Anhalt (Germany) and a maximum of 193.4 in País Vasco (Spain). The national house price indices range between 114.8 in Germany and 180.0 in Spain. Comparing these statistics over three different time periods (1999-2008, 2009-2012 and 2013-2018) reveals differences in the dispersion of the variables over time (see Table B.1 in Appendix B). While all variables show the lowest regional dispersion before the Global Financial Crisis, the standard deviation of GDP and employment is the largest between 2013 and 2018. In contrast, the standard deviation of regional house prices is the largest during the Global Financial Crisis and decreases thereafter.

2.2 Monetary policy shocks

We identify monetary policy shocks by means of high-frequency changes in OIS interest rates and stock prices around the ECB’s monetary policy decisions. A narrow time window around monetary policy events allows us to measure exogenous changes in the monetary policy stance (i.e. monetary policy surprises). For this purpose, we use the Euro Area Monetary Policy

Database (EA-MPD) by [Altavilla et al. \(2019b\)](#) containing high-frequency movements in OIS interest rates and EURO STOXX 50 around the ECB’s monetary policy announcements. The EA-MPD differentiates between three time windows: the publication of the press release, the press conference, and the union of these two windows, referred to as “monetary policy event”. In our analysis, we consider the window of the monetary policy event as a reference period ([Enders, Hünnekes and Müller, 2019](#), [Holm-Hadulla and Thürwächter, 2021](#)).¹⁰

2.2.1 Pros and cons of event-based monetary policy surprises

The use of an event-based identification of genuine monetary policy shocks comes with some caveats, but also clear advantages. On the one hand, as any event-based identification, this strategy is successful insofar as it captures all the relevant monetary policy events. During speeches, interviews and other public occasions, monetary authorities may partly signal policy shifts before the monetary policy events (i.e. press releases and conferences). The measured monetary policy surprises in our dataset ultimately reflect the changes in the risk-free yield curve and stock prices within a narrow event window due to deviations of the actual announcements from market expectations ([Rostagno et al., 2021](#)). Hence, this event-based identification strategy may over- or under-estimate monetary policy surprises taking shape in a period stretching beyond the event window if, for example, the relevant events are already “discounted” by market participants or if there are delayed market adjustments to the policy announcements.

On the other hand, this identification strategy is insulated from other problems afflicting conventional approaches ([Ramey, 2016](#)). Unlike empirical approaches relying on observed interest rates, monetary policy surprises identified from high-frequency event-studies are exogenous to economic conditions, which are already part of the market participants’ information set at the time of the announcement. Further, unlike DSGE models or structural VAR models, the theoretical assumptions needed to capture monetary policy shocks in high-frequency event-studies are minimal. This comes with important benefits. First, the risk of estimation issues due to model misspecification is low. Second, any possible time dependence in the reaction function used by monetary authorities is already taken into account, at least to the extent that market

¹⁰In our sample, Governing Council meetings took place in regular intervals of six weeks. At 13 : 45 CET a press release provides the policy decision and at 14 : 30 CET, the president explains the rationale of the decision in a press conference in more detail. The change of the financial market variables due to the monetary policy event is given as the change of the median value in the pre-release window (13 : 25 CET to 13 : 35 CET) and the median value in the post-conference window (15 : 40 CET to 15 : 50 CET).

participants have incorporated this variation when interpreting monetary policy announcements.

The identification of our monetary policy shocks poses two main challenges, namely the selection of “genuine” shocks and the aggregation of surprises from an event-based frequency to an annual frequency. We explain how we address both challenges in the next two subsections.

2.2.2 Identification of genuine monetary policy shocks

OIS interest rate changes around monetary policy events do not only reflect how market participants assess whether and how the ECB adjusts its policy instruments, but also their perception of potential superior information on the state and prospects of the economy the ECB might have. For instance, if the monetary authority announces an interest rate hike and market participants see it as a true monetary policy tightening, this will be accompanied by a negative stock price reaction. This is a so-called genuine monetary policy shock. Conversely, if market participants perceive this increase as a sign of buoyant economic prospects, this will have a positive impact on the stock price. This is a so-called central bank information shock (see [Jarociński and Karadi, 2020](#)).

We disentangle (genuine) monetary policy shocks and (central bank) information shocks by imposing sign and zero restrictions on high-frequency changes in OIS interest rates and stock prices. In line with [Jarociński and Karadi \(2020\)](#), high-frequency OIS interest rate changes are assumed to be uncorrelated with their own past values and with current and past values of other variables, since they are measured in a narrow time window around monetary policy announcements. We extend the same modelling assumption to stock price movements, as these are measured over the same narrow window.¹¹ Hence, we can use the series of OIS interest rate and stock price changes as reduced-form residuals and impose sign restrictions directly on their covariance matrix to identify monetary policy and information shocks.¹²

To capture the movements across the term structure, we use OIS interest rate changes at different points of the yield curve. We focus on the 3-month and 10-year maturities to ensure sufficient liquidity in the underlying instruments. Our focus on distant maturities (3 months and

¹¹This assumption differs from other approaches in the literature, who measure other financial variables over a longer time span (e.g. a month) and thus cannot rule out their endogenous reaction to high-frequency interest rate changes. These studies typically impose further structure on the model to extract the shock from co-movements between interest rate changes and other financial variables ([Jarociński and Karadi, 2020](#)).

¹²We implicitly use flat priors on the covariance matrix of our reduced-form residuals. When comparing methods, [Jarociński and Karadi \(2020\)](#) argue that their results with a Bayesian approach are similar to the frequentist results by [Gertler and Karadi \(2015\)](#).

10 years) is also justified by the fact that they are less prone to be affected by both conventional and unconventional monetary policy measures, compared with intermediate maturities.

Our identification strategy allows us to disentangle conventional and unconventional monetary policy shocks. We impose the following sign and zero restrictions.

	CMP_d	UMP_d	INF_d
$\Delta OIS3M_d$	+	0	+
$\Delta OIS10Y_d$	0	+	+
ΔSP_d	-	-	+

In the table above, $\Delta OIS3M_d$, $\Delta OIS10Y_d$ and ΔSP_d denote the change in the 3-month OIS interest rate, the 10-year OIS interest rate and the EURO STOXX 50 index at event date d , while CMP_d , UMP_d and INF_d refer to conventional monetary policy, unconventional monetary policy and information shocks, respectively. Finally, we compute total monetary policy shocks as the sum of conventional and unconventional monetary policy shocks. Our restrictions imply that a positive conventional (unconventional) monetary policy shock induces an increase in the 3-month (10-year) OIS interest rate, a decrease in the stock price and no movement in the 10-year (3-month) OIS interest rate, while a positive information shock is associated with an increase in all variables.¹³

Our identification strategy warrants an explanation of how to interpret conventional and unconventional monetary policy shocks. On the one hand, the reaction of OIS interest rates at the short end of the yield curve should uniquely reflect conventional monetary policy measures up to 2008. Thereafter, as standard measures stopped affecting the short end of the term structure due to an effective lower bound on risk-free rates, the ECB sought to enhance the conventional transmission of its monetary policy through non-standard measures, such as fixed-rate tenders with full allotment, forward guidance, and negative interest rate policy (see, for example, the discussion in [Gambacorta, Hofmann and Peersman, 2014](#), and [Falagiarda and Reitz, 2015](#)). On the other hand, the reaction of long-term OIS interest rates should primarily encompass the effects of several unconventional measures implemented since 2011, such as asset purchase programmes, longer-term refinancing operations and some types of forward guidance. Hence, our approach can capture the impact of monetary policy through its conventional and unconventional *transmission*

¹³Our main findings are largely unchanged if TMP_d is estimated directly by imposing a negative co-movement between the sum of the 3-month and the 10-year OIS interest rate changes and stock price changes, with information shocks inducing a positive co-movement between these two variables.

mechanisms, rather than the impact of the conventional and unconventional *measures per se*.

2.2.3 Temporal aggregation of event-based monetary policy shocks

To account for the annual frequency of our regional dataset, we apply a weighting procedure. Specifically, we assign theoretical weights to monetary policy shocks depending on the distance of the day of the event from the first day of the reference year. Formally, to calculate a monetary policy shock for year t , we consider all monetary policy shocks in year t and $t - 1$ and give a higher weight to shocks at the beginning of year t and at the end of year $t - 1$ compared with shocks at the end of year t and the beginning of year $t - 1$, that is:

$$\begin{aligned}
 w_{d,t} &= 1 - \left| \frac{d_t - d_t^1}{365} \right| \\
 W_{d,t} &= \frac{w_{d,t}}{\sum_{i=1}^N w_{i,t}} \\
 MP_t &= N \sum_{d=1}^N W_{d,t} MP_d,
 \end{aligned} \tag{1}$$

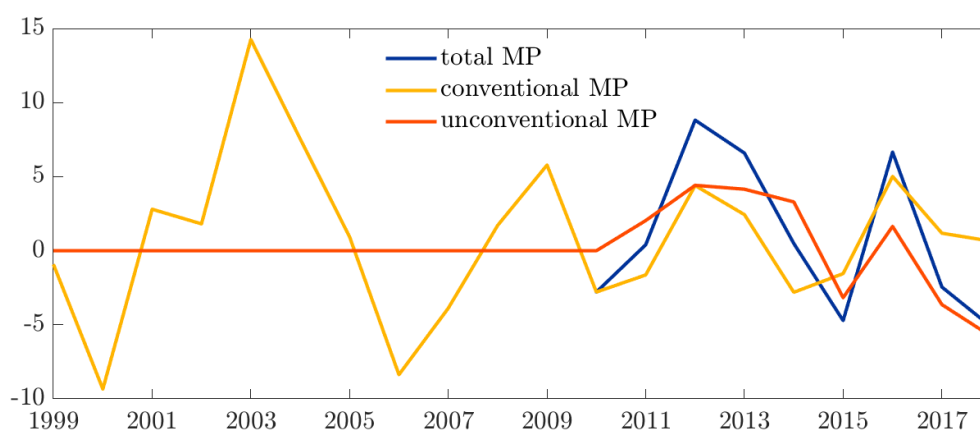
where $w_{d,t}$ denotes the theoretical weight attached to the monetary policy event on day d in year t or $t - 1$ given the reference year t , $W_{d,t}$ its normalised value such that $\sum_{d=1}^N W_{d,t} = 1$, N the number of monetary policy events in year t and $t - 1$, d_t^1 the first day of year t and MP_t our final measure of (total, conventional or unconventional) monetary policy shock in year t .

Intuitively, Equation (1) aligns the monetary policy surprises identified at high frequency with the concomitant economic developments, then building consistent low-frequency monetary policy shocks. To give an example, consider a monetary policy surprise in the fourth quarter of year $t - 1$, such as the monetary tightening observed on 3 December 2015, reflecting financial markets' disappointment about the increase of the size of the ECB's asset purchase programme ([The Financial Times, 2015b](#)). To the extent that this monetary policy shock has a relatively larger impact on the contemporaneous growth rates of economic variables, this impact will be more visible in year t , i.e. 2016, than in year $t - 1$, i.e. 2015.¹⁴

Figure 3 shows the implied time series for our total, conventional and unconventional monetary policy shocks. Looking at the total monetary policy shocks, monetary tightening

¹⁴This follows from a simple accounting exercise, which implies that 25 and 75 percent of the quarterly growth rate of any economic variable in the fourth quarter of year $t - 1$ contribute to its annual growth rates in years $t - 1$ and t , respectively. Our theoretical weights, calculated at daily frequency, are largely consistent with these quarterly weights.

Figure 3: Monetary policy surprises



Notes: The chart shows the time series of the (genuine) monetary policy shocks at annual frequency resulting from the weighting procedure.

starting in 2008 to curb rising inflation is followed by monetary accommodation in 2010 and 2011 to fight the Global Financial Crisis and then again in 2014 and 2015 as a reaction to the Sovereign Debt Crisis. As of 2015, when the large-scale APP are launched, the main impulse from monetary accommodation switches from the conventional to the unconventional transmission mechanism.¹⁵

3 Methodology

This section presents the theoretical framework and the empirical strategy adopted. First, we outline the channels of monetary policy that we aim to capture in our empirical assessment. Then, we describe our benchmark SPVAR model and discuss how we disentangle the channels of interest. We finally present a simple econometric framework to link the estimated monetary policy impact to housing-related economic and institutional characteristics at the regional level.

¹⁵Due to data availability in the EA-MPD, where monetary policy surprises for the 10-year tenure are recorded as of 7 July 2011, unconventional monetary policy shocks only start in 2011. Although a non-standard monetary policy tool, such as the Securities Markets Programme (SMP), had already been activated for a year, we believe that this should not significantly affect our results. Indeed, the objective of the SMP was “to ensure depth and liquidity” and “restore an appropriate monetary policy transmission”, thus clearly falling under our definition of a conventional transmission mechanism.

3.1 The transmission of monetary policy through the housing channel

Monetary policy propagates to the real economy through several direct and indirect channels. For illustrative purposes, we consider a closed economy with households, firms, financial intermediaries and a central bank. This framework is consistent with a broad class of general equilibrium models used to analyse the role of the housing market in the transmission of monetary policy, including models with collateral constraints (Iacoviello, 2005; Guerrieri and Iacoviello, 2017), non-rational expectations (Adam and Woodford, 2021) and household heterogeneity (Kaplan, Moll and Violante, 2018).

Let us assume that the central bank engenders an expansionary monetary policy shock, i.e. risk-free rates decline more than expected. This directly improves supply conditions on the credit market, inducing financial intermediaries to expand their lending to the private sector. This in turn supports households and firms' current spending decisions, thus stimulating aggregate demand across the consumption, housing, capital and labour markets. At the same time, as the central bank announces the monetary easing, private sector agents adjust their expectations to internalise the improved future economic prospects. Positive expectations exert upward pressures on financial and non-financial asset prices. In turn, house price increases boost homeowners' wealth, thus increasing private consumption. As house prices grow compared with construction costs, favourable Tobin's Q effects make housing investment more attractive. To the extent that housing is posted as collateral, an increase in house prices relaxes borrowing constraints and allows homeowners to smooth consumption over the life cycle, further boosting aggregate demand. Overall, monetary accommodation expands the resources available for the private sector, generating positive income and wealth effects for both households and firms and supporting activity.

In a first step, our SPVAR analysis identifies a subset of the various general equilibrium effects of monetary policy at play. Specifically, we consider household income sources, especially housing wealth, proxied by house prices and capturing the housing channel, and labour income, proxied by employment and capturing the employment channel. Our focus on the comparison between the housing and the employment channels is motivated by the growing evidence, both in the theoretical (Kaplan, Moll and Violante, 2018) and the empirical (Hauptmeier, Holm-Hadulla and Nikalixi, 2020; Lenza and Slacalek, 2021) literature, pointing to a larger role for labour income relative to housing wealth in transmitting monetary policy to the real economy.

Given the scope of our analysis and the limited availability of regional data on other variables, the residual effect of monetary policy includes the net effect of several other channels identified in the literature, such as intertemporal substitution, net interest rate exposure, net nominal balance sheet positions, stock market wealth (Slacalek, Tristani and Violante, 2020), as well as other income sources supporting corporate, public and net foreign demand.

In a second step, our empirical analysis lays out an anatomy of the impact of monetary policy on economic activity across regions. By means of formal econometric regressions, we dissect the regional impact of monetary policy along several dimensions related to the housing market, such as labour income, housing wealth, the construction share of total value added and the share of variable-rate mortgages. The mean-group estimation used in our first step becomes instrumental to this analysis, as it provides us with region-specific impacts of monetary policy. This approach is different from subsample analysis or quantile (auto)regressions (Koenker and Hallock, 2001; Koenker and Xiao, 2006), as it fully exploits the heterogeneity in the data and does not impose additional structure.

3.2 A Structural Panel VAR for the housing channel

We first consider the following reduced-form VAR model in companion form:

$$Y_{i,t} = B_i Y_{i,t-1} + C_i X_t + u_{i,t}, \quad (2)$$

where $Y_{i,t}$ is a vector of unit-specific endogenous variables for region i at time $t = 1, \dots, T$, X_t a vector of common exogenous variables (including a constant and a trend) and $u_{i,t}$ a serially uncorrelated vector of errors with zero mean and a constant positive definite variance-covariance matrix. Matrices B_i and C_i denote reduced-form parameters.

The equivalent representation in structural form is given by:

$$A_i Y_{i,t} = B_i Y_{i,t-1} + \Gamma_i X_t + \Delta_i \epsilon_{i,t}, \quad (3)$$

where A_i , B_i , Γ_i and Δ_i are matrices of structural parameters, which are related to the reduced-

form parameters as follows:

$$\begin{aligned}
A_i^{-1}B_i &= B_i \\
A_i^{-1}\Gamma_i &= C_i \\
A_i^{-1}\Delta_i\epsilon_{i,t} &= u_{i,t}.
\end{aligned}
\tag{4}$$

In our analysis, we focus on the effect of common exogenous variables Γ_i and the contemporaneous relationships among endogenous variables A_i , while we do not investigate the impact of region-specific structural shocks implied by Δ_i .

The benchmark SPVAR model includes three endogenous variables $Y_{i,t} = [\text{GDP}_{i,t}, \text{Employment}_{i,t}, \text{House prices}_{i,t}]$ where $\text{GDP}_{i,t}$ is measured as real GDP divided by population, $\text{Employment}_{i,t}$ as number of employees divided by population and $\text{House prices}_{i,t}$ as average house price index. We include as exogenous variable X_t the relevant measure of monetary policy shock, either total monetary policy $X_t = \text{TMP}_t$ or, simultaneously, conventional and unconventional shocks $X_t = [\text{CMP}_t, \text{UMP}_t]$. Considering similar regional data, [Beetsma, Cimadomo and Van Spronsen \(2021\)](#) argue that common, national and regional factors all play an important role in explaining regional business cycles. In particular, they find that one common (euro area) factor, mostly related to monetary policy, one national factor and one idiosyncratic factor can account for regional dynamics. To the extent that the lagged endogenous variables net out the impact of country- and region-specific developments, our benchmark specification appropriately disentangles the impact of common (conventional and unconventional) monetary policy shocks. As a robustness check, we also include other explanatory variables, focusing on the part of cross-sectional averages unexplained by our total monetary policy shocks, and find broadly similar results (Section 6).

Note that the vector of reduced-form coefficients C_i represents the overall impact of a monetary policy shock on GDP, employment and house prices. To disentangle the contribution of the housing and employment channels, we need to identify the structural coefficients in A_i and Γ_i denoting the contemporaneous relationships among endogenous variables. Once we estimate the reduced-form parameters with standard OLS, we use the scoring algorithm ([Amisano and](#)

Giannini, 1997) to impose the following identifying restrictions:

$$A_i = \begin{bmatrix} 1 & \alpha_{i,12} & \alpha_{i,13} \\ 0 & 1 & \alpha_{i,23} \\ 0 & 0 & 1 \end{bmatrix} \quad (5)$$

and

$$\Gamma_i = \begin{bmatrix} \gamma_{i,1} \\ \gamma_{i,2} \\ \gamma_{i,3} \end{bmatrix}, \quad (6)$$

which imply a recursive structure, with the first variable as the most endogenous variable. Using Equation (4), we obtain the following vector of structural coefficients:

$$\begin{aligned} C_i = A_i^{-1}\Gamma_i &= \begin{bmatrix} 1 & -\alpha_{i,12} & -\alpha_{i,13} + \alpha_{i,12}\alpha_{i,23} \\ 0 & 1 & -\alpha_{i,23} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \gamma_{i,1} \\ \gamma_{i,2} \\ \gamma_{i,3} \end{bmatrix} \\ &= \begin{bmatrix} \gamma_{i,1} - \alpha_{i,12}\gamma_{i,2} - (\alpha_{i,13} + \alpha_{i,12}\alpha_{i,23})\gamma_{i,3} \\ \gamma_{i,2} - \alpha_{i,23}\gamma_{i,3} \\ \gamma_{i,3} \end{bmatrix}, \end{aligned} \quad (7)$$

which allows us to disentangle the housing and employment channels from other direct and indirect channels. Specifically, looking at the impact of monetary policy on GDP in the first element of C_i , the three terms reveal the contribution from unidentified direct and indirect channels, $\gamma_{i,1}$, the contribution from the employment channel, $-\alpha_{i,12}\gamma_{i,2}$, and the contribution from the housing channel, $-(\alpha_{i,13} + \alpha_{i,12}\alpha_{i,23})\gamma_{i,3}$.

Note that our identification strategy only aims to disentangle the contribution of the employment and housing channels to the transmission of monetary policy to economic activity. As such, our identification affects neither the interpretation nor the estimated impact of monetary policy shocks. In our benchmark specification, we focus on a Cholesky structure among endogenous variables, with GDP ordered as the most endogenous variable and house prices as the most exogenous one. In this way, our estimates account for all the potential contemporaneous effects of the housing and the employment channels on the transmission of monetary policy to the business cycle. As the contemporaneous contributions tend to assign a larger weight to the

less reactive (or more exogenous) variables, the estimates from our benchmark model should be considered as an upper bound of the contribution of the employment and the housing channels.¹⁶

We estimate our SPVAR model with one lag for each region i and apply the mean-group (MG) estimation procedure proposed by [Pesaran and Smith \(1995\)](#) to obtain an average response across regions. Our choice of the number of lags is standard considering the frequency of our data, and ensures the use of a consistent model across regions.¹⁷

3.3 Analysing the regional heterogeneity of housing markets

In a second step, we provide an anatomy of the diverse impact of monetary policy across euro area regions. More specifically, it is formally tested which housing-related economic and institutional characteristics contribute the most to explain the regional impact of monetary policy. To that purpose, we estimate the following regression:

$$y_i = \alpha + \sum_{n=1}^N \beta_{i,n} x_{i,n} + \sum_{m=1}^M \gamma_{i,m} z_{i,m} + \epsilon_i, \quad (8)$$

where the dependent variable y_i represents the region-specific long-term (5-year) cumulative monetary policy impact as estimated via the mean-group procedure, α , β_i and γ_i are parameters, $x_{i,n}$ corresponds to the n th explanatory variable ($n = 1, \dots, N$), $z_{i,m}$ corresponds to the m th demographic, country and country-group control variable ($m = 1, \dots, M$) and ϵ is an error term. The set of regional economic and institutional explanatory variables $x_{i,n}$ includes labour income (measured as compensation per employee), housing wealth (homeownership rate times average house price level), construction and manufacturing shares of total value added, the share of variable-rate mortgages and a measure of lending activity. The demographic controls include total employment and population density at the regional level. Consistently with the dependent variable, which reflects the average estimated impact of monetary policy, all regressors are averaged over the sample period, except for the homeownership rate, only available for 2011.

¹⁶This is confirmed when we invert the ordering of the variables (see Section 6).

¹⁷Assuming two lags, the SPVAR model produces largely comparable results in qualitatively and quantitatively terms. However, the impulse response functions become less smooth and more volatile compared with our benchmark specification, hence impairing the interpretation of our findings.

4 The housing channel of monetary policy

Based on the mean-group estimates of our SPVAR model, Figure 4 shows the responses of GDP, employment and house prices to an expansionary monetary policy shock, standardised to its mean absolute value.¹⁸ We differentiate between responses to a total monetary policy shock (first row), conventional and unconventional monetary policy shocks (second row). As suggested by economic theory, GDP, employment, and house prices increase after a monetary policy easing shock, with the statistical significance at least at the 68 percent level. However, for house prices, the response on impact is not statistically different from zero. On average, total monetary policy shocks lead to an increase in (detrended) GDP and employment levels by 0.7 and 0.4 percent on impact, respectively, gradually declining over time. House prices exhibit instead a hump-shaped reaction, with a positive peak response of 0.15 percent after three years before fading out over the remainder of the horizon.¹⁹

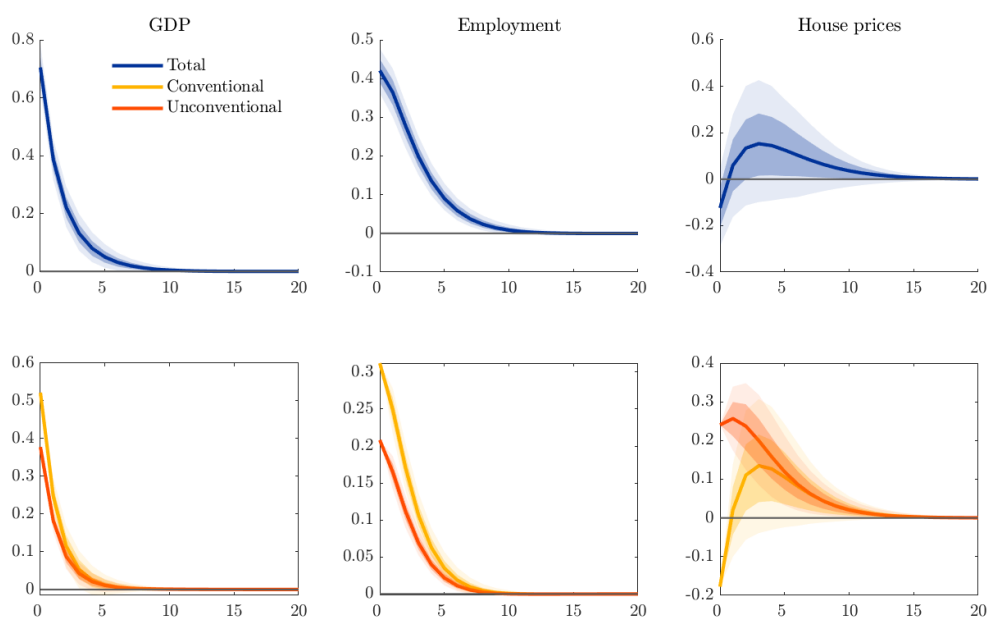
The responses to conventional and unconventional monetary policy shocks are significantly different for all the variables. For GDP and employment, the effect of conventional monetary policy shocks is larger compared to unconventional shocks. For house prices the opposite occurs, with the peak response to unconventional shocks being around twice the response to conventional shocks (almost 0.3 after 1 year versus slightly more than 0.1 percent after three years, respectively). The impact of a conventional monetary policy shock on house prices reported in the literature generally varies between 0 and 0.6 percent, with our estimate being close to the lower end of this range (see, e.g., [Musso, Neri and Stracca, 2011](#); [Nocera and Roma, 2017](#); [Zhu, Betzinger and Sebastian, 2017](#); [Huber and Punzi, 2020](#); [Hülsewig and Rottmann, 2021](#)).

By estimating the contemporaneous responses of our endogenous variables to a monetary policy shock on GDP as described in Equation (7), it is possible to examine the role of the housing and the employment channels. Figure 5 compares the share of the GDP response to a total, conventional and unconventional shock explained by house prices and employment at the 5-year horizon. With a share of less than 4 percent, the housing channel plays only a minor role in the transmission of a total and conventional monetary policy shock. In contrast, around 16 percent of the explained part in the transmission of unconventional monetary policy shocks to

¹⁸We choose to set the size of the monetary policy shocks to their mean absolute value since, although their mean value is not necessarily zero over the sample, this metric is a better gauge of their average estimated impact.

¹⁹[Corsetti, Duarte and Mann \(2020\)](#) find a smaller difference in the impact of monetary policy on GDP and house prices (with the long-term impact on GDP being almost twice that on house prices), while a similar impact is documented in [Rosenberg \(2020\)](#).

Figure 4: Impulse response functions to an expansionary monetary policy shock



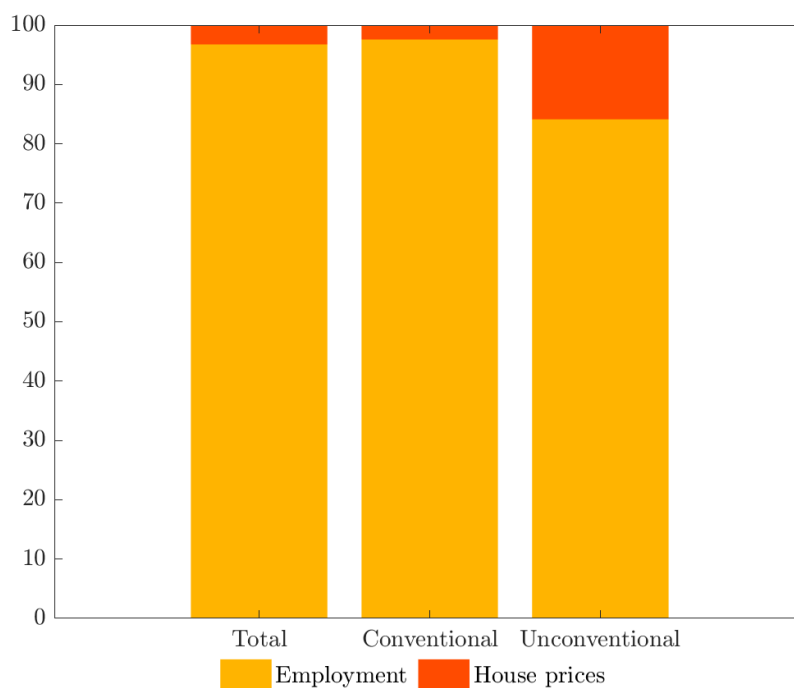
Notes: The size of the monetary policy shock is calculated as its mean absolute value, which is 5.2 basis points for the total, 4.6 basis points for the conventional and 1.7 basis points for the unconventional monetary policy shock. The y-axis reports the percentage change in (detrended) levels of each variable over the considered horizon. The x-axis reports the years. Solid lines denote point estimates and light (dark) shaded areas 95 percent (68 percent) confidence bands.

economic activity can be attributed to the housing channel.

A forecast error variance decomposition provides insight regarding the contribution of a monetary policy shock to fluctuations in GDP, employment and house prices at the 5-year horizon. As shown in Figure 6, total monetary policy shocks explain about 7 percent of the variation in both GDP and employment. When conventional and unconventional monetary policy shocks are included separately, conventional shocks account for about 4 percent of the variation in GDP and employment, while unconventional monetary policy shocks can explain 15 percent and 12 percent of fluctuations in GDP and employment, respectively. However, monetary policy shocks explain a relatively small share of house price fluctuations. Approximately 0.1 percent of the variations in house prices can be attributed to a total and conventional monetary policy shock and 2.7 percent to an unconventional shock.

These results are confirmed by a historical decomposition of GDP and house prices. As shown in Figure 7, contractionary monetary policy shocks played an important role in the development of GDP between the years 2003 and 2005 as well as between 2012 and 2014. By

Figure 5: Importance of housing and employment channels

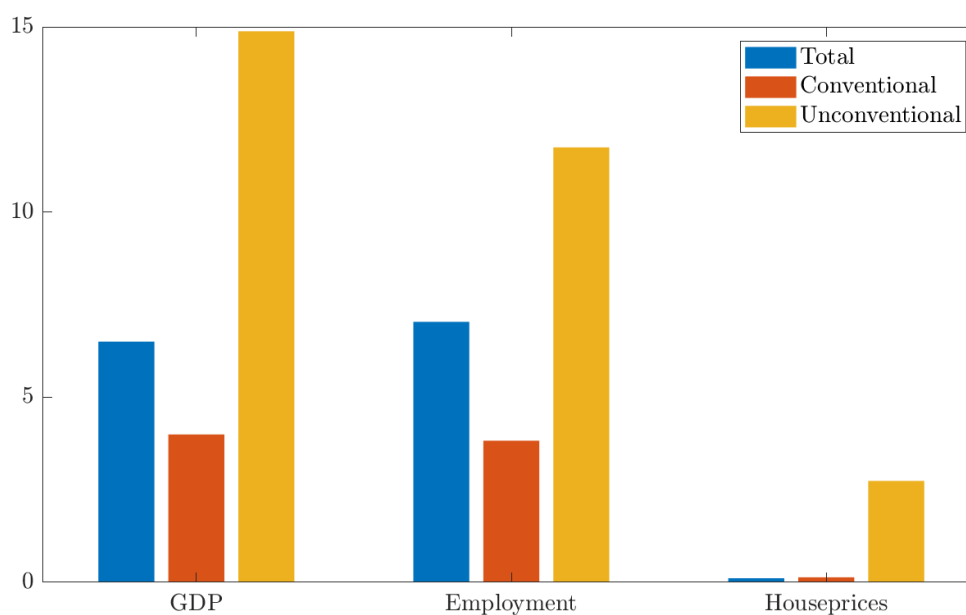


Notes: The y-axis shows the share of the contribution of employment and house prices out of the sum of their contributions to the GDP response to a total, conventional and unconventional monetary policy shock.

contrast, expansionary monetary policy shocks – in particular unconventional ones – are key factors supporting economic activity in the latter part of the sample. In particular, out of the total increase by 7.7 percent in the (detrended) level of (cross-regional average) GDP between 2013 and 2018, unconventional monetary policy contributed to 39 percent and conventional monetary policy only to 3 percent. House prices are instead affected only to a small extent by monetary policy throughout the sample period and their dynamics are mostly explained by other (non-identified) factors. However, monetary policy plays a larger role in the later years of the sample. Out of the total increase by 5.2 percent in the (detrended) level of (cross-regional average) house prices between 2013 and 2018, unconventional monetary policy contributed to 41 percent and conventional monetary policy induced a negative contribution by about 3 percent.

Overall, our results are in line with the small multipliers of house price changes on consumption typically found in the empirical macroeconomic literature. However, due to our use of a broad measure of economic activity and, hence, the presence of several other channels, our results hint to a less pronounced role for house prices in the transmission of monetary policy

Figure 6: Forecast error variance decomposition



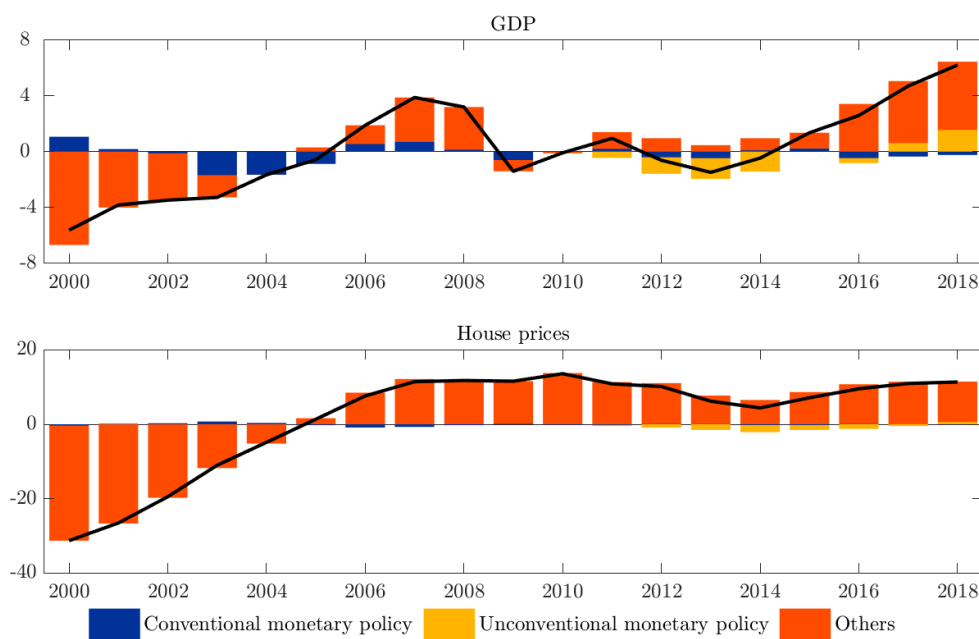
Notes: The y-axis reports the contribution of a total, conventional and unconventional monetary policy shock to variations in GDP, employment and house prices at the 5-year horizon.

compared with other studies. [Elbourne \(2008\)](#) and [Ozkan et al. \(2017\)](#) state that 12-15 percent for the UK and 20 percent for the US of the drop in aggregate consumption after a contractionary interest rate shock can be attributed to changes in house prices. Moreover, [Aladangady \(2017\)](#) and [Garbinti et al. \(2020\)](#) estimate a consumption multiplier of about 5 percent in the US and between 1 and 4 percent across euro area countries, to changes in home values. Both studies report larger responses for households with little wealth, suggesting that looser borrowing constraints are a primary driver of the marginal propensity to consume (MPC) out of housing wealth.

5 The regional heterogeneity of housing markets: An anatomy

A major advantage of the chosen estimation technique applied to our dataset is that it allows us to analyse the heterogeneous response of economic activity and house prices to monetary policy across regions and to link it to several economic and institutional features. To assess the role of the housing channel relative to other relevant channels, we explore how the effectiveness of monetary

Figure 7: Historical decomposition of GDP and house prices



Notes: The y-axis reports the (detrended) level of (cross-regional average) GDP (upper chart) and house prices (lower chart) as well as the contributions of conventional and unconventional monetary policy shocks and other (unidentified) factors.

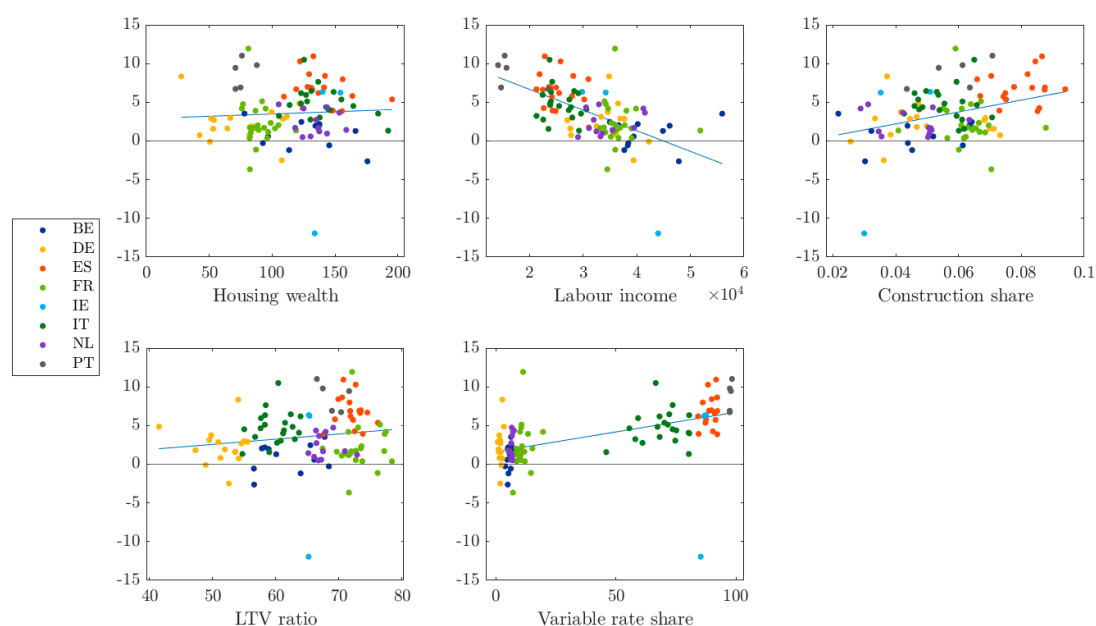
policy relates to different long-term characteristics across regions, including households' income levels (labour income and housing wealth), the production structure of the economy (in terms of construction and the manufacturing share of total value added),²⁰ and other key housing-related economic and institutional features, such as households' tenure status (homeownership rate), indebtedness (LTV ratio) and type of mortgages (share of variable-rate mortgages). The relationship between some of these factors (averaged over the sample period) and the estimated monetary policy impact is depicted in Figure 8. One can notice that the transmission of monetary policy to the economy is particularly heterogeneous across euro area regions. This unequal geography of monetary policy transcends the cross-country perspective, as the range of monetary policy effects on GDP spanned by dots of the same colour is wide.²¹

A potentially important driver of the heterogeneous impact of monetary policy across euro area regions is households' income, most notably housing wealth and labour income. A significant

²⁰In fact, sectors producing durable goods are key in the transmission of monetary policy via the user-cost-of-capital and interest-rate channels.

²¹We focus on the long-term (5-year) impact of monetary policy on real GDP. Note that using a shorter (1-year) horizon would yield qualitatively similar results.

Figure 8: Monetary policy impact on real GDP and regional factors



Notes: The y-axis reports the cumulative percentage change in (detrended) levels for GDP 5 years after an accommodative monetary policy shock. The x-axis reports the regional housing wealth (thousand euros per household), labour income (euros per employee, at 2015 prices), construction share (percent of value added), LTV ratio (percent), share of variable-rate loans (percent of total loans). Each dot represents a region.

relationship between the monetary policy impact and these two variables would allow us to infer whether an easing of monetary policy exacerbates or mitigates regional income inequality. As shown by the weakly positive correlation in the scatter plot in the upper left panel of Figure 8, monetary policy appears to be somewhat more effective at stimulating economic activity in regions with higher housing wealth.²² At the same time, monetary policy seems to be more effective in lower-income regions, given the negative correlation shown in the second panel of Figure 8. These results indicate that the ultimate impact of monetary policy on income inequality masks countervailing forces. On the one hand, a loosening of monetary policy may reduce regional inequality by stimulating activity more in regions at the bottom of the labour income distribution. On the other hand, it may also contribute to a larger regional dispersion by supporting activity in regions at the top of the housing wealth distribution. However, housing wealth reflects both the diffusion of wealth across the population (measured by the homeownership rate) as well as the

²²This relationship is stronger when considering the effect of monetary policy on house prices, as shown in Figure B.1 in Appendix B.

concentration of wealth among owner-occupying households (measured by average house prices). In our econometric analysis below, we formally test the relative importance of each driver of housing wealth.

Moreover, we investigate the relationship between the impact of monetary policy and three further dimensions of the housing market. First, we consider the production structure of the economy and explore how the region-specific construction intensity, measured by the share of construction value added in total value added, affects the effectiveness of monetary policy. As shown in Figure 8, the share of the construction sector relative to the overall economy is positively correlated with the impact of monetary policy on real economic activity.²³

Second, we investigate how households' indebtedness relates to the impact of monetary policy. Figure 8 suggests that the level of indebtedness, measured by the LTV ratio, is only weakly correlated with the impact of monetary policy across euro area regions.²⁴

Third, the diverse impact of monetary policy across regions can be given by heterogeneous mortgage market characteristics, such as the share of variable-rate mortgages. In countries where most mortgages have adjustable rates, policy-induced changes in interest rates have an almost immediate effect on household cash flows. As illustrated in the last panel of Figure 8, the impact of monetary policy on GDP is indeed larger in regions with a higher share of variable-rate loans. These regions are concentrated in Italy, Spain, Ireland and Portugal. This result is in line with the model simulations by [Calza, Monacelli and Stracca \(2013\)](#), who document a stronger impact of monetary policy on consumption in those countries where mortgage contracts are predominantly of the variable-rate type, and [Pica \(2022\)](#), who finds that a higher share of adjustable-rate mortgages and a higher homeownership rate interact to amplify the effects of monetary policy on economic activity in the euro area. However, given the decrease in the share of variable-rate mortgages observed over the second half of the sample period (especially in those countries where variable-rate contracts are traditionally prevailing), homeowners' interest-rate sensitivity fell in recent years (see, for example, [Bech and Mikkelsen, 2021](#)).

²³This suggests a role for the construction sector in conveying monetary policy shocks to the overall economy, in line with evidence on the user-cost-of-capital and interest-rate channels of monetary policy in affecting the production of durable and capital goods ([Dedola and Lippi, 2005](#); [Peersman and Smets, 2005](#)).

²⁴The positive relationship with the LTV ratio at the regional level is consistent with the evidence pointing to a different transmission of monetary policy for liquidity-constrained and non-constrained households ([Aladangady, 2017](#), [Guerrieri and Iacoviello, 2017](#)). By including an endogenously estimated threshold variable (i.e. the LTV ratio at the regional level) in our baseline model, we find indeed a non-linear transmission mechanism for monetary policy on housing and macroeconomic variables, with a significantly stronger impact when the LTV ratio is above a certain level. The results are available from the authors upon request.

We carry out a formal analysis in order to shed more light on the link between the monetary policy effectiveness and economic and institutional characteristics across euro area regions. Besides the variables mentioned above, we include controls commonly found to be important determinants of the transmission of monetary policy to the business cycle, such as the manufacturing share of value added and a measure of lending activity to households. Panel (a) of Table 2 reports the results of various regression specifications that link our estimated long-term impact of total monetary policy shocks on real GDP to the key variables discussed above. In the most parsimonious specifications, the regression coefficients of these variables have the expected sign (as in the graphical overview discussed above) and are found to be statistically significant, except for housing wealth and lending activity. The significance is robust to the inclusion of demographic factors. When housing wealth is replaced by its determinants, the homeownership rate is estimated to play a significant role.²⁵ When all variables are considered, labour income, the share of construction, the share of manufacturing and lending activity display a statistically significant coefficient. For labour income and the share of manufacturing the coefficient remains significant even after the inclusion of country and country-group dummies.²⁶ Similar findings are observed when considering the impact of conventional monetary policy (panel (b) in Table 2), except that the share of manufacturing is no longer significant. Focusing on unconventional monetary policy (panel (c) in Table 2), lending activity (proxied by the product of regional average house prices and LTV ratios) becomes statistically significant. This confirms the role of bank lending in supporting the effectiveness of (unconventional) measures and thus restoring the functioning of the monetary policy transmission mechanism after the Sovereign Debt Crisis (for more details, see [Altavilla et al., 2019a](#) and [Adalid and Falagiarda, 2020](#)).

We perform the same exercise considering the impact of monetary policy on house prices as dependent variable (Table B.2 in Appendix B). Besides confirming the importance of labour income, the results of these regressions highlight the role of housing wealth in the propagation of monetary policy, particularly in the case unconventional monetary policy shocks.

²⁵This result relates to the work by [Paz-Pardo \(2021\)](#), who shows that increases in labour income inequality and uncertainty are key drivers for a decrease in homeownership among younger households in several major advanced economies, suggesting that the evolution of homeownership rates is closely intertwined with labour markets, housing markets and financial conditions.

²⁶The *Vulnerable* dummy variable splits the regions into two large groups according to a conventional assessment of “vulnerability”. In the academic and policy literature, this assessment typically considers a certain type of macroeconomic imbalances, such as government debt-to-GDP ratios and current account deficits, and implies a division between more and less vulnerable countries (sometimes also referred to as periphery and core countries, respectively). The more vulnerable group contains all regions in Spain, Ireland, Italy and Portugal, and the less vulnerable group consists of all regions in Belgium, Germany, France and the Netherlands.

Table 2: Relationship between monetary policy impact on real GDP and regional factors

(a) Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Impact of TMP shock</i>								
Compensation per employee	-4.934***	-4.316***				-4.253***	-4.470***	-4.060**
Housing wealth	0.639					-1.011	-0.733	0.704
Homeownership rate		0.028**						
House price level		0.299						
Share of construction in GVA			0.581***			0.214*	0.200*	0.014
Share of manufacturing in GVA			0.063**			0.057**	0.057**	0.069***
Share of variable-rate mortgages				0.027***		0.002	0.013	0.020
Lending activity					0.598	1.511*	1.328	-0.437
Demographics controls	✓	✓	✓	✓	✓	✓	✓	✓
Vulnerable dummy	-	-	-	-	-	-	✓	-
Country dummies	-	-	-	-	-	-	-	✓
Observations	105	105	105	105	105	105	105	105
R-squared	0.424	0.439	0.189	0.324	0.015	0.494	0.501	0.538
(b) Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Impact of CMP shock</i>								
Compensation per employee	-3.903***	-3.932***				-3.494***	-3.412***	-3.747*
Housing wealth	0.187					1.141	1.036	1.612
Homeownership rate		0.006						
House price level		0.424						
Share of construction in GVA			0.560***			0.373***	0.378***	-0.022
Share of manufacturing in GVA			0.038			0.027	0.026	0.042
Share of variable-rate mortgages				0.018***		-0.003	-0.007	0.006
Lending activity					-0.094	-0.579	-0.510	-0.650
Demographics controls	✓	✓	✓	✓	✓	✓	✓	✓
Vulnerable dummy	-	-	-	-	-	-	✓	-
Country dummies	-	-	-	-	-	-	-	✓
Observations	105	105	105	105	105	105	105	105
R-squared	0.268	0.270	0.172	0.149	0.014	0.322	0.323	0.451
(c) Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Impact of UMP shock</i>								
Compensation per employee	-1.874**	-1.934**				-3.792***	-4.051***	-4.741**
Housing wealth	1.010					-1.701	-1.368	-1.316
Homeownership rate		0.014						
House price level		1.214						
Share of construction in GVA			0.114			-0.090	-0.106	-0.134
Share of manufacturing in GVA			0.060**			0.075***	0.076***	0.076**
Share of variable-rate mortgages				0.010**		-0.014	-0.001	-0.006
Lending activity					1.032**	3.240***	3.021**	1.770
Demographics controls	✓	✓	✓	✓	✓	✓	✓	✓
Vulnerable dummy	-	-	-	-	-	-	✓	-
Country dummies	-	-	-	-	-	-	-	✓
Observations	105	105	105	105	105	105	105	105
R-squared	0.116	0.115	0.079	0.085	0.076	0.217	0.227	0.251

Notes: The table present regressions of the cumulative monetary policy impact on real GDP at the regional level (as estimated in section 4) on regional factors (compensation per employee in logs, housing wealth in logs, homeownership rate in percent, the average house price level in logs, the share of construction and manufacturing in GVA, the share of variable-rate mortgages in percent, and a proxy for lending activity). Housing wealth is computed as the product of the homeownership rate and the average house price level. The proxy for lending activity is computed as the product of housing wealth and the LTV ratio. Demographics controls include total employment and population density at the regional level. The Vulnerable dummy is a binary variable that takes value one for regions of Italy, Spain, Portugal and Ireland, and zero for regions of Germany, France, the Netherlands and Belgium. A constant is included. An outlier is excluded. *** p < 0.01, ** p < 0.05, * p < 0.1

Overall, as the coefficient on compensation per employee remains significant across all specifications, our findings point to the effectiveness of monetary policy in reducing regional inequality by stimulating economic activity more in regions with lower labour income. Together with the absence of a clear predominance of one of the two determinants of housing wealth (diffusion of owner-occupying housing and home valuations), this suggests that monetary policy easing has an overall beneficial impact on cross-regional inequality.

Our results add to a growing literature on monetary policy and inequality. Most contributions examine the issue at the household or individual level. Some studies find that expansionary monetary policy can mitigate income inequality as lower-income households disproportionately benefit from positive effects via the stimulus to economic activity and employment, which outweigh those via financial markets (for the US, see [Coibion et al., 2017](#); for the euro area, see [Casiraghi et al., 2018](#), [Lenza and Slacalek, 2021](#) and [Altavilla et al., 2021](#)). This stands in contrast to [Amberg et al. \(2021\)](#), who show that the income response to monetary policy in Sweden is U-shaped, and to [Andersen et al. \(2020\)](#), who find that monetary easing in Denmark raises income shares at the top of the income distribution while reducing them at the bottom, hence leading to higher income inequality. The impact of monetary policy on wealth inequality is also a subject of debate. [Lenza and Slacalek \(2021\)](#) state that monetary policy has only a negligible impact on wealth inequality. A U-shaped response of wealth inequality is found by [Casiraghi et al. \(2018\)](#), while according to [Andersen et al. \(2020\)](#) monetary easing is more beneficial to the net wealth of higher income households, thereby increasing wealth inequality.

Little attention has been given to the geographical dimension of inequality and how it is affected by monetary policy. An outstanding exception is the work by [Hauptmeier, Holm-Hadulla and Nikalexi \(2020\)](#), who focus on the heterogeneity of the impact of monetary policy across euro area regions. The authors find that monetary easing shocks have a significantly more pronounced and persistent effect on output in poorer than in richer regions, implying a mitigation of regional inequality. Besides confirming this result, our study differentiates between income sources, i.e. housing wealth and labour income. Focusing on the US, [Beraja et al. \(2019\)](#) examine the transmission of monetary policy via mortgage markets at the regional level. In contrast to previous recessions, they find that, during the Global Financial Crisis, depressed regions reacted less to interest rate cuts, thus increasing regional consumption inequality.

6 Robustness Checks

6.1 Additional common components

To check the robustness of our findings, we first extend the set of exogenous variables in our baseline VAR model. As shown, for example, by [Vansteenkiste and Hiebert \(2011\)](#) and [Campos, Fidrmuc and Korhonen \(2019\)](#), there are significant interlinkages among regional housing markets and business cycles in the euro area. Hence, the set of exogenous variables, which in the baseline model only includes the monetary policy shocks, is expanded to include the euro area GDP, employment and house prices. Following [Chudik and Pesaran \(2015\)](#), these euro area variables are calculated as cross-sectional means of all the regions within our dataset, namely $Y_t^* = N^{-1} \sum_{i=1}^N Y_{i,t}$, where $Y_{i,t}$ denotes the vector of endogenous variables in our SPVAR model defined in Equation (3). Insofar as these variables are endogenous to monetary policy changes, they incorporate to some extent our monetary policy shock. To avoid double-counting, we first regress the cross-sectional averages of GDP, employment and house prices on total monetary policy shocks. Formally, we posit the following linear relation between common components and total monetary policy shock:²⁷

$$Y_t^* = \Omega_0 + \Omega_1 TMP_t + \omega_t \quad (9)$$

where $\omega_t \sim N(0, \sigma_\omega)$. The non-monetary policy common components are then extracted by subtracting the product of the estimated coefficient $\hat{\Omega}_1$ and the total monetary policy shock from the cross-sectional averages, namely $\tilde{Y}_t^* = Y_t^* - \hat{\Omega}_1 TMP_t$. Finally, we introduce these non-monetary policy common components as additional exogenous regressors in the SPVAR by augmenting the vector $X_t = [MP_t, \tilde{Y}_{t-d}^*]$ where MP_t denotes TMP_t or $[CMP_t, UMP_t]$.²⁸

When including these additional exogenous variables, the results of the baseline SPVAR model estimation are broadly confirmed (Figure B.2 in Appendix B). An accommodative monetary policy shock has a positive impact on GDP and employment. The impact on house prices is initially negative, albeit insignificant, and fades to zero subsequently. Unlike in the baseline,

²⁷We do not perform this regression on conventional and unconventional monetary policy shocks, since their combined information corresponds to the one contained in the total monetary policy shock.

²⁸For the purpose of our analysis, we assume a delay parameter $d = 1$, aligning the timing of non-monetary policy common components with the lagged endogenous variables. Note that this approach differs from the common correlated effect (CCE) estimator proposed by [Chudik and Pesaran \(2015\)](#). However, the CCE estimator would not suit our purposes because it would only allow us to retrieve the coefficients of region-specific variables.

an unconventional monetary policy shock has a larger impact on GDP and employment than a conventional monetary policy shock. As in the baseline specification, an unconventional shock has a larger and statistically significant impact on house prices compared to a conventional one.

6.2 A pooled fixed-effects estimator

In order to check the robustness of our mean-group estimates, a pooled OLS regression is applied to the demeaned regional dataset, resulting in a fixed-effects estimator. Figure B.3 in Appendix B displays the impulse response functions to an accommodative monetary policy shock under this specification. In line with the mean-group estimation results, the impact of a monetary policy easing shock on GDP, employment and house prices is positive, but slightly larger in size. In addition, the impact on house prices is statistically significant.

6.3 An alternative structural identification strategy

The estimated contributions from the housing and the employment channel in our benchmark SPVAR model depend on the ordering of the endogenous variables. As the contemporaneous contributions tend to assign a larger weight to the less “reactive” (or more exogenous) variables, we consider the estimates from our benchmark SPVAR model as an upper bound of the contribution of the employment and, especially, the housing channels. In fact, both theoretical and empirical arguments would suggest an alternative ordering to model the contemporaneous relationships among the endogenous variables in our benchmark SPVAR model.

On theoretical grounds, asset prices are typically placed as the most endogenous variables, as they are highly sensitive to contemporaneous and expected economic news or shocks (see, for instance, [Stock and Watson, 2016](#)). Moreover, employment typically lags GDP, as labour market frictions impede an immediate adjustment to the business cycle ([Mortensen and Pissarides, 1994](#)). In line with these considerations, there are papers in the literature imposing a recursive structure in VARs in which house prices react to GDP in the same period ([Nocera and Roma, 2017](#), [Musso, Neri and Stracca, 2011](#), [Giuliodori, 2005](#)).

From an empirical perspective, pairwise [Granger \(1969\)](#) causality tests on comparable euro area aggregate data at quarterly frequency confirm these theoretical predictions. According to the results of the tests, shown in Table B.3 in Appendix B, GDP (Granger) causes both employment and house prices. Employment causes only house prices, while house prices cause

neither GDP nor employment. Hence, as a robustness exercise, we invert our preferred ordering and consider GDP as the most exogenous variable and house prices as the most endogenous one. This alternative ordering implies nil contemporaneous contributions from the housing and the employment channels, which appear restrictive assumptions, especially at annual frequency.

Figure B.4 in Appendix B shows the variance decomposition when we order the endogenous variables as follows: $Y_{i,t} = [\text{House prices}_{i,t}, \text{Employment}_{i,t}, \text{GDP}_{i,t}]$. Confirming our results, the contribution of unconventional monetary policy shocks to the variation in GDP and employment is more than three times larger than the contribution of conventional shocks. Variations in house prices can be explained by the different monetary policy shocks to a much smaller extent. Moreover, this alternative ordering confirms our results on the limited role of the house price channel as a conveyor of monetary policy shocks to economic activity.²⁹

7 Conclusion

By means of a structural panel VAR estimated with novel regional data, this paper investigates the role of the housing market in the transmission of conventional and unconventional monetary policy in the euro area. We show that the housing channel plays a limited role in the propagation of monetary policy to the economy, but its contribution is amplified in the case of unconventional monetary policy.

The transmission of monetary policy to the economy is found to be heterogeneous across regions, with a larger impact in areas with lower labour income and higher homeownership rates. This suggests that poorer regions stand to benefit the most from monetary policy accommodation. While the easing of monetary policy is found to mitigate regional inequality through its stimulus to the economy, the unintended consequences of the ongoing monetary policy normalisation warrant close monitoring by policy-makers, particularly in the case of resurgent fragmentation risks.

²⁹Results for the role of the employment and housing channels from the alternative ordering are available from the authors upon request.

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Appendix A House prices at the regional level: The ED database

Regional house prices are derived from the loan-level database of the European DataWarehouse (ED), a securitisation repository that collects, validates and makes available detailed, standardised and asset class-specific loan-level data for asset-backed securities (ABS) transactions.³⁰ The data are collected in the context of the ABS loan-level initiative, which establishes specific loan-by-loan information requirements for ABS accepted as collateral in Eurosystem credit operations. This initiative was launched in 2012 and aimed to improve transparency in ABS markets and facilitate the risk assessment of these instruments used by Eurosystem counterparties as collateral in monetary policy operations. Banks are required to submit at least at quarterly frequency detailed information regarding the loans backing the ABS, including loan, borrower and collateral characteristics.

For the purpose of this analysis, we only consider the loans underlying residential mortgage-backed securities (RMBS). The reporting templates are populated with information on the loan (e.g. original and outstanding balance, date of origination, maturity, purpose, interest rate, repayment type, performance), the borrower (e.g. employment status, annual gross income, age), and the property (e.g. valuation, property type, geographic location—with the first two digits of the postcode typically available). These fields can be either static (reported at origination) or dynamic (updated at each submission), as well as mandatory (always populated) or optional (whereby missing values can be found). Eight euro area countries are covered in the ED database: Germany, France, Italy, Spain, the Netherlands, Belgium, Portugal and Ireland.

The raw data are processed and cleaned as follows. First, imputation techniques are used for the main static variables whenever we observe for each loan (i) missing values in one or more submissions; (ii) inconsistent values across submissions. This imputation procedure allows us to keep a large number of loans that would have otherwise been discarded and therefore to increase the coverage of the sample. Second, we drop outliers by considering only loans used for the purchase of a property with a price below EUR 5 million and above EUR 10,000. Third, we exclude loans with missing information on the key variables used in the analysis. Third, as multiple loans can be used to purchase the same property, especially in the Netherlands, we aggregate loans originated at the same time by a single borrower for the purchase of a single

³⁰ED loan-level data has been used by [Ertan, Loumioti and Wittenberg-Moerman \(2017\)](#), [Amzallag et al. \(2019\)](#), [Gianinazzi, Pelizzon and Plazzi \(2018\)](#), [van Bekkum, Gabarro and Irani \(2018\)](#), [Gaudêncio, Mazany and Schwarz \(2019\)](#), [Kang, Loumioti and Wittenberg-Moerman \(2020\)](#), [Klein, Mössinger and Pfungsten \(2021\)](#) and [Beyene et al. \(2022\)](#).

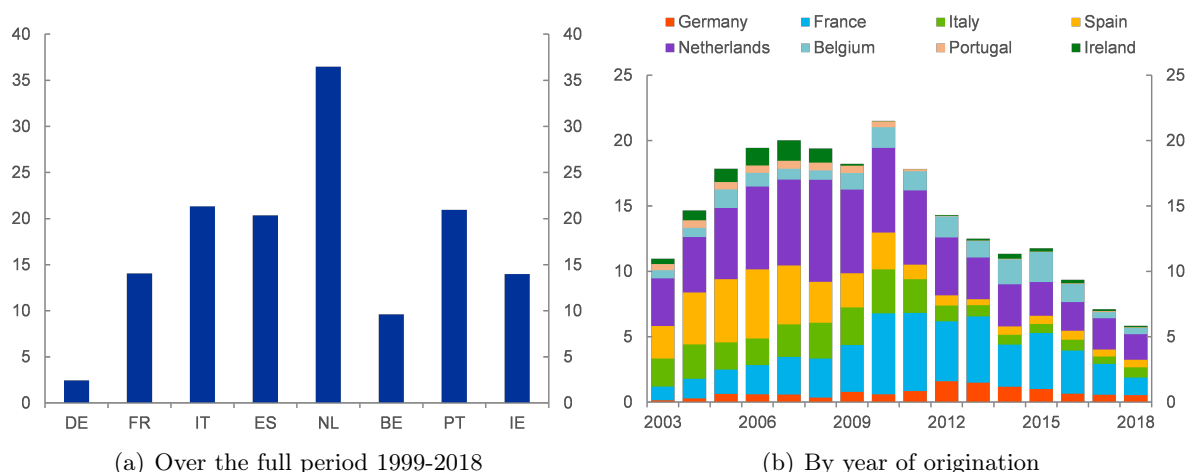
property, as in [Gianinazzi, Pelizzon and Plazzi \(2018\)](#). The summary statistics of some of the key variables included in the cleaned loan-level dataset are reported in [Table A.1](#).

Table A.1: Summary statistics of the ED dataset (over the period 1999-2018)

	DE	FR	IT	ES	NL	BE	PT	IE
Number of loans (in thousand)	687.2	3381.6	1814.6	1886.6	2799.6	1125.9	496.6	291.6
Loan size (median, in EUR thousand)	87.3	87	100	120	160.4	100	68.6	180
Maturity (median, in years)	20	17	20	30	30	19.3	30.4	25
Share of fixed-rate loans (in %)	98.0	89.3	27.2	10.8	93.5	94.5	2.4	14.1
Borrower's income (median, in EUR thousand)	43.5	37.4	25.1	27.5	50	48.1	17.1	54.4
Property valuation (median, in EUR thousand)	183	137.2	170	177.5	238.4	175	109.7	260

A graphical illustration of the coverage of the dataset is provided in [Figure A.1](#). The overall volume of the loans in our dataset is a significant share of total loan origination in all countries, except Germany. This is due to the fact that mortgages in this country are much more commonly pooled into covered bonds than RMBS. The coverage varies significantly over time in all countries in our sample, reaching a peak in the aftermath of the Global Financial Crisis, when banks started to retain securitised products on their balance sheets in order to use them as collateral for Eurosystem's credit operations. The coverage of our data has decreased thereafter, reflecting the contraction in the securitisation markets observed in many euro area countries and the concomitant pick-up in mortgage credit.

Figure A.1: Share of mortgage loans covered by ED data (percent)

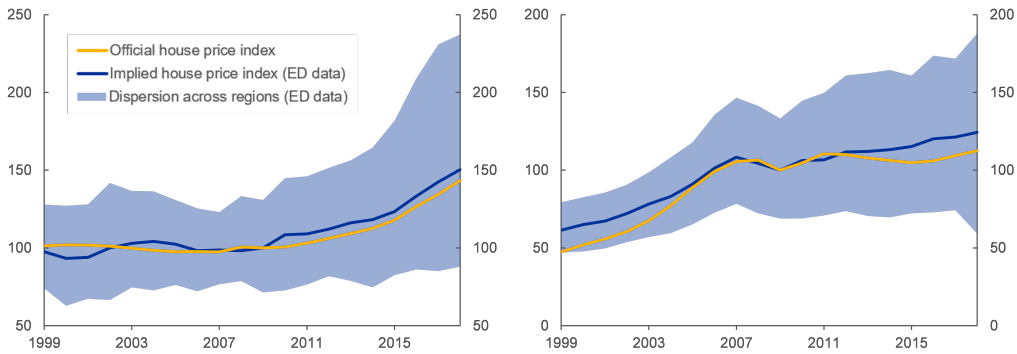


Notes: Sum of original balance of loans of the ED dataset over total new business volumes from the MFI Interest Rate Statistics of the ECB.

The property valuation contained in the ED data is used to derive house price indexes for euro area regions and countries. The resulting country aggregates are then compared with the correspondent official series (Figure A.2). A graphical inspection of the two series shows that the implied house price indexes closely resemble the official ones for all countries, suggesting that our sample is well representative of house price dynamics at the national level.

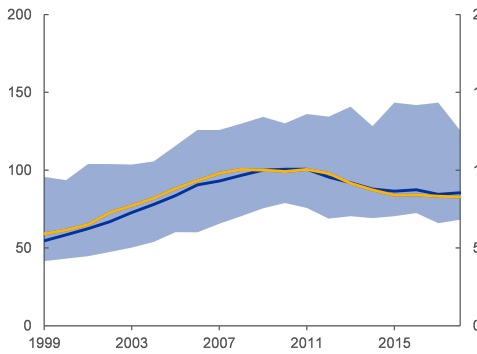
A similar exercise is conducted for mortgage rates in order to check whether our data is representative of credit dynamics. As the ED database does not provide information on the interest rate of floating-rate mortgages at origination, this exercise can be only performed for countries where fixed-rate mortgages have been more popular over the sample period (i.e. Germany, France, the Netherlands and Belgium). The implied mortgage rates closely follow the official country rates over time (Figure A.3). The results also point to very similar developments across regions, suggesting that bank lending policies tend to be uniform within a country.

Figure A.2: House price indexes (2009=100)

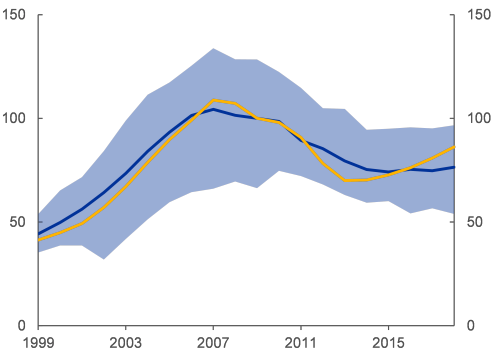


(a) Germany

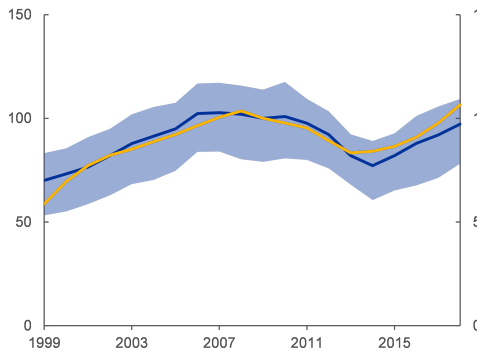
(b) France



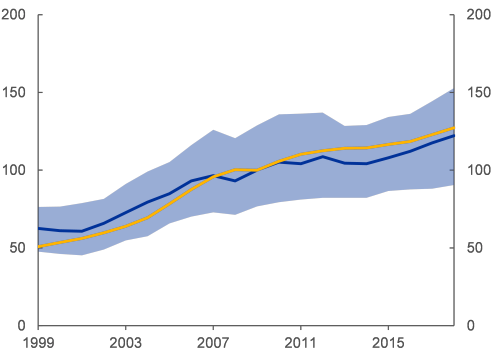
(c) Italy



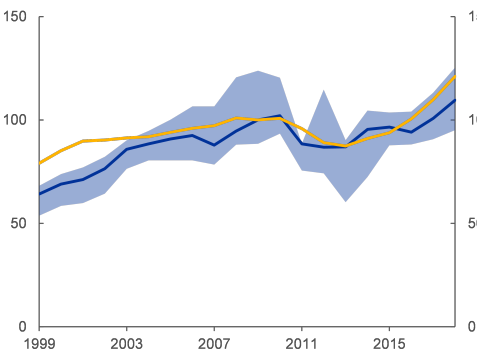
(d) Spain



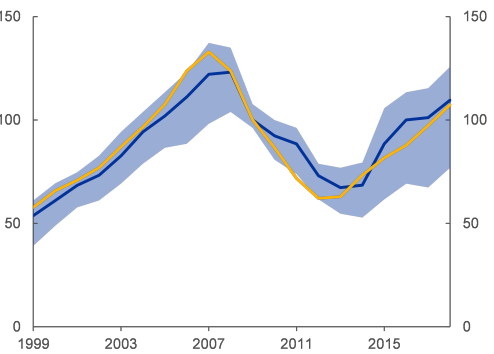
(e) The Netherlands



(f) Belgium

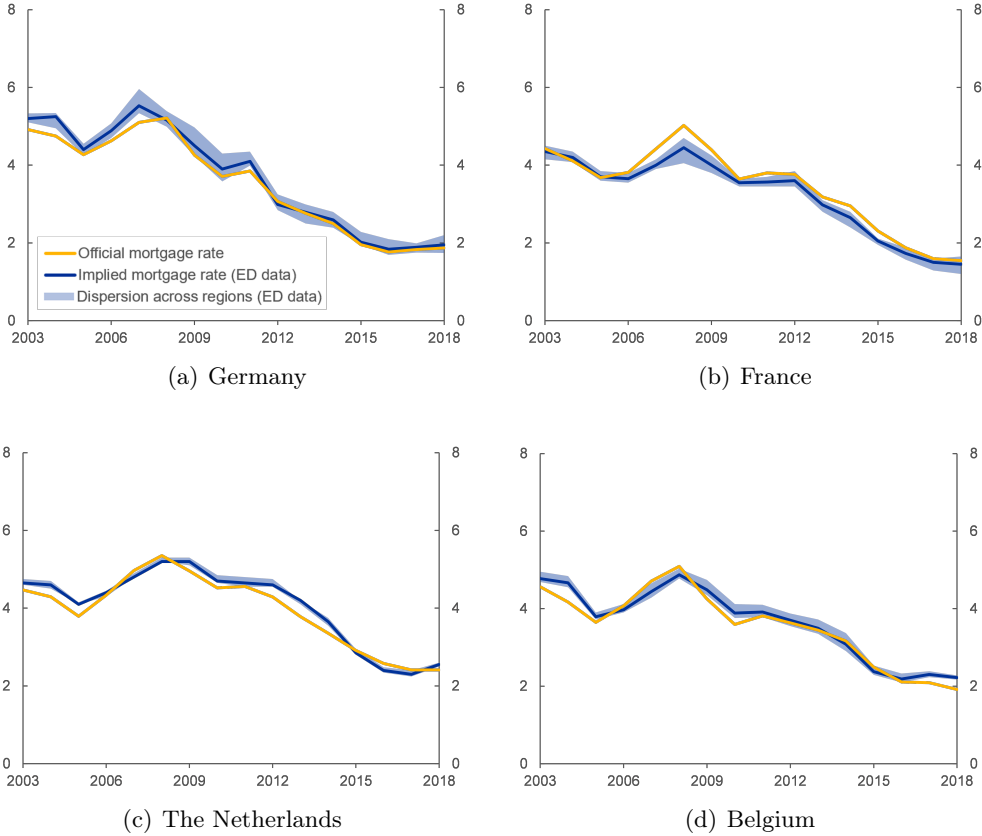


(g) Portugal



(h) Ireland

Figure A.3: Mortgage rates (in percentages per annum)



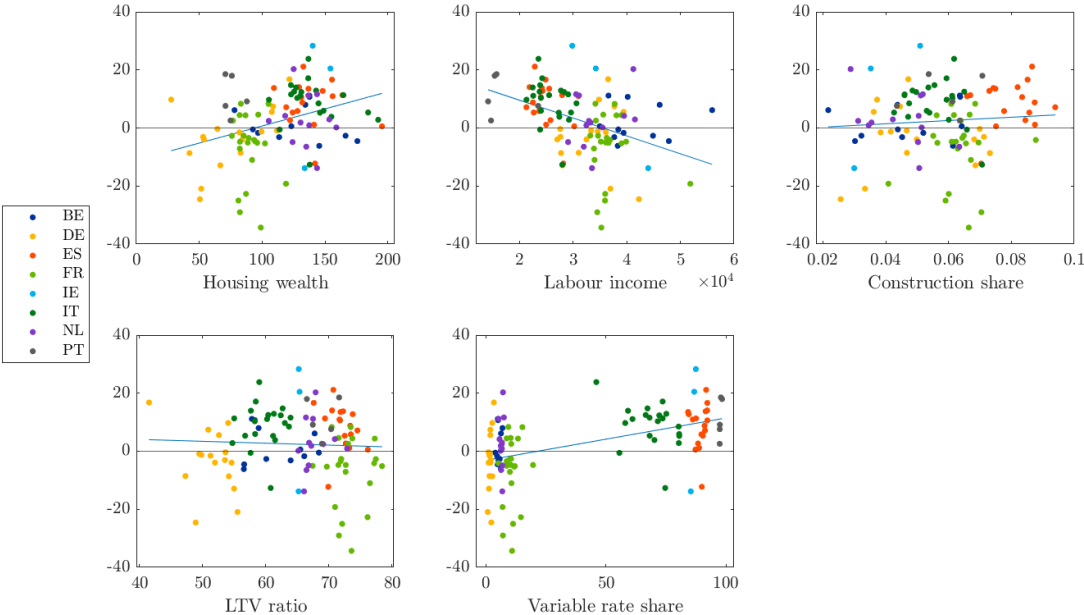
Appendix B Additional tables and charts

Table B.1: Summary Statistics over sub-periods

		Mean	Median	Minimum	Maximum	Standard Deviation
GDP	1999-2008	28923	28021	13786	66418	8844
GDP	2009-2012	29438	28133	14070	65112	9233
GDP	2013-2018	30394	28307	14914	65178	10368
Employment	1999-2008	43.86	43.08	31.31	65.43	6.68
Employment	2009-2012	43.48	42.78	31.55	66.83	7.06
Employment	2013-2018	43.33	42.24	30.15	68.23	7.36
House prices	1999-2008	132.89	129.02	93.25	187.27	22.32
House prices	2009-2012	163.03	164.57	93.44	233.93	34.34
House prices	2013-2018	156.51	156.57	104.69	237.29	26.20

Notes: Real GDP and employment are given in per capita terms. National GDP and employment are calculated as cross-regional aggregate of all regions within a country. National house prices are given by GDP-weighted cross-regional means of all regions within a country.

Figure B.1: Monetary policy impact on house prices and regional factors



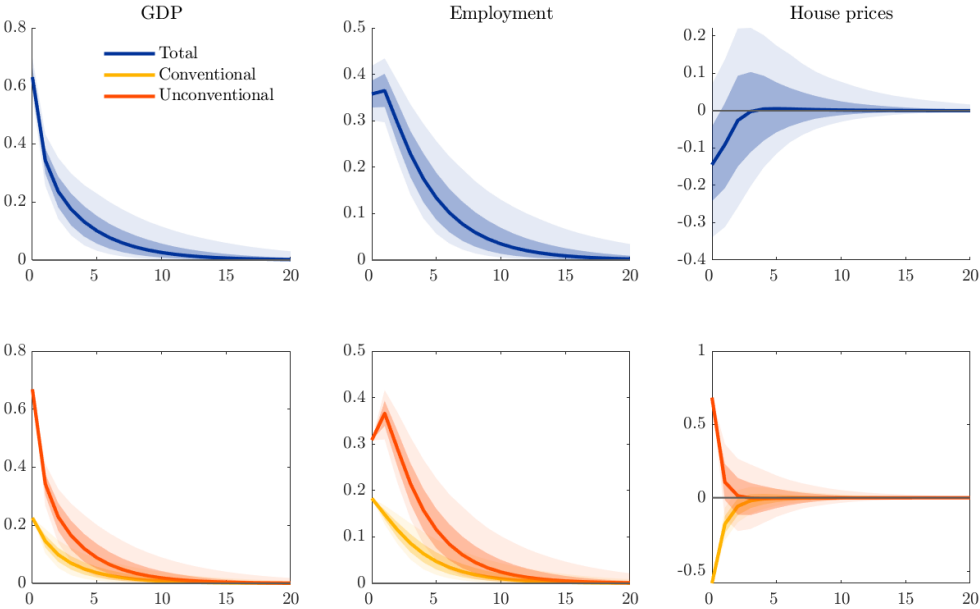
Notes: The y-axis reports the cumulative percentage change in (detrended) levels for house prices 5 years after an accommodative monetary policy shock. The x-axis reports the regional housing wealth (thousand euros per household), labour income (euros per employee, at 2015 prices), construction share (percent of value added), LTV ratio (percent), share of variable-rate loans (percent of total loans). Each dot represents a region.

Table B.2: Relationship between monetary policy impact on house prices and regional factors

(a) Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Impact of TMP shock</i>								
Compensation per employee	-12.237***	-10.965***				-11.144***	-10.637***	-17.825**
Housing wealth	7.749***					7.839**	7.189*	8.024
Homeownership rate		0.158***						
House price level		7.093***						
Share of construction in GVA			0.406			-0.297	-0.265	-0.433
Share of manufacturing in GVA			0.080			0.020	0.019	-0.004
Share of variable-rate mortgages				0.079***		0.015	-0.011	-0.057
Lending activity					4.500***	-1.112	-0.687	-5.339
Demographics controls	✓	✓	✓	✓	✓	✓	✓	✓
Vulnerable dummy	-	-	-	-	-	-	✓	-
Country dummies	-	-	-	-	-	-	-	✓
Observations	105	105	105	105	105	105	105	105
R-squared	0.331	0.332	0.013	0.243	0.066	0.339	0.343	0.407
(b) Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Impact of CMP shock</i>								
Compensation per employee	-5.918**	-1.797				0.284	0.752	-21.486**
Housing wealth	-1.780					-5.839	-6.439	9.553
Homeownership rate		0.080						
House price level		-7.738**						
Share of construction in GVA			0.943*			0.325	0.354	-1.407
Share of manufacturing in GVA			0.101			0.080	0.078	0.046
Share of variable-rate mortgages				0.039**		0.046	0.022	-0.044
Lending activity					-0.633	1.396	1.789	-8.752
Demographics controls	✓	✓	✓	✓	✓	✓	✓	✓
Vulnerable dummy	-	-	-	-	-	-	✓	-
Country dummies	-	-	-	-	-	-	-	✓
Observations	105	105	105	105	105	105	105	105
R-squared	0.067	0.109	0.052	0.062	0.023	0.098	0.100	0.187
(c) Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Impact of UMP shock</i>								
Compensation per employee	-5.259**	-10.905***				-19.487***	-19.834***	-10.680
Housing wealth	6.996***					10.942***	11.387***	0.549
Homeownership rate		-0.037						
House price level		15.781***						
Share of construction in GVA			-0.747*			-0.823*	-0.845*	-0.403
Share of manufacturing in GVA			0.063			0.077	0.078	0.084
Share of variable-rate mortgages				0.011		-0.104***	-0.086*	-0.073
Lending activity					3.001*	1.364	1.072	3.703
Demographics controls	✓	✓	✓	✓	✓	✓	✓	✓
Vulnerable dummy	-	-	-	-	-	-	✓	-
Country dummies	-	-	-	-	-	-	-	✓
Observations	105	105	105	105	105	105	105	105
R-squared	0.171	0.301	0.071	0.036	0.061	0.342	0.344	0.418

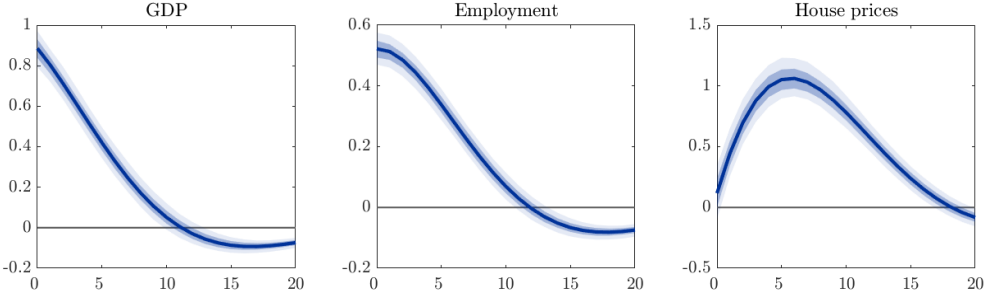
Notes: The table presents regressions of the cumulative monetary policy impact on house prices at the regional level (as estimated in section 4) on regional factors (compensation per employee in logs, housing wealth in logs, homeownership rate in percent, the average house price level in logs, the share of construction and manufacturing in GVA, the share of variable-rate mortgages in percent, and a proxy for lending activity). Housing wealth is computed as the product of the homeownership rate and the average house price level. The proxy for lending activity is computed as the product of housing wealth and the LTV ratio. Demographics controls include total employment and population density at the regional level. The Vulnerable dummy is a binary variable that takes value one for regions of Italy, Spain, Portugal and Ireland, and zero for regions of Germany, France, the Netherlands and Belgium. A constant is included. An outlier is excluded. *** p < 0.01, ** p < 0.05, * p < 0.1

Figure B.2: Impulse response functions to an expansionary monetary policy shock - common components



Notes: The y-axis reports the percentage change in (detrended) levels of each variable over the considered horizon. The x-axis reports the years. This specification includes non-monetary policy common components. Solid lines denote point estimates and light (dark) shaded areas 95 percent (68 percent) confidence bands.

Figure B.3: Impulse response functions to an expansionary monetary policy shock - pooled fixed-effect estimator



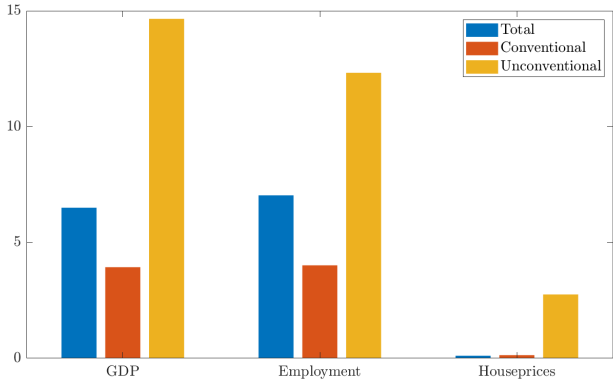
Notes: The y-axis reports the percentage change in (detrended) levels of each variable over the considered horizon. The x-axis reports the years. These are the results of a fixed-effects regression. Solid lines denote point estimates and light (dark) shaded areas 95 percent (68 percent) confidence bands.

Table B.3: Granger causality test results

	GDP	Employment	House Prices
GDP	/	0.000	0.005
Employment	0.269	/	0.010
House prices	0.143	0.587	/

Notes: The table shows the p-values of a Granger causality test. If the value in row i and column j is smaller than 0.01 (0.05), then the null hypothesis that variable i does not Granger cause variable j has to be rejected at the 1% (5%) significance level.

Figure B.4: Variance decomposition of key variables - alternative ordering



Notes: The y-axis reports the contribution of a total, conventional and unconventional monetary policy shock to variations in GDP, employment and house prices at the 5-year horizon.

Acknowledgements

We would like to thank Paola Di Casola, Simon Hildebrandt, Frédéric Holm-Hadulla, Bartosz Maćkowiak, Klaus Masuch, Beatrice Pierluigi, Thomas Westermann and an anonymous referee for their helpful comments and suggestions. This paper has also benefitted from discussions with participants at seminars at the ECB, the University of Bremen, the University of Neuchâtel, at the 6th Household Finance Workshop (Leibniz Institute SAFE), at the 16th CEUS Workshop on European Economics, and at the 2022 ECHOPPE Conference on the Economics of Housing and Housing Policies.

The views expressed in this paper are those of the authors and do not necessarily represent those of the European Central Bank.

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ISBN 978-92-899-5400-6

ISSN 1725-2806

doi:10.2866/439771

QB-AR-22-117-EN-N