

# Housing Markets and the Heterogeneous Effects of Monetary Policy Across the Euro Area\*

Stefano Pica<sup>†</sup>

*Boston University*

This Version: October 3, 2021

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## Abstract

Monetary policy has heterogeneous effects across Euro Area countries. There are strong correlations between cross-country monetary policy potency and housing and mortgage market institutions, namely the share of adjustable-rate mortgages (ARM) and the homeownership rate (HoR). To disentangle the relative importance of ARM share and the HoR, I incorporate these features into a quantitative currency-union New Keynesian model with rich household balance sheets. I calibrate the model to Spain and the Euro Area. The model fits well: the consumption response in Spain is 1.8 times stronger than the Euro Area in the model relative to 2.5 in the data. My results reveal that higher ARM shares and higher HoR interact to amplify the effects of monetary policy on aggregate consumption due to smaller interest payments and higher collateral value of housing. I use the model to show that different forms of banking unions decrease the heterogeneous effects of monetary policy by weakening the pass-through to mortgage rates. Finally, including house prices into the price index entails a trade-off between stabilizing output and inflation.

**JEL:** C22, E02, E12, E31, E43, E52, E58, F33, F45, G21, G51

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\*I would particularly like to thank my advisers Adam Guren, Stephen Terry, and Bob King for their support and guidance. Part of the research in this paper was carried out while I was visiting the DG-Research of the European Central Bank as part of the Summer Research Graduate Programme, and I gratefully acknowledge their hospitality and financial support. Clodomiro Ferreira, Daniel Greenwald, Peter Karadi, Fabio Schiantarelli (discussant), and Jirka Slacalek provided thoughtful discussions and comments. I also would like to thank seminar participants at Boston University, the ECB, and the BU-BC Green Line Macro Meeting for helpful suggestions. This paper uses data from the Eurosystem Household Finance and Consumption Survey.

<sup>†</sup>Contact: Stefano Pica, Boston University Economics Department, 270 Bay State Road, Boston MA. E-mail: [stpica@bu.edu](mailto:stpica@bu.edu). Web: [stefanopica.com](http://stefanopica.com)

# 1 Introduction

Monetary policy has heterogeneous effects across countries in the Euro Area. Following a policy rate increase, it is well documented that aggregate consumption in Spain decreases more severely than in Germany<sup>1</sup>. Recent evidence suggests that housing wealth effects are an important driver of the heterogeneous consumption responses to monetary policy (Slacalek, Tristani, and Violante (2020)), but the literature still lacks an understanding of what the specific sources are behind the differential cross-country responses. In this paper, I investigate and quantify the role of the housing and mortgage market institutions in shaping the monetary transmission mechanism across the Euro Area. I do so empirically and in a quantitative model that pays particular attention to institutional details for the aforementioned country-specific markets. I focus on the role of adjustable-rate mortgage (ARM) shares and homeownership rates (HoR), two features that are extremely different across European countries and that I show drive the empirical responses to monetary policy shocks<sup>2</sup>.

To this end, I perform an econometric analysis of monetary policy shocks across Euro Area countries using local projection methods (Jordà (2005)). Because I am particularly interested in studying the aggregate effects of mortgage rates across countries, I use high-frequency movements at longer ends of the Overnight Indexed Swap (OIS) rates around policy announcements as identified monetary policy shocks. An expansionary monetary policy shock makes some countries (Spain, Ireland, Finland) react two to four times more strongly than some others (Germany, France) which often do not have significant responses. I provide evidence of economically sizable and statistically significant correlations between monetary policy effectiveness (as measured by peak or trough responses) and country-specific housing and mortgage market institutions. Countries that react the most in terms of aggregate consumption, house prices, newly issued mortgage loans, and mortgage rates are those that have a) a higher ARM share relative to total outstanding mortgages; b) higher HoR; and c) bigger fractions of homeowners with mortgages<sup>3</sup>. The features of the

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<sup>1</sup>Corsetti, Duarte, and Mann (2021) find that a 25-basis-point increase in the policy rate decreases aggregate consumption in Spain by as much as 0.6% compared to a maximum decrease of about 0.05% in Germany. Slacalek, Tristani, and Violante (2020), with a different empirical methodology, reach a similar quantitative conclusion.

<sup>2</sup>To give a sense of the underlying cross-sectional heterogeneity, in 2014 the ARM share in Spain was around 90% compared to 45% in the Euro Area and 11% in Germany. By the same token, the HoR in Spain was 80% compared to 60% in the Euro Area and 44% in Germany.

<sup>3</sup>Corsetti, Duarte, and Mann (2021) show that consumption and house price reactions across countries strongly correlate empirically with the share of ARM and HoR after a conventional monetary policy shock. My results complement theirs in two dimensions: firstly, by showing that this is true for newly issued mortgages and mortgage rates as well, pointing to the importance of mortgages in the transmission mechanism; and secondly, by analyzing a time period over which the ECB has faced the zero lower bound

housing and mortgage markets I focus on, however, do not necessarily jointly explain the heterogeneous monetary transmission mechanism. Countries that have a higher ARM share are also those that have higher HoR. Hence, an identification problem arises: it might well be that only one of these features explains the heterogeneity in practice, and not all of them.

To disentangle the relative importance of ARM share and the HoR, I turn to a quantitative currency-union two-agents New Keynesian (TANK) model. The model has a Home-Foreign structure as in [Faia and Monacelli \(2008\)](#). The Foreign country is a closed economy and can be thought of as a currency union: the Euro Area. The Home country is a small open economy and can be interpreted as any given Euro Area country. Within each country, households have rich balance sheets: they decide on long-term mortgage amounts, house size, and rental service choices as in [Greenwald \(2018\)](#). The population is made of borrowers and savers: the former are impatient and constrained by a loan-to-value constraint, while the latter are patient and unconstrained. A family of landlords provides rental units to the borrowers, and I introduce nominal rigidities in the form of sticky-wage frictions. To close the model, I assume a monetary authority that employs a Taylor rule at the Euro-Area-level and equalize the short interest rates across countries. The advantage of such a unified currency-union framework with rich country-level housing and mortgage market institutions is that it allows me to analyze and compare the effects of specific features of the aforementioned markets in the transmission mechanism of monetary policy across the different Euro Area countries.

The countries in the model economy crucially differ in two key housing and mortgage market institutions. Firstly, borrowers are subject to within-period heterogeneity in utility from owning, leading them to endogenously choose whether to be homeowner or renter as in [Greenwald and Guren \(2019\)](#). This heterogeneity stems from true housing preference as well as household demographic characteristics not otherwise captured in the model. The way I rationalize in the model the fact that a country has a higher homeownership rate than another one is by assuming that households are on average happier to own. This difference in the distribution of owning utility across countries stands in for the quality of the rental market and ownership subsidies. Secondly, I assume that in each country households hold an exogenous fraction of fixed-rate mortgages (FRM) and ARM. While the mortgage type choice is in principle an endogenous household decision, I model it as exogenous because it is in practice influenced by country-specific housing finance regulation<sup>4</sup>. An important equilibrium feature of the model is the pass-through of the policy rate to the mortgage

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on short rates.

<sup>4</sup>In [Section 4.2](#) I argue that the quantitative results would change little if I modeled the mortgage type decision to be endogenous.

rate. I show that countries with a higher ARM share display a larger pass-through to mortgage rates, which is also a correlation I demonstrate empirically.

I calibrate the Home economy to Spain and the Foreign economy to the Euro Area. To do so, I make use of the second wave of the Eurosystem Household Finance and Consumer Survey, which was administered around 2014 and contains harmonized data across European countries on household balance sheets. I calibrate Spain to have a 90% share of ARM and 80% HoR, with the proportion of homeowners with mortgages being 30%. Similarly, I calibrate the Euro Area to have a 45% share of ARM and 60% HoR, with the proportion of homeowners with mortgages being 20%. As the main monetary policy experiment, I consider a near-permanent decrease of 1% in interest rates which shifts downward the whole term structure, and compare the monetary transmission mechanism across Spain and the Euro Area.

As in the data, the model results show that Spain reacts more strongly than the Euro Area. Comparing the impulse response function peaks and troughs over a 15Q horizon, the mortgage rate on the outstanding stock of mortgages in Spain reacts about 2.2 times more than the Euro Area relative to 1.8 in the data. This is because in the Euro Area, most outstanding mortgages are fixed-rate which means a higher mortgage rate was locked in for those mortgages in the past. The upshot is that indebted households in Spain face much lower total payments on the stock of mortgages. Additionally, Spanish household rush to lock in lower rates, so that newly issued mortgages in Spain increase by 2.8 times as much as in the Euro Area – same as in the data. These effects combined deliver an aggregate consumption response in Spain which is 1.8 times stronger than the Euro Area relative to 2.5 in the data.

To understand the channels behind these responses, I use the model to disentangle how much of the monetary policy-induced responses come from the differential ARM share as opposed to the differential HoR. To do so, I consider a counterfactual economy in which Spain has the correct ARM share but the Euro-Area-level HoR. This counterfactual economy displays exactly the same quantitative effects on mortgage rates as the baseline economy. This is because while Spain faces the same short-term interest rate as the Euro Area, the presence of a higher ARM share determines a stronger pass-through to the mortgage rate in equilibrium – a result which I also discuss analytically. A consequence of this features is that the ARM share also explains all of the responses in newly issued mortgages. Conversely, when I consider a counterfactual economy in which Spain has the correct HoR but the Euro-Area-level share of ARM, a different scenario emerges. I find that mortgage-related variables respond roughly in line with the responses in the Euro Area. However, the movements in house prices (and price-to-rent) are virtually all driven by the differential HoR. Intuitively, borrowers in Spain have a higher average utility

from owning, which also makes them more willing to change tenure status following a demand-drive shock. These forces push the house price and the price-to-rent upwards relative to the Euro Area.

To sum up, the heterogeneous responses in mortgage-related variables between Spain and the Euro Area are mostly driven by the differential share of ARM. In contrast, the heterogeneous responses in house prices and price-to-rent ratios are instead explained by differences in HoR. In terms of aggregate consumption, however, I find that none of the single features alone can explain the aggregate responses of Spain relative to the Euro Area that I find in the baseline economy. On one hand, the higher ARM share in Spain causes the households to pay less interests on their mortgages. On the other hand, the higher HoR leads to an increase in the collateral value of housing via higher house prices. As a consequence, households can borrow more against their house while also paying less interests on their mortgages, a situation which lead them to spend more on their non-durable consumption. Therefore, housing and mortgage market institutions interact to amplify the potency of monetary policy on economic activity.

The last set of findings concerns the analysis of two counterfactuals. In the first experiment, I study how different forms of banking union alter the stabilization properties of the monetary authority. I find that a banking union, which I model as a Euro-Area-wide mortgage market, is successful in decreasing the heterogeneous transmission mechanism of monetary policy – especially so when the ARM share in Spain is lowered to equate that of the Euro Area. Under these banking arrangements, the monetary authority faces a trade-off between a weakened heterogenous transmission and a movement of resources towards the richer households of the economy. In the second experiment, I build on the recent European Central Bank (ECB) monetary policy strategy review to discuss the consequences of including house prices into the Euro Area price index. I show that reacting to house prices reduces the volatility of output but increases the volatility of inflation. This trade-off is qualitatively robust but quantitatively different depending on the nature of the monetary shock and the inclusion of rents instead than of house prices into the price index.

**Relation to the Literature.** This paper is related to three strands of the literature. Empirically, it relates to existing work analyzing the effects of monetary policy across countries in the Euro Area including [Lenza and Slacalek \(2018\)](#), [Almgren et al. \(2019\)](#), [Slacalek, Tristani, and Violante \(2020\)](#), [Corsetti, Duarte, and Mann \(2021\)](#), and [Koeniger, Lennartz, and Ramelet \(2021\)](#). Given that my focus is on mortgage contracts, I complement the results in these papers by showing heterogeneous responses of aggregate variables to monetary shocks at the *longer end of the yield curve*. I additionally compute the impulse response functions of mortgage rates as well as of newly issued mortgages and

show correlations of these responses with housing and mortgage market institutions.

Turning to theoretical models, my work is related to two additional lines of study. The first comprises models looking at monetary policy and exchange rates in small open economy and currency unions such as [Gali and Monacelli \(2005\)](#), [Faia and Monacelli \(2008\)](#), [Gali and Monacelli \(2008\)](#), [De Paoli \(2009\)](#), [Corsetti, Dedola, and Leduc \(2010\)](#), and [Gali and Monacelli \(2016\)](#). I complement these models with rich within-country household balance sheets such as long-term mortgages in order to compare the effects of a common interest rate movement across countries with different housing institutions.

The second line of work relates to New Keynesian models featuring housing and mortgage debt such as [Iacoviello \(2005\)](#), [Iacoviello and Neri \(2010\)](#), [Calza, Monacelli, and Stracca \(2013\)](#), and [Greenwald \(2018\)](#). Relative to these papers, I study the dynamics to monetary policy shocks across countries in a currency union, where a common interest rate is set by the central bank and countries with different characteristics display heterogeneous effects to monetary policy<sup>5</sup>.

**Overview.** The rest of the paper is organized as follows. Section 2 shows the relevance of ARM shares and of the HoR to account for heterogeneous effects of monetary policy shocks across Euro Area countries. Section 3 introduces the model, describes the calibration, and presents the key analytical equilibrium conditions. Section 4 provides the model results on the interest rate transmission, and Section 5 analyzes policy-relevant counterfactuals. Section 6 concludes. Additional results can be found in the appendices A-C.

## 2 The Empirical Relevance of Housing and Mortgage Markets in the Monetary Transmission

In this section I study the effects of monetary policy shocks across the early adopters of the Euro for a variety of variables of interest. I then correlate country-specific monetary policy effectiveness with the housing and mortgage institutions, namely the ARM share and the HoR.

There are two points worth stressing at this stage, stemming from the fact that the focus of the paper is on the housing and mortgage market. Firstly, I place particular emphasis

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<sup>5</sup>An older working paper version of [Corsetti, Duarte, and Mann \(2021\)](#) included a Home-Foreign framework to study changes in ARM share and Loan-to-Value constraints in a small open economy calibrated to Spain. Differently from that paper, I model long-term mortgages as well as the rental market both at the Euro-Area-level and at the small economy country level. Such a framework allows me to analyze the differential monetary policy transmission mechanism stemming from the dissimilar housing and mortgage market institutions alone, and also allows me to study the consequences at the country-level of a Euro-Area-wide mortgage market.

on the responses to monetary policy shocks on price-to-rent ratios, mortgage rates, newly issued mortgages, and aggregate consumption. Secondly, I study monetary shocks to the longer end of the yield curve. Given the long-term nature of mortgage contracts, movements in longer rates are going to be more effective drivers of macroeconomic fluctuations. As a consequence, my main empirical analysis looks over the “unconventional” time period 2007-2019, over which the ECB reached the zero-lower-bound on short rates<sup>6</sup>.

## 2.1 Identification

My empirical analysis relies on high frequency identification of monetary policy shocks (an approach first started with [Kuttner \(2001\)](#)) and leverages on local projection methods ([Jordà \(2005\)](#)).

In the context of high frequency identification in the US, monetary policy shocks have been identified as changes in Federal Funds futures around Federal Reserve announcements. In Europe, a few recent papers have adopted this approach by relying on movements in the Overnight Indexed Swap (OIS) rates around ECB announcements. The OIS is an interest rate swap over a specific maturity (say, 1 year) whereby two parties exchange a fixed interest rate for the floating European overnight interest rate. In essence, it is a measure of expectations about future overnight interest rates in the European interbank market. Hence, changes in OIS around ECB press conferences can be interpreted as *caused by* monetary policy<sup>7</sup>. I make use of the Euro Area Monetary Policy Event Study Database constructed by [Altavilla et al. \(2019\)](#), which provides changes in the median price of OIS rates at different maturities between the 10-minute window preceding each ECB announcement and the 10-minute window following it. The identifying assumptions are that a) OIS rates before and after the announcements are only moved by monetary policy, and b) the ECB does not respond to changes in OIS rates<sup>8</sup>.

Given that the focus of this paper is on the role of mortgages in the transmission mechanism, I make use of the unexpected movements in the longer end of the yield curve in the main monetary policy experiment. I therefore pick the 2-year OIS changes, which is the longest high frequency term available since the early 2000s. As a robustness exercise, I

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<sup>6</sup>Over this period, the ECB has employed a variety of measures aimed at stimulating the economy without the possibility of moving the short rates. These measures include forward guidance and several programmes of asset purchases and long-term liquidity provision.

<sup>7</sup>The same identification approach for the Euro Area has been employed by [Almgren et al. \(2019\)](#) in the context of local projection instrumental variables methods, by [Slacalek, Tristani, and Violante \(2020\)](#) in the context of a BVAR, and by [Corsetti, Duarte, and Mann \(2021\)](#) in the context of a dynamic factor model. For a more detailed discussion on OIS rates, see [Almgren et al. \(2019\)](#).

<sup>8</sup>[Jarociński and Karadi \(2020\)](#) separate monetary policy shocks from central bank information shocks. I abstract from this distinction in my analysis in order to focus on a broader measure of monetary shocks.



show that the results are very similar when I run a conventional monetary policy analysis using changes in the shorter term OIS.

## 2.2 Data and Empirical Specification

The main analysis runs from 2007 Q1 to 2019 Q3 for the eleven early adopters of the Euro: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain<sup>9</sup>. For completeness, I also include the Euro Area aggregates. I use quarterly data on country-specific aggregate consumption, price-to-rent ratios, newly issued mortgages, and mortgage interest rates. I also make use of a few Euro-Area-level variables, such as the harmonized index of consumer prices (HICP) and aggregate output. Mortgage interest rates are measured in annualized percentage terms, while all other variables are measured in log-levels. To construct monetary policy shocks at the quarterly level, I sum up the OIS changes within quarters as in [Slacalek, Tristani, and Violante \(2020\)](#). As discussed in the previous section, I use the 2-year OIS changes as identified monetary policy shocks<sup>10</sup>. My results are robust to a conventional monetary policy analysis, as I argue in [Appendix A.3](#). Data sources are outlined in [Appendix B](#).

I follow [Jordà \(2005\)](#) and estimate the response of the relevant variables to monetary policy shocks using local projections methods. For each country  $c$  and each horizon  $h=0, \dots, H$ , I estimate the following specification:

$$y_{t+h}^c - y_{t-1}^c = \alpha^{h,c} + \beta^{h,c} \epsilon_t^{MP} + \sum_{k=1}^K \gamma_k^{h,c} X_{t-k}^{h,c} + u_t^{h,c} \quad (1)$$

where  $y$  is the variable of interest,  $\epsilon^{MP}$  is the monetary policy shock, and  $X$  is a set of control variables. The impulse response functions are constructed, for each country  $c$ , from the sequence of the coefficients on the monetary policy shocks, that is  $\{\beta^{h,c}\}_{h=0}^H$ .

As a benchmark, I set the number of lags to  $K=2$  quarters and the horizon of the impulse response function to  $H=10$  quarters. The set of lagged controls  $X$  includes the left-hand-side variable, the monetary shock, the Euro Area mortgage rate, the Euro Area HICP, the Euro Area aggregate output, and the Euro Area price-to-rent ratio.

## 2.3 Heterogeneous Impulse Response Functions

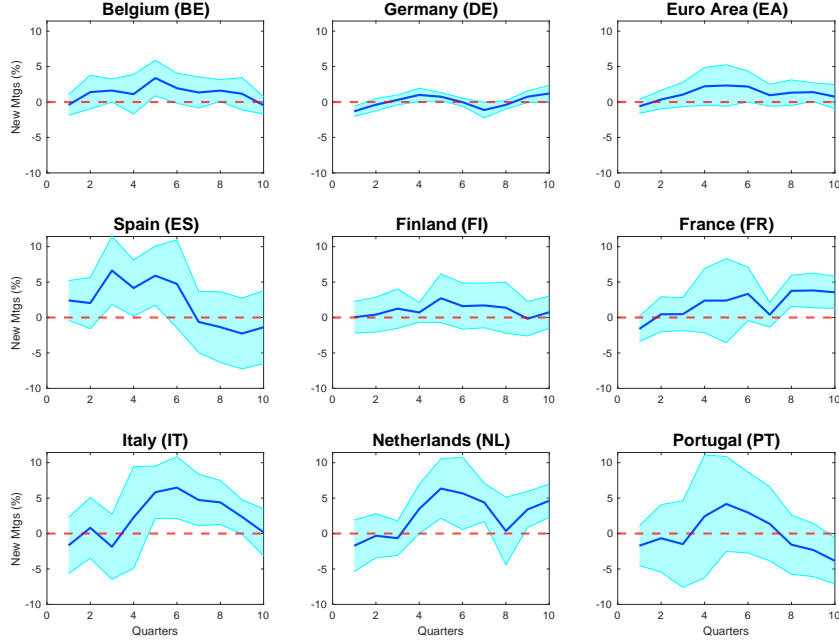
In this section I present impulse response functions for each country to an expansionary shock of one standard deviation, as in [Almgren et al. \(2019\)](#). I construct 95% confidence

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<sup>9</sup>The sample of countries with data on newly issued mortgages is a bit smaller, with Austria, Ireland, and Luxembourg missing.

<sup>10</sup>Even though most of the variation in the 2-year OIS changes happens between 2008 and 2012, the results in this section change very little if I run the analysis starting from 2003 Q1 (when mortgage rate data starts) instead of from 2007 Q1.





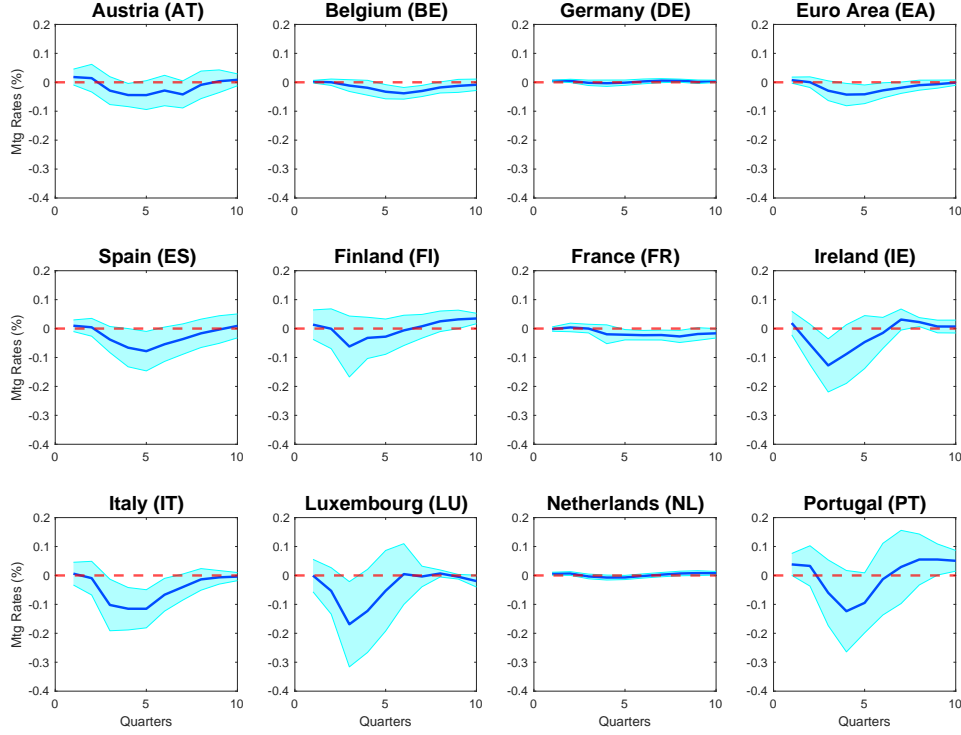
**Figure 1:** Impulse response functions of newly issued mortgages to an expansionary monetary policy shock of one standard deviation.

*Note:* For each country, the response is estimated using equation (1). The light blue shaded areas represent the 95% confidence intervals constructed using Newey-West standard errors. The estimation is performed over the period 2007 Q1 to 2019 Q3, with the 2Y OIS changes as identified monetary policy shocks.

intervals using Newey-West standard errors.

Figures 1 and 2 present two of the main empirical results of this paper. They show the impulse response functions of newly issued mortgages and outstanding mortgage rates, respectively. The results imply that a one standard deviation expansionary shock causes an increase in newly issued mortgages across the Euro Area, with some countries reacting much more severely than others. In particular, while a few countries such as Spain, Portugal, Italy, and the Netherlands increase their flow of new mortgages by about 5%, some others are far less reactive. For example, the Euro Area peaks at around 1.8% and Germany below 1%. The results on newly issued mortgages are echoed in the mortgage rate responses. Mortgage rates decrease following a monetary expansion, highlighting a strong pass-through for some countries and a much weaker one for some others. Again, Spain and Portugal are among the countries that react the most, reaching a trough of about 0.1%.

Results on aggregate consumption and price-to-rent ratios are more standard and therefore provided in Appendix A.1. In terms of aggregate consumption, an expansionary monetary policy shock of one standard deviation leads to an increase in Spain of about 0.5%, which is more than double the response of the Euro Area. By the same token, the price-to-rent ratio increase in Spain by 1%, more than twice as much as in the Euro Area.



**Figure 2:** Impulse response functions of outstanding mortgage interest rates to an expansionary monetary policy shock of one standard deviation.

*Note:* For each country, the response is estimated using equation (1). The light blue shaded areas represent the 95% confidence intervals constructed using Newey-West standard errors. The estimation is performed over the period 2007 Q1 to 2019 Q3, with the 2Y OIS changes as identified monetary policy shocks.

I decide to focus on price-to-rent ratios instead of on house prices because these ratios are widely understood to be the basis of household decisions about whether to rent or to buy. However, the results of my analysis are virtually unchanged if I substitute price-to-rent ratios with house prices. This is because monetary policy in the Euro Area barely moves rents relative to house prices.

Heterogeneity in the transmission of monetary shocks across the Euro Area has been recently quantified by [Corsetti, Duarte, and Mann \(2021\)](#) using a dynamic factor model. They find significant heterogeneity in consumption, consumer prices, house prices, and unemployment. While I confirm their results on aggregate consumption and house prices, my analysis provides evidence of heterogeneous responses in mortgage market variables (figures 1 and 2). Through the lenses of the model I present in Section 3, I show that the aforementioned heterogeneity is essential to explain the differential responses in aggregate consumption across Euro Area countries.

## 2.4 The Role of Housing and Mortgage Markets

In this section I correlate the country-specific monetary policy effectiveness discussed in the previous section with key housing and mortgage market institutions. To do so, I make use of the Eurosystem Household Finance and Consumption Survey (HFCS).

The HFCS is coordinated by the ECB and conducted in a decentralized manner, with each national central bank conducting the survey. The strength of the survey is that it is harmonized across countries, and contains detailed household-level data on assets, liabilities, and income. The HFCS is conducted every three years in most of the countries starting in 2010, and I rely on the second wave which was administered between 2013 and 2015 and contains around 75 thousands families.

I compute a few measures which have a direct mapping with the model I present in Section 3. To start with, for each country I compute the share of ARM over the total outstanding mortgage stock. There are striking differences in this measure across Euro Area countries. Most notably, while in Ireland, Spain, Finland and Portugal about 90% of outstanding mortgages are adjustable-rate, in Germany and France the counterpart figure is of about 10%. I also compute homeownership rates<sup>11</sup>. I further distinguish between two related measures. I define “outright homeowners” the fraction of households who own their main residence with no outstanding mortgages on it. Finally, I compute the fraction of households who have mortgages on their main residence. Obviously, in each country the sum of the latter two measures defines the HoR.

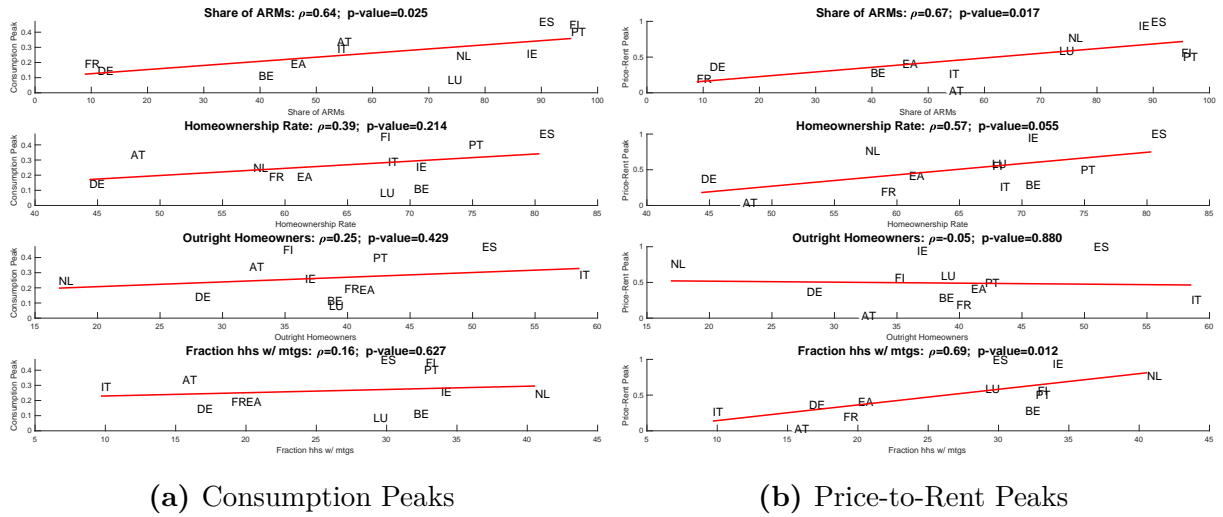
In figures 3 and 4 I plot the relationships between monetary policy effectiveness to an expansionary policy shock and the previously discussed measures of housing and mortgage market characteristics. Similarly to [Almgren et al. \(2019\)](#), I measure the strength of monetary policy transmission in each country by the peak response of the impulse response functions. For the mortgage interest rate responses, I consider the trough responses given the pass-through from policy rates (recall Figure 2). Before I proceed in analyzing the results of my correlation analysis, a word of caution is necessary. Because I only consider the early adopters of the euro, this analysis is meant to motivate the main futures of the currency-union TANK model I present in Section 3 rather than to uncover strong empirical relationships between the 12 data points.

A few results stand out. Firstly, aggregate consumption (panel 3a), price-to-rent ratios (panel 3b), newly issued mortgages (panel 4a), and outstanding mortgage rates (panel 4b) react more strongly in countries that have higher ARM share and higher HoR. These relationships are in general statistically strong with p-values often below 5%, except for newly issued mortgages for which only 8 countries (instead than 11) are considered.

Secondly, it is interesting to disaggregate the correlations with the HoR into its

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<sup>11</sup>I define the homeownership rate as the fraction of households who own their main residence.



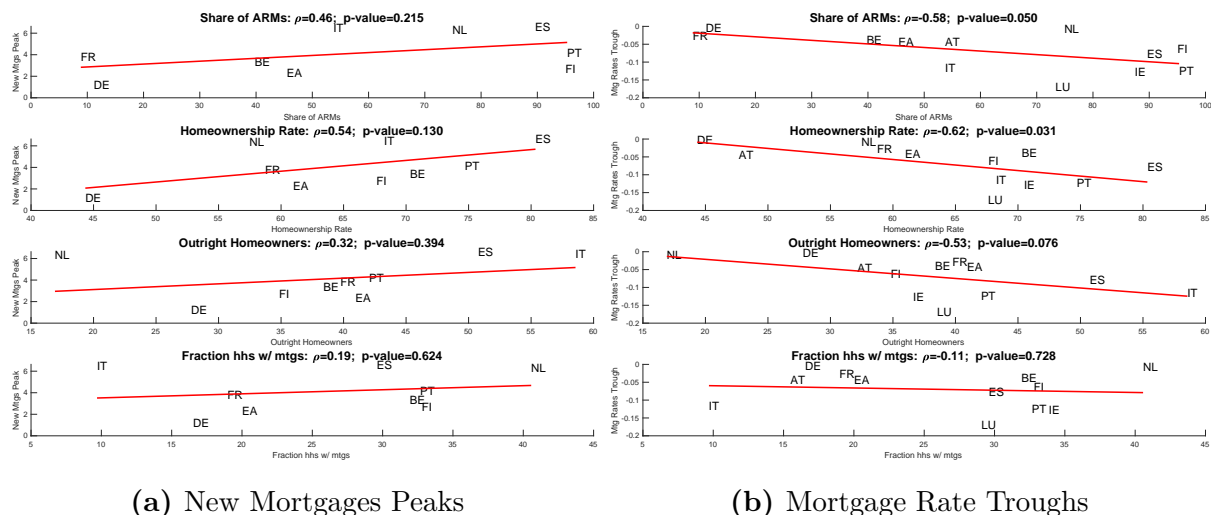
**Figure 3:** Scatter plots of impulse response function intensities and housing and mortgage market characteristics.

*Note:* On the y-axis, I measure the strength of monetary policy by means of peak responses for both aggregate consumption and price-to-rent ratios. On the x-axis of each subplot, I make use of shares of ARM and various homeownership measures. For each country, the impulse response functions are estimated using equation (1) over the period 2007 Q1 to 2019 Q3, with the 2Y OIS changes as identified monetary policy shocks. The corresponding impulse response functions are shown in figures A.1 and A.2. Calculations of housing and mortgage market characteristics are based on the Eurosystem Household Finance and Consumption Survey.

components. For example, reactions to price-to-rent ratios across countries are strongly correlated with their HoRs (recall panel 3b). This correlation is entirely driven by the fraction of households holding mortgages (correlation of 0.69 and p-value of 0.012) rather than by the fraction of outright homeowners.

It is worth stressing at this point that existing research correlates monetary policy effectiveness with characteristics of the housing and mortgage markets. Calza, Monacelli, and Stracca (2013) document that aggregate consumption and house price responses are stronger for countries with relatively more variable-rate mortgages. This same result has been confirmed for Euro Area countries by Corsetti, Duarte, and Mann (2021), who also find strong correlations with HoRs. I complement these two papers by showing that the reactions of mortgage market variables are not only strikingly different between countries, but strongly correlate with housing characteristics (Figure 4). For each country, I additionally split the HoR into its two components (fractions of homeowners with and without mortgages) showing that both are often significant in explaining the underlying heterogeneity<sup>12</sup>.

<sup>12</sup>Almgren et al. (2019) document that in the Euro Area the variable that correlates the most with output responses is the fraction households who are wealthy hand-to-mouth. Most of these households own the property in which they live without a mortgage on it. In my analysis, these households are



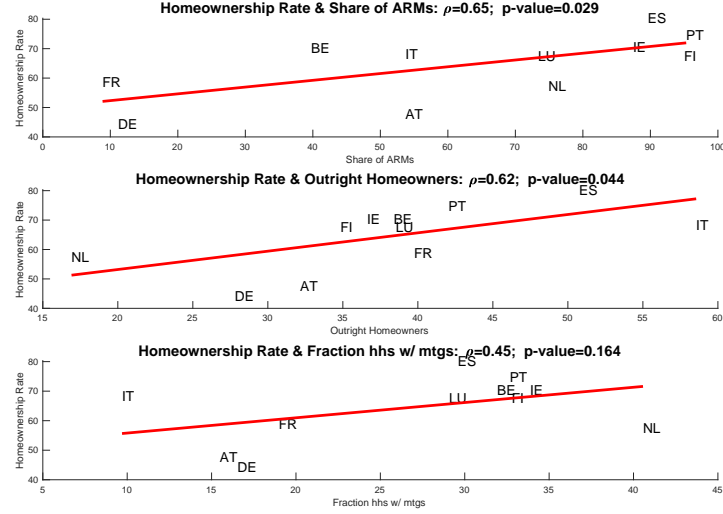
**Figure 4:** Scatter plots of impulse response function intensities and housing and mortgage market characteristics.

*Note:* On the y-axis, I measure the strength of monetary policy by means of peak responses for newly issued mortgages, and trough responses for mortgage rates. On the x-axis of each subplot, I make use of shares of ARM and various homeownership measures. For each country, the impulse response functions are estimated using equation (1) over the period 2007 Q1 to 2019 Q3, with the 2Y OIS changes as identified monetary policy shocks. The corresponding impulse response functions are shown in figures 1 and 2. Calculations of housing and mortgage market characteristics are based on the Eurosystem Household Finance and Consumption Survey.

The main takeaway from all the correlations shown in figures 3 and 4 is that monetary policy effectiveness to the macroeconomy is strongly related to a few housing and mortgage market characteristics. These latter country-specific features, however, do not necessarily jointly explain the heterogeneous monetary transmission mechanism. Figure 5 shows that countries that have a higher HoR are also those that have bigger ARM shares, higher fraction of households holding mortgages, and higher fraction of outright homeowners. Therefore, an identification problem arises whereby it might well be that only one of those features explain the heterogeneous monetary transmission mechanism in practice, and not all of them. Section 3 builds a quantitative TANK model with the purpose of providing intuitions of the mechanisms at work as well as of quantifying the relative importance of each of the previously mentioned country-specific housing features.

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captured by the outright homeowners.



**Figure 5:** Scatter plots of the shares of ARM and various measures of HoR.

*Note:* These calculations are based on the Eurosystem Household Finance and Consumption Survey.

### 3 A Currency-Union Two-Agent New Keynesian Model

In order to disentangle the role of the housing and mortgage market institutions in the monetary transmission mechanism as well as to quantify the relative importance of the ARM share and the HoR, I build a discrete time currency-union Two-Agent New Keynesian (TANK) model. The main contribution of the paper is to complement the Home-Foreign type of model (Faia and Monacelli (2008)) with rich within-country housing and mortgage market institutions (Greenwald (2018)). The advantage of such a unified framework lies in the possibility to analyze the role of the housing and mortgage market institutions into the heterogenous transmission mechanism of monetary policy highlighted empirically in Section 2. This model also allows me to explore how changes across countries to the aforementioned institutions affect the central bank’s ability to stimulate the economy.

#### 3.1 Model Setup

The world economy is composed of two countries: Home and Foreign. As formally described later on, I assume that the Home economy is small relative to Foreign. Each economy consists of a family of borrowers, a family of savers, and a family of landlords who transact in the housing and mortgage markets. Given the small size of Home relative to Foreign, one can think of Foreign as the Euro Area and Home as any country belonging to the currency union. Therefore, the monetary authority decides the interest rate at the Foreign level and equalizes the short interest rates across countries.

In terms of notation, variables with an asterisk denote Foreign quantities while variables

without an asterisk denote Home quantities. In the discussion that follows, I focus on the Home economy and note the ways in which the Foreign economy differs from Home.

**Preferences.** The households in this economy are indexed by  $j \in \{b, s\}$ , standing for borrowers and savers. The borrowers belong to a family with measure  $\chi_b$  and have a discount factor  $\beta_b$ , while the savers belong to a family with measure  $\chi_s = 1 - \chi_b$  and have a discount factor  $\beta_s > \beta_b$ . Households belonging to the same family trade consumption and housing services within the family, providing perfect insurance against idiosyncratic risk. As a consequence, each family can be aggregated up to a representative agent.

Borrowers and savers maximize their expected lifetime utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_j^t u \left( \frac{C_{j,t}}{\chi_j}, \frac{N_{j,t}}{\chi_j}, \frac{H_{j,t}}{\chi_j} \right), \quad (2)$$

where  $C_{j,t}/\chi_j$  is per-capita non-durable consumption of agent  $j$ ,  $N_{j,t}/\chi_j$  is per-capita labor hours supplied, and  $H_{j,t}/\chi_j$  is per-capita housing services. The per-period utility function takes the form:

$$u(C, N, H) = \log(C) + \xi \log(H) - \iota \frac{N^{1+\phi}}{1+\phi}.$$

where  $\xi$  is an housing preference parameter,  $\iota$  is a labor disutility parameter, and  $\phi$  is the inverse Friesch elasticity of labor supply<sup>13</sup>.

Finally, there is a family of risk-neutral landlords who maximizes the sum of discounted profits coming from renting out housing units to borrowers. This family can be aggregate up to a representative firm, which it is owned by the savers of the economy<sup>14</sup>.

**Mortgage contract.** The only source of borrowing in the model economy is mortgages, modeled as a nominal perpetuity with geometrically declining payments as in [Chatterjee and Eyigungor \(2015\)](#) and [Greenwald \(2018\)](#). As standard in this class of models, the impatient households borrow mortgages while the patient households issue them<sup>15</sup>.

One of the key aspects of the model is to explicitly allow for the fact that any economy has a specific mix of fixed-rate mortgages and adjustable-rate ones. Specifically, I assume that borrowers hold an exogenous fraction  $\alpha$  of fixed-rate mortgages and a fraction  $(1 - \alpha)$

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<sup>13</sup>This same functional form of the utility function has been used in related papers ([Iacoviello and Neri \(2010\)](#), [Greenwald \(2018\)](#)). Assuming a more general CRRA utility of consumption with a risk aversion parameter of 2 or a more general function for housing services is inconsequential for the main results of this paper.

<sup>14</sup>As argued by [Greenwald and Guren \(2019\)](#), a key assumption for realist joint dynamics of credit conditions and house prices is the imperfect segmentation in the housing market. I follow them and assume this to be the case in both Home and Foreign.

<sup>15</sup>See for example [Iacoviello \(2005\)](#), [Iacoviello and Neri \(2010\)](#), [Rubio \(2011\)](#), and [Greenwald \(2018\)](#).



of adjustable-rate ones<sup>16</sup>. This allows me to differentiate the Home and Foreign country in the model based on their ARM share, and allows me to study the dynamic effects of changes in the share in each economy. While the mortgage type choice is in principle an endogenous household decision, I model it as exogenous because it is in practice influenced by country-specific housing finance regulation<sup>17</sup>. Furthermore, the ARM share across countries is relatively stable over time (see figure 1 in [Badarinza, Campbell, and Ramadorai \(2018\)](#)). To show the workings of the contract, suppose a lender gives a borrower 1€ at time  $t$ . Then the savers receive  $(1 - \nu)^k(\alpha q_t + (1 - \alpha)q_{t+k})$ € at time  $t + k$ , for all  $k > 0$ , where  $\nu$  is the fraction of principal paid each period and  $q_t$  is the mortgage rate.

In this economy, the mortgage debt is refinanced with an exogenous probability  $\rho$ . This means that in each period, a fraction  $\rho$  of borrowers repays the outstanding balance on their loan in order to refinance. Once they refinance, they can choose a new loan size  $m_{bt}$  subject to a loan-to-value (LTV) constraint. The LTV constraint is expressed as  $m_{bt} \leq \theta^{LTV} p_t^h h_{bt}$ , where  $\theta^{LTV}$  is the maximum LTV ratio,  $p_t^h$  is the housing price, and  $h_{bt}$  is the newly purchased house size. Notice that the LTV constraint only applies at origination, a feature common to the US as well as to Euro Area countries.

**Additional financial contracts.** Savers in each economy can trade a one-period nominal bond  $b_t$ , which delivers a risk-free interest rate  $R_t$  and is in zero net supply. The nominal interest rate is controlled by the monetary authority through its Taylor rule in the Foreign economy. I additionally assume that the savers of both economies have access to a complete set of contingent claims traded internationally. This assumption delivers the standard international risk sharing formula in equilibrium.

**Housing.** As for mortgages, a fraction  $\rho$  of the borrowers, the savers, and the landlords can decide in each period the optimal house size to buy, denoted by  $h_j$ ,  $j \in \{b, s, l\}$ . At the start of each period, homeowners pay a constant maintenance cost  $\delta$  on their outstanding house value. The supply of owned houses is fixed to  $\bar{H}$ <sup>18</sup>.

Borrowers have the option of renting or owning. I follow [Greenwald and Guren \(2019\)](#)

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<sup>16</sup>Close papers in this aspect are [Rubio \(2011\)](#) and [Garriga, Kydland, and Šustek \(2017\)](#), both calibrated to the US. [Rubio \(2011\)](#) assumes 2 different types of borrowers, those holding fixed-rate mortgages and those holding adjustable-rate ones. Similarly to my setting, instead, [Garriga, Kydland, and Šustek \(2017\)](#) assume there is only one representative agent who can choose endogenously between mortgage types. While feasible in principle, I refrain from endogenizing the choice between mortgage types for the reasons discussed in the main text.

<sup>17</sup>For example, [Bank of Spain \(2017\)](#) makes it clear that the lack of long-term swap contracts available to banks prior to 2015 led them to only issue ARM, as they couldn't hedge the interest rate risk.

<sup>18</sup>The presence of a flexible housing supply would imply smaller movements in house prices. Because demand-driven shocks typically move house prices and rents in the same direction under a fixed supply specification, the assumption of fixed housing supply is inconsequential for price-to-rent ratios.

and assume that every period they receive a service flow (positive or negative) from owning housing. In particular, if a borrower  $i$  owns one unit of housing, she receives  $\omega_{b,t}^i$  of the numeraire, where  $\omega_{b,t}^i \sim \Gamma_{\omega,b}$  is i.i.d. across borrowers and time. This inter-period heterogeneity guarantees that in each period the borrowers with a high enough owning utility benefit want to own housing, while the rest want instead to rent. As it will become clear later on, the threshold utility benefit from owning depends in equilibrium on the aggregate macroeconomic conditions.

The borrower heterogeneity from owning stems from true housing preference as well as household demographic characteristics not otherwise captured in the model. Under this structure, a differential HoR between Home and Foreign can be achieved by assuming that one country features a distribution  $\Gamma_{\omega,b}$  with a different mean than the other country. This difference in the distribution of owning utility across countries stands in for the quality of the rental market and ownership subsidies. To give a concrete example, the most important reason for which Germany has the lowest homeownership rate of the Euro Area (40%) is thought to be its extensive social housing sector (see Voigtländer (2009) for a qualitative analysis and Kaas et al. (2021) for a quantitative one). Furthermore, German households did not benefit from high subsidies the way households in other European countries such as Spain and the Netherlands did (see also Van den Noord (2005) for a related analysis of tax treatments).

Similarly to borrowers, landlords also receive a service flow from owning housing. This form of heterogeneity within the family of landlords can stand in for the fact that some houses are more suitable to rent than others due to geography or moral hazard. Differences across countries in this heterogeneity might stem from institutional aspects characterizing the housing construction sector. For example, following the Second World War, the German government provided direct subsidies and tax-privileges to landlords in order to promote construction of homes – which did not happen in other countries<sup>19</sup>. If a landlord  $i$  owns one unit of housing, she receives  $\omega_{l,t}^i$  of the numeraire, where  $\omega_{l,t}^i \sim \Gamma_{\omega,l}$  is i.i.d. across landlords and time. Landlords buy housing units to transform them into rental units for use by borrowers. Because the heterogeneous utility benefits to borrowers and landlords do not necessarily stand in for financial benefits or costs as previously discussed, they are rebated lump-sum to them in equilibrium. Finally, savers are allowed to transact in the housing markets with the borrowers and landlords although they never rent.

**The labor market** features sticky-wage frictions that are standard in the New Keynesian literature (Erceg, Henderson, and Levin (2000), Schmitt-Grohé and Uribe (2005), and Auclert, Rognlie, and Straub (2018)). I assume that households provide hours of work to

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<sup>19</sup>Although I model heterogeneity in the owning utility of landlords, I do not generate cross-country differences in this way.

a continuum of unions and face quadratic utility costs of adjusting the nominal wage set by the unions. Appendix C.2 provides the details and the derivations. I show that under a symmetric equilibrium, all households work the same number of hours:

$$\frac{N_{b,t}}{\chi_b} = \frac{N_{s,t}}{\chi_s} = N_t,$$

where  $N_t$  is aggregate labor demand, and that the Wage Phillips Curve takes the form:

$$\pi_t^W (\pi_t^W - 1) = \frac{\varphi}{\psi} N_t \left( u^N(N_t) - \frac{\varphi - 1}{\varphi} (1 - \tau) \frac{W_t}{P_t} \tilde{u}^c \right) + \tilde{\beta} \pi_{t+1}^W (\pi_{t+1}^W - 1). \quad (3)$$

where  $\tilde{u}^c = \chi_b u^c(C_{b,t}/\chi_b) + \chi_s u^c(C_{s,t}/\chi_s)$  is the average marginal utility, and  $\tilde{\beta} = \chi_b * \beta_b + \chi_s * \beta_s$  is the average discount factor in the economy.

**The borrowers** choose consumption  $C_{b,t}$ , new mortgages  $m_{b,t}$ , new house size  $h_{b,t}$ , and housing services  $s_{b,t}$ . Due to frictions in the labor market, they take hours worked  $N_{b,t}$  as given. The endogenous state variables are: total start-of-period housing  $H_{b,t-1}$ , total start-of-period debt balances  $M_{b,t-1}$ , and – because there are some fixed-rate mortgages in the economy – total promised payments on existing debt  $X_{b,t-1}$ . Thus they maximize:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_b^t u \left( \frac{C_{b,t}}{\chi_b}, \frac{N_{b,t}}{\chi_b}, \frac{s_{b,t}}{\chi_b} \right),$$

while facing a set of constraints. First, the budget constraint reads:

$$\begin{aligned} C_{b,t} \leq & \underbrace{(1 - \tau) \frac{W_t}{P_t} N_{b,t}}_{\text{LaborIncome}} + \underbrace{\rho(m_{b,t} - (1 - \nu)\pi_t^{-1}M_{b,t-1})}_{\text{NetMortgageIssuance}} - \underbrace{\rho p_{h,t}(h_{b,t} - H_{b,t-1})}_{\text{NetHousingPurchases}} \\ & - \underbrace{\pi_t^{-1} \nu M_{b,t-1}}_{\text{PrincipalPayment}} - \underbrace{\pi_t^{-1} (1 - \tau) [\alpha X_{b,t-1} + (1 - \alpha) q_{t-1} M_{b,t-1}]}_{\text{InterestPayment}} - \underbrace{\delta p_{h,t} H_{b,t-1}}_{\text{Maintenance}} \\ & - \underbrace{p_{r,t}(s_{b,t} - H_{b,t-1})}_{\text{Rent}} + \underbrace{\left( \int_{\bar{\omega}_{b,t-1}} \omega d\Gamma_{\omega,b} \right) A_{b,t-1}}_{\text{OwnerSurplus}} + \underbrace{T_{b,t}}_{\text{Rebates}}, \end{aligned}$$

where  $W_t/P_t$  is the real wage,  $\pi_t$  is the inflation rate,  $p_{h,t}$  is the house price,  $q_t$  is the mortgage rate,  $p_{r,t}$  is the rental rate,  $\omega$  is the utility benefit from owning, and  $A_{b,t-1}$  is an expression that is uninfluential for the results and that can be found in Appendix C.1.1. Notice that in equilibrium all borrowers with  $\omega_{i,t} > \bar{\omega}_{b,t}$  choose to be homeowners, where  $\bar{\omega}_{b,t}$  is defined by market clearing:

$$\Gamma_{\omega,b}(\bar{\omega}_{b,t}) = \frac{H_{l,t}}{H_{b,t} + H_{l,t}},$$

where the LHS is the fraction of borrowers who rent, and the RHS is the fraction of housing services consumed by the borrower that is rented out by the landlord. The quantity  $T_{b,t}$

rebates lump-sum the taxed income, the deducted interest payments, and the utility benefits from owning (all in real terms).

Second, the borrower is subject to an LTV constraint applied only at origination:

$$m_{b,t} \leq \theta^{LTV} p_t^h h_{b,t},$$

Finally, the laws of motion for the state variables are:

$$\begin{aligned} M_{b,t} &= \underbrace{\rho m_{b,t}}_{NewLoans} + \underbrace{(1-\rho)(1-\nu)\pi_t^{-1} M_{b,t-1}}_{OldLoans} \\ X_{b,t} &= \underbrace{\rho q_t m_{b,t}}_{NewLoans} + \underbrace{(1-\rho)(1-\nu)\pi_t^{-1} X_{b,t-1}}_{OldLoans} \\ H_{b,t} &= \underbrace{\rho h_{b,t}}_{NewHousing} + \underbrace{(1-\rho) H_{b,t-1}}_{OldHousing}. \end{aligned}$$

**The landlords** belong to a family whose purpose is to buy housing  $h_{l,t}$  and rent it out to borrowers. Because they are risk-neutral, landlords can be aggregated up to look like a representative firm, which is owned by the savers and maximizes the sum of discounted profits:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^s F_t,$$

where  $\Lambda_{0,t}^s$  is the stochastic discount factor (SDF) of the savers. The budget constraint reads:

$$F_t \leq \underbrace{p_{r,t} H_{l,t-1}}_{Rent} - \underbrace{\rho p_{h,t} (h_{l,t} - H_{l,t-1})}_{NetHousingPurchases} - \underbrace{\delta p_{h,t} H_{l,t-1}}_{Maintenance} + \underbrace{\left( \int_{\bar{\omega}_{l,t-1}} \omega d\Gamma_{\omega,l} \right) A_{l,t-1}}_{OwnerSurplus} + \underbrace{T_{l,t}}_{Rebates},$$

where  $T_{l,t}$  rebates the owner utility benefits received by the landlords. Similarly to the borrower's problem, market clearing imposes:

$$\Gamma_{\omega,l}(\bar{\omega}_{l,t}) = \frac{H_{b,t}}{H_{b,t} + H_{l,t}},$$

Finally, the law of motion of housing stock  $H_{l,t}$  is:

$$H_{l,t} = \underbrace{\rho h_{l,t}}_{NewHousing} + \underbrace{(1-\rho) H_{l,t-1}}_{OldHousing}.$$

**The savers** choose consumption  $C_{s,t}$ , bonds  $B_t$ , new mortgages  $m_{s,t}$ , and new house size  $h_{s,t}$ . As the borrowers, they take hours worked  $N_{s,t}$  as given due to frictions in the labor market. They maximize:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_s^t u \left( \frac{C_{s,t}}{\chi_s}, \frac{N_{s,t}}{\chi_s}, \frac{H_{s,t}}{\chi_s} \right),$$

while facing a set of constraints. First, the budget constraint reads:

$$\begin{aligned}
C_{s,t} \leq & \underbrace{(1-\tau)\frac{W_t}{P_t}N_{s,t}}_{\text{LaborIncome}} - \underbrace{\rho(m_{s,t} + (1-\nu)\pi_t^{-1}M_{s,t-1})}_{\text{NetMortgageIssuance}} - \underbrace{\rho p_{h,t}(h_{s,t} - H_{s,t-1})}_{\text{NetHousingPurchases}} + \underbrace{\pi_t^{-1}\nu M_{s,t-1}}_{\text{PrincipalPayment}} + \underbrace{T_{s,t}}_{\text{Rebates}} \\
& + \underbrace{\pi_t^{-1}[\alpha X_{s,t-1} + (1-\alpha)q_{t-1}M_{s,t-1}]}_{\text{InterestPayment}} - \underbrace{(R_t^{-1}B_t - \pi_t^{-1}B_{t-1})}_{\text{NetBondPurchases}} - \underbrace{\delta p_{h,t}\bar{H}_s}_{\text{Maintenance}} + \underbrace{F_t}_{\text{ProfitsLandlord}}, \quad (4)
\end{aligned}$$

The lump sum rebates  $T_{s,t}$  includes the taxed income.

Second, the laws of motion of mortgage balance  $M_{s,t}$ , total promised payments on existing debt  $X_{s,t}$ , and housing stock  $H_{s,t}$  are:

$$\begin{aligned}
M_{s,t} &= \underbrace{\rho m_{s,t}}_{\text{NewLoans}} + \underbrace{(1-\rho)(1-\nu)\pi_t^{-1}M_{s,t-1}}_{\text{OldLoans}} \\
X_{s,t} &= \underbrace{\rho q_t m_{s,t}}_{\text{NewLoans}} + \underbrace{(1-\rho)(1-\nu)\pi_t^{-1}X_{s,t-1}}_{\text{OldLoans}} \\
H_{s,t} &= \underbrace{\rho h_{s,t}}_{\text{NewHousing}} + \underbrace{(1-\rho)H_{s,t-1}}_{\text{OldHousing}}.
\end{aligned}$$

Finally, the savers (at Home as well as in Foreign) have access to internationally traded claims. These have not been explicitly introduced in the budget constraint (4) to reduce clutter.

**The final good sector** is operated by perfectly competitive producers who face a simple linear aggregate production technology with flexible prices:

$$Y_t = N_t.$$

As a consequence, the final goods price is given by  $P_t = W_t$  and profits are zero. This implies that a) the real wage is equal to unity:  $W_t/P_t = 1$ ; and b) price inflation equals wage inflation:  $\pi_t \equiv P_t/P_{t-1} = \pi_t^W \equiv W_t/W_{t-1}$ .

**The world economy** is composed of two countries – Home and Foreign. The world economy has unitary measure, with Home having measure  $n$  and Foreign  $(1-n)$ . I follow the limit-case approach, as in [Faia and Monacelli \(2008\)](#), and assume that the Home economy is small relative to Foreign, that is  $n \rightarrow 0$ . This assumption implies in equilibrium that Home does not affect Foreign's dynamics, while the opposite is not true.

Aggregate consumption in the Home economy (which includes non-durables as well as expenditures on housing) is described by the following index of domestic and imported bundles of goods:

$$AC_t \equiv \left[ (1-\gamma)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}},$$

where  $\eta > 0$  is the elasticity of substitution between domestic and foreign goods, and  $\gamma \equiv (1-n)\lambda$  denotes the weight of imported goods in the Home consumption. This weight

depends on  $(1 - n)$ , the relative size of Home, and on  $\lambda$ , the degree of trade openness of Home. Analogously, consumption preferences in Foreign are defined as:

$$AC_t^* \equiv \left[ (1 - \gamma^*)^{\frac{1}{\eta}} C_{F,t}^{*\frac{\eta-1}{\eta}} + \gamma^{*\frac{1}{\eta}} C_{H,t}^{*\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}.$$

where  $\gamma^* \equiv n\lambda^*$ .

Each consumption bundle  $C_{H,t}$  and  $C_{F,t}$  is composed of imperfectly substitutable varieties:

$$C_{H,t} \equiv \left[ \left( \frac{1}{n} \right)^{\frac{1}{\epsilon}} \int_0^n C_{H,t}(i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}}; \quad C_{F,t} \equiv \left[ \left( \frac{1}{1-n} \right)^{\frac{1}{\epsilon}} \int_n^1 C_{F,t}(i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}};$$

$$C_{H,t}^* \equiv \left[ \left( \frac{1}{n} \right)^{\frac{1}{\epsilon}} \int_0^n C_{H,t}^*(i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}}; \quad C_{F,t}^* \equiv \left[ \left( \frac{1}{1-n} \right)^{\frac{1}{\epsilon}} \int_n^1 C_{F,t}^*(i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}}.$$

where  $\epsilon > 1$  is the elasticity of substitution across the differentiated products.

The consumption-based price indices that correspond to the above specifications of preferences are given by:

$$P_t = \left[ (1 - \gamma) P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta} \right]^{\frac{1}{1-\eta}}; \quad P_t^* = \left[ (1 - \gamma^*) P_{F,t}^{*1-\eta} + \gamma^* P_{H,t}^{*1-\eta} \right]^{\frac{1}{1-\eta}}.$$

$P_{H,t}$  is the price sub-index for home-produced goods expressed in the domestic currency,  $P_{F,t}$  is the price sub-index for foreign-produced goods expressed in the domestic currency,  $P_{H,t}^*$  is the price sub-index for home-produced goods expressed in the foreign currency, and  $P_{F,t}^*$  is the price sub-index for foreign-produced goods expressed in the foreign currency. The price sub-indices are defined as follows:

$$P_{H,t} = \left[ \left( \frac{1}{n} \right) \int_0^n P_{H,t}(i)^{1-\epsilon} di \right]^{\frac{1}{1-\epsilon}}; \quad P_{F,t} = \left[ \left( \frac{1}{1-n} \right) \int_n^1 P_{F,t}(i)^{1-\epsilon} di \right]^{\frac{1}{1-\epsilon}};$$

$$P_{H,t}^* = \left[ \left( \frac{1}{n} \right) \int_0^n P_{H,t}^*(i)^{1-\epsilon} di \right]^{\frac{1}{1-\epsilon}}; \quad P_{F,t}^* = \left[ \left( \frac{1}{1-n} \right) \int_n^1 P_{F,t}^*(i)^{1-\epsilon} di \right]^{\frac{1}{1-\epsilon}}.$$

**Law of one price.** I assume that the law of one price holds, meaning that  $P_{H,t}(i) = \zeta_t P_{H,t}^*(i)$  and  $P_{F,t}(i) = \zeta_t P_{F,t}^*(i)$ , where  $\zeta_t$  is the nominal exchange rate. Notice that by plugging the previous expressions into the corresponding price-subindices formulae, we can derive that  $P_{H,t} = \zeta_t P_{H,t}^*$  and  $P_{F,t} = \zeta_t P_{F,t}^*$ . That is, the law of one price also holds at the price of the consumption bundles. However, given the presence of home bias, purchasing power parity does not hold, that is,  $P_t \neq \zeta_t P_t^*$ . Hence, I denote the real exchange rate as  $Q_t = \frac{\zeta_t P_t^*}{P_t}$ .

**Total variety demands.** Market clearing for domestic variety  $i$  must satisfy:

$$Y_t(i) = n C_{H,t}(i) + (1 - n) C_{H,t}^*(i),$$

and in Appendix C.3 I show that this implies:

$$Y_t = \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} [(1 - \lambda)Y_t + \lambda Q_t^\eta Y_t^*]. \quad (5)$$

Equation (5) shows that Foreign aggregate output  $Y_t^*$  as well as the real exchange rate  $Q_t$  affect Home aggregate output  $Y_t$ . As shown in Appendix C.3, however, the opposite does not hold true: the Foreign economy is not affected by movements in Home output or movements in the real exchange rate.

**The monetary authority** operates in a currency union and therefore follows a Taylor rule at the Foreign country level (the monetary union). I focus on two different shocks, which I present sequentially as follows.

The first shock I consider is an inflation target (IT) shock as in Garriga, Kydland, and Šustek (2017), Greenwald (2018), and Garriga, Kydland, and Šustek (2021). This shock is highly persistent and shifts the whole level of the yield curve while making the real rate move very little. This is the sense in which the IT shock is a *nominal* shock, which makes it very convenient to study movement in the nominal rates in isolation. Formally, I defined the IT shock as a white noise process  $\epsilon_{\bar{\pi},t}$  so that the persistent inflation target is:

$$\log \bar{\pi}_t^* = \phi_{\bar{\pi}} \log \bar{\pi}_{t-1}^* + \epsilon_{\bar{\pi},t}, \quad (6)$$

and the Taylor rule takes the form:

$$\log(R_t^*/R_{ss}^*) = \log \bar{\pi}_t^* + \phi_R [\log(R_{t-1}^*/R_{ss}^*) - \log \bar{\pi}_{t-1}^* + \log \bar{\pi}_t^*] + \phi_\pi [\log \pi_t^* - \log \bar{\pi}_t^*]. \quad (7)$$

The second shock I consider is a white noise monetary policy shock  $\epsilon_{MP,t}$ , the standard shock used in the New Keynesian literature. Differently from the previously considered nominal shock, the monetary policy shock is fairly temporary and moves the real interest rate in the same direction as and quantitatively similarly to the short rate. The relevant Taylor rule becomes:

$$\log(R_t^*/R_{ss}^*) = \phi_R \log(R_{t-1}^*/R_{ss}^*) + \phi_\pi \log \pi_t^* + \epsilon_{MP,t}. \quad (8)$$

Finally, being in a currency union, the monetary authority sets the nominal interest rates to be the same across countries:  $R_t = R_t^*$ . To do so, the central bank makes the nominal exchange rate across countries equal to a constant ( $\zeta_t = \bar{\zeta}$ ) which paired with uncovered interest parity leads to the equalization of the nominal rates.

**A competitive equilibrium** is a sequence of prices and aggregate variables such that: (i) households and firms maximize their objective values, and (ii) the following markets clear:



- Bonds are in zero net supply:  $B_t = 0$ ;
- The labor market clears:  $N_{b,t} + N_{s,t} = N_t$ ;
- The mortgage market clears:  $M_{b,t} + M_{s,t} = 0$ ;
- The housing market clears:  $H_{b,t} + H_{s,t} + H_{l,t} = \bar{H}$ ;
- Housing services:  $s_{b,t} = H_{b,t-1} + H_{l,t-1}$ ;
- The goods market clears:  $C_{b,t} + C_{s,t} + \delta p_t^h \bar{H} = Y_t$ .

### 3.2 Key Equilibrium Conditions

I now present two optimality conditions which are relevant in determining the role across the Home and Foreign economies of the two housing and mortgage market institutions emphasized in this paper, namely the ARM share and the HoR. The remaining optimality conditions are detailed in Appendix C.1.

Firstly, the importance of the mix of adjustable- and fixed-rate mortgages in determining the pass-through from the short rate to the mortgage rate in any given economy is most visible through the first order condition of newly issued mortgages for the savers:

$$\Omega_{s,t}^m + q_t \Omega_{s,t}^x = 1, \quad (9)$$

which states that the marginal benefit of issuing one euro worth of mortgage debt (the left-hand-side) equals its cost (right-hand-side). More specifically,  $\Omega_{s,t}^m$  is the marginal continuation benefit to the savers of an additional euro of mortgage debt issued:

$$\Omega_{s,t}^m = E_t \Lambda_{t,t+1}^s \pi_{t+1}^{-1} [(1 - \alpha)q_t + \rho(1 - \nu) + \nu + (1 - \rho)(1 - \nu)\Omega_{s,t+1}^m], \quad (10)$$

where  $\Lambda_{t,t+1}^s = \beta_s \frac{u_{s,t+1}^c}{u_{s,t}^c}$  is the saver stochastic discount factor with  $u_{s,t}$  denoting the saver marginal utility of consumption at time  $t$ . Notice that in equation (10), part of the continuation value entails receiving each subsequent period the mortgage rate from the fraction of borrowers with ARM,  $(1 - \alpha)q_t$ , in the states of the world when they don't refinance (with probability  $1 - \rho$ ). Similarly,  $\Omega_{b,t}^x$  is the marginal continuation benefit to the savers of an additional euro of promised initial payments:

$$\Omega_{s,t}^x = E_t \Lambda_{t,t+1}^s \pi_{t+1}^{-1} [\alpha + (1 - \rho)(1 - \nu)\Omega_{s,t+1}^x], \quad (11)$$

and its quantitative importance depends on the fraction of borrowers in the economy with fixed-rate mortgages  $\alpha$ . This marginal continuation benefit is multiplied by the mortgage rate in equation (9) because at any time  $t$ , the saver locks in the mortgage rate for the whole duration of the mortgage contract.

To see how the pass-through from the short-term nominal rate to the mortgage rate works, assume that there are no fixed-rate mortgages ( $\alpha = 0$ ). Hence, equation (11) is not relevant anymore and equation (9) reduces to  $\Omega_{s,t}^m = 1$ . Rewrite equation (10) to obtain:

$$E_t[\Lambda_{t,t+1}^s \pi_{t+1}^{-1}(q_t + 1)] = 1. \quad (12)$$

Notice that for the saver, the optimality with respect to bonds leads to the familiar Euler equation:

$$E_t[\Lambda_{t,t+1}^s \pi_{t+1}^{-1} R_t] = 1. \quad (13)$$

Comparing equations (12) and (13) makes it clear that in an economy with only ARM, there is perfect pass-through between the short rate and the mortgage rate:  $R_t = q_t + 1$ . This also tells us that the further away we are from the full adjustable case scenario, the lower the pass-through. This is because as  $\alpha$  increases away from zero towards one,  $\Omega_{s,t}^x$  becomes quantitatively more important relative to  $\Omega_{s,t}^m$  which shrinks towards zero making equation (12) further away from holding<sup>20</sup>. Intuitively, in an ARM-only economy, a no-arbitrage condition must hold whereby the savers are indifferent between investing 1 euro in the bond (yielding  $R_t$  next period) and issuing 1 euro worth of mortgages (yielding  $q_t + 1$  next period).

Secondly, the optimality conditions for housing hint to the importance of differential HoRs in determining house price dynamics across the Home and Foreign economies. As in [Greenwald and Guren \(2019\)](#), the borrower first order condition with respect to house size implies:

$$p_t^h = \frac{\mathbb{E}_t \Lambda_{t,t+1}^b \{p_{r,t+1} + \bar{\omega}_{b,t} + p_{h,t+1}[(1 - \delta) - (1 - \rho)\mathcal{C}_{t+1}]\}}{1 - \mathcal{C}_t}. \quad (14)$$

The term  $\mathcal{C}_t$  is the marginal collateral of housing, representing the benefit to the borrowers from investing into housing thus relaxing the LTV constraint. Notice that  $\mathcal{C}_t = \mu_t \theta_{LTV}$ , where  $\mu_t$  is the multiplier on the LTV constraint. The term  $\Lambda_{t,t+1}^b = \beta_b \frac{u_{b,t+1}^c}{u_{b,t}^c}$  is the borrower stochastic discount factor.

Equation (14) states that the marginal benefits from investing one more euro in housing includes the foregone rental cost next period  $p_{r,t+1}$ , the utility benefit from owning  $\bar{\omega}_{b,t}$ , and the housing value next period. Swings in the utility from owning housing  $\bar{\omega}_{b,t}$ , determined for example by demand-driven forces that affect disproportionately more economies with particularly high levels of HoRs, can put strong pressures into house prices. This channel reveals to be quantitatively important in the model results of Section 4.

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<sup>20</sup>This model nests [Greenwald \(2018\)](#) when  $\alpha = 1$  (mortgages are only fixed-rate), a good approximation to study the debt dynamics in the United States.

### 3.3 Calibration

The model period is one quarter, and the world economy is calibrated in two steps. In the first step, I calibrate the Foreign economy to the Euro Area (EA). As the Home economy is assumed to be small, the Foreign economy block of the model is completely independent from the details of the Home economy. The results from the first step are illustrated in Table 1. In the second step, I calibrate the Home economy to Spain (ES). In steady state, the influence of the Foreign economy on the Home economy is visible from equation (5). Hence, the Home economy needs to be calibrated together with the Foreign economy. The results from this second step are reported in Table 2. In both calibration steps, most of the parameters relating to the housing and mortgage markets are calibrated internally to hit moments from the Eurosystem Household Finance and Consumption Survey (HFCS). Some other parameters which are more standard in the New Keynesian literature are calibrated externally. As a general calibration strategy, whenever I need to assign parameters that to the best of my knowledge have never been calibrated or estimated to Euro Area countries and for which I have no relevant microdata for, I use US values and assign them to be the same across the EA and ES.

**Demographics and preferences.** To determine the borrower population share, I make use of the second wave of the HFCS, which I discussed in Section 2.4 and that was administered around 2014. In the model, the borrowers can be renters or mortgaged homeowners. Conversely, the savers are outright homeowners. In the data, I find the fraction of borrowers to be 59% in the EA and 49% in ES.

As the focus of the paper is on long rates, I calibrate the saver discount factor to yield the average EA long-term (10Y) rate over 2007-2019 (2.64%). This is imposed in both economies. I set the borrower discount factor externally in both economies to the value calibrated in Greenwald (2018) (i.e., 0.96). Increasing this value to the one used in Iacoviello and Neri (2010) (i.e., 0.97) or decreasing it further does not affect the results of the paper.

I calibrate the labor disutility in both economies ( $\iota^*$  and  $\iota$ ) so that aggregate labor (and so output) in steady state is equal to unity. This makes it easier and more accurate the comparison of aggregate variables across economies following an aggregate shock. Next, I calibrate the Frisch elasticity in both economies to 2, the value estimated in Burriel, Fernández-Villaverde, and Rubio-Ramírez (2010) for Spain. I also calibrate the housing preference parameters ( $\xi^*$  and  $\xi$ ) to hit the 2014 target of total mortgage stock to GDP from Hypostat (2019), which is 0.428 for the EA and 0.532 for ES.

Finally, I calibrate the heterogeneity in the benefits to borrower and landlord homeownership closely following Greenwald and Guren (2019). In particular, the ownership

| Parameter                           | Name                  | Value   | Internal | Target/Source   |
|-------------------------------------|-----------------------|---------|----------|---|
| <i>Demographics and Preferences</i> |                       |         |          |   |
| Borrower discount factor            | $\beta_b^*$           | 0.96    | N        | Greenwald (2018)  |
| Saver discount factor               | $\beta_s^*$           | 0.993   | N        | Avg. EA 10Y rate, 2007-2019                             |
| Borrower measure                    | $\chi_b^*$            | 0.591   | N        | 2014 EA fraction of renters & mortgaged homeowners      |
| Labor disutility                    | $\iota^*$             | 0.838   | Y        | $N_{SS}^* = 1$  |
| Inverse Frisch elasticity           | $\phi^*$              | 0.5     | N        | Burriel, Fernández-Villaverde, and Rubio-Ramirez (2010) |
| Housing preference                  | $\xi^*$               | 0.407   | Y        | $M_{SS}^*/Y_{SS}^* = 0.428$                             |
| Landlord het. (location)            | $\mu_{\omega,l}^*$    | -0.002  | N        | Greenwald and Guren (2019)                              |
| Landlord het. (scale)               | $\sigma_{\omega,l}^*$ | 0.020   | N        | Greenwald and Guren (2019)                              |
| Borrower het. (location)            | $\mu_{\omega,b}^*$    | -0.0155 | Y        | 2014 EA home ownership rate                             |
| Borrower het. (scale)               | $\sigma_{\omega,b}^*$ | 0.008   | N        | Greenwald and Guren (2019)                              |
| <i>Housing and Mortgages</i>        |                       |         |          |   |
| Share of ARMs                       | $1 - \alpha^*$        | 0.529   | N        | 2014 EA share of adjustable rate mortgages              |
| Mortgage amortization               | $\nu^*$               | 0.435%  | N        | Greenwald (2018)  |
| Income tax rate                     | $\tau^*$              | 0.24    | N        | Christoffel, Coenen, and Warne (2008)                   |
| Max LTV ratio                       | $\theta_{LTV}^*$      | 0.85    | N        | EA Median LTV   |
| Housing depreciation                | $\delta^*$            | 0.005   | N        | Standard  |
| Refinancing rate                    | $\rho^*$              | 0.034   | N        | Greenwald (2018)  |
| Housing stock                       | $\bar{H}^*$           | 21.727  | Y        | $p_t^{*,h} = 1$   |
| <i>Labor Market</i>                 |                       |         |          |   |
| Elasticity subst. tasks             | $\varphi^*$           | 21      | N        | Auclert, Rognlie, and Straub (2018)                     |
| Disutility wage changes             | $\psi^*$              | 250.64  | Y        | Implies standard value for wage flexibility: 0.1        |
| <i>Monetary Policy</i>              |                       |         |          |   |
| Taylor rule (inflation)             | $\phi_\pi$            | 1.5     | N        | Standard  |
| Taylor rule (smoothing)             | $\phi_R$              | 0.865   | N        | Christoffel, Coenen, and Warne (2008)                   |
| Inflation target (pers.)            | $\phi_{\bar{\pi}}$    | 0.994   | N        | Garriga, Kydland, and Šustek (2017)                     |

**Table 1:** Calibration for the Euro Area (Foreign economy).

*Note:* The model is calibrated at steady state at quarterly frequency. The “Internal” column indicates whether the parameters are calibrated to match a targeted moment internally (Y) or in closed form (N).

distributions are specified as logistic with c.d.f.:

$$\Gamma_{\omega,j}(\omega) = \left[ 1 + \exp \left\{ - \left( \frac{\omega - \mu_{\omega,j}}{\sigma_{\omega,j}} \right) \right\} \right]^{-1} \quad j \in \{b, l\}$$

These distributions determine the position and the slopes of the demand and supply curves in the price-to-rent and homeownership space. In both economies, I calibrate the scale parameters as well as the landlord location parameter to Greenwald and Guren (2019). However, I calibrate internally the borrower location parameter  $\mu_{\omega,b}$  to match the HoRs among “borrowers” from the HFCS (20% in the EA, 29.6% in ES). Given that the savers are homeowners in the model, this procedure provides the correct country-level HoR (61% in the EA, 80% in ES). As argue earlier on, I interpret differences in the average owning utility  $\mu_{\omega,b}$  between the EA and ES as accounting for the quality of the rental market and ownership subsidies.

| Parameter                           | Name                | Value   | Internal | Target/Source   |
|-------------------------------------|---------------------|---------|----------|---|
| <i>Demographics and Preferences</i> |                     |         |          |   |
| Borrower discount factor            | $\beta_b$           | 0.96    | N        | Same as Euro Area                                       |
| Saver discount factor               | $\beta_s$           | 0.993   | N        | Same as Euro Area                                       |
| Borrower measure                    | $\chi_b$            | 0.492   | N        | 2014 ES fraction of renters & mortgaged homeowners      |
| Labor disutility                    | $\iota$             | 0.752   | Y        | $N_{SS} = 1$  |
| Inverse Frisch elasticity           | $\phi$              | 0.5     | N        | Same as Euro Area                                       |
| Housing preference                  | $\xi$               | 0.06    | Y        | $M_{SS}/Y_{SS} = 0.532$                                 |
| Landlord het. (location)            | $\mu_{\omega,l}$    | -0.002  | N        | Same as Euro Area                                       |
| Landlord het. (scale)               | $\sigma_{\omega,l}$ | 0.020   | N        | Same as Euro Area                                       |
| Borrower het. (location)            | $\mu_{\omega,b}$    | 0.015   | Y        | 2014 ES home ownership rate                             |
| Borrower het. (scale)               | $\sigma_{\omega,b}$ | 0.008   | N        | Same as Euro Area                                       |
| <i>Housing and Mortgages</i>        |                     |         |          |   |
| Share of ARMs                       | $1 - \alpha$        | 0.896   | N        | 2014 ES share of adjustable rate mortgages              |
| Mortgage amortization               | $\nu$               | 0.435%  | N        | Same as Euro Area                                       |
| Income tax rate                     | $\tau$              | 0.24    | N        | Same as Euro Area                                       |
| Max LTV ratio                       | $\theta_{LTV}$      | 0.85    | N        | ES Median LTV   |
| Housing depreciation                | $\delta$            | 0.005   | N        | Same as Euro Area                                       |
| Refinancing rate                    | $\rho$              | 0.034   | N        | Same as Euro Area                                       |
| Housing stock                       | $\bar{H}$           | 7.177   | Y        | $p_t^h = 1$   |
| <i>Labor Market</i>                 |                     |         |          |   |
| Elasticity subst. tasks             | $\varphi$           | 21      | N        | Same as Euro Area                                       |
| Disutility wage changes             | $\psi$              | 279.135 | Y        | Implies standard value for wage flexibility: 0.1        |
| <i>International Finance</i>        |                     |         |          |   |
| Home bias                           | $\lambda$           | 0.187   | N        | Burriel, Fernández-Villaverde, and Rubio-Ramirez (2010) |
| Elasticity subst. consumpt.         | $\eta$              | 7.671   | N        | Burriel, Fernández-Villaverde, and Rubio-Ramirez (2010) |

**Table 2:** Calibration for Spain (Home economy).

*Note:* The model is calibrated at steady state at quarterly frequency. The “Internal” column indicates whether the parameters are calibrated to match a targeted moment internally (Y) or in closed form (N).

**Housing and mortgages.** I calibrate the ARM share in each country ( $1 - \alpha$ ) and  $(1 - \alpha^*)$  from the HFCS. This leads to a share of 53% in the EA, and a share of 90% in ES. This is one of the main parameters of the model which I vary throughout the paper to analyze its effects on the monetary transmission mechanism as well as to study different forms of banking unions. Turn to the maximum LTV ratio parameters  $\theta$  and  $\theta^*$ , I find in the HFCS no quantitatively important differences across countries. Indeed, the median LTV ratio has been very similar across Euro Area countries and very stable over time at around 85%. For this reason, I assign that value to both the Home and Foreign economies and decide therefore to not generate differences in this way.

Next, I internally calibrate the total housing stock ( $\bar{H}^*$  and  $\bar{H}$ ) to normalize the house price in both economies to one. I calibrate the refinancing rate ( $\rho^*$  and  $\rho$ ) and the mortgage amortization rate ( $\nu^*$  and  $\nu$ ) to the levels calibrated for the US by Greenwald (2018). I set the income tax rate to the value computed by Christoffel, Coenen, and Warne (2008) for the EA, and I assume it to be the same in ES.

**Labor Market.** I closely follow [Auclert, Rognlie, and Straub \(2018\)](#) and set, for both economies, the elasticity of substitution of tasks from labor packers ( $\varphi^*$  and  $\varphi$ ) to the value they use for the US<sup>21</sup>. Accordingly, I internally calibrate the household disutility of nominal wage changes ( $\psi^*$  and  $\psi$ ) so that the implied wage flexibility parameters equal the standard value of 0.1. The wage flexibility parameters are defined as:

$$\kappa_w = \frac{\varphi}{\psi N u^N(N)}; \quad \kappa_w^* = \frac{\varphi^*}{\psi^* N^* u^{*,N}(N^*)}$$

where  $u^N(N)$  and  $u^{*,N}(N^*)$  are the marginal utilities of labor evaluated at the aggregate levels of labor,  $N$  and  $N^*$ . In practice, wage rigidities might not be the same across Euro Area countries. However, since the focus of this paper is on housing and mortgage markets, I do not generate cross-country differences based on the labor markets.

**Monetary Policy.** The monetary authority in the EA follows the Taylor rules (7) and (8). The parameter on the inflation response is standard, while the one determining the interest rate smoothing has been estimated by [Christoffel, Coenen, and Warne \(2008\)](#) in the context of the Euro Area. For the inflation target process (equation (6)), I use the persistence parameter estimated for the US by [Garriga, Kydland, and Šustek \(2017\)](#), who also study the impact of this type of shock on long-term mortgages.

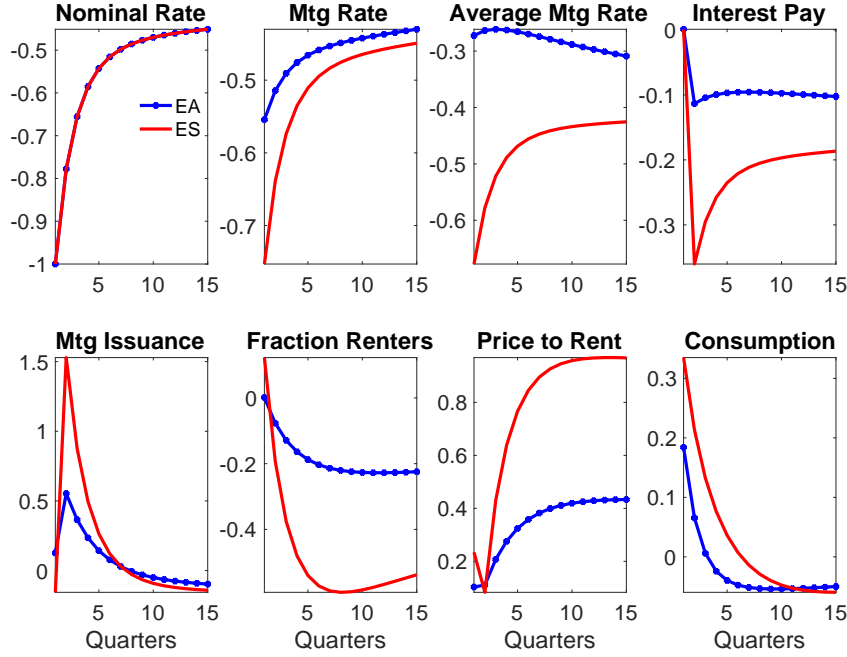
**International Finance.** [Burriel, Fernández-Villaverde, and Rubio-Ramirez \(2010\)](#) estimate a DSGE model for Spain, and I make use of their estimated parameter values for both the home bias ( $\lambda$ ) and the elasticity of substitution between Foreign and Home consumption bundles ( $\eta$ ). It is worth noticing that the presence of home bias implies that Foreign output as well as the real exchange rate affect aggregate output at Home. This effect is, however, quantitatively small. When I calibrate the model assuming a zero degree of trade openness ( $\lambda = 0$ ), I find virtually identical results for both the steady state and the dynamics of the Home economy.

## 4 Model Results

This section shows the effects that the ARM shares and the HoR play in the transmission mechanism of monetary policy in the Euro Area. I linearize the model equations to first-order around the deterministic steady state and plot the relevant impulse response functions to an inflation target shock ( $\epsilon_{\pi,t}$ ) introduced in the Taylor rule (7). I compute and describe the impulse responses to a monetary policy shock ( $\epsilon_{MP,t}$ ) introduced in the Taylor rule (8) in Appendix A.4.

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<sup>21</sup>This in turn is the same value used in [Christiano, Eichenbaum, and Evans \(2005\)](#).



**Figure 6:** Impulse response functions to an inflation target shock normalized to a 1% fall in the nominal rate, both for the Euro Area (EA) and Spain (ES).

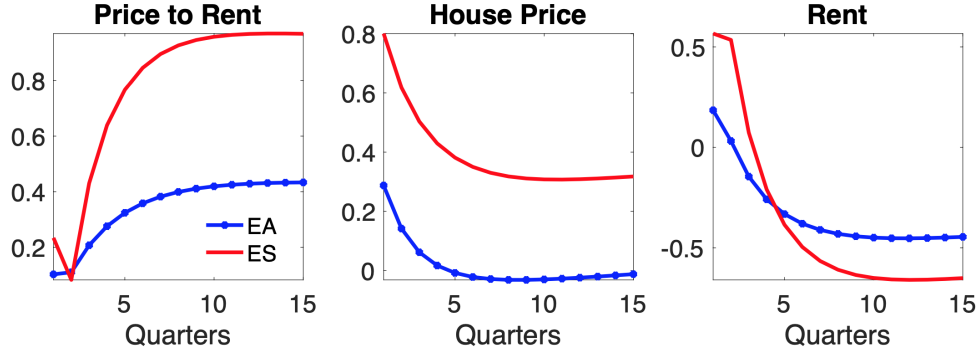
*Note:* The y-axes measure a 1% deviation relative to steady state, except for the mortgage rate, the average mortgage rate, interest payments, and mortgage issuance which are measured in percentage points. The x-axes measure time in quarters. The nominal rate and mortgage rate are annualized.

## 4.1 Heterogenous Monetary Transmission

My main result is that, as in the data, a shock to the long end of the yield curve, captured through an inflation target shock, leads Spain to react more strongly than the Euro Area. It is useful to remind at this point that, in terms of calibration, the key difference between Spain (ES) and the Euro Area (EA) lies in the differential ARM share and the HoR. I discuss the differential responses of the two countries as follows, and then turn to Section 4.2 to unravel the sources behind them.

In Figure 6 I plot the impulse response functions to an inflation target shock inducing the nominal rate to fall by 1% on impact. Given that Spain belongs to the currency-union, it inherits the nominal rate set by the Euro Area monetary policy authority. The first visible result lies in the pass-through to mortgage rates on new mortgages: a 1% decline of the short rate leads to a fall in mortgage rates applied to new mortgages of 0.75% in ES but only of 0.55% in the EA. The pass-through mechanism is discussed in Section 3.2 and is pinned down by the mortgage optimality condition of savers. Furthermore, the mortgage rate on new mortgages takes time to transmit to the average mortgage rate on outstanding mortgages in the EA, as this economy is characterized by a relatively higher FRM share with previously locked-in rates. As a consequence, the average mortgage rate in the EA barely moves on impact but gradually declines as new mortgages are issued at





**Figure 7:** Impulse response functions to an inflation target shock normalized to a 1% fall in the nominal rate, both for the Euro Area (EA) and Spain (ES).

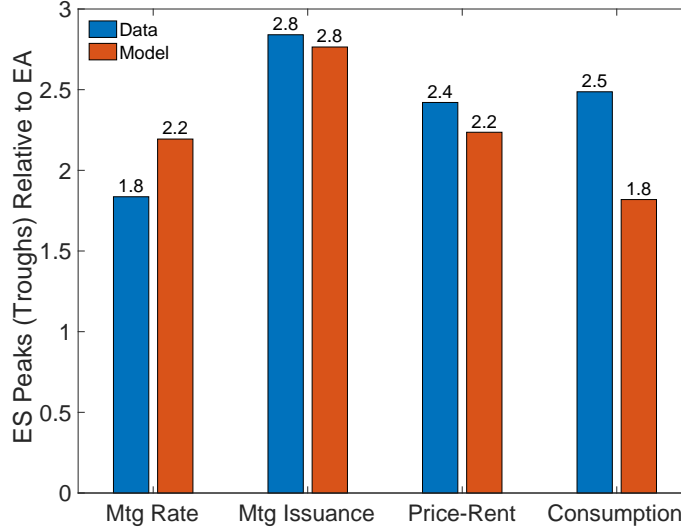
*Note:* The y-axes measure a 1% deviation relative to steady state. The x-axes measure time in quarters.

the lower mortgage rate. To the contrary, most mortgages in ES are adjustable-rate and therefore the average mortgage rate in the economy closely follows the dynamics of the mortgage rate on new mortgages.

Next, I focus on the effects of the differential mortgage rate pass-through to the borrower balance sheets. Interest payments in ES fall up to three times as much as those in the EA, making it easier for the indebted households to take advantage of the good times and take on more newly issued mortgages. This boost in fiscal capacity leads more borrowers to transition from renting to owning: the fraction of renters drops by 0.6% in ES but only by 0.23% in the EA over a 15Q horizon. This differential housing tenure shift is also reflected in equilibrium prices, with the ES price-to-rent peaking at almost 1% relative to the 0.4% peak in the EA. Turning to aggregate consumption, my results show a peak of 0.33% in ES, which is twice as much as the peak experienced by the EA.

I then disentangle the movements of the price-to-rent ratios into movement of house prices and movements of rents. Figure 7 shows that while house prices increase after the expansionary shock, rents in both ES and the EA quickly become negative after a few quarters. This is consistent with the evidence found for Italy and Switzerland in [Koeniger, Lennartz, and Ramelet \(2021\)](#), as well as with the evidence for the US in [Dias and Duarte \(2019\)](#). As for the rest of the variables of interest, both the house price and rent react more strongly in ES relative to the EA, thereby contributing roughly equally to the sizable differential response in price-to-rent.

Finally, Figure 8 summarizes monetary policy effectiveness as measured by relative peaks (or troughs for the mortgage rate) across countries, both from the data (Section 2.3) and from the model. The model overshoots the data in terms of the mortgage rate relative responses: ES reacts 1.8 times more than EA in the data, but 2.2 times more in the model. In terms of newly issued mortgages and price-to-rent ratios, the model aligns almost perfectly with the data. Furthermore, the aggregate consumption response in ES is



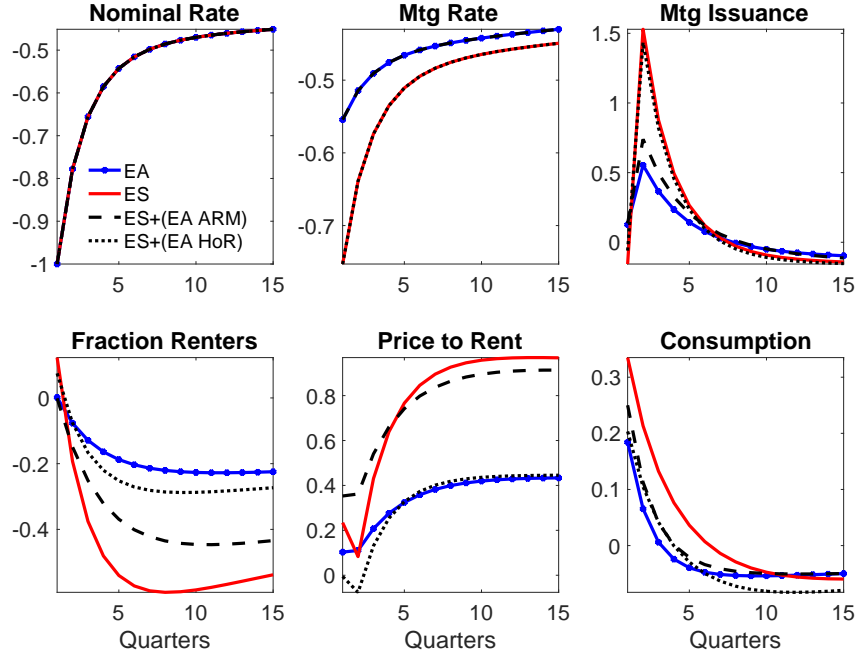
**Figure 8:** Bar plots of relative peak (trough for the mortgage rate) responses of Spain (ES) and the Euro Area (EA).

1.8 times stronger than the EA in the model relative to 2.5 times in the data. Therefore, while I only target key cross-sectional housing and mortgage market institutions such as the ARM share and the HoR, the model is able to quantitatively match the dynamic monetary policy effectiveness across countries.

## 4.2 Decomposing the Effects of ARM Shares and the HoR

At this point, it is useful to ask how much of the aforementioned results are determined by the ARM shares and how much are determined by the HoR. In Figure 9 I show the responses of two more economies: ES re-calibrated to have the EA share of ARM (but the correct HoR), and ES re-calibrated to the EA level of HoR (but the correct share of ARM). The economy “ES+(EA ARM)” is calibrated to hit all the targets described in Table 2 except the share of ARM, which is calibrated to the Euro Area level. Similarly, the economy “ES+(EA HoR)” is calibrated to hit all the targets described in Table 2 with the exception of the HoR, which is calibrated to the Euro Area level. To begin with, the center top panel shows that the pass-through to mortgage rates is exclusively dictated by the differential share of ARM: ES with the EA share of ARM features the same EA pass-through. This is in line with the derivations and intuitions provided in Section 3.2. The right top panel makes it clear that the cost of financing is key to mortgage issuance. The ES economy with the correct share of ARM account for virtually all the increase in newly issued mortgages, while the economy with the reduced share only displays a modest increase of 35% relative to the EA economy.

Turning to the housing markets, however, reveals a different picture. The decrease in



**Figure 9:** Impulse response functions to an inflation target shock normalized to a 1% fall in the nominal rate.

*Note:* I show results for the Euro Area (EA), Spain (ES), Spain re-calibrated to the EA share of ARM “ES+(EA ARM)”, and Spain re-calibrated to the EA HoR “ES+(EA HoR)”. The y-axes measure a 1% deviation relative to steady state, except for the mortgage rate and mortgage issuance which are measured in percentage points. The x-axes measure time in quarters. The nominal rate and mortgage rate are annualized.

the fraction of renters is mostly driven by the HoR, as the ES economy with the correct level of HoR peaks at -0.45%, not far from the benchmark economy counterpart (-0.6%). However, the ES economy with the EA level of HoR peaks only at -0.29%, very close to the EA response. These differences are reflected in the price-to-rent dynamics, where the ES economy with EA HoR closely tracks the EA economy, while the ES economy with the correct level of HoR closely tracks the benchmark ES economy. The intuition for this is that in Spain, the average owning utility is high: households have a strong preference to own over to rent, leading to high overall homeownership rate. Therefore, when Spanish households are confronted with a demand shock which improves their financial conditions, they are more likely to become new homeowners. In terms of their housing optimality condition (14), the owning utility benefit  $\bar{\omega}_{b,t}$  increase relatively more than the EA counterpart  $\bar{\omega}_{b,t}^*$ , resulting in a stronger house price pressure.

The takeaway from the decomposition highlighted in Figure 9 is that while the ARM share is key in determining the responses of the mortgage market variables, the HoR accounts for most of the responses in the housing market. But which forces matter the most for the aggregate consumption dynamics? It turns out that both of them are important. Recall that the EA consumption response peaks on impact at 0.18%. Calibrating ES to

the EA level of HoR but the correct ARM share determines a modest increase of only 2bp relative to the EA response. Even though borrowers pay less interests on their mortgage payments, they decide it is a good time to increase their mortgage stock. To do so, they invest in new housing – which leads to a subdued increase in aggregate non-durable consumption. Similarly, calibrating ES to the EA share of ARM but the correct level of HoR determines an increase of 7bp relative to the EA response. This is because, due to stronger house price responses, the collateral value of housing increases and borrowers can take out new mortgages through a more relaxed LTV constraint. However, when both institutions are calibrated to their correct ES values, the response increases by 15bp. This suggest a non-linear interaction whereby the share of ARM and the HoR interact to amplify the potency of monetary policy on economic activity. This is because both channels are active simultaneously: on one side, it is a good time to borrow because interest payments are low and borrowers increase their house size in order to do so; on the other side, housing wealth is higher because of strong responses to house prices which in turn relaxes the LTV constraint allowing for even more borrowing. Borrowers can therefore increase their non-durable consumption which leads to stronger responses in aggregate economic activity.

## 5 Model Counterfactuals

The model presented in Section 3 is a useful laboratory to study how changes in the housing and mortgage markets alter the stabilization properties of the Euro Area monetary policy. In this section, I perform two counterfactuals. In the first experiment, I introduce two different forms of banking union in the form of a common design for the mortgage markets in the Euro Area countries. While a banking union formally already exists, it is in practice very limited (see [Garicano \(2019\)](#) for an analysis of the problems and potential ways forward to build a stronger union). In a second experiment, I build on the recent strategy review ([ECB \(2021\)](#)) and explore the inflation-output trade-off the ECB faces when weighting for housing costs in the price index.

### 5.1 Towards a Banking Union

There is a lot of discussion in both academic and policy circles about the potential benefits a European fiscal integration and a banking union could bring to its member states (for a recent overview, see [Bilbiie, Monacelli, and Perotti \(2021\)](#)). At its current stage, the banking union is fairly limited: it is made of a common bank supervision (Single Supervisory Mechanism) and of a common resolution procedure for failing banks (Single Resolution Mechanism). One of the features that are missing is a risk-sharing arrangement

through which funding costs for banks (and households) equalize across the different countries of the Euro Area.

I start off my analysis with a “weak” banking union (BU1), in which mortgages can be offered across countries. A no-arbitrage condition must hold between savers of the different countries and, as a consequence, they all offer the same mortgage rate on newly issued mortgages at equilibrium. In terms of equations, the first order condition for newly issued mortgages for the savers (equations (9)-(11)) only holds in the EA but not in ES, meaning that the mortgage rate is pinned down in the EA. Notice that under this scenario, ES still has a high ARM share. I then move to a stronger banking union (BU2), in which the BU1 is augmented so that the ARM share of ES is changed to the one of the EA<sup>22</sup>.

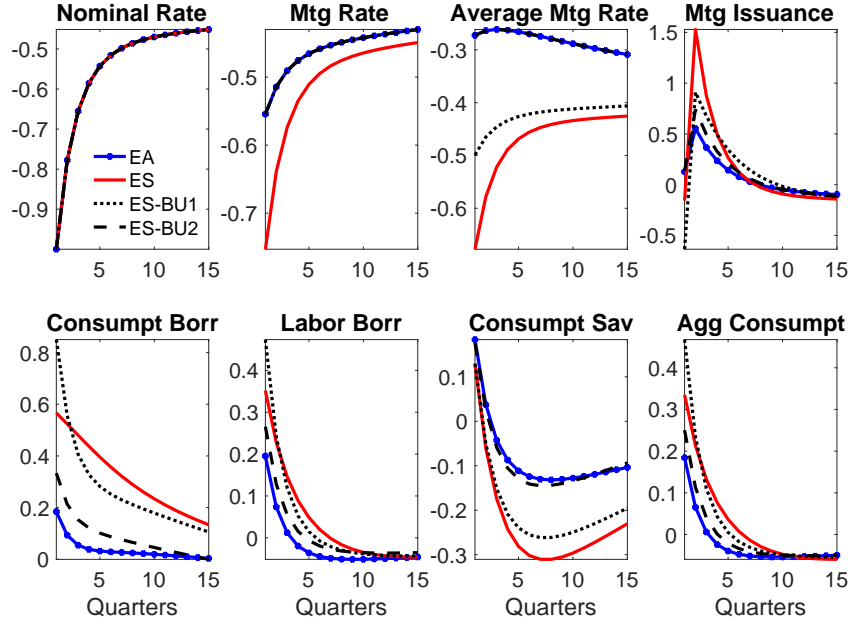
Figure 10 shows the interest rate transmission results under the two different forms of banking unions. Both banking arrangements lead to a smaller pass-through to mortgage rates, but only the BU2 is successful in making ES average mortgage rate respond as much as the EA one. This is because, while in BU1 ES has a high ARM share, ES has the EA level of ARM share under the BU2<sup>23</sup>. A consequence of the weakened pass-through to mortgage rates is that borrowers in ES ask for a smaller amount of mortgages, particularly so under the BU2. In terms of economic activity, BU2 is the most effective at reducing the cross-country heterogeneity, as it brings down the relative ES/EA aggregate consumption peak response from 1.82 to 1.35. Most notably, the BU1 actually determines an increase of aggregate consumption of ES relative to the baseline for the first 2 quarters – but a decrease thereafter. This very temporary increase in aggregate consumption is all driven by borrowers, who work more in equilibrium and spend the labor income in non-durable consumption. Under BU1, the savers do not optimize on newly issued mortgages. This distorted environment implies a higher marginal utility of labor relative to the marginal utility of consumption, leading to higher wage inflation dictated by the wage Phillips curve (equation (3)). In the face of an increase in nominal wage changes, the equilibrium labor goes up and borrowers are forced to work more. They optimally re-balance the lower utility from working more with the higher non-durable consumption, leading the aggregate economy to temporarily shoot up relative to the baseline economy.

In terms of redistribution of resources between households, savers clearly win from the banking unions relative to the borrowers. Given the strong pass-through in the

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<sup>22</sup>While in practice BU1 could be quickly arranged by imposing to all the banks of the EA to issue mortgages at the same mortgage rate, BU2 would take longer to implement as mortgages of a specific type can only be replaced after the end date of the contract.

<sup>23</sup>Effectively, BU2 is equivalent to the case discussed in Section 4.2 where ES has the EA level of ARM share. The fact that savers do not maximize their mortgage issuance under the BU2 is not consequential to the dynamics of the mortgage rate, since the savers in the EA face the same actual problem and so choose the same mortgage rate those in ES would have chosen if they could.



**Figure 10:** Impulse response functions to an inflation target shock under two different forms of banking unions.

*Note:* The shock is normalized to a 1% fall in the nominal rate. I show results for the Euro Area (EA), Spain (ES), Spain under a weak banking union “ES-BU1”, and Spain under a stronger banking union “ES-BU2”. The y-axes measure a 1% deviation relative to steady state, except for the mortgage rate and mortgage issuance which are measured in percentage points. The x-axes measure time in quarters. The nominal rate and mortgage rate are annualized.

baseline ES economy, savers are forced to give up non-durable consumption in order to provide borrowers with the resources they want in terms of new mortgages. However, under the banking arrangements, borrowers ask for less funds (therefore consuming less) allowing the savers to consume more relative to the baseline economy. This redistribution of resources between households poses a trade-off to the monetary authority between a weakened heterogeneous transmission mechanism and a redistribution of resources towards the wealthier households.

## 5.2 The Inflation-Output Trade-Off

On July 2021, the ECB published a new strategy review to assess whether new measures were needed in the face of the challenges the Euro Area endured during the previous two decades. One of the main decisions has been to enhance the representativeness of the Harmonized Index of Consumer Prices (HICP) to include owner-occupied housing expenditures. In the United States, such expenditures are accounted for in the CPI through “imputed rents”, the implicit rent home owners would need to pay if they were instead renting their homes. While some European countries also use such a method

to include owner-occupied housing costs into the national price indices, the European Statistical System producing the HICP uses a methodology which does not align with using implicit costs<sup>24</sup>. As a consequence, the ECB has decided to include in the years to come the housing transaction prices as owner-occupied expenditures. I thereby explore the inflation-output trade-offs for different constructed price index definitions, one which includes the house price (as suggested by the strategy review) and one which includes the rental price (which approximates imputed rents) as an alternative.

I define the Euro Area strategy review price index  $P^{*,SR}$  as follows:

$$P_t^{*,SR} = p_{k,t}^{*,\gamma} P_t^{*,1-\gamma}$$

where  $p_{k,t}^*$  is either the house price  $p_{h,t}^*$  or the rental price  $p_{r,t}^*$ . With  $\gamma = 0$ , the strategy review price collapses to the model price index of Section 3; with a positive  $\gamma$ , the ECB weights the housing cost into the strategy review price index. The Euro Area Taylor rule now includes the strategy review inflation index which accounts for either the house price inflation  $\pi_{h,t}^*$  or the rent inflation  $\pi_{r,t}^*$ :

$$\pi_t^{*,SR} = \pi_{k,t}^{*,\gamma} \pi_t^{*,1-\gamma} \quad (15)$$

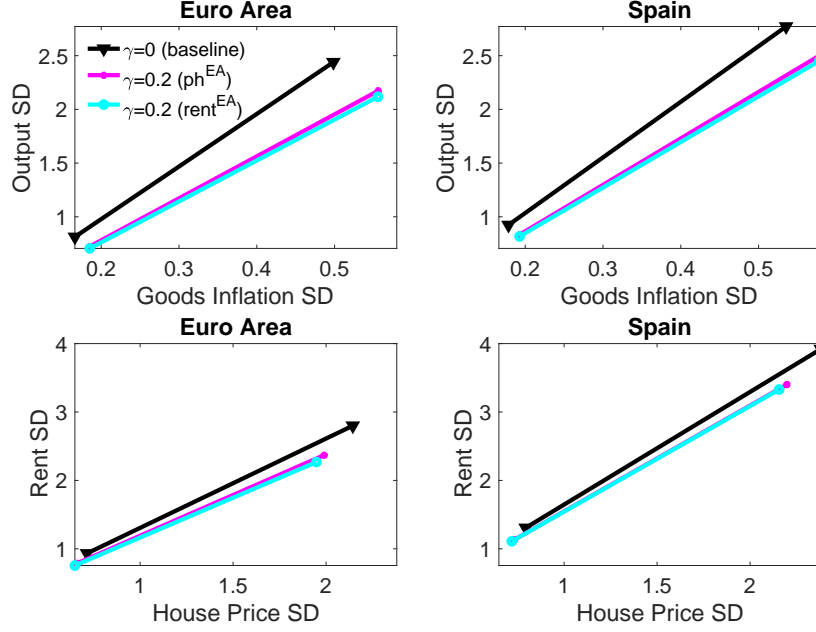
Figure 11 plots the trade-offs between output, goods inflation, rent, and house price for an expansionary monetary policy shock affecting both the Euro Area and Spain. I follow Kaplan, Moll, and Violante (2018) in plotting the frontiers for different shock sizes, which are normalized to lead to a decrease of the nominal interest rate on impact of between  $-1.5\%$  and  $-0.5\%$  under the baseline Taylor rule ( $\gamma = 0$ ). Each frontier represent a trade-off under different types of equation (15) in the Taylor rule (8). On the axes, I plot the standard deviation of the impulse response functions over 20Q. Notice that Spain displays bigger standard deviations in each of the outcomes of interest, in line with the main results of the paper (Section 4). I plot the results for  $\gamma = 0$  and  $\gamma = 0.2$ , and results for a smaller  $\gamma$  would be monotonically decreasing so that the specific value of 0.2 is picked only for illustrative purposes.

The results show that whenever the monetary authority considers expanding the price index to include housing costs, it faces a trade-off between stabilizing output and prices. In particular, including house prices or rents into the price index leads the monetary authority to react less strongly to the shock, as the weight on the goods inflation is now smaller and the housing prices do not react as much. As a consequence, the economy gets

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<sup>24</sup>The HICP can only capture expenditures involving movements of money from hand to hand. Therefore, imputed rents, own production of goods, and remuneration in kind are excluded. Furthermore, mortgage interest payments are also excluded because they are considered a distributive transaction and not consumption.





**Figure 11:** Trade-offs between output, goods inflation, house price, and rent for different Taylor rules (8) that include the term in equation (15) under expansionary monetary policy shocks of different sizes.

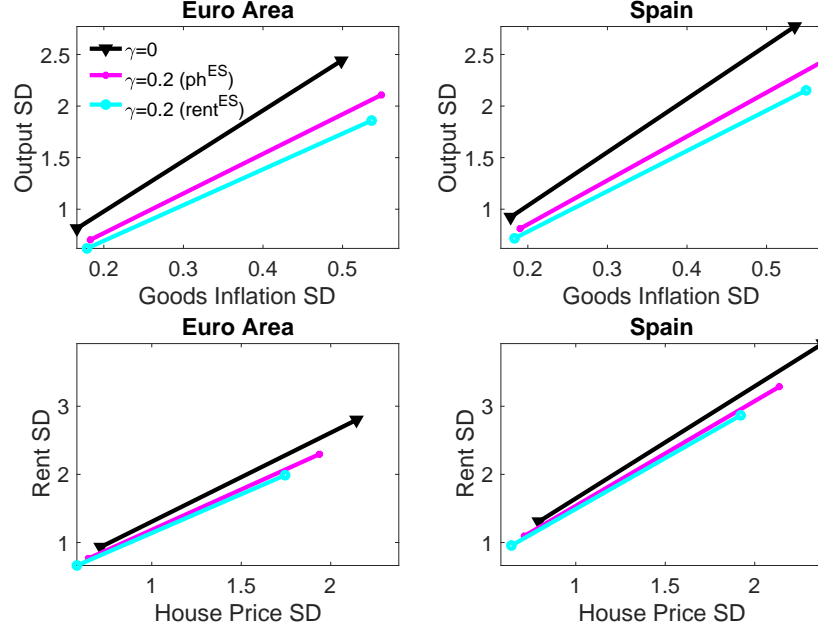
*Note:* The axes measure the standard deviation of the impulse response functions over 20Q. The shocks considered move the nominal interest rate on impact between  $-1.5\%$  and  $-0.5\%$  under the baseline Taylor rule ( $\gamma = 0$ ).

expanded less leading to smaller responses in the house price, in rent, and in output. The downside of it is that the goods inflation reacts more, exactly because it is weighted less in the Taylor rule. One additional point to highlight is that the monetary authority stabilizes more effectively the economy when responding to rent inflation relative to house price inflation. This is because rent inflation picks up more after the monetary policy shock relative to house price inflation, meaning that for the Taylor rule to hold the equilibrium interest rate responds less stimulating the economy more weakly.

In Figure 12 I repeat the exercise but assume that the monetary authority reacts to Spain house price and rent instead. That is, the relevant inflation index used in the Taylor rule is:

$$\pi_t^{*,SR} = \pi_{k,t}^\gamma \pi_t^{*,1-\gamma} \quad (16)$$

where  $\pi_{k,t}$  is either the Spain house price inflation  $\pi_{h,t}$  or the Spain rent inflation  $\pi_{r,t}$ . The idea underlying the exercise is that the monetary authority might consider weighting more aggressively housing prices of the countries that react the most to monetary policy shocks (such as Spain). The results show that by doing so, the monetary authority actually stabilizes the economy more both in Spain and in the whole Euro Area. This is particularly true when weighting rent inflation, which responds more strong to monetary policy shocks



**Figure 12:** Trade-offs between output, goods inflation, house price, and rent for different Taylor rules (8) that include the term in equation (16) under expansionary monetary policy shocks of different sizes.

*Note:* The axes measure the standard deviation of the impulse response functions over 20Q. The shocks considered move the nominal interest rate on impact between  $-1.5\%$  and  $-0.5\%$  under the baseline Taylor rule ( $\gamma = 0$ ).

triggering a weaker interest rate reaction from the monetary authority. This exercise therefore suggests that by weighting more the housing prices of the most responsive countries, the monetary authority is able to stabilize the economy more effectively.

In Appendix A.5 I repeat the same exercises but for the inflation target shock of the Taylor rule (7). Differently from the monetary policy shock, in this case the monetary authority faces a less favorable trade-off between output and prices. Output does not necessarily get stabilized relative to the baseline case, but goods inflation always increases its volatility. At the same time, while house price and rent inflation get stabilized (not shown), the house price and rent actually increase their volatility. Furthermore, responding to house prices instead than to inflation is actually better because house prices are more volatile under inflation target shocks, thereby triggering the monetary authority to react less strongly and better stabilize the economy.

Putting together the previous results points to an important policy lesson. When deciding to include housing prices into the price index, the monetary authority faces a trade-off between stabilizing output and stabilizing prices. Moreover, it is crucial to understand the volatility of house price and rent inflations for monetary shocks of different nature. For example, a conventional monetary policy shocks leads to a bigger increase in

rent inflation relative to house price inflation, making it more convenient for the monetary authority to respond to rents relative to house prices. However, an inflation target shock has the opposite effect, thereby making it more convenient for the monetary authority to respond to house prices relative to rents.

## 6 Conclusion

Heterogenous institutions across Euro Area countries can impair the uniform transmission of monetary policy (Cœuré (2019)). While it is clear that housing and mortgage markets are very different across countries, it is far less obvious how they might matter for the transmission mechanism. In this paper, I document strong correlations between the degree of cross-country heterogeneity of monetary policy effectiveness and key housing and mortgage market institutions, namely the ARM share and the HoR. I introduce these institutions into a quantitative currency-union two-agents New Keynesian model, which I calibrate to Spain and the Euro Area. As in the data, the model results show that Spain reacts more strongly than the Euro Area in terms of aggregate consumption, price-to-rent ratios, mortgage rates, and newly issued mortgages. My results point to the importance of the interaction between ARM shares and HoR for the transmission to aggregate economic activity.

The model represents a useful laboratory to analyze policy-relevant counterfactuals. I show that different forms of banking union weaken the monetary transmission mechanism, especially so if countries share similar mortgage market institutions such as the ARM share. I also show that adding house prices to the HICP lead the ECB to face a trade-off between output and inflation stabilization. Looking ahead, my model additionally suggests that policies that homogenize the home ownership rate across countries (subsidies, improvements to rental markets) lead to a more uniform transmission mechanism of monetary policy.

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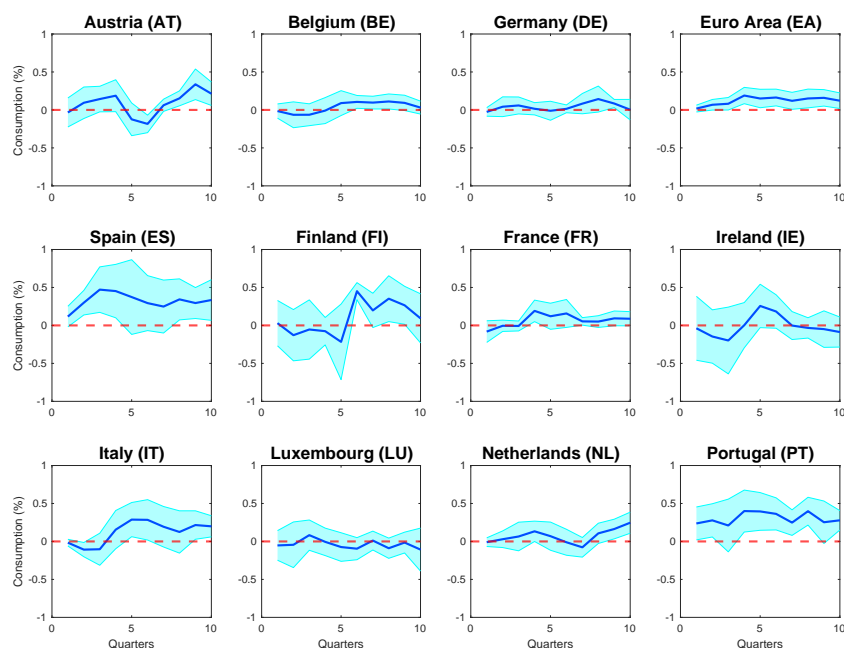
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# Appendix A Additional Figures

## A.1 Main Empirical Experiment: More Impulse Response Functions

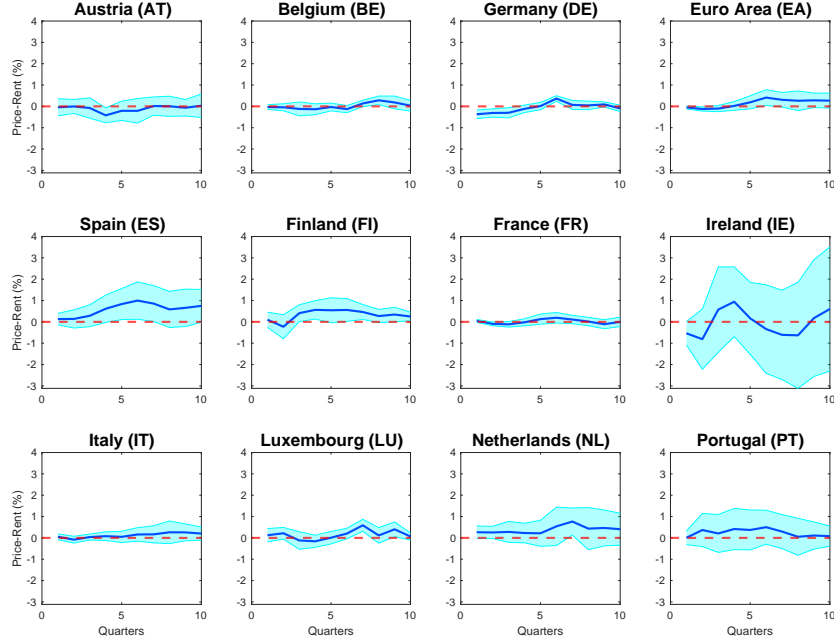
In this appendix I provide the impulse response functions for aggregate consumption (Figure A.1) and price-to-rent ratios (Figure A.2) from the main empirical experiment of Section 2. The results uncover important heterogeneity across Euro Area countries. An expansionary monetary policy shock of one standard deviation leads to an increase in aggregate consumption in Spain of about 0.5%, which is more than double the response of the Euro Area. The results point instead to a subdued response in Belgium, Germany, and Luxembourg. Portugal and Finland react almost as much as Spain.

Turning to price-to-rent ratios of Figure A.2, the results are similar overall. The magnitudes of the impulse response functions are stronger, revealing that house prices react more severely than aggregate consumption. Confidence intervals are also wider, however, pointing to higher uncertainty associated with these responses.



**Figure A.1:** Impulse response functions of aggregate consumption to an expansionary monetary policy shock of one standard deviation.

*Note:* For each country, the response is estimated using equation (1). The light blue shaded areas represent the 95% confidence intervals constructed using Newey-West standard errors. The estimation is performed over the period 2007 Q1 to 2019 Q3, with the 2Y OIS changes as identified monetary policy shocks.



**Figure A.2:** Impulse response functions of price-to-rent ratios to an expansionary monetary policy shock of one standard deviation.

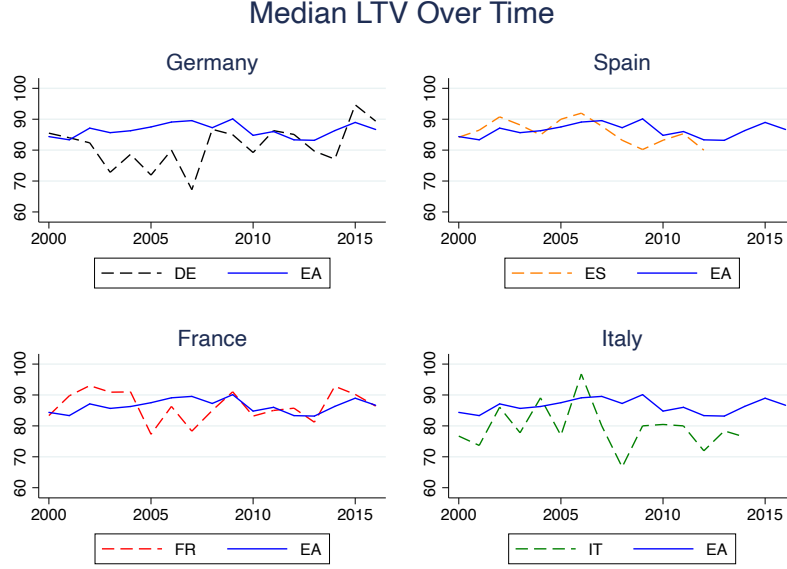
*Note:* For each country, the response is estimated using equation (1). The light blue shaded areas represent the 95% confidence intervals constructed using Newey-West standard errors. The estimation is performed over the period 2007 Q1 to 2019 Q3, with the 2Y OIS changes as identified monetary policy shocks.

## A.2 Calibration Figures

Previous literature investigating LTV ratio differences across countries has reached mixed results. Based on a survey of banks, [ECB \(2009\)](#) report a list of “typical” LTV ratios across Euro Area countries. These values have then been used by [Calza, Monacelli, and Stracca \(2013\)](#) to show empirically that countries with higher LTV ratios react more in terms of residential investment and house prices (but not consumption) to monetary policy shocks. On the other hand, [Corsetti, Duarte, and Mann \(2021\)](#) find that those same LTV ratios do not correlate with cross-country monetary policy effectiveness.

In figure [A.3](#) I plot the loan-to-value (LTV) ratios across the four biggest Euro Area countries since the early 2000s. I aggregate all household-level mortgages at each year of origination from the HFCS at the country level. The results show that LTV ratios have been quite stable over time and also very similar across countries. In the quantitative model, I therefore avoid to generate cross-country differences based off LTV ratios.





**Figure A.3:** Median Loan-to-Value ratios for four Euro Area countries since the early 2000s. *Note:* Calculations are based on the Eurosystem Household Finance and Consumption Survey.

### A.3 Empirical Analysis of Conventional Monetary Policy

This appendix extends the empirical exercise performed in Section 2.2 by considering a more standard conventional monetary policy analysis. In this regard, I follow the identification of Corsetti, Duarte, and Mann (2021). They run their analysis from 2000 Q1 to 2016 Q4 and make use of a shorter term OIS instrument than the one I use in my main analysis, namely the 1-year OIS rates<sup>25,26</sup>. Additionally, I use the 3-month short rate as the policy rate instead of the Euro Area-wide mortgage rate which I instead employ in the main policy experiment run in Section 2.2. I then estimate impulse response function using equation (1).

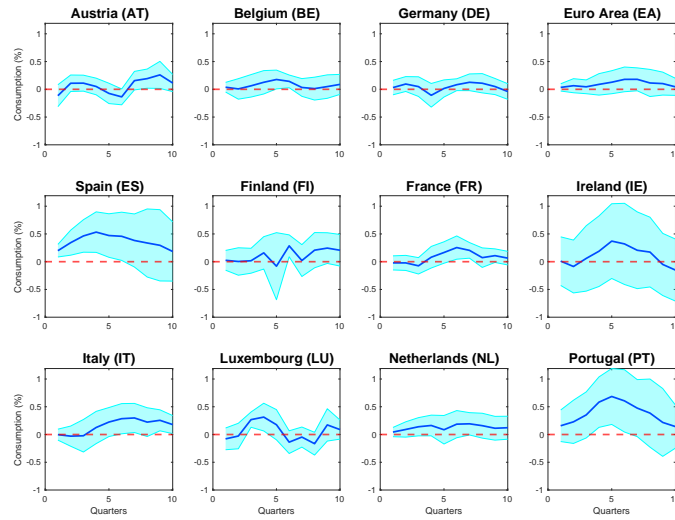
Figure A.4 displays results for aggregate consumption, Figure A.5 for price-to-rent ratios, Figure A.6 for newly issued mortgages, and Figure A.7 for mortgage rates. The results are overall similar to the ones in section 2.3. Impulse response functions are heterogeneous across countries, with countries like Spain and Portugal always reacting more severely. Comparing the reactions to the conventional analysis of this section with the reactions to the unconventional analysis of Section 2.2 shows some differences in

<sup>25</sup>In their appendix, Corsetti, Duarte, and Mann (2021) show that for a small monthly VAR the best instrument strength is provided by the 3-month OIS, while for the quarterly VAR counterpart the best instrument is the 1-year OIS.

<sup>26</sup>Different scholars have used different OIS rate changes as their instrument for a conventional monetary policy analysis. For example, Slacalek, Tristani, and Violante (2020) use the 1-month OIS, while Almgren et al. (2019) use the 3-month OIS. Results are similar when I assume different terms of OIS changes except for mortgage rates, which display higher pass-through for higher terms of OIS changes.

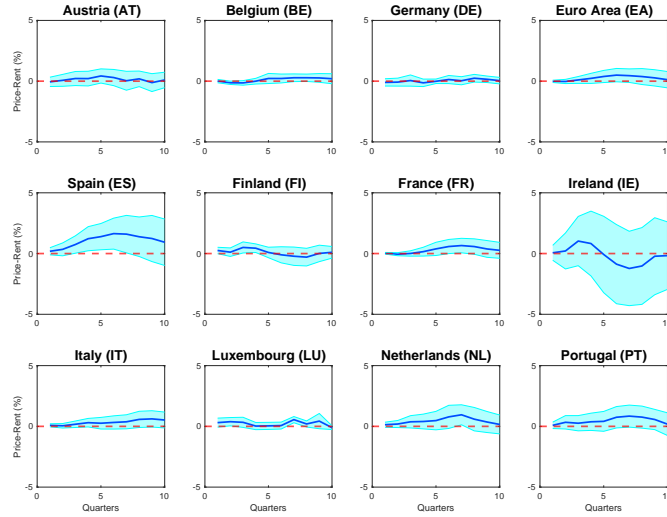
magnitudes. In particular, countries react more following conventional policy shocks, which can be observed by comparing reactions to newly issued mortgages in Figure A.6 to those of Figure 1. This is true for all variables considered except mortgage rates, which instead tend to react more following shocks to the longer end of the yield curve.

Finally, figures A.8 and A.9 show scatter plots of the relationship between the previously mentioned impulse response functions and the housing and mortgage market characteristics. The results line up with those of Section 2.4, uncovering strong correlations between impulse response function peaks (or troughs for mortgage rates) and the share of ARM as well as HoRs.



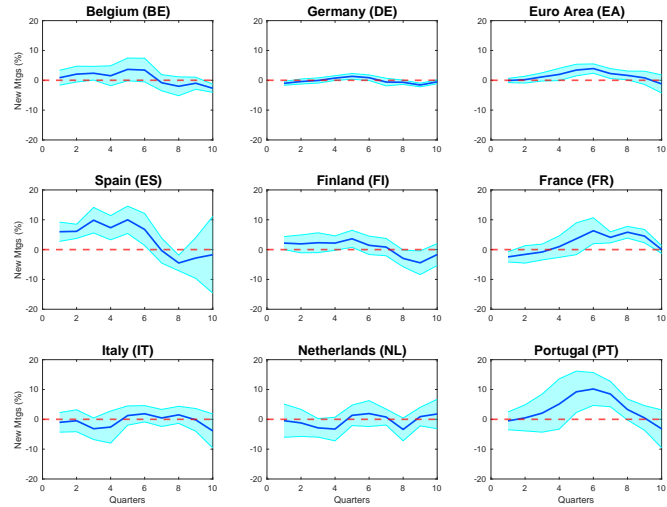
**Figure A.4:** Impulse response functions of aggregate consumption to an expansionary monetary policy shock of one standard deviation.

*Note:* For each country, the response is estimated using equation (1). The light blue shaded areas represent the 95% confidence intervals constructed using Newey-West standard errors. The estimation is performed over the period 2000 Q1 to 2016 Q4, with the 1Y OIS changes as identified monetary policy shocks.



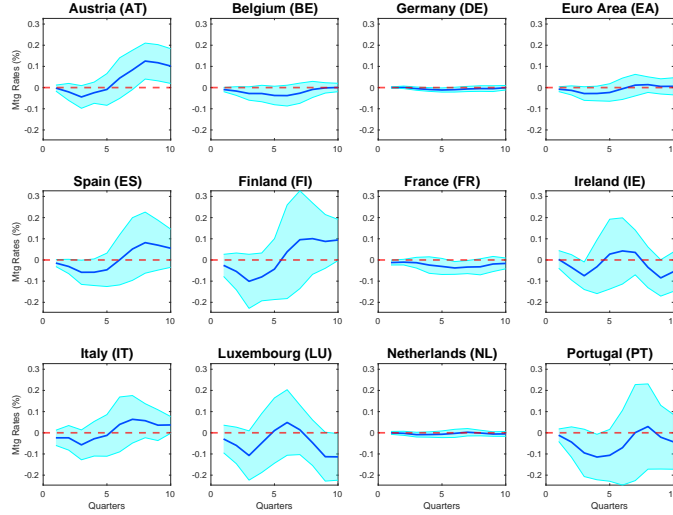
**Figure A.5:** Impulse response functions of price-to-rent ratios to an expansionary monetary policy shock of one standard deviation.

*Note:* For each country, the response is estimated using equation (1). The light blue shaded areas represent the 95% confidence intervals constructed using Newey-West standard errors. The estimation is performed over the period 2000 Q1 to 2016 Q4, with the 1Y OIS changes as identified monetary policy shocks.



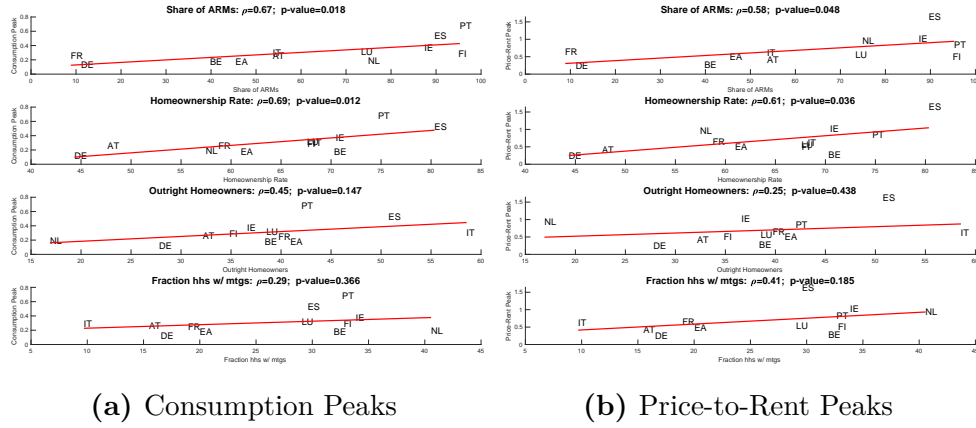
**Figure A.6:** Impulse response functions of newly issued mortgages to an expansionary monetary policy shock of one standard deviation.

*Note:* For each country, the response is estimated using equation (1). The light blue shaded areas represent the 95% confidence intervals constructed using Newey-West standard errors. The estimation is performed over the period 2007 Q1 to 2016 Q4, with the 1Y OIS changes as identified monetary policy shocks. Notice I start the estimation in 2007 Q1 and not in 2000 Q1 because that is when the data starts.



**Figure A.7:** Impulse response functions of outstanding mortgage rates to an expansionary monetary policy shock of one standard deviation.

*Note:* For each country, the response is estimated using equation (1). The light blue shaded areas represent the 95% confidence intervals constructed using Newey-West standard errors. The estimation is performed over the period 2003 Q1 to 2016 Q4, with the 1Y OIS changes as identified monetary policy shocks. Notice I start the estimation in 2003 Q1 and not in 2000 Q1 because that is when the data starts.

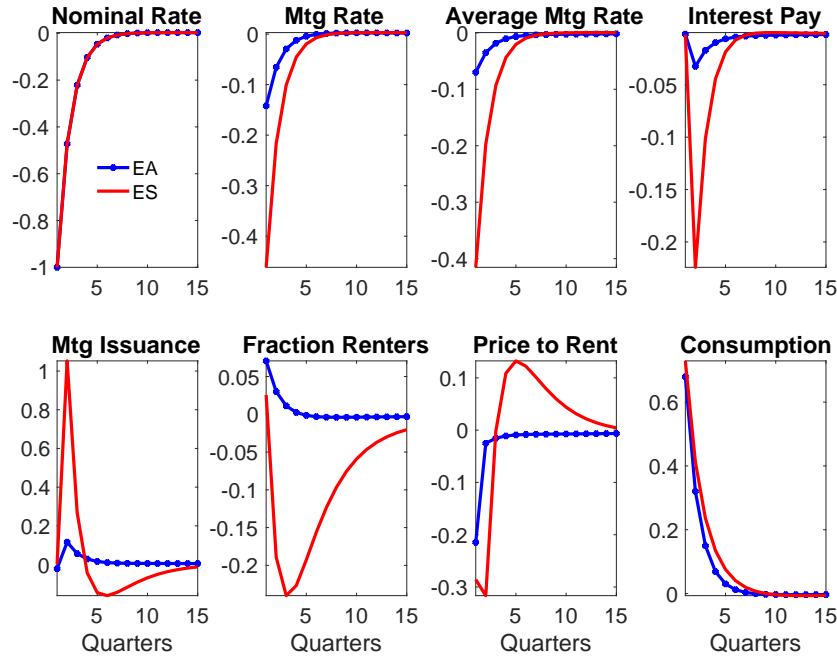


**Figure A.8:** Scatter plots of impulse response function intensities and housing and mortgage market characteristics.

*Note:* On the y-axis, I measure the strength of monetary policy by means of peak responses for both aggregate consumption and price-to-rent ratios. On the x-axis of each subplot, I make use of shares of ARM and various homeownership measures. For each country, the impulse response functions are estimated using equation (1) over the period 2000 Q1 to 2016 Q4, with the 1Y OIS changes as identified monetary policy shocks. Calculations of housing and mortgage market characteristics are based on the Eurosystem Household Finance and Consumption Survey.



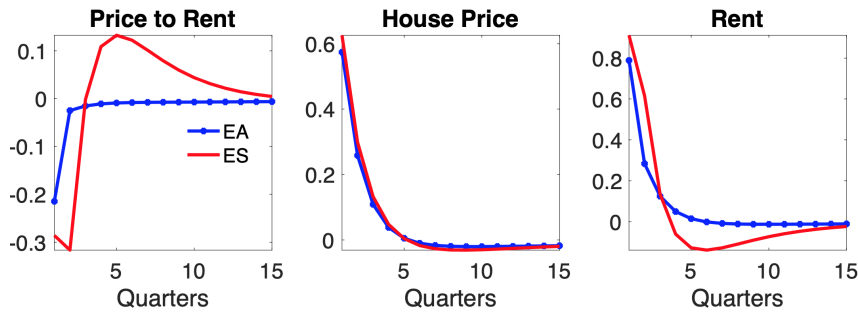
shown in the far right bottom panel of Figure A.10.



**Figure A.10:** Impulse response functions to a monetary policy shock normalized to a 1% fall in the nominal rate, both for the Euro Area (EA) and Spain (ES).

*Note:* The y-axes measure a 1% deviation relative to steady state, except for the mortgage rate, interest payments, and mortgage issuance which are measured in percentage points. The x-axes measure time in quarters. The nominal rate and mortgage rate are annualized.

Turning to price-to-rent ratios, Figure A.11 shows that rents move positively and more strongly than house prices and determine the difference in price-to-rent ratio movements between ES and the EA. This is, however, at odds with the evidence put forth by Koeniger, Lennartz, and Ramelet (2021) for Italy and Switzerland, as well as by Dias and Duarte (2019) for the US.

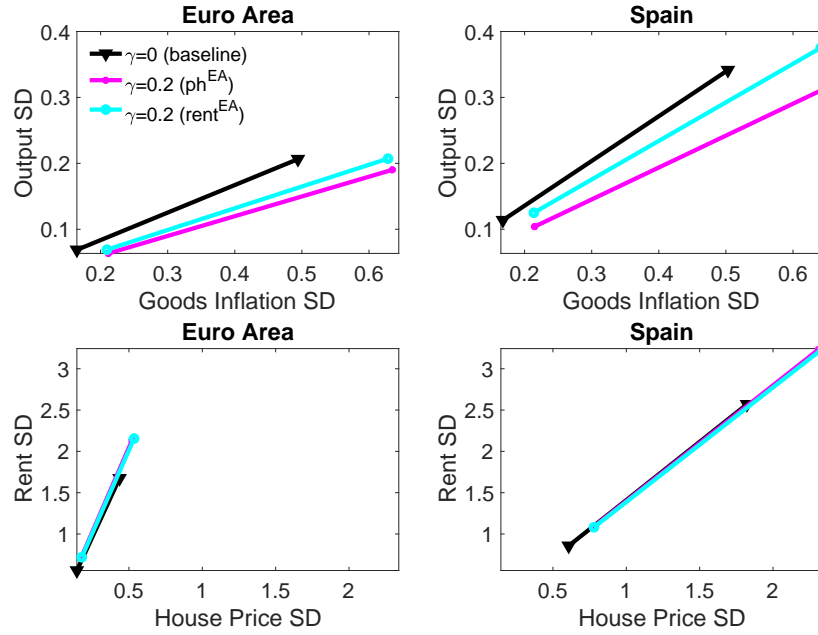


**Figure A.11:** Impulse response functions to a monetary policy shock normalized to a 1% fall in the nominal rate, both for the Euro Area (EA) and Spain (ES).

*Note:* The y-axes measure a 1% deviation relative to steady state. The x-axes measure time in quarters.

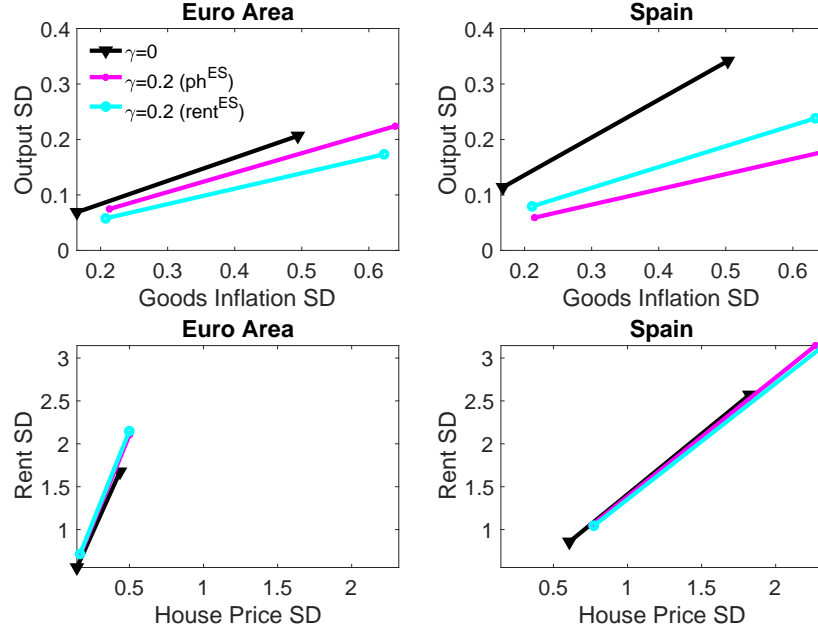
## A.5 Trade-Offs Under Inflation Target Shocks

Figure A.12



**Figure A.12:** Trade-offs between output, goods inflation, house price, and rent for different Taylor rules (7) that include the term in equation (15) under expansionary inflation target shocks of different sizes.

*Note:* The axes measure the standard deviation of the impulse response functions over 20Q. The shocks considered move the nominal interest rate on impact between  $-1.5\%$  and  $-0.5\%$  under the baseline Taylor rule ( $\gamma = 0$ ).



**Figure A.13:** Trade-offs between output, goods inflation, house price, and rent for different Taylor rules (7) that include the term in equation (16) under expansionary inflation target shocks of different sizes.

*Note:* The axes measure the standard deviation of the impulse response functions over 20Q. The shocks considered move the nominal interest rate on impact between  $-1.5\%$  and  $-0.5\%$  under the baseline Taylor rule ( $\gamma = 0$ ).

## Appendix B Data Sources

The following is a list of all of the data sources used in the aggregate-level empirical analysis.

**Aggregate Consumption:** *Household and NPISH final consumption expenditure, Chain linked volumes.* Seasonally adjusted, quarterly frequency. Source: Eurostat.

**Aggregate Output:** *Gross Domestic Product at market prices, Chain linked volumes.* Seasonally adjusted, quarterly frequency. Source: Eurostat.

**Harmonized Index of Consumer Prices (HICP):** *All-items HICP.* Seasonally adjusted, quarterly frequency. Source: Eurostat.

**Real House Prices/Rents/Price-to-Rents:** Seasonally adjusted, quarterly frequency. Source: OECD.

**Newly Issued Mortgages:** *Total amount of residential loans advanced during the period. Gross lending includes new mortgage loans and external remortgaging (i.e. remortgaging with another bank) in most countries.* Units are million euros, quarterly frequency. I deflate each country-level series by the HICP and I deseasonalize them leveraging the X-13-ARIMA-SEATS procedure. Source: European Mortgage Federation.

**Mortgage Rates:** *Annualised agreed rate (AAR) / Narrowly defined effective rate*



*(NDER), Credit and other institutions (MFI except MMFs and central banks) reporting sector - Lending for house purchase, Total original maturity, Outstanding amount business coverage, Households and non-profit institutions serving households (S.14 and S.15) sector, denominated in Euro. Monthly frequency, which I average to quarterly. Source: ECB SDW.*

**3-Month Short Rate:** *Euro area (changing composition) - Money Market - Euribor 3-month - Historical close, average of observations through period - Euro, provided by Reuters. Monthly frequency, which I average to quarterly. Source: ECB SDW.*

**OIS Changes:** *Change in the median quote from the window 13:25-13:35 before the press release to the median quote in the window 15:40-15:50 after the press conference (Monetary Event Window). Dates of policy event frequency (roughly monthly), which I sum up to quarterly. Source: Euro Area Monetary Policy event study Database (EA-MPD).*

## Appendix C Model Derivations and Solution

This appendix is organized as follows. Section C.1 lists the optimality conditions of the agents of the model economy. I derive the wage Phillips curve in Section C.2, and the main equations of the Home-Foreign structure in Section C.3.

### C.1 Optimality Conditions

#### C.1.1 Borrower Solution

Optimality with respect to housing services implies that the rental price equals the marginal rate of substitution between housing services and consumption:

$$p_{r,t} = \frac{u_{b,t}^h}{u_{b,t}^c} \quad (\text{C.1})$$

Optimality with respect to new mortgages reads as:

$$\mu_t + \Omega_{b,t}^m + q_t \Omega_{b,t}^x = 1 \quad (\text{C.2})$$

where  $\Omega_{b,t}^m$  and  $\Omega_{b,t}^x$  are, respectively, the marginal continuation costs to the borrower of taking an additional euro of face value debt, and of promising an additional euro of initial payments:

$$\Omega_{b,t}^m = E_t \Lambda_{t,t+1}^b \pi_{t+1}^{-1} [(1 - \tau)(1 - \alpha)q_t + \rho(1 - \nu) + \nu + (1 - \rho)(1 - \nu)\Omega_{b,t+1}^m] \quad (\text{C.3})$$

$$\Omega_{b,t}^x = E_t \Lambda_{t,t+1}^b \pi_{t+1}^{-1} [(1 - \tau)\alpha + (1 - \rho)(1 - \nu)\Omega_{b,t+1}^x] \quad (\text{C.4})$$

Notice the differences with the corresponding first order condition for new mortgages of the saver, equations (9)-(11). Firstly, the borrowers are constrained by the LTV so that the rate at which they value the relaxation ( $\mu_t$ ) shows up in the optimality trade-off. Secondly, the borrowers deduct their mortgage payments at rate  $\tau$ , decreasing all their future continuation costs.

Finally, the borrowers optimize with respect to new housing leading to equation (14) – as already discussed in Section 3.2. The relevant normalization for the ownership utility term in the borrower budget constraint is:  $A_{b,t} = \frac{(H_{b,t} + H_{l,t})^2}{H_{l,t}}$ .

#### C.1.2 Saver Solution

In Section 3.2 I discuss the optimality conditions of the savers with respect to bonds (the Euler equation (13)) and with respect to newly issued mortgages (equations (9)-(11)). The optimality with respect to house size implies:

$$p_{h,t} = \frac{u_{s,t}^h}{u_{s,t}^c} + E_t [\Lambda_{t,t+1}^s p_{h,t+1} (1 - \delta)] \quad (\text{C.5})$$

Finally, the assumption that the savers of both economies have access to international complete markets for state-contingent assets leads to the standard formula of international risk sharing:

$$u_{s,t}^{*,c} = u_{s,t}^c Q_t \quad (\text{C.6})$$

where  $u_{s,t}^{*,c}$  ( $u_{s,t}^c$ ) is the marginal utility of consumption of the savers in the Foreign (Home) economy, and  $Q_t$  is the real exchange rate.

### C.1.3 Landlord Solution

The landlords only optimize with respect to new house size, leading to:

$$p_{h,t} = E_t \Lambda_{t,t+1}^s [p_{r,t+1} + \bar{\omega}_{l,t} + p_{h,t+1}(1 - \delta)] \quad (\text{C.7})$$

where the relevant normalization for the ownership utility term in the landlord budget constraint is:  $A_{l,t} = \frac{(H_{b,t} + H_{l,t})^2}{H_{b,t}}$ .

## C.2 The Labor Market and The Wage Phillips Curve

In deriving the wage Phillips curve, I follow [Auclert, Rognlie, and Straub \(2018\)](#) and extend their result to households with different discount factors.

Each household  $i$  provides hours of work  $n_{ikt}$  to a continuum of unions indexed by  $k \in [0, 1]$ . Therefore, household  $i$  provides a total of  $n_{it} \equiv \int_k n_{ikt} dk$  hours of work. Unions aggregate hours of work into tasks:  $N_{kt} = \int n_{ikt} di$ . A competitive labor packer packages these tasks into aggregate labor demand using the technology:

$$N_t = \left( \int_k N_{kt}^{\frac{\varphi-1}{\varphi}} dk \right)^{\frac{\varphi}{\varphi-1}}$$

and sell these services to perfectly competitive producers in the final good sector introduced in Section 3 at price  $W_t$ .

Next, each union  $k$  that adjusts the nominal wage  $W_{kt}$  determines a quadratic utility cost to households. Specifically, each household utility (2) features an additive cost  $\frac{\psi}{2} \int_k \left( \frac{W_{kt}}{W_{kt-1}} - 1 \right)^2 dk$ . In a symmetric equilibrium, unions set equal wages and ask households to supply the same hours of labor, implying:

$$\frac{N_{b,t}}{\chi_b} = \frac{N_{s,t}}{\chi_s} = N_t$$

Finally, I follow the derivation in [Auclert, Rognlie, and Straub \(2018\)](#) and show that in my setting the wage Phillips curve takes the form:

$$\pi_t^W (\pi_t^W - 1) = \frac{\varphi}{\psi} N_t \left( u^N(N_t) - \frac{\varphi-1}{\varphi} (1 - \tau) \frac{W_t}{P_t} \tilde{u}^c \right) + \tilde{\beta} \pi_{t+1}^W (\pi_{t+1}^W - 1)$$

where  $\tilde{u}^c = \chi_b u^c(C_{b,t}/\chi_b) + \chi_s u^c(C_{s,t}/\chi_s)$  is the average marginal utility, and  $\tilde{\beta} = \chi_b * \beta_b + \chi_s * \beta_s$  is the average discount factor in the economy. The full proof will be made available in the next draft.

### C.3 The Home-Foreign Structure

For notational convenience, I impose the goods-market clearing conditions of each country:  $AC_t \equiv C_t + \delta p_t^h \bar{H} = Y_t$ ;  $AC_t^* \equiv C_t^* + \delta p_t^{*,h} \bar{H}^* = Y_t^*$ . We can additionally express the consumption bundles  $C_{H,t}$  and  $C_{F,t}$  as function of aggregate country-level output:

$$C_{H,t} = \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} (1 - \gamma) Y_t; \quad C_{F,t} = \left( \frac{P_{F,t}}{P_t} \right)^{-\eta} \gamma Y_t;$$

$$C_{H,t}^* = \left( \frac{P_{H,t}^*}{P_t^*} \right)^{-\eta} \gamma^* Y_t^*; \quad C_{F,t}^* = \left( \frac{P_{F,t}^*}{P_t^*} \right)^{-\eta} (1 - \gamma^*) Y_t^*;$$

Finally, we can derive the intermediate good-level demand of each consumption bundle:

$$C_{H,t}(i) = \left( \frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\epsilon} \left( \frac{1}{n} \right) C_{H,t}; \quad C_{F,t}(i) = \left( \frac{P_{F,t}(i)}{P_{F,t}} \right)^{-\epsilon} \left( \frac{1}{1-n} \right) C_{F,t};$$

$$C_{H,t}^*(i) = \left( \frac{P_{H,t}^*(i)}{P_{H,t}^*} \right)^{-\epsilon} \left( \frac{1}{n} \right) C_{H,t}^*; \quad C_{F,t}^*(i) = \left( \frac{P_{F,t}^*(i)}{P_{F,t}^*} \right)^{-\epsilon} \left( \frac{1}{1-n} \right) C_{F,t}^*;$$

**Total Variety Demands.** Market clearing for domestic variety  $i$  must satisfy:

$$Y_t(i) = n C_{H,t}(i) + (1-n) C_{H,t}^*(i)$$

$$= \left( \frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\epsilon} \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} \left[ (1-\gamma) Y_t + \frac{1-n}{n} \gamma^* Q_t^\eta Y_t^* \right]$$

Accordingly, market clearing for foreign variety  $i$  must satisfy:

$$Y_t^*(i) = n C_{F,t}(i) + (1-n) C_{F,t}^*(i)$$

$$= \left( \frac{P_{F,t}(i)}{P_{F,t}} \right)^{-\epsilon} \left( \frac{P_{F,t}}{P_t} \right)^{-\eta} \left[ \frac{n}{1-n} \gamma^* Q_t^{-\eta} Y_t + (1-\gamma^*) Y_t^* \right]$$

Next, we substitute in the expressions  $\gamma \equiv (1-n)\lambda$  and  $\gamma^* \equiv n\lambda^*$ . Further, to portray our small open economy we take  $n \rightarrow 0$  to get:

$$Y_t(i) = \left( \frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\epsilon} \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} [(1-\lambda) Y_t + \lambda^* Q_t^\eta Y_t^*]$$

$$Y_t^*(i) = \left( \frac{P_t^*(i)}{P_t^*} \right)^{-\epsilon} Y_t^*$$

It is clear from these latter equations that while consumption of the Foreign economy affects the Home economy, the opposite does not hold true. At the same time, changes in the real exchange rate do not affect Foreign aggregate demand.

In a symmetric equilibrium, each producer charges the same price and produces the same level of output. For the Foreign economy, this means  $P_t^*(i) = P_t^*$  and  $Y_t^*(i) = Y_t^*$ . Similarly for the Home economy, this means  $P_{H,t}(i) = P_{H,t}$  and  $Y_t(i) = Y_t$ . Furthermore, assuming  $\lambda = \lambda^*$  implies:

$$Y_t = \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} [(1 - \lambda)Y_t + \lambda Q_t^\eta Y_t^*]$$

which is equation (5).