Transmission of Monetary Policy in a Currency Area with Heterogeneous Households*

– preliminary and incomplete –

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This version: October 2024
First Version: March 2023

Abstract

Monetary policy has heterogeneous effects on real GDP and inflation across Euro Area member states. To investigate the underlying drivers we construct a two-region currency union model with idiosyncratic risk and cross-region household heterogeneity. The model matches household-level heterogeneity in homeownership rates, mortgage types, and the prevalence of hand-to-mouth households. These features account for 70% of the cross-region differences in GDP responses to monetary policy shocks. This is primarily driven by the interplay of demand amplification through hand-to-mouth households, and demand dampening through trade effects.

Keywords: Monetary policy, currency union, housing.

*We thank Klaus Adam, Zhen Huo, Matthias Meier, and Adrien Wicht for insightful discussions, as well as participants at various seminars and conferences for helpful comments. Lukas Hack (University of Mannheim): Lukas.Hack@uni-mannheim.de. Hannes Twieling (University of Mannheim): Hannes.Twieling@uni-mannheim.de. Lukas Hack and Hannes Twieling acknowledge financial support from the German Research Foundation (DFG) through CRC TR 224 (Hack: Project C05, Twieling: Project C02).

1 Introduction

The impact of monetary policy on economic outcomes varies significantly across the member states of the Euro Area[1], presenting a challenge to achieving even monetary policy transmission and price stability within the currency area. Therefore, it is crucial to understand the underlying forces driving heterogeneous responses and their relative strength.

Empirical investigations led to suggestive evidence that household heterogeneity in the prevalence of liquidity-constrained, hand-to-mouth households, adjustable-rate mortgages, and homeownership rates, are likely drivers of heterogenous transmission (e.g. Almgren et al., 2022; Corsetti et al., 2022; Pica, 2022). Nevertheless, identification based on reduced-form methods is difficult because cross-sectional variation is limited to Euro Area member states, and the different forms of household heterogeneity tend to be correlated across countries.[2] Moreover, Euro Area countries cannot be treated as independent regions but rather interact through various economic linkages.

To overcome these challenges, we propose a structural approach. First, we construct a quantitative two-region heterogeneous-agent New Keynesian (HANK) model with a common currency area and cross-region heterogeneity in the number of hand-to-mouth households, housing tenure status as well as in the prevalence of adjustable-rate mortgages. To the best of our knowledge, this is the first two-region HANK model with cross-region household heterogeneity.[3] Second, the model rationalizes 70% of the heterogeneity in the GDP responses to monetary policy shocks, primarily through the interplay between hand-to-mouth heterogeneity and trade openness. Finally, we demonstrate that trade is decisive for heterogeneous responses to monetary policy shocks. Policies that increase trade openness can synchronize inflation responses perfectly but at the expense of amplified heterogeneity for GDP, which

[1]For example, the peak GDP response to monetary policy shocks in Spain is more than two times larger than in Germany, as we show in Section 2.

[2]Studying time variation is not feasible due to lack of microdata at a suitable frequency.

[3]In simultaneous work, Bayer et al. (2023) and Chen et al. (2023) study two-region HANK models but focus on cross-country differences in fiscal policies, as we discuss below.

may even flip signs compared to the baseline.[4]

Empirical facts. We document micro-level cross-country differences in household heterogeneity based on survey data and macro-level cross-country heterogeneity in GDP and inflation responses to high-frequency identified monetary policy shocks.[5] We focus on the core countries which we group into two regions, France & Germany, the *North*, and Italy & Spain, the *South*. At the household level, we find that a higher fraction of households are hand-to-mouth in the South, even conditional on housing tenure status. Similarly, there are more homeowners in the South and the mortgages held by these owners are more likely to have adjustable rates. These aspects render household demand in the South more responsive to monetary policy because hand-to-mouth households respond stronger to changes in their disposable income and monetary policy may directly affect the disposable income of homeowners through adjustable-rate mortgages. Consistent with this, we find that the GDP response to monetary policy shocks is more pronounced in the South.

Model. Motivated by these facts, we construct a two-region HANK model. Households are ex-ante heterogeneous in their housing tenure status which determines whether they are renters, outright owners, or mortgagors, and are subject to idiosyncratic income risk against which they self-insure via a liquid bond. The bond is traded within the currency area. The New Keynesian elements are wage and price stickiness through Rotemberg adjustment costs in conjunction with monopolistic competition in labor and intermediate goods markets. Labor supply and wages are set by unions that sell differentiated labor services to labor packers. Intermediate goods are produced with a linear technology from labor services and transformed to region-specific final goods. These final goods are traded, while

[4]By increased trade openness, we refer to a decrease in the home bias for domestically produced goods and an increase in the elasticity of substitution across goods produced in different regions. Euro Area policy may affect these parameters through, e.g., fostering trade in services across member states.

[5]The micro-level evidence is based on the ECB's Household Finance and Consumption Survey, and the monetary policy shocks are based on the Euro Area Monetary Policy Event-Study Database from Altavilla et al. (2019).

households have a home bias for domestically produced goods. To match both, household heterogeneity in hand-to-mouth (and hence, in marginal propensities to consume) and hump-shaped empirical impulse responses, we closely follow Auclert et al. (2020): At the micro level, we assume heterogeneity in discount rates across housing tenure status and region to match the differential hand-to-mouth shares. At the macro level, we assume that households infrequently update their private belief about the future aggregate state which allows for generating hump-shaped responses to shocks, as found in the data.

Calibration. We calibrate the model in two steps. First, we match the household-level data moments from the survey data and set certain parameters that are common across households to standard values. Second, we estimate key parameters of the model by impulse response function matching, based on the method of simulated moments. Importantly, we target only the GDP response of the South to a monetary policy shock. The response of the North, and hence, the differential response across regions is not targeted. We do estimate the adjustment costs of wages and prices, interest rate smoothing, and the inflation coefficient in the Taylor rule, as well as the updating frequency of households with regard to the aggregate state.

Results. The model matches the cross-region differences in the GDP responses to monetary policy shocks fairly well. This holds in terms of the level and the shape. At the peak response, the model can account for 70% of the differential effects across both regions. We decompose the differences in impulse responses into the underlying demand components, finding that they are primarily driven by homeowners whereas renters are less important. Conversely, trade provides an important counteracting force that dampens the differential effects substantially. Net exports of the North increase in response to the shock which puts downward pressure on output in the South but upward pressure on output in the North. Ignoring these trade effects would amplify the differential response by 80% at the peak, relative to the baseline. We further show that realistic heterogeneity in hand-to-mouth is key for the differential demand amplification across regions. When we shut down the discount rate heterogeneity, we obtain hardly any differences across regions. This suggests that the interplay of demand amplification through hand-to-mouth households and the counteraction through trade crucially shape the differential effects across regions. This finding supports our modeling strategy that both, incomplete markets and meaningful trade interaction are crucial ingredients to understanding the heterogeneous responses found in the data.

We further inspect the importance of trade and study a counterfactual with increased trade openness. Specifically, we assume that both regions have no home bias and that the elasticity of substitution across both goods is large. In such a counterfactual, price differences across regions cannot be entertained as an equilibrium outcome. Any price difference is exploited by households substituting domestic and foreign goods until the price difference vanishes. Thus, consumer good inflation rates behave completely symmetric across regions. This qualitatively alters the cross-region differences in output responses because net exports of the North are amplified, relative to the baseline. Therefore, the output response of the North can be substantially larger than the response of the South, despite more demand amplification through household heterogeneity in the South. The underlying mechanism works through labor supply. Southern households increase consumption by more, leading to a higher valuation of leisure, relative to the North. This makes production in the North more competitive. With a high elasticity of substitution, households can exploit the lower cost of production more intensely. In particular, they exploit this relation until consumer prices are completely equalized.

Our results have important implications for policies that aim to foster trade (integration) within the Euro Area. Such policies may help to synchronize inflation rates across regions. This removes an important trade-off currently faced by the European Central Bank. Instead of monitoring various inflation rates, it is sufficient to control Euro Area inflation to achieve price stability not only on average but in each single member country. However such policies come at the cost of potentially larger heterogeneity in production.

Related literature. This paper relates to the literature studying heterogeneity in the transmission of monetary policy in the Euro Area. Early work by Calza et al. (2013) notes that mortgage rate types affect the reaction of aggregate consumption to monetary policy shocks in OECD countries. More recent findings by Pica (2022) show how homeownership rates and adjustable rate mortgages affect the transmission of monetary shocks in the Euro Area. Focusing on liquidity constraints, Almgren et al. (2022) point out that there is a strong positive correlation between the reaction of GDP to a monetary policy shock and the share of hand-to-mouth households across Euro Area member states. Combining micro and macro level evidence with a tractable HANK model, Slacalek et al. (2020) study the different channels through which monetary policy affects household choices in the four largest Euro Area countries. Their channels heavily rely on the presence of hand-to-mouth agents. Finally, Corsetti et al. (2022) construct a dynamic factor model consisting of the Euro Area founding members. They find positive correlations between GDP responses to Monetary policy shocks and hand-to-mouth households, adjustable mortgage rates, homeownership rates, and wage stickiness. We add to this literature by integrating various potential driving forces of cross-country heterogeneity in impulse responses into a quantitative currency union HANK model and decomposing the effect of various channels.

This paper is also closely connected to the literature on the transmission of shocks in quantitative open economy HANK models. Auclert et al. (2021b) and Guo et al. (2020) study the effect of international shocks in the presence of household heterogeneity in a small open economy setting. Bayer et al. (2023) and Chen et al. (2023) propose currency union open economy HANK models to study fiscal policies in a currency union. Our paper in turn focuses on monetary policy, adds important characteristics of household heterogeneity, and points out the importance of cross-country interactions in a currency union.

Further, we relate to a literature that studies structural differences in currency unions in representative agent economies (Benigno, 2004; Bletzinger and von Thadden, 2021; Kekre, 2022).

Finally, we connect to the fast literature that studies monetary policy and hand-to-mouth agents (Auclert, 2019; Kaplan et al., 2018; Luetticke, 2021; McKay et al., 2016).

2 Empirical analysis

In this section, we document important empirical regularities across Euro Area countries. We focus on France & Germany as well as Italy & Spain as the four core countries which account for a large fraction of Euro Area GDP. We refer to these groups as *North* and *South* respectively. We find that the South's GDP responds substantially stronger to monetary policy shocks which is consistent with more hand-to-mouth households, higher homeownership rates, and more adjustable-rate mortgages that we find in the micro data.

2.1 Macro-level evidence

Data. We estimate the impulse response of real GDP to high-frequency identified monetary policy shocks via local projections,

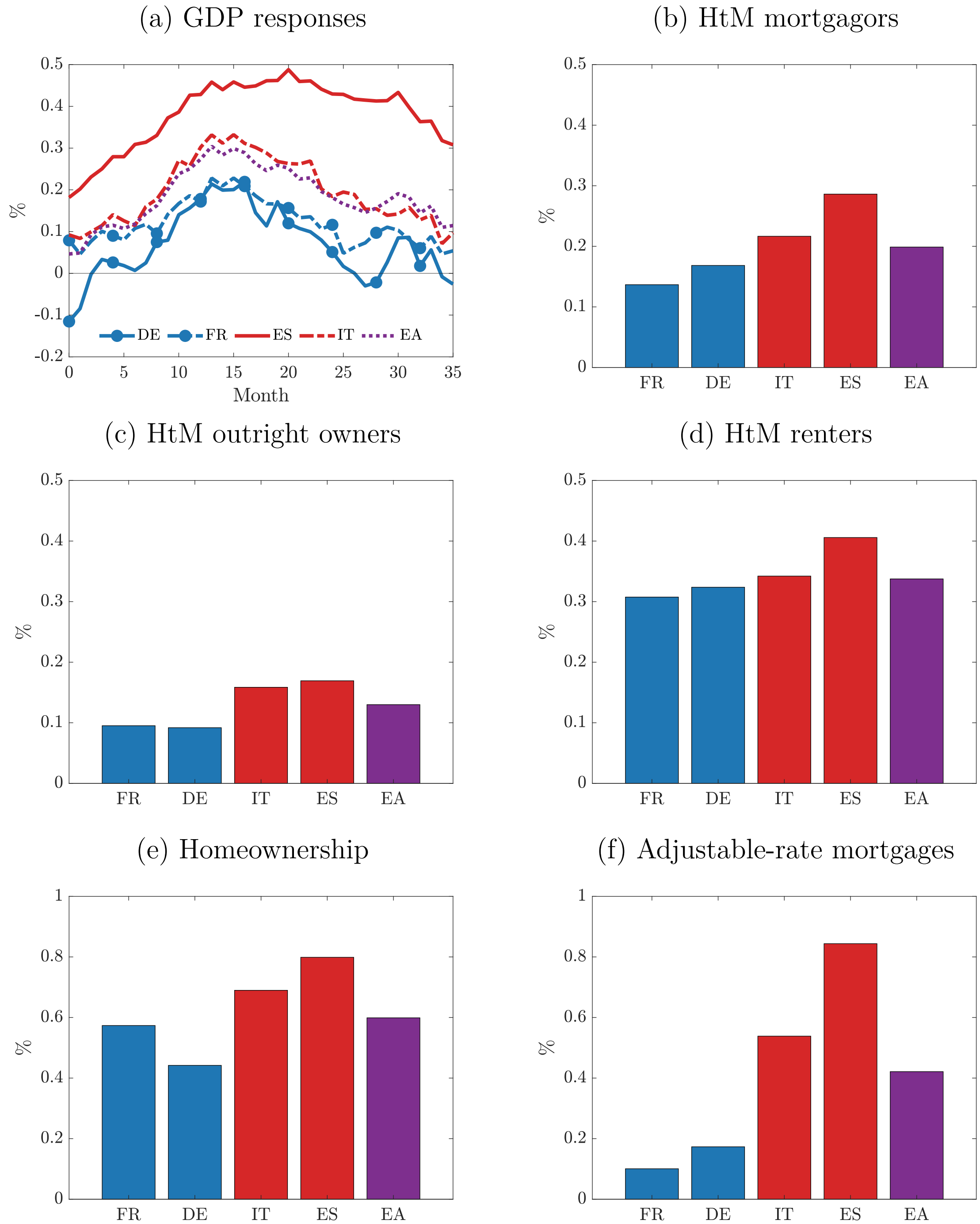
$$y_{n,t+h} = \alpha_n^h + t + \beta_n^h \, \varepsilon_t^{MP} + \zeta_n^h \, X_{n,t} + v_{t+h}^h, \qquad h = 0, 1, ..., H \tag{2.1}$$

where n indexes the country, $y_{n,t+h}$ refers to the logarithm of real GDP, ε_t^{MP} is a monetary policy shock and $X_{n,t}$ is vector of control variables. We interpolate real GDP to monthly frequency using the Chow and Lin (1971).[6] The monetary policy shock is a monetary policy surprise from Altavilla et al. (2019). We choose a one-year horizon to incorporate responses in adjustable-rate mortgages which are only updated once or twice per year.[7] Finally, the control vector includes lags of country-level log GDP, Euro Area log GDP and HICP, the EONIA, and lags of the shock. The sample runs from 2000 to 2019.

[6]Interpolation to monthly frequency is standard (e.g. Almgren et al., 2022; Leeper et al., 1996). We use the unemployment rate, industrial production, and the turnover and volume of trade index to interpolate real GDP.

[7]We aggregate the surprises from Altavilla et al. (2019) to monthly frequency by using the same weighting scheme as Almgren et al. (2022) which assigns more weight to shocks early in the month.

Figure 1: Empirical evidence for asymmetric responses



Notes: Panel (a) shows estimated impulse responses of GDP to a high-frequency identified monetary policy shock, based on the local projection in (2.1). Panels (b)-(d) show the share of hand-to-mouth (HtM) households, conditional on housing tenure status. Panels (e) and (f) show the number of homeowners, relative to all households and the number of adjustable-rate mortgages, relative to all mortgages.

Results. We show impulse responses $\beta_n^0, ..., \beta_n^H$ to an expansionary monetary policy shock equal to one percentage point. The results for the four core countries as well as for the average response across all Euro Area members are in Panel (a) of Figure 1. The Euro Area average displays the point-wise average response across all member states, weighted by the average GDP in our sample. The red lines show that the South tends to respond strongly compared with both, the Euro Area average response (purple dotted line) and the North (lines with markers). For example, at the peak of the German response, we find that the response of Spain is twice as large. This suggests that there is a sizable heterogeneity in the transmission of monetary policy across the core countries.

2.2 Micro-level evidence

Data. We compute country-specific statistics based on the Household Finance and Consumption Survey (HFCS), and pool the first three waves. We distinguish households by their housing tenure status, i.e., whether they rent or own their home and whether they still have outstanding mortgages. For each subgroup, we compute the share of hand-to-mouth (HtM) households following the definition of Slacalek et al. (2020).[8] We further measure homeownership rates as the share of homeowners in the total population and the importance of adjustable-rate mortgages as the fraction of mortgages that feature adjustable rates, relative to all mortgages of the respective country.

Results. Panels (b) to (f) in Figure 1 display average shares for each core country, as well as Euro Area averages which are weighted by average GDP, consistent with the average local projections. Across housing tenure status, we find that there are more hand-to-mouth households in the South. Renters feature most hand-to-mouth households but the cross-country differences are slightly smaller. Among homeowners, we find that mortgage holders are more constrained, perhaps because debt service makes it hard to accumulate liquid savings.

[8] They assume that households are liquidity constraint when they hold liquid assets below their biweekly income, or negative liquid assets with less than a biweekly income distance to the credit limit.

Finally, homeowners are counted as wealthy hand-to-mouth because they own a house which is an illiquid asset. Homeownership rates in the South are also higher putting more weight on owners, relative to renters. Finally, there is a stark difference in the prevalence of adjustable-rate mortgages across regions. For example, only one out of ten mortgages in France features adjustable rates whereas it is almost nine out of ten in Spain.

Overall, this illustrates that heterogeneous GDP responses tend to be correlated with the prevalence of hand-to-mouth households, homeownership rates, and the importance of adjustable-rate mortgages. This is consistent with Corsetti et al. (2022) and suggests that these household-level cross-country heterogeneities are potential channels that drive heterogeneous GDP responses to monetary policy shocks.

3 Model

The model features two economic regions which are populated by a continuum of households of mass α and $1-\alpha$, respectively. We refer to these regions as North and South, in anticipation of our calibration. We state the model from the perspective of the North because cross-region differences enter only via the model calibration. Both regions are connected through the trade of goods and an integrated asset market. Variables of the South are denoted with an asterisk and time is discrete.

3.1 Households

Households supply labor, save in a liquid bond, and consume region-specific aggregate consumption baskets that follow from a nested constant elasticity of substitution (CES) demand structure which takes variety goods from North and South producers as inputs.

Dynamic problem. Households are ex-ante heterogeneous with respect to their housing tenure status which is indexed by $k \in \{o, m, r\}$, referring to outright owners, mortgage holders, and renters, respectively. Each household i solves the following dynamic problem

$$V_t^k(e_{i,t}, b_{i,t-1}, x_{i,t}) = \max_{c_{i,t}, b_{i,t}} \Bigg(\frac{c_{i,t}^{1-\gamma}}{1-\gamma} - \varphi \frac{n_t^{1-\nu}}{1-\nu} + \beta_k \mathbb{E}_t \Big[\xi V_{t+1}^k(e_{i,t+1}, b_{i,t}, x_{i,t}+1) + (1-\xi) V_{t+1}^k(e_{i,t+1}, b_{i,t}, 0) \Big] \Bigg) \tag{3.1}$$

$$\text{s.t.} - \underline{b} \leq b_{i,t}, \quad \text{and} \quad \ln(e_{i,t+1}) = \rho_e \ln(e_{i,t}) + v_{i,t+1}, \tag{3.2}$$

with $v_{i,t} \overset{iid}{\sim} N(0, \sigma_e)$, and subject to a budget constraint which we discuss below. Flow utility is additively separable and depends on constant relative risk aversion γ, inverse Frisch elasticity of labor supply ν, and a labor disutility shifter φ. The beginning-of-period bond holdings $b_{i,t-1}$ are given and households allocate disposable income to consumption $c_{i,t}$ and liquid bond holdings $b_{i,t}$. The labor supply decision is delegated to a labor union which we explain in Section 3.2. The endowment with labor efficiency units $e_{i,t}$ is subject to idiosyncratic risk. Housing tenure status enters through the budget constraint as we abstract from utility through housing service. This is appropriate because housing tenure status is not a choice variable of the household. Instead, housing tenure status enters through the budget constraints as follows.

Outright homeowner

$$c_{i,t} + b_{i,t} = e_{i,t} w_t n_t + (1 + r_t) b_{i,t-1} + d_{i,t} \tag{3.3}$$

Mortgage holder

$$c_{i,t} + b_{i,t} = e_{i,t} w_t n_t + (1 + r_t) b_{i,t-1} + d_{i,t} - r_{m,t} m_{k,t} \tag{3.4}$$

Renter

$$c_{i,t} + b_{i,t} = e_{i,t} w_t n_t + (1 + r_t) b_{i,t-1} + d_{i,t} - h_{k,t} \tag{3.5}$$

All household types allocate their disposable income to consumption and savings. Variables w_t and r_t denote the aggregate real wage and the real interest rate on bond holdings. All households face disposable income from labor, the previous period's bond holdings, and dividends $d_{i,t}$ which are allocated proportionally to efficiency units $e_{i,t}$. This is a standard choice to avoid meaningful redistribution of resources through firm profits. Outright owners do not need to pay for housing services because they own their homes and hold no mortgage. We abstract from housing depreciation which is likely similar across both regions and therefore of minor importance for cross-region asymmetries. Mortgage holders differ only in the mortgage $m_{k,t}$ for which they have to pay real interest rate $r_{m,t}$. The evolution of real interest rates will depend on the amount of adjustable-rate mortgage that will be governed by an exogenous parameter, see Section 3.3. Finally, renters pay real rent $h_{k,t}$. The measure of each household type is denoted by ϕ_k and $\alpha = \sum_k \phi_k$ holds.

We do not model housing tenure status and adjustable- or fixed-rate mortgages as choice variables. Introducing a microfounded theory of these choices is beyond the scope of our paper since the literature is not yet settled on the underlying drivers of the cross-country heterogeneity. Instead, our strategy is to carefully account for the empirical heterogeneity when calibrating the model in Section 3.4. This may be reasonable because we will take a first-order perturbation around the steady state and hence, consider small shocks that are less likely to affect housing tenure status differentially across regions.

Finally, we follow Auclert et al. (2020) in two important dimensions. First, we allow for ex-ante heterogeneity in discount factors β_k which admits matching the hand-to-mouth shares by housing tenure status found in the data. This is important because it implies realistic marginal propensities to consume. Second, we assume that households are inattentive with respect to the aggregate state. With probability ξ, households do not update their belief about the future evolution of the aggregate state.[9] The idiosyncratic state variable $x_{i,t}$ tracks

[9]The beliefs about the aggregate state enter the household problem through the time indexation of the value function. The aggregate state includes the labor compensation per efficiency unit $w_t n_t$, the aggregate dividend payments $d_t = \int_i d_{i,t} di$, and interest rates $r_t, r_{m,t}$.

the period in which the household was updating its beliefs for the last time. Importantly, beliefs refer to the future evolution of the aggregate state and not its contemporaneous values. The latter is always understood by households, ensuring that budget constraints hold. Assuming inattentive households is a convenient modeling device that allows humps in heterogeneous agent economies, as found in the data.[10] This is important in our setting to be able to match the empirically identified impulse response functions.

Consumption bundles. Households spread their aggregate consumption across North and South goods baskets, denoted by $c_{N,t}$ and $c_{S,t}$, respectively. Each goods basket consists of different varieties $c_{N,t}(j)$ and $c_{S,t}(j)$ from the respective region as

$$c_{N,t} = \left(\int_0^\alpha c_{N,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}, \quad c_{S,t} = \left(\int_\alpha^1 c_{S,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{3.6}$$

where we assume that the mass of varieties coincides with the number of households that populate the region. The elasticity of substitution across varieties from a given country is ϵ. In the second CES stage, households aggregate the North and South consumption baskets to their final domestic consumption basket

$$c_t = \left(\lambda^{\frac{1}{\eta}} c_{N,t}^{\frac{\eta-1}{\eta}} + (1-\lambda)^{\frac{1}{\eta}} c_{S,t}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \tag{3.7}$$

where the elasticity of substitution across North and South goods baskets is η and households have a bias for domestically produced goods, given by $\lambda \geq 1/2$. The derivation of demand schedules and associated price indices is standard and relegated to Appendix B.

[10] For example, consider the aggregate wage w being above steady state for multiple periods. Households that do not update their beliefs think that the contemporaneous increase in the wage is perfectly transitory. Hence, they save a large fraction of the income gain to spread consumption across multiple periods. This effect decreases as households are accumulating more wealth leading to a sluggish increase in consumption demand which builds up over time.

3.2 Production

Labor supply is set by labor unions which sell labor services varieties to intermediate goods producers through a representative labor packer. The intermediate good varieties are produced with linear technology and labor is the only production input.

Labor unions. We assume a continuum of monopolistically competitive labor unions, as in Auclert et al. (2018). Each household provides $n_{i,t}(u)$ hours of work to labor union u. The union collects labor supply across households $n_t(u) = \int n_{i,t}(u)di$ and differentiates it to a specific labor service variety. A representative labor packer buys all varieties and aggregates them using a CES technology with an elasticity of substitution ϵ_w. The union takes the implied demand schedule as given and sets the nominal wage $W_t(u)$ charged for the labor variety $n_t(u)$. It maximizes the average discounted stream of utility of all union members, subject to Rotemberg-type wage adjustment costs that are denominated in utils and uniform across all members.[11] Formally, the unions solves

$$\max_{W_t(u)} \mathbb{E}_0 \sum_{t=0}^{\infty} \left(\beta^t \int \frac{c_{i,t}^{1-\gamma}}{1-\gamma} di - \varphi \frac{n_t(u)^{1+\nu}}{1+\nu} - \frac{\kappa_w}{2} \left(\frac{W_t(u)}{W_{t-1}(u)} - 1 \right)^2 \right) \tag{3.8}$$

$$\text{s.t.} \quad n_t(u) = \left(\frac{W_t(u)}{W_t} \right)^{-\epsilon_w} n_t, \tag{3.9}$$

where n_t denotes the aggregate labor demand. The key assumption is that labor supply is equal across all union members. In a symmetric equilibrium, all unions choose the same (aggregate) nominal wage $W_t \equiv (\int W_t(u)^{1-\epsilon_w} du)^{\frac{1}{1-\epsilon_w}} = W_t(u)$ and the first-order condition of the union implies an aggregate wage Phillips curve

$$(\Pi_{w,t} - 1)\Pi_{w,t} = \beta \mathbb{E}_t \left((\Pi_{w,t+1} - 1)\Pi_{w,t+1} \right) + \frac{\epsilon_w}{\kappa_w} \left(\varphi n_t^{1+\nu} - \frac{\epsilon_w - 1}{\epsilon_w} w_t n_t \int c_{i,t}^{-\gamma} e_{i,t} di \right) \tag{3.10}$$

[11] The firm uses the deterministic average discount factor $\beta = \sum_k \phi_k \beta_k$, where ϕ_k denotes the measure of households with housing tenure status k.

where $\Pi_{w,t} = \frac{W_t}{W_{t-1}}$ denotes wage inflation and $w_t = W_t/P_{c,t}$ is the real wage. In the zero inflation steady state with $\Pi_{w,t} = 1$, the left-hand side is equal to zero and the right-hand side is a standard static labor supply condition, accounting for market power $\epsilon_w < \infty$ and uniform labor supply across households.

Variety producers. We assume a continuum of monopolistically competitive firms that produce intermediate good varieties. Firm j buys labor $n_t(j)$ from the representative labor packer and produces the variety $y_t(j)$ with a linear technology where labor is the only production factor. The variety is bought by households from both regions. The firm sets its retail price $P_{p,t}(j)$ and maximizes the expected discounted stream of profits, subject to Rotemberg-type adjustment costs.[12] Formally, the firm solves

$$\max_{P_{p,t}(j)} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{P_{c,t}} \left(P_{p,t}(j) y_t(j) - W_t n_t(j) - \frac{\kappa}{2} \left(\frac{P_{p,t}(j)}{P_{p,t-1}(j)} - 1 \right)^2 P_{p,t} y_t \right) \tag{3.11}$$

$$\text{s.t.} \quad y_t(j) = \left(\frac{P_{p,t}(j)}{P_{p,t}} \right)^{-\epsilon} y_t, \quad \text{and} \quad y_t(j) = a_t n_t(j), \tag{3.12}$$

where y_t denotes aggregate output and a_t is total factor productivity. The nominal flow profits are converted to real domestic consumption units as we divide with $P_{c,t}$. In a symmetric equilibrium, all firms set the same retail price $P_{p,t} \equiv \left(\int_0^{\alpha} \frac{1}{\alpha} P_{p,t}(j)^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}} = P_{p,t}(j)$ and the first-order condition of the firm implies an aggregate Phillips curve

$$(\Pi_{p,t} - 1)\Pi_{p,t} = \beta \mathbb{E}_t \left(\frac{y_{t+1}}{y_t \Pi_{c,t+1}} (\Pi_{p,t+1} - 1)\Pi_{p,t+1}^2 \right) + \frac{1}{\kappa} \left((1-\epsilon) + \epsilon \frac{w_t}{a_t} \frac{P_{c,t}}{P_{p,t}} \right)$$

where $\Pi_{p,t} = P_{p,t}/P_{p,t-1}$ denotes producer price inflation. It is convenient to re-write the

[12] The firm uses the deterministic average discount factor $\beta = \sum_k \phi_k \beta_k$. We abstract from a stochastic discount factor in anticipation of the solution method. Up to first-order, a stochastic discount factor is irrelevant because certainty equivalence holds.

Philips curve as

$$(\Pi_{p,t}-1)\Pi_{p,t} = \beta \mathbb{E}_t \left(\frac{y_{t+1}}{y_t \Pi_{c,t+1}} (\Pi_{p,t+1}-1)\Pi_{p,t+1}^2 \right) + \frac{1}{\kappa}\left((1-\epsilon) + \epsilon \frac{w_t}{a_t} \left[\lambda + (1-\lambda) T_t^{1-\eta} \right]^{-\frac{1}{1-\eta}} \right) \quad (3.13)$$

where $T_t \equiv \frac{P_{p,t}^*}{P_{p,t}}$ denotes the terms-of-trade.

3.3 General equilibrium

We derive the relevant market clearing conditions and discuss the supply of housing services. Finally, we explain how the degree of adjustable-rate mortgages is modeled and close the model with a monetary policy rule.

Goods markets. We have a continuum of α North and $1-\alpha$ South varieties. All households demand all varieties and all North intermediate good producers pay their respective price adjustment costs in North varieties. This implies the following equation for aggregate demand of variety j

$$y_t(j) = \int_0^\alpha c_{i,t}(j) di + \int_\alpha^1 c_{i,t}^*(j) di + \frac{\kappa}{2}(\Pi_{p,t}-1)^2 y_t. \quad (3.14)$$

The first term is the demand from domestic households. The second term is the demand from foreign households. The final term is the demand from domestic firms to pay the price adjustment cost, which is proportional to domestic output. Substituting the demand schedules, and relative price expressions, aggregating over all $j \in [0,\alpha]$ and imposing goods market clearing yields

$$a_t n_t = \left(1 - \frac{\kappa}{2}(\Pi_{p,t}-1)^2)\right)^{-1} \left\{ \lambda \left[\lambda + (1-\lambda) T_t^{1-\eta} \right]^{\frac{\eta}{1-\eta}} c_t + (1-\lambda^*) \frac{1-\alpha}{\alpha} \left[\lambda^* T_t^{1-\eta^*} + (1-\lambda^*) \right]^{\frac{\eta}{1-\eta}} c_t^* \right\}, \quad (3.15)$$

where the left-hand side is aggregate North production as a function of North labor supply and the right-hand side denotes aggregate demand. The derivation and the symmetric equation for goods produced in the South are given in Appendix B. Finally, we can use the nested CES structure to express consumer price inflation as a function of the terms-of-trade and producer price inflation

$$\Pi_{c,t} = \left(\frac{\lambda \left(\Pi_{p,t}\right)^{1-\eta}}{\lambda + (1-\lambda)(T_{t-1})^{1-\eta}} + \frac{(1-\lambda)(\Pi^*_{p,t})^{1-\eta}}{\lambda(T_{t-1})^{\eta-1} + (1-\lambda)} \right)^{\frac{1}{1-\eta}} . \tag{3.16}$$

Housing services. The supply of housing services is not modeled explicitly. Instead, we assume that intermediate goods producers own the housing stock. The rent payments from the households thus accrue to these firms. There are no costs to be covered because we abstract from depreciation to be consistent with our assumptions for homeowners. The rent payments are exogenous. Note that a suitably calibrated exogenous housing supply will imply the same steady state rent payments.

Interest rates. Mortgage holders pay interest on their outstanding mortgages. The nominal interest rate payment is given by

$$i_{m,t} = \theta \; i_{b,t} + (1-\theta) \; i_{b,ss} + \omega, \tag{3.17}$$

where $i_{b,ss}$ denotes the nominal interest rate on bonds in the steady state. Parameter θ denotes the share of adjustable-rate mortgages and therefore governs the responsiveness of nominal mortgage rates to changes in the nominal interest rate on bonds. The parameter ω is a wedge that allows for a permanent interest rate differential. Finally, the Fisher equation $1 + r_{s,t} = \frac{1+i_{s,t-1}}{\Pi_{c,t}}$ maps nominal rates into (ex-post) real rates for $s = m, b$. For brevity, we define $r_t \equiv r_{b,t}$ and $i_t \equiv i_{b,t}$.

The asset market is integrated across both regions with market clearing condition

$$\int_0^\alpha b_{i,t}\ di + \chi_t \int_\alpha^1 b^*_{i,t}\ di = \phi_m\ m_{m,t} + \chi_t\ \phi^*_m\ m^*_{m,t}, \tag{3.18}$$

where $\chi_t = ((\lambda^* T_t^{(1-\eta)} + (1-\lambda^*))/(\lambda + (1-\lambda) T_t^{1-\eta}))^{\frac{1}{1-\eta}}$ converts South into North consumption baskets. Thus, the left-hand side is the aggregate savings of the region, denominated in consumption baskets of the North and the right-hand side is the total amount of outstanding mortgages held by households. Parameters ϕ_m and ϕ^*_m denote the measure of households that hold mortgages $m_{m,t}$ and $m^*_{m,t}$ respectively.

Dividends. The intermediate good producers accrue profits due to market power and rent payments as described above. There are further profits from financial intermediation that are given by

$$f_t = \phi_m\ m_{m,t}\ r_{m,t} + \chi_t\ \phi^*_m\ m^*_{m,t}\ r^*_{m,t} - \int_0^\alpha b_{i,t}\ r_t\ di - \chi_t \int_\alpha^1 b^*_{i,t}\ r^*_t\ di, \tag{3.19}$$

where the first two terms capture the debt service paid by mortgage holders whereas the last two terms capture interest rate payments to bondholders. Note that these profits follow mechanically from interest rate differentials as we do not explicitly model a financial sector. We assume that each region receives profits, proportional to the population size. This provides an equalizing force that rules out that cross-region differences are driven by region-specific profits. Each region's profit share is paid in dividends to households, proportional to labor efficiency units. This ensures that within-country redistribution does not drive our results.

Monetary policy. The monetary policy authority responds to union-wide inflation rate $\pi_t = (\Pi_{c,t})^{\alpha}(\Pi^*_{c,t})^{1-\alpha} - 1$ based on the following policy reaction function

$$i_t = \rho i_{t-1} + (1-\rho)\ \phi\pi_t + \varepsilon_t^{MP}, \tag{3.20}$$

where ρ and ϕ govern the degree of interest rate smoothing and the response to inflation, respectively. Finally, $\epsilon_t^{MP} \overset{iid}{\sim} N(0, \sigma_{\epsilon^{MP}})$ is a monetary policy shock. We abstract from other policies and focus on monetary policy transmission.

Equilibrium and solution. The decentralized general equilibrium of our model demands that all agents behave optimally, given their information sets, as described above. Both final goods markets, both labor markets, and the common asset market must clear at any date t. We use standard methods to solve for the steady state numerically. We then compute responses to aggregate shocks based on a first-order perturbation in sequence space, following Auclert et al. (2021a).

3.4 Calibration

We calibrate the model to the four largest economies of the Euro Area, using household-level survey data to discipline the cross-region household heterogeneity.

Calibration strategy. We calibrate the model to a quarterly frequency. The North region consists of France & Germany and the South region consists of Italy & Spain. The calibration follows three steps. First, we calibrate the ex-ante household heterogeneity to match household-level data moments from the survey data. Household-level moments are always computed as the average across countries, weighted by average real GDP from 2001 until 2019. In the second step, we take parameter values from the literature which affect the steady state of the economy. Finally, we estimate key parameters that govern the response to aggregate shocks but do not affect the steady state.

Cross-region heterogeneity. The parameters that are heterogeneous across both regions are summarized in Table 1. The process for the endowment of efficiency units implies a first-order autoregressive process for labor income in the steady state. The GRID database provides the annual standard deviation and first-order autocorrelation of residualized income for many European economies, including the four core countries.[13] We choose the standard deviation and autocorrelation of the endowment process to match the average moments of each region.

Table 1: Cross-region heterogeneity

South	Value	North	Value	Description	Target
β_o^*	0.978	β_o	0.985	discount factor	differential HtM shares across regions
β_m^*	0.967	β_m	0.980		
β_r^*	0.957	β_r	0.970		
LTV_m^*	0.45	LTV_m	0.45	loan-to-value	cross-region average
h_s^*	9.60	h_s	9.60	small house	cross-region average of value-to-income
h_l^*	33.28	h_l	33.28	large house	
θ^*	0.66	θ	0.14	mortgage types	region-specific share of adjustable-rates
h_r^*	0.27	h_r	0.29	rent payments	region-specific rent-to-income
ϕ_o^*	0.51	ϕ_o	0.35	mass of households	region-specific
ϕ_m^*	0.22	ϕ_m	0.15		
ϕ_r^*	0.27	ϕ_r	0.50		
σ_e^*	0.279	σ_e	0.251	SD of endowment	annual SD of income
ρ_e^*	0.886	ρ_e	0.888	AR of endowment	annual AR of income
$\underline{b}^*$	3.10	$\underline{b}$	0.00	borrowing limit	symmetric per capita GDP

Notes: The annual income data moments are taken from the GRID database. The remaining data moments are taken from the pooled first three waves of the HFCS. Region-specific parameters are computed as the GDP-weighted average, using the average GDP from 2001 until 2019. Similarly, common parameters are the GDP weighted average across both regions. Indices o, m, r refer to outright owners, mortgage holders, and renters respectively.

The remaining heterogeneity parameters are based on data moments from the HFCS. We

[13] The GRID database has been compiled by Fatih Guvenen, Luigi Pistaferri, and Gianluca Violante and their collaborators. It provides annual income data moments estimated from high-quality administrative data.

start with the homeownership rate $1 - \phi_r$ which is region specific, as shown in Figure 1. The amount of mortgage holders out of homeowners $\phi_m/(1 - \phi_r)$ is the average across both regions. Rent payments $h_r = h_{r,t}$ are set to match the region-specific rent-to-income ratio in the steady state. Mortgage holders have a common loan-to-value ratio because there is no cross-region difference in the data. There are two house sizes h_s and h_l that coincide with house values and we choose them to match the average house value-to-income ratios in the data. These variables determine the outstanding mortgages $m_k \equiv m_{k,t}$. The share of adjustable-rate mortgages θ is set as shown in Figure 1 and governs the response of the mortgage debt service to aggregate shocks.

Table 2: Calibration of hand-to-mouth

	Owner	Mortgagor	Renter
South			
Model	0.10	0.17	0.18
Data	0.16	0.24	0.37
North			
Model	0.04	0.09	0.14
Data	0.09	0.15	0.32
South-North			
Model	0.06	0.08	0.04
Data	0.07	0.09	0.05

Notes: The table shows hand-to-mouth shares in levels and cross-region differences (South-North), by housing tenure status. The empirical hand-to-mouth shares are computed from the pooled first three waves of the HFCS for each country, following the definition from Slacalek et al. (2020). We report region-specific average hand-to-mouth computed as the GDP-weighted average, using the average GDP from 2001 until 2019. Hand-to-mouth in the model are defined as households with savings below their biweekly income, relative to the borrowing limit.

Hand-to-mouth shares are an endogenous model outcome which makes them harder to match. Indeed, we cannot match the hand-to-mouth shares in levels. Instead, we match the differential hand-to-mouth shares across regions and housing tenure status.[14] We show the results in

[14] We define hand-to-mouth in the model as households with savings below their biweekly income, relative to the borrowing limit. This means that a household is hand-to-mouth if $b_{i,t} \leq -\underline{b} + \frac{1}{6} w_t n_t e_{i,t}$.

Table 2. We understate the cross-country difference by one percentage point for each housing tenure status. Thus, our hand-to-mouth calibration can be seen as conservative concerning its explanatory power for the cross-region differences in impulse responses. Finally, we choose the borrowing limits $\underline{b}$ to ensure a steady state that features symmetric per-capita output.[15]

Symmetric parameters. The remaining household parameters are given in Table 3 and set as follows. The Frisch elasticity of $1/\nu = 0.25$ and relative risk aversion equal to $\gamma = 2.00$ are standard choices. Both countries have the same population size $\alpha = 1 - \alpha = 0.50$. The steady state which is symmetric in output demands the same equilibrium labor supply in both regions. We set the labor disutility shifter φ to normalize steady state labor supply to unity. The mortgage wedge is set to a preliminary value $\omega = 0.0025$ and is not important for our quantitative findings.

For the production side, we follow Bletzinger and von Thadden (2021) who calibrate their Eura Area economy to a North and South region as well. We depart from their Cobb-Douglas assumption and allow for a slightly larger elasticity of substitution across regions, only for computational purposes. Finally, we assume that the elasticity of substitution across labor service varieties is identical to intermediate good varieties. These parameters determine the steady state of our two-region economy.

Estimation. In the final step, we follow Auclert et al. (2020) and estimate key parameters that govern the responses to aggregate shocks. Specifically, we estimate Taylor rule parameters ϕ and ρ, as well as the degree of household inattention ξ and the cost-shifters for price and wage adjustment costs, assuming $\kappa = \kappa_w$ to mirror the symmetry in the elasticities. The estimation relies on the method of simulated moments and targets the impulse response function of the South region to a monetary policy shock as displayed in Figure 1 in

[15] A symmetric borrowing limit would imply larger per-capita in the South which is counterfactual. Moreover, our choice of borrowing limits delivers qualitatively consistent net foreign asset positions because the North becomes a net lender in the steady state.

Table 3: Symmetric parameters

Parameter		Value	Description	Target or source
Households	φ	0.74	labor disutility shifter	$N_{ss} = 1$
	γ	2.00	inverse of intertemporal EOS	standard
	ν	4.00	inverse Frisch elasticity	standard
	ω	0.0025	mortgage rate wedge	preliminary
	α	0.50	relative region size	symmetric regions
Production	λ	0.80	home bias	
	η	1.10	EOS across regions	Bletzinger & von Thadden (2021)
	ϵ	5.00	EOS across varieties	
	ϵ_w	5.00	EOS across labor services	symmetric to varieties
Estimation	ϕ	1.51	Taylor rule inflation coefficient	
	ρ	0.93	degree of interest rate smoothing	internally estimated
	ξ	0.90	household inattention	
	$\kappa = \kappa_w$	720.66	price/wage adjustment cost	

Notes: The first two panels contain calibrated parameters. The last panel contains the parameters that are estimated based on the method of simulated moments to match the empirical output response of the South region to a monetary policy shock.

Section 2.[16] Importantly, the response of the North region is untargeted. The cross-region differences only stem from the discussed cross-region heterogeneities.

The resulting parameter estimates are given in the last panel of Table 3. An inflation coefficient of $\phi = 1.51$ is standard. The degree of interest rate smoothing and household inattention is sizeable and similar to Auclert et al. (2020). Finally, we find $\kappa = \kappa_w = 720.66$ which implies very flat Phillips curves. The reason is simply that the empirical responses are very persistent and the model can replicate them with very slow and small price and wage adjustments. Empirically, inflation responses are quite small which seems to be qualitatively consistent with flat Philips curves.[17]

[16]Naturally, one can match response from the model and the data that correspond to a standard deviation monetary policy shock. The appropriate size of the model shock then simply follows from an appropriate choice for $\sigma_{\epsilon^{MP}}$ which we also estimate, along with the other parameters.

[17]Contemporaneous work by Beaudry et al. (2023) shows that the imposition of a Taylor rule may also

4 Results

We study the model responses to a monetary policy shock and provide model-based decompositions. We find that the interplay of demand amplification through hand-to-mouth heterogeneity and demand dampening through trade are the key determinants of cross-region differences in impulse responses. Finally, we study a counterfactual with increased trade openness that suggests that sizing up the trade channel can be particularly powerful.

4.1 Baseline

Output responses. We report the responses of output to an expansionary monetary policy shock in Panel (a) of Figure 2. The solid red line (without markers) displays the response of the South that is targeted in the estimation. The blue solid line (with markers) displays the untargeted response of the North. The corresponding dashed lines contain the empirical impulse responses introduced in Section 2. The model matches both, the targeted and untargeted responses quite well. Indeed, at the peak of the empirical impulse responses, the model can account for 70% of the cross-region differences.

We next study the differential output response, defined as the South response minus the North response, $dy_t^* - dy_t$. We provide a demand-based decomposition of this differential response. From the aggregated demand equations of both regions, it follows that

$$dy_t^* - dy_t = \underbrace{dc_{o,t}^* - dc_{o,t}}_{\text{Owners}} + \underbrace{dc_{m,t}^* - dc_{m,t}}_{\text{Mortgagors}} + \underbrace{dc_{r,t}^* - dc_{r,t}}_{\text{Renters}} + \underbrace{dE_t^* - dE_t}_{\text{Trade}}, \tag{4.1}$$

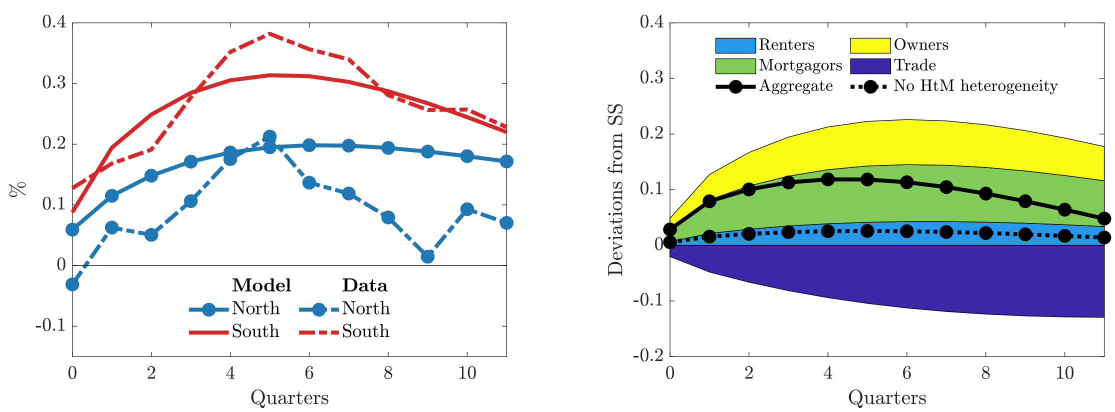
where the first three terms account for differential domestic demand by housing tenure status and the last term denotes differential net exports. Note that all objects on the right-hand side are appropriately defined to account for terms-of-trade. This demand-based composition simply follows from goods market clearing and is an exact decomposition that does not require solving the model with a modified calibration. Panel (b) of Figure 2 shows the

contribute to estimating flat Phillips curves.

results. The top area in yellow represents the differential demand contribution coming from outright homeowners. The second green area represents the differential demand contribution from mortgage holders. The third light-blue area provides the same for renters. One can see that homeowners are the crucial group driving the differential response whereas renters are of less importance. Finally, the dark-blue area at the bottom represents the effect of trade which delivers a sizeable negative contribution. The four components add up to the differential response that is given as a black solid line.

Figure 2: Output responses

(a) Impulse responses (b) Decomposition of differential response



Notes: Panel (a) shows the impulse responses of GDP to an expansionary monetary policy shock in the data and in the model. The empirical responses are the same as in Section 2. Panels (b) provide a decomposition of the differential model responses based on (4.1). The solid black line shows the total differential response and the dotted black line shows the total differential response in a counterfactual without discount factor heterogeneity.

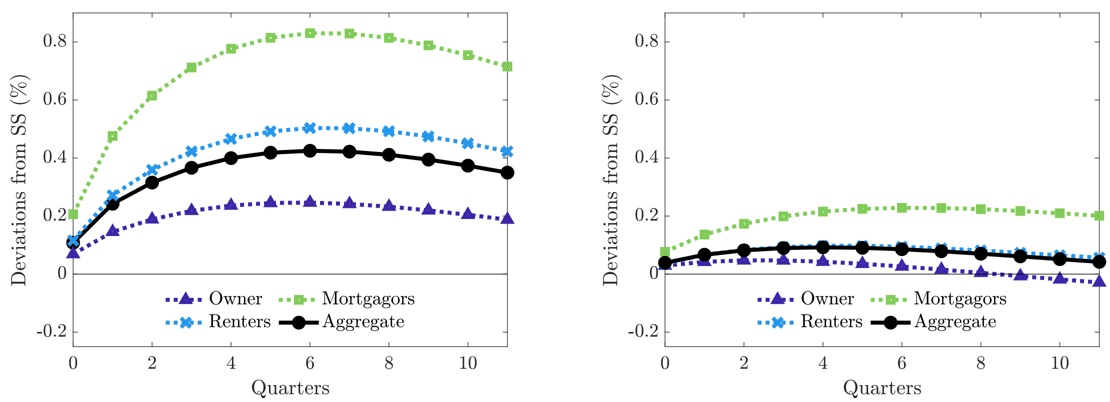
The trade channel dampens the differential response across both regions. Prices in the South raise by more because South households prefer domestic goods due to their home bias. Thus, households substitute away from goods produced in the South and consume more North goods instead. This reallocation of demand dampens the differential output effects discussed above.

We further run a counterfactual without discount factor heterogeneity that we set to match the hand-to-mouth in our baseline calibration. The counterfactual differential response is given as a dotted black line. The differential response vanishes almost completely. This suggests that the interplay between demand amplification through realistic hand-to-mouth heterogeneity and demand-dampening through trade is key to understanding the heterogeneous responses across Euro Area member states.

Consumption responses. Consumption demand is the key driver behind the cross-region output differences. Thus, we study the consumption responses across space and household types. Figure 3 shows the consumption response by housing tenure status for the South and North, in Panels (a) and (b) respectively. Mortgage holders respond the strongest, followed by renters and outright owners. This pattern holds in both regions, although the overall amplitudes are substantially larger in the South.

Figure 3: Consumption responses

(a) South (b) North



Notes: The figure shows the model consumption responses to an expansionary monetary policy shock, in percent deviation of the steady state. We display these responses for each region and for each tenure status, and the region-specific aggregate responses.

We next study the disposable income response to understand the cross-region consumption differences, averaging across housing tenure status.[18] The results are provided as black solid lines in Figure 4. While disposable income strongly increases for the South, we find that this actually decreases in the North. This rationalizes why the consumption response is so much stronger in the South. One may wonder why households in the North still consume more,

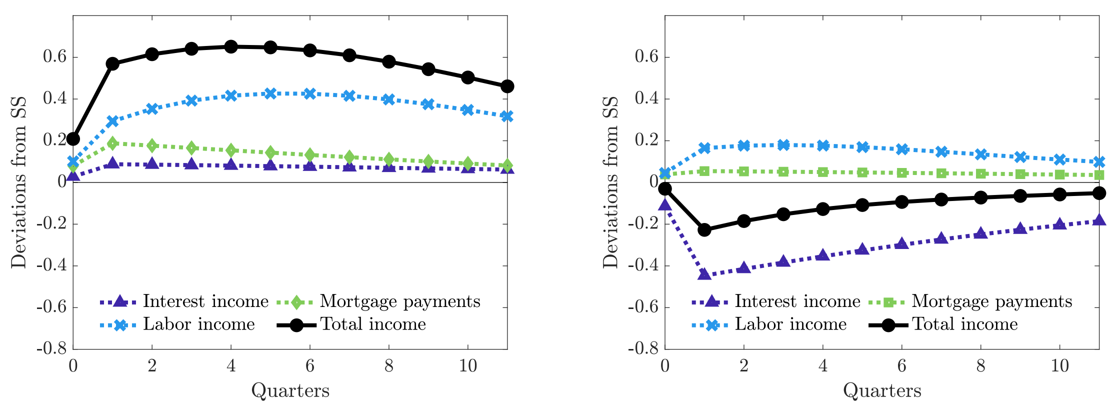
[18]We refer to disposable income as the right-hand side of the budget constraint, i.e., the amount of income which the household can allocate to consumption or net savings.

despite the decline in income. The reason is that the interest rate cut induces the household to dis-save, as we discuss below.

We further decompose disposable income into contributions from labor income, mortgage payments, and interest income.[19] The key differences is coming from interest income displayed as dotted purple lines (triangular markers). The North is a net lender in the steady state and interest rate income declines in response to the expansionary monetary policy shock, and vice versa for the South. The blue dotted line (cross markers) represents labor income which also responds stronger in the South. This is because the home bias leads to more consumption demand in the South. Firms need to pay higher wages to cater to this demand. Finally, the response of mortgage payments leads to more disposable income response in the South because the pass-through of the rate cuts from the shock to mortgage rates increases in the share of adjustable-rate mortgages.

Figure 4: Disposable income responses

(a) South (b) North



Notes: The figure shows the model disposable income responses to an expansionary monetary policy shock, in percent deviation of the steady state. We display these responses for each region and for each tenure status, and the region-specific aggregate responses. Disposable income is defined as income including labor income, dividends and interest rate payments.

Finally, we summarize the household responses in Table 4, distinguishing again by housing tenure status. Specifically, we display the responses of consumption, net savings, and dispos-

[19] We add dividends and labor income together since dividends are distributed proportionally to labor income.

able income cumulated over a 12-quarter horizon. The net savings response confirms that North households run down their savings to compensate for income losses. The substitution effect dominates leading North households to increase consumption despite less disposable income. Focusing on housing tenure status, we see that in the North, only mortgage holders see an increase in disposable income because they hold little bonds. In contrast, all households in the South do gain disposable income.

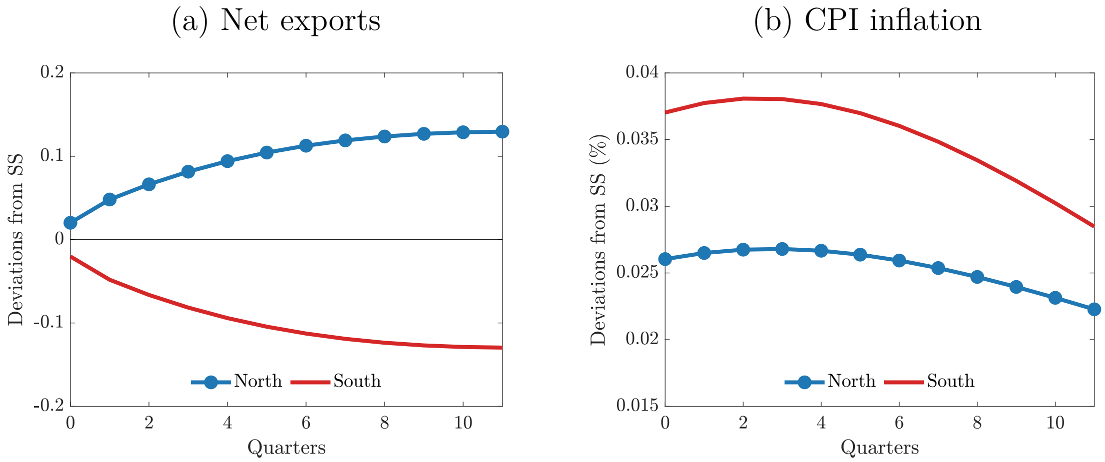
Table 4: Budget constraint decomposition of the household response

	South				North			
	Agg.	Outright	Mortgagor	Renter	Agg.	Outright	Mortgagor	Renter
Consumption	4.22	1.39	1.73	1.10	0.85	0.10	0.35	0.40
Net savings	2.44	0.82	1.11	0.51	-2.10	-1.84	0.05	-0.31
Disp. income	6.66	2.20	2.84	1.62	-1.25	-1.74	0.40	0.08
Labor	4.26	2.18	0.93	1.15	1.68	0.59	0.25	0.84
Savings	0.86	0.02	0.37	0.46	-3.48	-2.32	-0.39	-0.76
Mortgage	1.54	0.00	1.54	0.00	0.54	0.00	0.54	0.00

Notes: The table shows the model disposable income responses to an expansionary monetary policy shock, cumulated over a 12-quarter horizon. The top panel shows the household choices, consumption, and net savings, which add up to disposable income. The bottom panel shows the different sources of disposable income. All responses are displayed for each region and for each tenure status, along with the region-specific aggregate responses.

Inflation and trade responses. Next, we study the responses of net exports and inflation to further understand the importance of trade. Panel (a) of Figure 5 displays net exports for both countries. By construction, this response is symmetric because the net exports of the North (blue solid line with markers) equal the net imports of the South (red solid line). Panel (b) shows the corresponding responses of the consumer price inflation rates $\Pi_{c,t}$, which increase more in the South than in the North. The responses of both outcomes can be explained with a typical expenditure-switching mechanism. Consumption demand increases by more in the South, leading to higher price pressure because households prefer domestic

Figure 5: Net exports and inflation responses to a monetary policy shock



Notes: The figure shows the model responses of net exports and CPI inflation to an expansionary monetary policy shock.

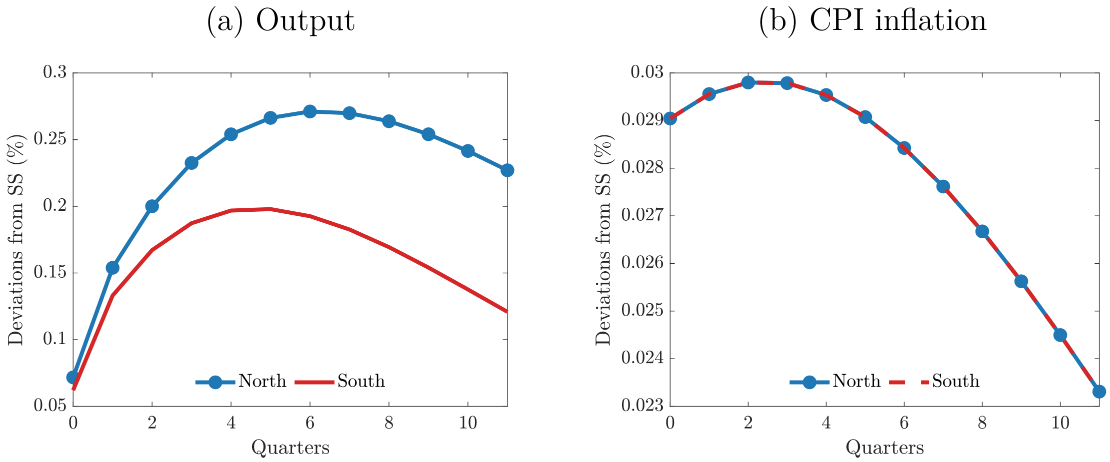
over foreign goods. Consequently, this leads to an improvement in the terms-of-trade from the perspective of the Northern region, resulting in increased exports from the North to the South.

4.2 The role of trade openness

Our findings suggest that trade is an important balancing channel to counteract cross-region differential responses to monetary policy shocks. This channel crucially depends on the home bias and elasticity of substitution when aggregating North- and South-specific baskets to final goods. Fundamentally, these parameters reflect, both the taste of households but also institutional details that may be influenced by policy choices. For example, policies could foster the trade of services by harmonizing legal requirements. We thus study a counterfactual with increased trade openness to learn how important such policies potentially can be. Specifically, we increase the elasticity of substitution between North and South baskets to $\eta = \eta^* = 10$, and we assume no taste for goods produced in one particular region $\lambda = \lambda^* = 0.5$.

Figure 6 displays the results for output and inflation in Panels (a) and (b), respectively. In this counterfactual, differential CPI inflation responses completely vanish. In equilibrium, no

Figure 6: High degree of trade openness: Output and CPI inflation



Notes: The figure shows the model responses of output and CPI inflation to an expansionary monetary policy shock. We study a counterfactual with increased trade openness defined by no home bias and a large elasticity of substitution, as described in Section 4.2.

price differences can be entertained because households would immediately exploit them, as North and South goods are close substitutes. The output response is not equalized, however. In contrast, the differential output response flips its sign. In this counterfactual, the North output responds more strongly, despite having more hand-to-mouth in the South. Since prices are equalized, it follows that output must adjust to clear both markets.

More concretely, net exports increase by more, sizing up the trade channel. Fundamentally, this reflects a labor supply effect. As households in the South increase consumption by more, it follows that the valuation of leisure is larger, compared with the North. Hence, marginal costs are smaller in the North, making this region more competitive. The high elasticity of substitution implies that households exploit such differences in marginal costs by more, which sizes up the trade channel.

Overall, our results emphasize the importance of the expenditure-switching mechanism and associated trade channel in currency union HANK models. This has important policy implications. Policies that foster trade openness may reduce or even eliminate differential inflation responses. This removes an important trade-off currently faced by the European Central Bank. Instead of monitoring various inflation rates, it is sufficient to control Euro Area inflation to achieve price stability not only on average but in each single member country. However, increased trade openness can overturn cross-region differences in output responses. Depending on parameters, this effect may even amplify cross-region differences in output response which is highly welfare relevant.

5 Conclusion

In this paper, we investigate the sources of heterogeneous monetary policy transmission among Euro Area member states. We constructed a two-region currency Union HANK model that allows for rich cross-region household heterogeneity. The heterogeneous output responses to monetary policy shocks in the Euro Area are driven by the interplay of two forces. On the one hand, regions with more hand-to-mouth households respond stronger because these households lead to demand amplification at the aggregate. On the other hand, within union trade provides a sizeable counteracting force. In the baseline calibration, we can rationalize 70% of the differential output responses because the former channel dominates. Counterfactual simulations suggest that policies that foster trade openness can size up the trade channel substantially. Quantitatively, this can lead to synchronization of inflation but not of output responses. In fact, the differential output effects may even flip the sign when trade dominates the demand amplification.

Overall, the study underscores the importance of cross-region heterogeneity in hand-to-mouth households and trade in a currency union. In future versions of this draft, we will investigate the trade effects empirically and study the policy implications for supply shocks.

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A Data

To be added soon.

B Model derivations

Incomplete. To be completed soon.

Consumption bundles Households spread their aggregate consumption choices across North and South good baskets, denoted by $c_{N,t}$ and $c_{S,t}$, respectively. Each goods basket consists of different varieties for which the households choose consumption $c_{N,t}(j)$ and $c_{S,t}(j)$. The households then solve the following first-stage consumption decision given a certain maximal expenditure E. $P_{p,t}(j)$ denotes the price of one unit of a domestic variety j (producer price) in units of the domestic currency. α denotes the size of the domestic economy, while ϵ is the elasticity of substitution between goods varieties.

$$\max_{(c_{N,t}(j))_{j\in[0,\alpha]}} \left[\int_0^\alpha c_{N,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}} \quad s.t. \quad \int_0^\alpha P_{p,t}(j)c_{N,t}(j)dj = E$$

And equivalent for the foreign consumption basket. The optimal variety choice is given by

$$c_{N,t}(j) = \left[\frac{P_{p,t}(j)}{P_{p,t}}\right]^{-\epsilon} \frac{c_{N,t}}{\alpha}, \quad P_{p,t} = \left[\int_0^\alpha \frac{1}{\alpha} P_{p,t}(j)^{1-\epsilon} dj\right]^{\frac{1}{1-\epsilon}}$$

$$c_{S,t}(j) = \left[\frac{P^*_{p,t}(j)}{P^*_{p,t}}\right]^{-\epsilon} \frac{c_{S,t}}{1-\alpha}, \quad P^*_{p,t} = \left[\int_\alpha^1 \frac{1}{1-\alpha} P^*_{p,t}(j)^{1-\epsilon} dj\right]^{\frac{1}{1-\epsilon}}$$

In the second stage, the households choose the optimal composition of domestic and foreign consumption baskets within the aggregate consumption expenditure. The aggregate consumption basket weighs the domestic consumption good according to a home bias λ. The same weighting scheme is employed in the consumer price index formulation. η denotes the elasticity of substitution between domestic and foreign good baskets.

$$c_t = \left[\lambda^{\frac{1}{\eta}} c_{N,t}^{\frac{\eta-1}{\eta}} + (1-\lambda)^{\frac{1}{\eta}} c_{S,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \quad P_{c,t} = \left[\lambda P_{p,t}^{1-\eta} + (1-\lambda) P^{*\,1-\eta}_{p,t}\right]^{\frac{1}{1-\eta}}$$

A similar maximization problem gives the optimal consumption choice for domestic and foreign consumption goods baskets

$$c_{N,t} = \left(\frac{P_{p,t}}{P_{c,t}}\right)^{-\eta} c_t \lambda, \quad c_{S,t} = \left(\frac{P^*_{p,t}}{P_{c,t}}\right)^{-\eta} c_t (1-\lambda)$$

Goods markets. We have a continuum of α domestic and $1-\alpha$ foreign varieties. All households demand all varieties and all domestic intermediate good producers pay their respective price adjustment costs in domestic varieties. This implies the following equation for aggregate demand of variety j

$$y_t(j) = \int_0^\alpha c_{H,i,t}(j)di + \int_\alpha^1 c^*_{F,i,t}(j)di + \frac{\kappa}{2}(\Pi_{p,t}-1)^2 y_t. \tag{B.1}$$

The first term is the demand from domestic households. The second term is the demand from foreign households. The final term is the demand from domestic firms to pay the price adjustment cost, which is proportional to domestic output. Substituting the demand schedules of the household side and aggregating over all $j \in [0,\alpha]$ yields

$$y_t = \lambda \left(\frac{P_{p,t}}{P_{c,t}}\right)^{-\eta} c_t + (1-\lambda^*)\frac{1-\alpha}{\alpha}\left(\frac{P_{p,t}}{P^*_{c,t}}\right)^{-\eta} c^*_t + \frac{\kappa}{2}(\Pi_{p,t}-1)^2 y_t. \tag{B.2}$$

Substituting the relative prices with terms-of-trade expressions and imposing goods market clearing yields

$$\begin{aligned} a_t n_t = & \left(1-\frac{\kappa}{2}(\Pi_{p,t}-1)^2\right)\right)^{-1} && \text{(B.3)} \\ & \left\{\lambda\left[\lambda+(1-\lambda)T_t^{1-\eta}\right]^{\frac{\eta}{1-\eta}} c_t + (1-\lambda^*)\frac{1-\alpha}{\alpha}\left[\lambda^* T_t^{1-\eta^*}+(1-\lambda^*)\right]^{\frac{\eta}{1-\eta}} c^*_t\right\} \\ a^*_t n^*_t = & \left(1-\frac{\kappa^*}{2}(\Pi^*_{p,t}-1)^2\right)\right)^{-1}, && \text{(B.4)} \\ & \left\{\lambda^*\left[\lambda^*+(1-\lambda^*)T_t^{\eta^*-1}\right]^{\frac{\eta^*}{1-\eta^*}} c^*_t + (1-\lambda)\frac{\alpha}{1-\alpha}\left[\lambda T_t^{\eta-1}+(1-\lambda)\right]^{\frac{\eta^*}{1-\eta^*}} c_t\right\}, \end{aligned}$$

where the second equation follows from analogous steps for varieties produced in the South. Note that η and λ are assumed to be symmetric across both regions.

Finally, we can use the nested CES structure to express consumer price inflation as a function of the terms-of-trade and producer price inflation

$$\Pi_{c,t} = \left(\frac{\lambda\,(\Pi_{p,t})^{1-\eta}}{\lambda+(1-\lambda)(T_{t-1})^{1-\eta}} + \frac{(1-\lambda)(\Pi^*_{p,t})^{1-\eta}}{\lambda(T_{t-1})^{\eta-1}+(1-\lambda)}\right)^{\frac{1}{1-\eta}}, \tag{B.5}$$

$$\Pi^*_{c,t} = \left(\frac{\lambda^*(\Pi^*_{p,t})^{1-\eta}}{\lambda^*+(1-\lambda^*)(T_{t-1})^{\eta-1}} + \frac{(1-\lambda^*)\,(\Pi_{p,t})^{1-\eta}}{\lambda^*(T_{t-1})^{1-\eta}+(1-\lambda^*)}\right)^{\frac{1}{1-\eta}} \tag{B.6}$$