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

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ESCB ChaMP Research Network: Workstream 1

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Disclaimer: The views expressed are those of the authors and do not necessarily reflect the views of the Bank of Italy or the Euro-system.

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  - Consequences of introducing house prices in the euro area price index?

Preview of Findings

- Countries with stronger empirical responses in consumption, price-rent, mtg issuance, and mtg rates are those with higher ARM shares and higher HoR
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  - But ARM shares and HoR are correlated across countries
- To quantify relative importance of ARM share and HoR, turn to currency union New Keynesian model. Two countries: Spain (ES) and Euro Area (EA)
- I calibrate the model to key housing institutions and show that monetary policy has stronger effects in ES relative to the EA in line with data
  - Consumption in ES increases 2.4x as much as EA in model (2.5x in data)

Preview of Findings cnt'd

- ARM and HoR interact to amplify effects of monetary policy:
  - ↑ ARM: Higher mortgage interest rate pass-through (cash flow effect)
  - ↑ HoR: More mortgaged homeowners active in the market (level effect)

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- ECB Strategy Review: introduce house prices into EA price index
  $\Longrightarrow$ stabilize output at the cost of less stable goods inflation Details
  - Monetary authority has less space of action if tries to control house prices

Literature Review

- Housing and the Macroeconomy: Mian, Rao, Sufi (2013), Mian, Sufi (2008, 2014), Berger, Guerrieri, Lorenzoni, Vavra (2018), Greenwald (2018), Guren, Greenwald (2020)
  - Here: Study cross-country effect of ARM & HoR in the MP transmission
- Housing & Monetary Policy: Iacoviello (2005), Iacoviello, Neri (2010), Rubio (2011), Calza, Monacelli, Stracca (2013), Greenwald (2018), Slacalek, Tristani, Violante (2020), Corsetti, Duarte, Mann (2021), Almgren, Gallegos, Kramer, Lima (2021), Koeniger, Lennartz, Ramelet (2021)
  - Here: Empirical evidence on mortgages; NK model to quantify role of housing and mtg market institutions
- Monetary Policy in Open Economy: Galí, Monacelli (2005, 2008), Faia, Monacelli (2008), De Paoli (2009), Corsetti, Dedola, Leduc (2010)
  - Here: Currency union with rich within-country households balance-sheets

Outline

Data

- Quarterly data spanning $2000Q1$–$2014Q4$, 11 countries
- ECB: 3M short rate (EURIBOR) as policy rate, Overnight Interest Rate Swaps (OIS) around policy announcements Altavilla, Brugnolini, Gürkaynak, Motto (2019)
  - MP shock: Sum intra-day 1M OIS changes over each quarter as in Slacalek, Tristani, Violante (2020)
- EUROSTAT: Consumpt, Output, Harmonized CPI (HICP)
- OECD: House Price Index, Rent
- European Mortgage Federation: Mtg flows ($2007Q1$-) & rates ($2010Q1$-)
- Household Finance and Consumption Survey: 2014 ARM Shares & HoRs

Empirical Specification

Data | All IRF Results

- Jordà (2005) local projection method over $2007Q1$–$2019Q3$, 11 countries:

$$y_{t+h}^{c} - y_{t-1}^{c} = \alpha^{h,c} + \beta^{h,c}\epsilon_{t}^{MP} + \sum_{k=1}^{K} \gamma_{k}^{h,c} X_{t-k}^{h,c} + u_{t}^{h,c}$$

$\forall h = 0, \ldots, 10$ quarters, c country, K=2 lags

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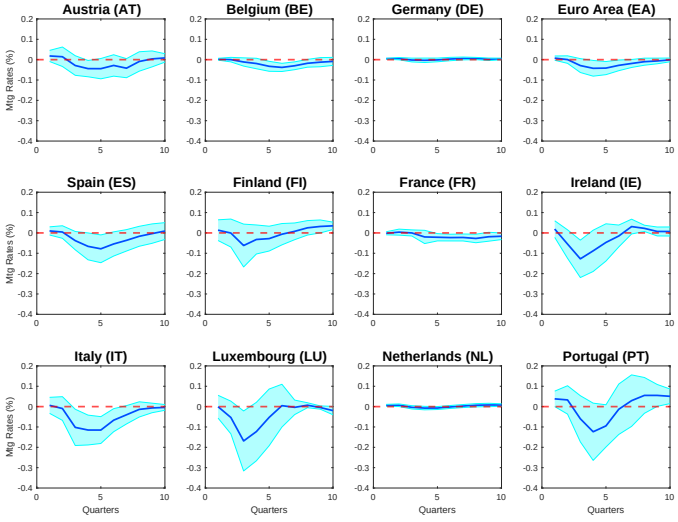
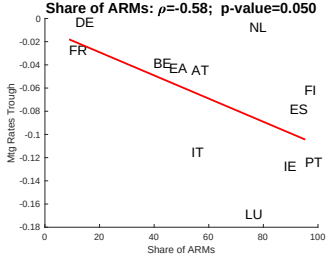
- Correlate MP effectiveness (peaks or troughs) with ARM shares & HoR

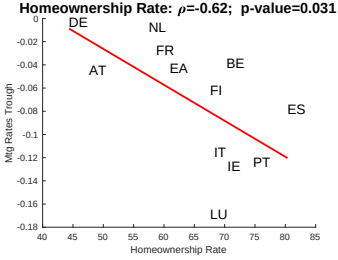
Heterogenous Pass-Through to Mtg Rates Across EA

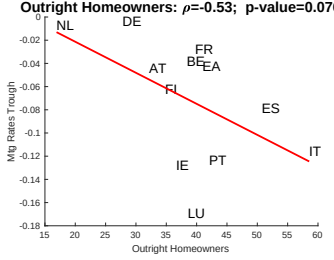
All IRFs

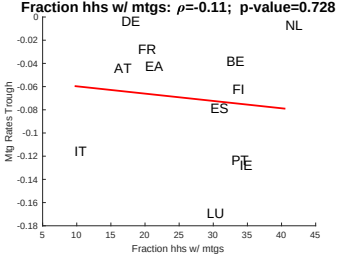


Mtg Rate Troughs Correlate With ARM Shares & HoR

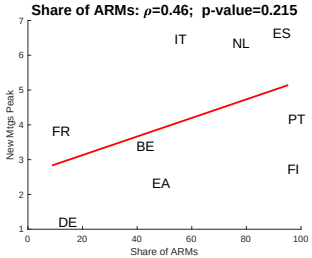


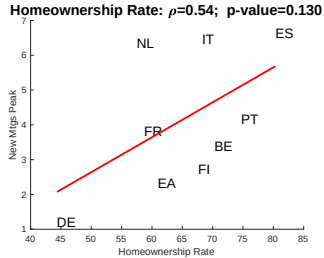


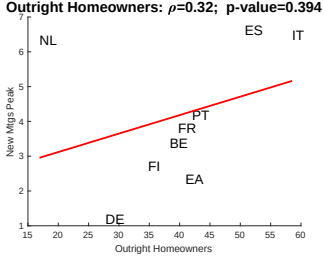


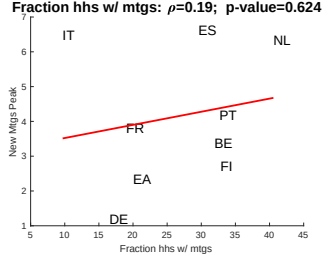


New Mtgs Peaks Correlate With ARM Shares & HoR

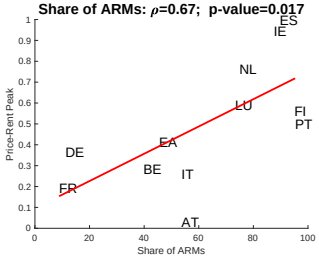


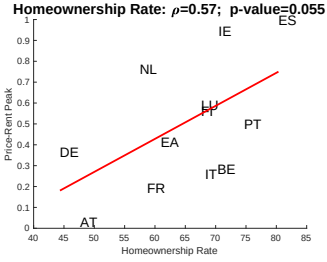


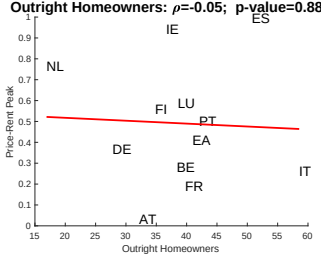


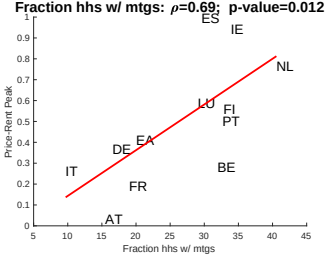


Price-to-Rent Peaks Correlate With ARM Shares & HoR

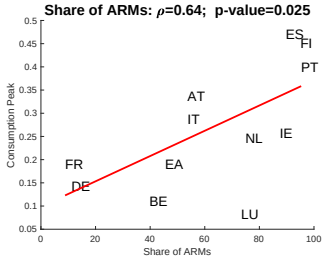


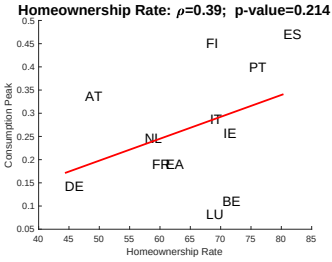


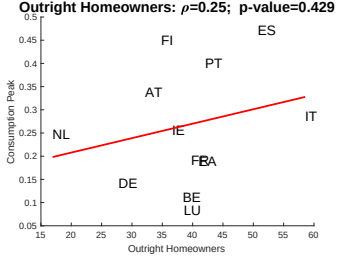


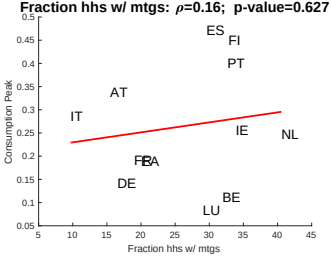


Consumption Peaks Correlate With ARM Shares & HoR

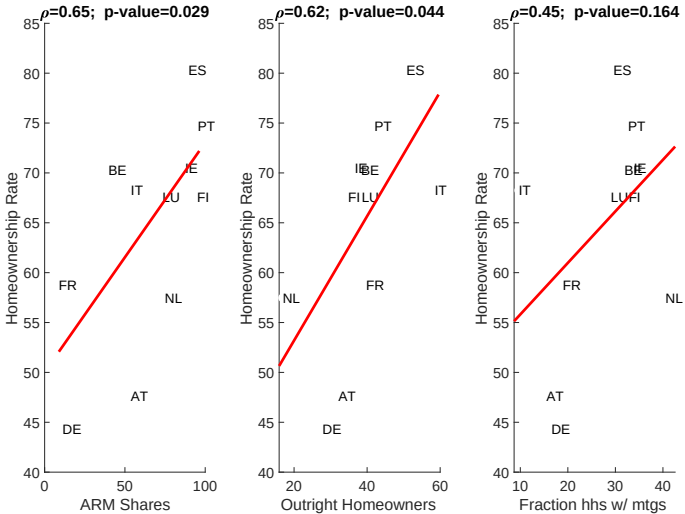








Identification Problem: ARM Shares Correlate With HoR!



Setup & Key Housing Institutions

More model details

- Currency-union New Keynesian model with rich household balance sheets
  - Home (ES) and Foreign (EA). Home small wrt Foreign Faia-Monacelli (2008)
  - Tractably embed rich housing and mtg market characteristics Greenwald (2018)
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- Borrowers and landlords face within-period heterogeneous shocks in utility from owning $\implies$ endogenous HoR Greenwald, Guren (2021)
  - ES has higher HoR than EA as households are happier to own
  - Differences in ownership utility reflective of rental market quality, subsidies

Bird's Eye View: Agents

- Borrowers: representative family with measure χ_b of impatient households
  - Each borrower i can buy housing or rent. If decide to own, she receives $\omega_{i,b}$ units of final goods ($\omega_{i,b}$ is iid and drawn from $\Gamma_{\omega,b}$) Preferences
  - Fraction ρ of borrowers demand mortgages, face a loan-to-value constraint
  - Fraction α of mortgages are FRMs, reminder $(1-\alpha)$ are ARMs

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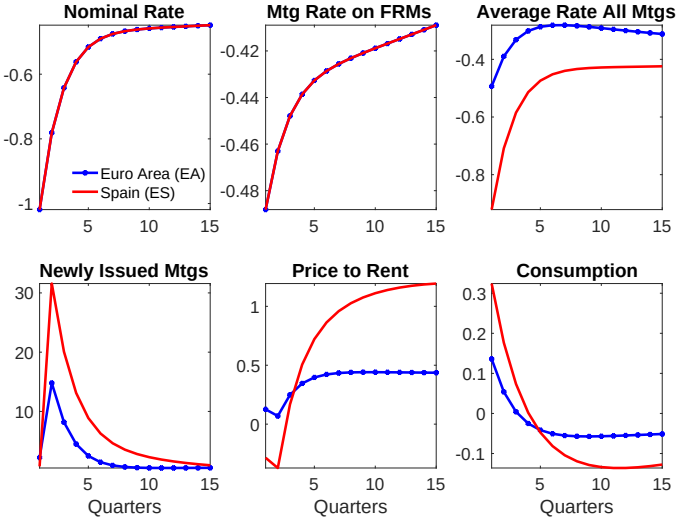
- Savers: representative family with measure $\chi_s = 1 - \chi_b$ of patient households. They are outright homeowners Saver Problem
  - Unconstrained, provide liquidity to borrowers in form of mortgages
  - Trade bonds both nationally and internationally (International Risk Sharing)

Closing the Model

- Landlord: representative firm; transform housing into rental units Landlord
  - Owned by the savers
- Labor unions: standard, determine wage Phillips curve Labor Market
- Monetary authority: Taylor rule at the euro area level; equalize nominal interest rates across countries (monetary union) Monetary Authority
  - Main focus: highly persistent shock that shifts whole level of yield curve without moving real rate Garriga, Kydland, Sustek (2017)
- Markets clear: bonds, mortgage, goods, rental, owner-occupied housing (which is in fixed supply) Market Clearings

As in the data, Spain More Responsive

MP shock | ARM & HoR Decomposition



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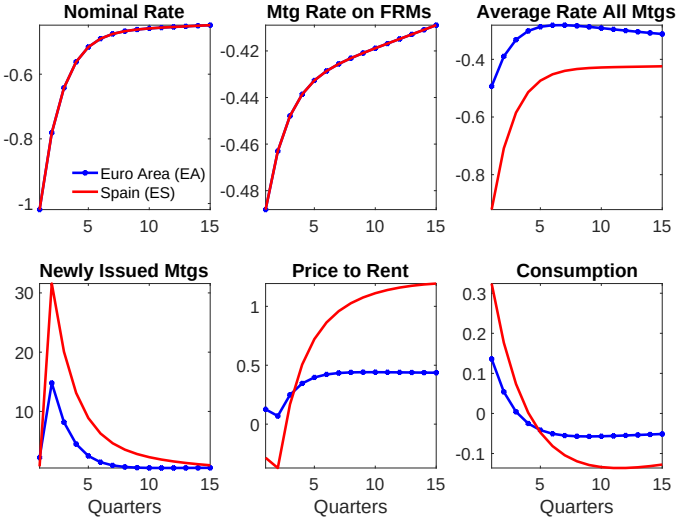

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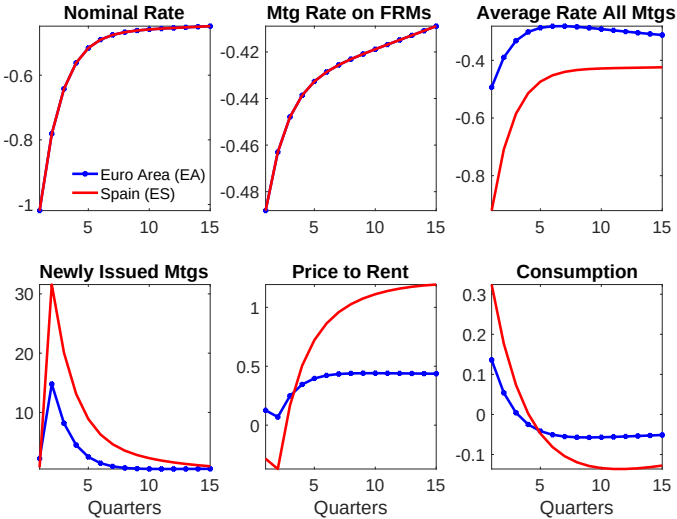

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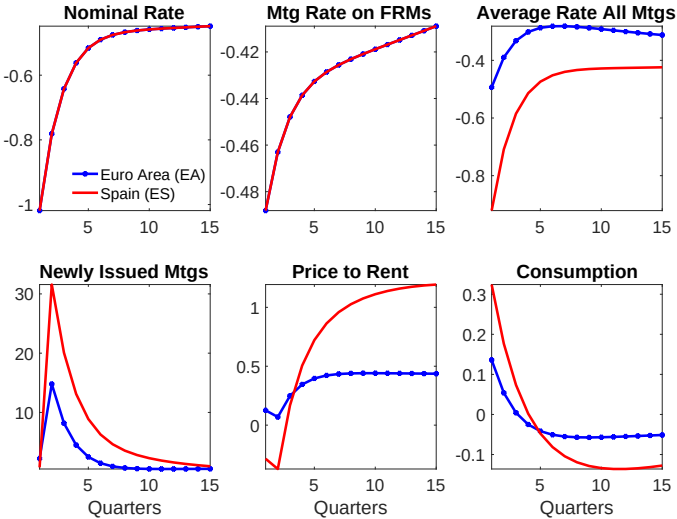

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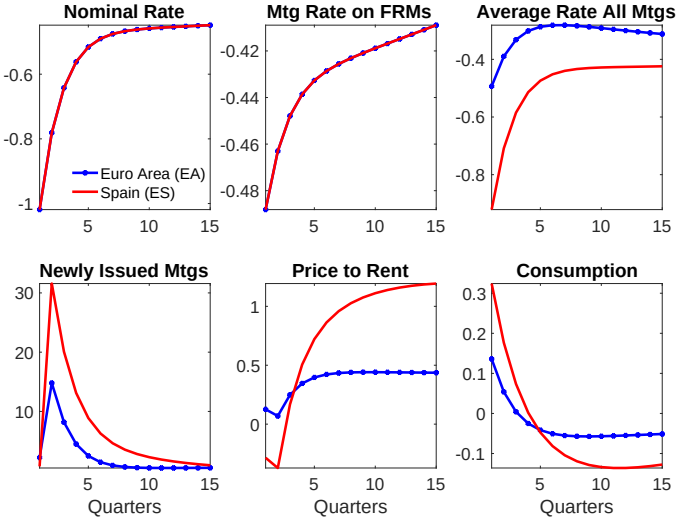

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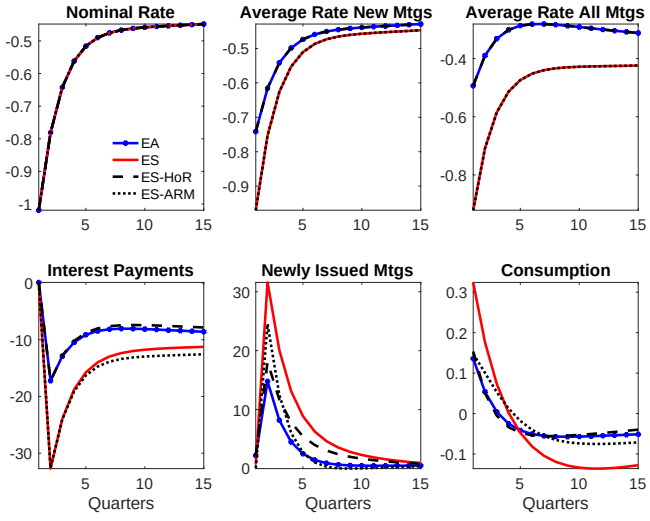
- More newly issued mtgs in ES
- ES price-to-rent reacts more strongly
- Stronger transmission to aggregate consumption

HoR & ARM Amplify Each Other

Prices



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  - Via cheaper mtg payments (cash flow effect)

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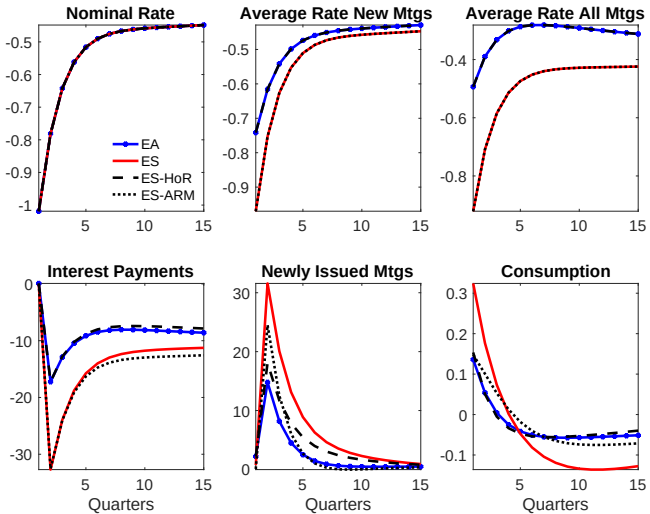

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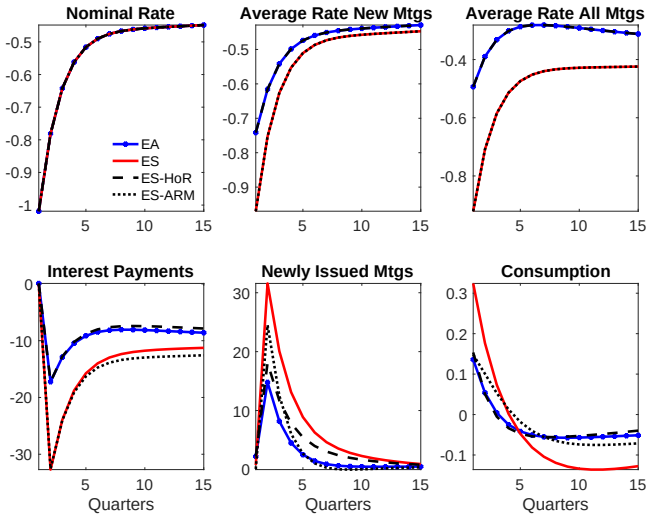

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- HoR increases new mtgs and tenure changes
  - More mortgaged homeowners active (level effect)
- Both channels at work interact to ↑ aggregate consumption

Towards a EA-wide Mortgage Market

- Lot of discussion on potential benefits of a stronger European fiscal union
  - Fairly limited at is current stage Garicano (2019), Bilbiie-Monacelli-Perotti (2021)

- Mortgage markets are local in nature: hard to get a mortgage in a country to buy housing in another. Consistent with institutions being very different

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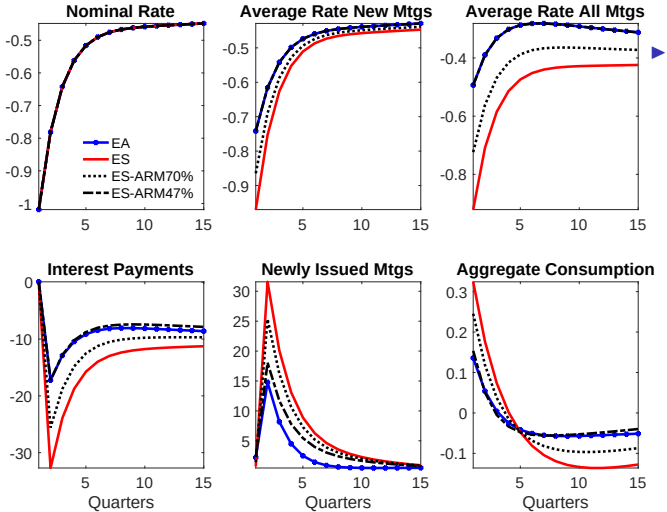
- In a EA-wide mortgage market, financial regulation becomes more similar across countries and mortgage contracts are issued in a similar proportion

Towards a EA-wide Mortgage Market

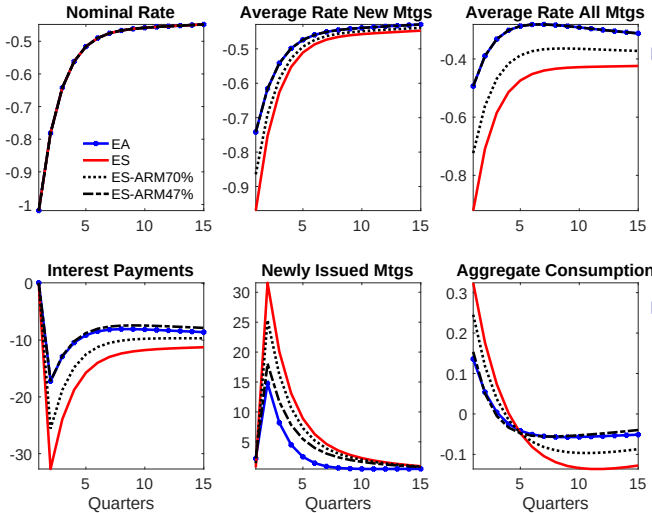
- Lot of discussion on potential benefits of a stronger European fiscal union
  - Fairly limited at is current stage Garicano (2019), Bilbiie-Monacelli-Perotti (2021)
- Mortgage markets are local in nature: hard to get a mortgage in a country to buy housing in another. Consistent with institutions being very different
- In a EA-wide mortgage market, financial regulation becomes more similar across countries and mortgage contracts are issued in a similar proportion
- I contrast ES and the EA with two additional economies:
  - ES-ARM70% is calibrated to ES but ARM share is decreased from 90% to 70%
  - ES-ARM47% is calibrated to ES but ARM share is decreased to EA level (47%)

EA-Wide Mortgage Market Reduces Heterogeneity . . .



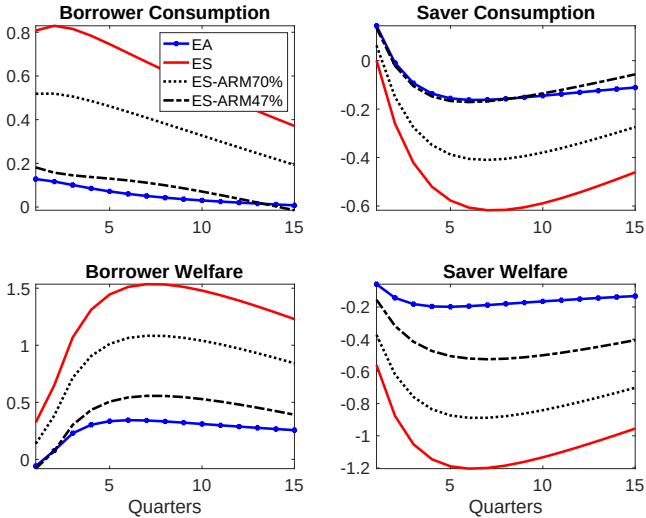
- ES-ARM70% reduces pass-through to average mtg rates
  - Lower mtg payments, mtg issuance, consumption ($\downarrow 40\%$)

EA-Wide Mortgage Market Reduces Heterogeneity . . .



- ES-ARM70% reduces pass-through to average mtg rates
  - Lower mtg payments, mtg issuance, consumption ($\downarrow 40\%$)
- ES-ARM47% eliminates differential pass-through to average mtg rates
  - Eliminates differential consumption response!

. . . at the Cost of Redistribution Towards the Wealthier



- ES borrowers enjoy cash flow effect on mtg payments
  - Strongly diminished in a unified mortgage market

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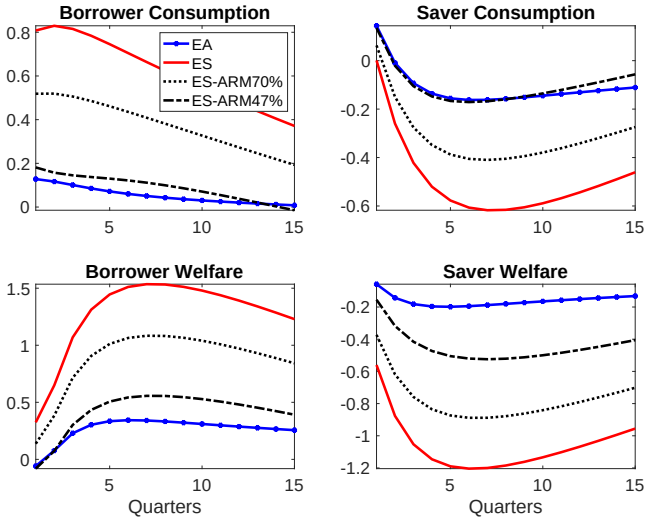


- ES borrowers enjoy cash flow effect on mtg payments
  - Strongly diminished in a unified mortgage market
- Savers win from a prolonged expansion of the economy

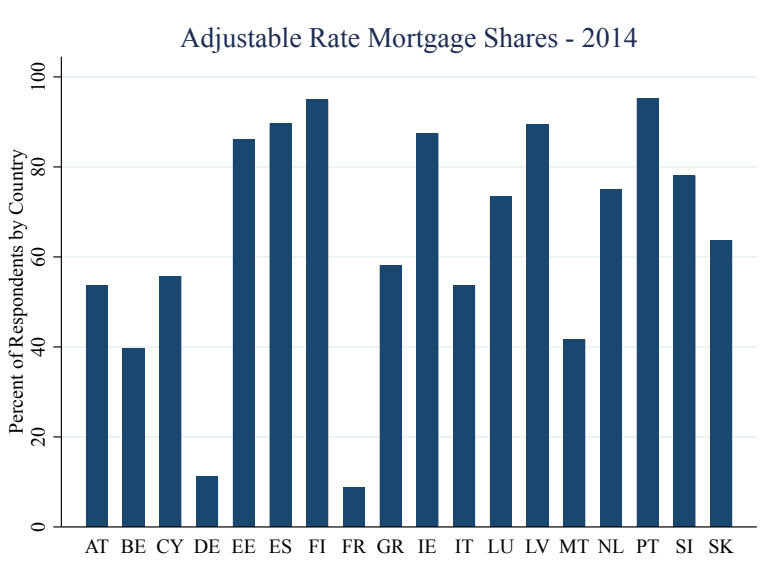
Conclusion

- Strong correlations between cross-country MP effectiveness and housing and mortgage market institutions
- Calibrated currency-union NK model accounts for the responses of Spain relative to the euro area in terms of mtgs, house prices, and consumption
  - Consumption in ES increases 2.4x as much as EA in model (2.5x in data)
- A EA-wide mortgage market is effective in reducing heterogeneous monetary transmission if it requires shared financial regulation
- Including house prices into the euro area price index leads to a trade-off between stabilizing output and goods inflation

Appendix

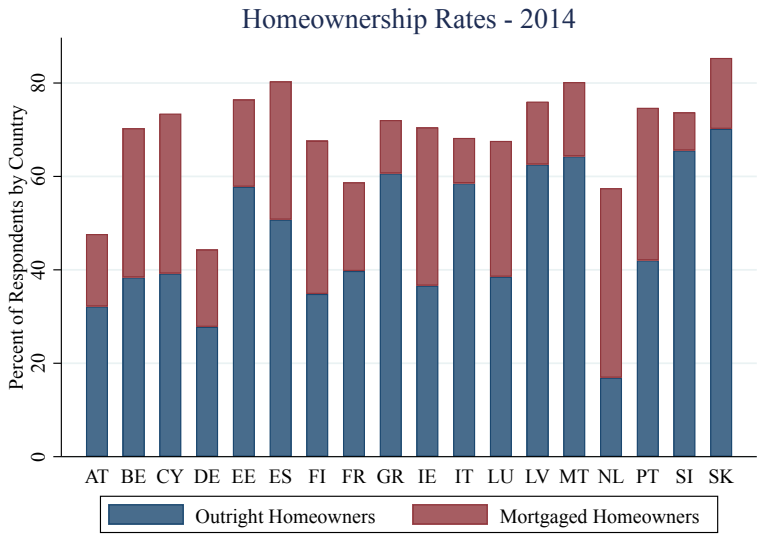
Heterogenous ARM Shares Across the EA

Back



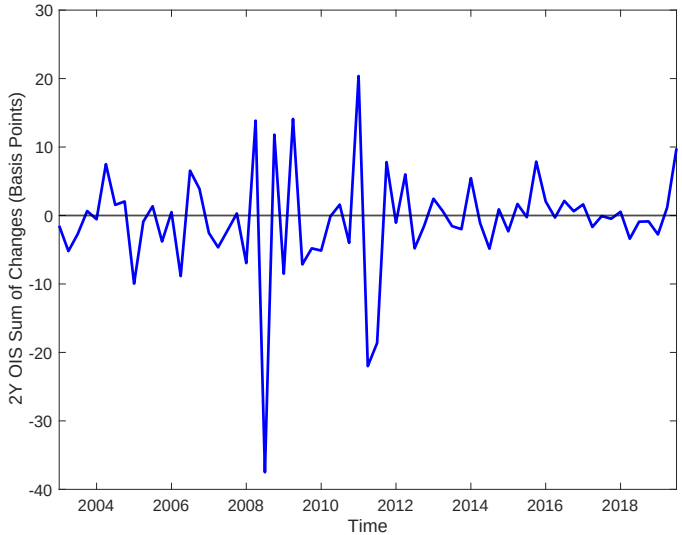
Heterogenous Homeownership Rates Across the EA

Back



MP Shocks: 2Y OIS Changes

Back



Data Back

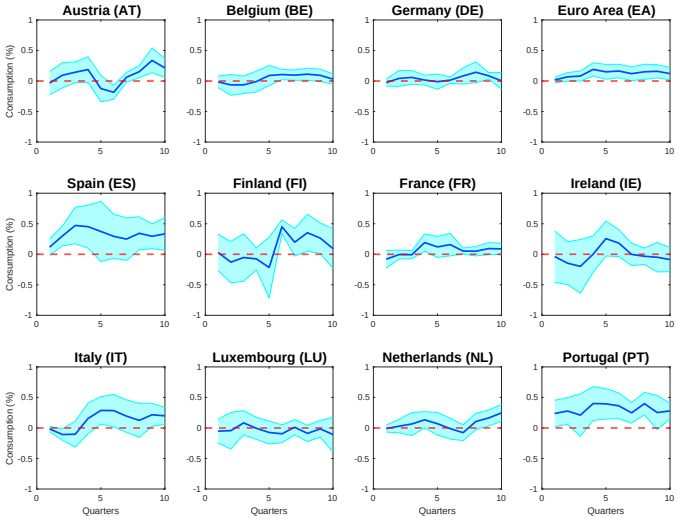
- Quarterly data spanning $2007Q1$–$2019Q3$, 11 countries (early adopters euro)
- ECB: Average mortgage interest rates, Overnight Interest Rate Swaps OIS around policy announcements Altavilla, Brugnolini, Gürkaynak, Motto (2019)
  - MP shocks: Sum intra-day 2-year OIS changes over each quarter
- OECD: House Price Index, Rent
- EUROSTAT: Consumption, Output, Harmonized CPI (HICP)
- European Mortgage Federation: Newly issued mortgages ($2007Q1$-)
- Household Finance and Consumption Survey: 2014 ARM shares & HoRs

Results: Empirical IRFs to MP Shocks Back

- GDP Components: Consumption
- Mortgages: New Mtgs, Mtg Rates
- Housing: Price-Rent

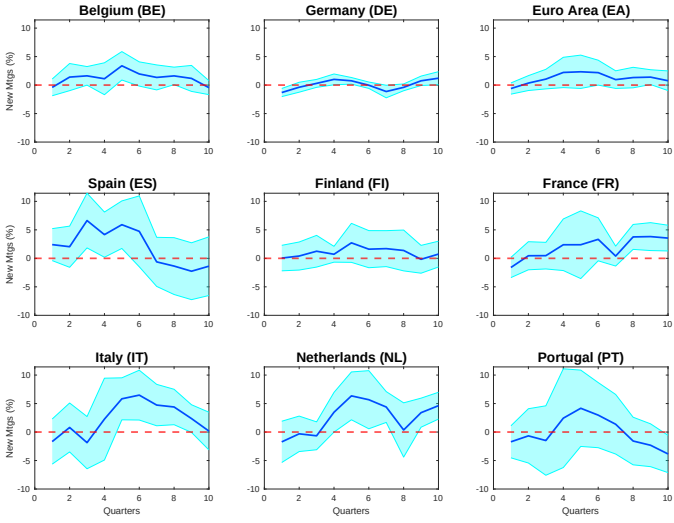
Heterogenous Consumption Responses Across EA

Back



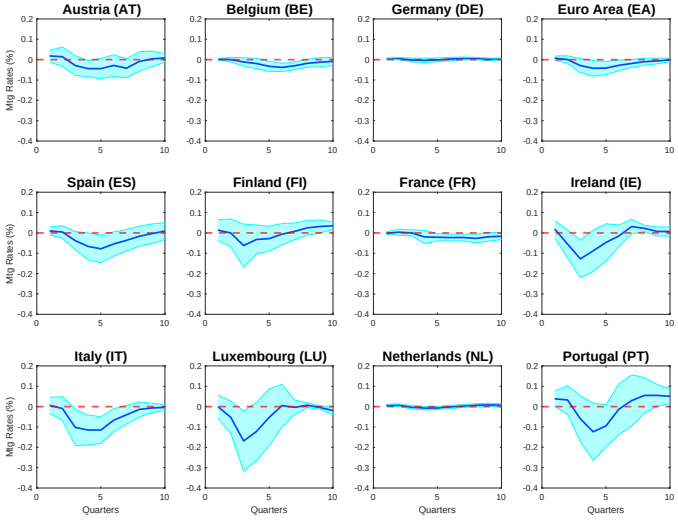
Heterogenous Newly Originated Mtgs Across EA

Back



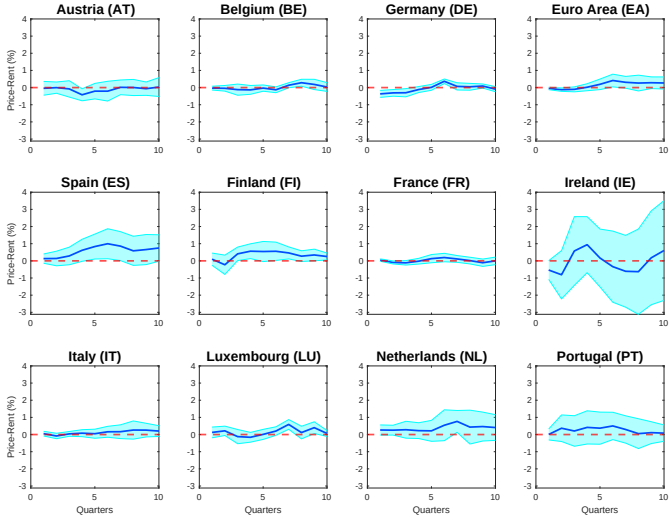
Heterogenous Pass-Through to Mtg Rates Across EA

Back



Heterogenous Price-to-Rent Responses Across EA

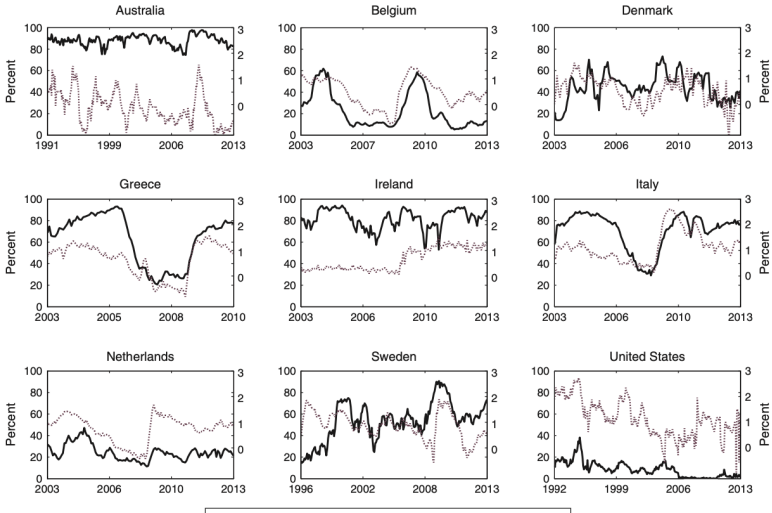
Back



ARM Shares Over time

Back

Figure 1. (Color online) Time Series of ARM Share and FRM–ARM Spread at the Country Level



Bird's Eye View: Agents Back

- Borrowers: representative family with measure χ_b of impatient households
  - Each borrower i can buy housing or rent. If decide to own, she receives $\omega_{i,b}$ units of final goods ($\omega_{i,b}$ is iid and drawn from $\Gamma_{\omega,b}$) Preferences
  - Fraction ρ of borrowers demand mortgages, face a loan-to-value constraint
  - Fraction α of mortgages are FRMs, reminder $(1-\alpha)$ are ARMs

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- Savers: representative family with measure $\chi_s = 1 - \chi_b$ of patient households. They are outright homeowners Saver Problem
  - Unconstrained, provide liquidity to borrowers in form of mortgages
  - Trade bonds both nationally and internationally (International Risk Sharing)

Workings of the Mortgage Contract

- Suppose a lender gives a borrower $1€$ at time t.

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- Lender receives $(1-\nu)^k(\alpha q_t^F + (1-\alpha)q_{t+k-1}^A)$€ at time $t+k$, for all $k > 0$
- ν is the fraction of principal paid each period, α fraction of FRMs
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- FRM economy: $\alpha = 1$ Greenwald (2018), while $\alpha \in (0,1)$ to match euro area countries

Borrower State Variables

- Law of motion for outstanding mortgages $M_{b,t}$ (where π_t is inflation):

$$M_{b,t} = \underbrace{\rho m_{b,t}}_{NewLoans} + \underbrace{(1-\rho)(1-\nu)\pi_t^{-1} M_{b,t-1}}_{OldLoans}$$

- Law of motion for payments on fixed-rate mortgages $X_{b,t}$:

$$X_{b,t} = \underbrace{\rho q_t^F m_{b,t}}_{NewLoans} + \underbrace{(1-\rho)(1-\nu)\pi_t^{-1} X_{b,t-1}}_{OldLoans}$$

- Law of motion for housing $H_{b,t}$:

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

Borrower Problem

- Choose consumption $C_{b,t}$, new mortgages $m_{b,t}$, new housing $h_{b,t}$, and rental units $s_{b,t}$ to maximize utility subject to:

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

where p_t^h is the house price, and p_t^r is the rental rate

- Loan-to-value constraint: $m_{bt} \leq \theta^{LTV} p_t^h h_{bt}$

Closing the Model

- Landlord: representative firm; transform housing into rental units Landlord
  - Owned by the savers
- Labor unions: standard, determine wage Phillips curve Labor Market
- Monetary authority: Taylor rule at the euro area level; equalize nominal interest rates across countries (monetary union) Monetary Authority
  - Main focus: highly persistent shock that shifts whole level of yield curve without moving real rate Garriga, Kydland, Sustek (2017)
- Markets clear: bonds, mortgage, goods, rental, owner-occupied housing (which is in fixed supply) Market Clearings

Equilibrium Mortgage Pricing Intuitions Optimality

- The mortgage interest rate on new and outstanding ARMs q_t^A equals the nominal short-rate on bonds R_t (which is set by monetary policy)
  - In euro area countries, q_t^A is typically linked to ECB reference rate (Euribor)

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Equilibrium Mortgage Pricing Intuitions Optimality

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- The savers choose the mortgage interest rate on new FRMs q_t^F and lock it for the whole duration of the mortgage contract
  - q_t^F moves less than R_t by the expectations hypothesis
- Crucially, countries with higher ARM shares feature stronger pass-through to the average mortgage interest rates (and so higher cash flow effect)

Model Calibration and Solution

- Match housing and mortgage market moments from the Household Finance and Consumption Survey (HFCS) around 2014:
  - ARM share $(1-\alpha)$: EA 45%, ES 90% ARM-FRM
  - Mortgaged Homeowners: EA 20%, ES 30% (higher mean of $\Gamma_{\omega,b}(\omega)$)
  - Outright Homeowners (χ_s): EA 40%, ES 50%
  - $\Longrightarrow$ HoR: EA 60%, ES 80% HoR
- NK parameters are standard and set equally across countries Table EA Table ES
- **Solution method**: first-order perturbation around the steady state to obtain impulse responses to a near-permanent 1% fall in nominal rate

Borrower & Saver Preferences

Back

- Family of borrowers and savers, permanent types with measure χ_j, $j \in \{b, s\}$; $\beta_s > \beta_b$. Expected utility:

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

  with per-period utility:

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

- Variables without asterisk for Home, with asterisk for Foreign

Borrower Problem cont'd

Back to Borrower Problem

- Law of motions for mortgages, payments, housing:

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

- In equilibrium all borrowers with $\omega_{i,t} > \bar{\omega}_{b,t}$ will choose to buy:

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

- LHS: fraction of borrowers who rent; RHS: fraction of borrower-rented housing

Borrower Optimality

Back to Borrower

- Optimality with respect to house size:

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

  where $\mathcal{C}_t = \mu_t \theta_{LTV}$ is the marginal collateral value of housing, μ_t LTV multiplier, and $\Lambda_{t,t+1}^b$ is the SDF

- Marginal benefits of housing (RHS): foregone rental cost next period p_{t+1}^r, utility benefit from owning $\bar{\omega}_{b,t}$, and housing value next period

- Housing services: $p_t^r = u_{b,t}^h / u_{b,t}^c$

Borrower Optimality cont'd

Back to Borrower

- Optimality with respect to newly issued mortgages:

$$\mu_t + \Omega^m_{b,t} + q_t \Omega^x_{b,t} = 1$$

where $\Omega^m_{b,t}$ and $\Omega^x_{b,t}$ are the marginal continuation costs of taking an additional euro of face value debt, and of promising an additional euro of initial payments

$$\Omega^m_{b,t} = E_t \Lambda^b_{t,t+1} \pi^{-1}_{t+1} [(1-\tau)(1-\alpha) q_t + \rho(1-\nu) + \nu + (1-\rho)(1-\nu)\Omega^m_{b,t+1}]$$

$$\Omega^x_{b,t} = E_t \Lambda^b_{t,t+1} \pi^{-1}_{t+1} [(1-\tau)\alpha + (1-\rho)(1-\nu)\Omega^x_{b,t+1}]$$

Optimality in the Housing Markets

- Borrower optimality with respect to house size:

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

  where $\Lambda_{t,t+1}^b$ is the SDF, $\bar{\omega}_{b,t}$ is the utility benefit from owning, $\mathcal{C}_t = \mu_t \theta_{LTV}$ is the marginal collateral value of housing, μ_t is the LTV multiplier

- Savers and landlords have similar optimality, expect they are not constrained ($\mathcal{C} = 0$) and savers are not subject to owning heterogeneity ($\bar{\omega}_{s,t} = 0$)

- Fixed housing supply. Housing clearing: $H_{b,t} + H_{s,t} + H_{l,t} = \bar{H}$

Saver Problem

Back Saver Optimality

- Choose $C_{s,t}$, $m_{s,t}$, $h_{s,t}$, and B_t subject to:

$$C_{s,t} \leq \underbrace{\frac{W_t}{P_t}N_{s,t}}_{LaborIncome} - \underbrace{\rho(m_{s,t} + (1-\nu)\pi_t^{-1}M_{s,t-1})}_{NetMortgageIssuance} - \underbrace{\rho p_t^h(h_{s,t} - H_{s,t-1})}_{NetHousingPurchases}$$
$$+ \underbrace{\pi_t^{-1}[\alpha X_{s,t-1} + (1-\alpha)q_{t-1}M_{s,t-1}]}_{InterestPayment} - \underbrace{(R_t^{-1}B_t - \pi_t^{-1}B_{t-1})}_{NetBondPurchases}$$

- Law of motions:

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

Saver Optimality

Back to Saver

- Optimality with respect to bonds (Euler Equation):

$$R_t E_t \left[\Lambda^s_{t,t+1} \pi^{-1}_{t+1} \right] = 1$$

where $\Lambda^s_{t,t+1}$ is the SDF:

$$\Lambda^s_{t,t+1} = \beta_s \frac{u^c_{s,t+1}}{u^c_{s,t}}$$

- Optimality with respect to house size:

$$p^h_t = \frac{u^h_{s,t}}{u^c_{s,t}} + E_t \left[\Lambda^s_{t,t+1} p^h_{t+1} (1 - \delta) \right]$$

Saver Optimal Mtg Issuance Pins Down Mtg Rate q_t^F Back

- Saver optimality with respect to newly issued mortgages:

$$\Omega_{s,t}^m + q_t^F \Omega_{s,t}^x = 1$$

where $\Omega_{s,t}^m$ is the marginal continuation benefit of an additional euro of issued mtg debt ($\Lambda_{t,t+1}^s$ is the SDF):

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

and $\Omega_{s,t}^x$ is the marginal continuation benefit of an additional euro of promised initial payments:

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

Landlord Problem

Back

- Choose $h_{l,t}$ to maximize sum of discounted profits:

$$F_t \leq \underbrace{p_t^r H_{l,t-1}}_{Rent} - \underbrace{\rho p_t^h (h_{l,t} - H_{l,t-1})}_{NetHousingPurchases} + \underbrace{\left(\int_{\bar{\omega}_{l,t-1}} \omega d\Gamma_{\omega,l} \right)}_{OwnerSurplus}$$

- Law of motion of housing:

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

- Optimality with respect to house size:

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

Home Consumption Preferences (Faia-Monacelli-2008)

- Index of domestic and imported bundles of goods:

$$C_t + \delta p_t^h \bar{H} \equiv \left[(1-\gamma)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

where $\gamma \equiv (1-n)\lambda$ is the weight of imported goods in the H consumption; λ degree of openness

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

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

Foreign Preferences | Home Price Indeces | Foreign Price Indeces | Home Demands | Foreign Demands | Law of One Price

Total Variety Demands

- Market clearing for domestic variety i must satisfy:

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

- Substitute demands, take $n \to 0$, and integrate to get:

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

- Economic activity of F & changes in the real exchange rate Q_t affect H, but the opposite is not true

International Risk Sharing

Back

- Savers in both economies have access to international complete markets
- They can trade the same Arrow-Debreu securities, so equalized first order condition state by state:

$$\beta_s \frac{u^c_{s,t+1}}{u^c_{s,t}} \pi^{-1}_{t+1} = \beta^*_s \frac{u^{*c}_{s,t+1}}{u^{*c}_{s,t}} \pi^{*-1}_{t+1} \frac{\zeta_t}{\zeta_{t+1}} \quad \Longrightarrow \quad u^{*c}_{s,t} = u^c_{s,t} Q_t$$

- Standard result in international macro Chari, Kehoe, McGrattan (2002), but here it applies to savers only

Foreign Consumption Preferences

Back

- Index of domestic and imported bundles of goods:

$$C_t^* + \delta p_t^{*,h} \bar{H}^* \equiv \left[(1-\gamma^*)^{\frac{1}{\eta}} C_{F,t}^{*\frac{\eta-1}{\eta}} + \gamma^{*\frac{1}{\eta}} C_{H,t}^{*\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

where $\gamma^* \equiv n\lambda^*$; λ^* degree of openness

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

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

Home Price Indeces

Back

- The Home consumption preferences imply:

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

where the price sub-indices are defined as:

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

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

Foreign Price Indeces

Back

- The Foreign consumption preferences imply:

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

where the price sub-indices are defined as:

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

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

Home Consumption Demands

Back

- The cons bundles $C_{H,t}$ and $C_{F,t}$ can be expressed as:

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

- Intermediate good-level demand:

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

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

Foreign Consumption Demands

Back

- The cons bundles $C^*_{H,t}$ and $C^*_{F,t}$ can be expressed as:

$$C^*_{H,t} = \left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\eta} \gamma^* Y^*_t; \quad C^*_{F,t} = \left(\frac{P^*_{F,t}}{P^*_t}\right)^{-\eta} (1-\gamma^*) Y^*_t;$$

- Intermediate good-level demand:

$$C^*_{H,t}(i) = \left(\frac{P^*_{H,t}(i)}{P^*_{H,t}}\right)^{-\epsilon} \left(\frac{1}{n}\right) C^*_{H,t};$$

$$C^*_{F,t}(i) = \left(\frac{P^*_{F,t}(i)}{P^*_{F,t}}\right)^{-\epsilon} \left(\frac{1}{1-n}\right) C^*_{F,t}$$

LOP & Exchange Rate

Back

- The Law of One Price holds: $P_{H,t}(i) = \zeta_t P^*_{H,t}(i)$ and $P_{F,t}(i) = \zeta_t P^*_{F,t}(i)$, where ζ_t is the nominal exchange rate
- It will also hold at the consumption bundle level: $P_{H,t} = \zeta_t P^*_{H,t}$ and $P_{F,t} = \zeta_t P^*_{F,t}$
- However, given home bias, purchasing power parity will not hold: $P_t \neq \zeta_t P^*_t$
- Denote the real exchange rate as $Q_t = \frac{\zeta_t P^*_t}{P_t}$

Labor Market Frictions

Back

- Sticky-wage frictions that are standard in the NK literature

  Erceg, Henderson, Levin (2000), Schmitt-Grohé, Uribe (2005), Auclert, Rognlie, Straub (2018)

- Households provide hours of work to a continuum of unions and face quadratic utility costs of adjusting the nominal wage set by the unions

- All households work the same number of hours in equilibrium

- Wage Phillips Curve:

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

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

Monetary Authority

Back

- Constant nominal exchange rate across countries $\implies R_t = R_t^*$
- Taylor rule as in Garriga, Kydland, Sustek (2017) & Greenwald (2018) in Foreign:

$$\begin{aligned}\log(R_t^*/R_{ss}^*) &= \log \bar{\pi}_t^* + \phi_R[\log(R_{t-1}^*/R_{ss}^*) - \log \bar{\pi}_{t-1}^* + \log \bar{\pi}_t^*] \\ &\quad \phi_\pi[\log \pi_t^* - \log \bar{\pi}_t^*] + \epsilon_{MP,t}\end{aligned}$$

where $\bar{\pi}_t^*$ is a time-varying inflation target defined by: $\log \bar{\pi}_t^* = \phi_{\bar{\pi}} \log \bar{\pi}_{t-1}^* + \epsilon_{\bar{\pi},t}$ and $\epsilon_{MP,t}$ is a white noise MP shock

- Inflation target shock shifts the whole yield curve downwards while affecting the real rate very little (differently from conventional monetary policy shock)

Equilibrium Conditions

Back

- 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: $M_{b,t} = M_{s,t}$
- The housing market clears: $H_{b,t} + H_{s,t} + H_{l,t} = \bar{H}$
- Housing services: $s_{b,t} = H_{b,t-1} + H_{l,t-1}$
- Goods market clears: $C_{b,t} + C_{s,t} + \delta p_t^h \bar{H} = Y_t$

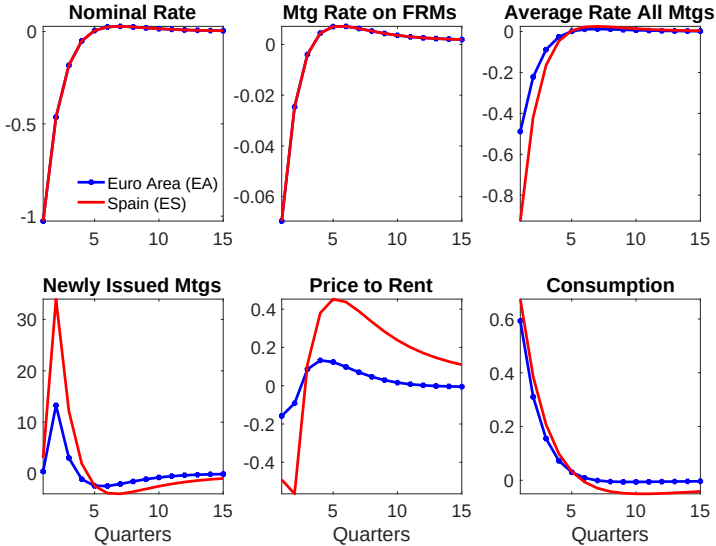
Parameter	Name	Value	Internal	Target/Source
			Demographics and Preferences	
Borrower discount factor	β_b^*	0.96	N	Greenwald (2018)
Saver discount factor	β_s^*	0.993	N	Avg. EA 10Y rate, 2007-2019
Borrower measure	χ_b^*	0.591	N	2014 EA fraction of renters & mortgaged homeowners
Labor disutility	ι^*	0.838	Y	$N_{SS}^* = 1$
Inverse Frisch elasticity	ϕ^*	0.5	N	Burriel, Fernández-Villaverde, and Rubio-Ramirez (2010)
Housing preference	ξ^*	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)
			Housing and Mortgages	
Share of ARMs	$1-\alpha^*$	0.529	N	2014 EA share of adjustable rate mortgages
Mortgage amortization	ν^*	0.435%	N	Greenwald (2018)
Income tax rate	τ^*	0.24	N	Christoffel, Coenen, and Warne (2008)
Max LTV ratio	θ_{LTV}^*	0.85	N	EA Median LTV
Housing depreciation	δ^*	0.005	N	Standard
Refinancing rate	ρ^*	0.034	N	Greenwald (2018)
Housing stock	$\bar{H}^*$	21.727	Y	$p_{SS}^{*h} = 1$
			Labor Market	
Elasticity subst. tasks	φ^*	21	N	Auclert, Rognlie, and Straub (2018)
Disutility wage changes	ψ^*	250.64	Y	Implies standard value for wage flexibility: 0.1
			Monetary Policy	
Taylor rule (inflation)	ϕ_π	1.5	N	Standard
Taylor rule (smoothing)	ϕ_R	0.865	N	Christoffel, Coenen, and Warne (2008)
Inflation target (pers.)	$\phi_{\bar{\pi}}$	0.994	N	Garriga, Kydland, and Šustek (2017)

Parameter	Name	Value	Internal	Target/Source
		Demographics and Preferences		
Borrower discount factor	β_b	0.96	N	Same as Euro Area
Saver discount factor	β_s	0.993	N	Same as Euro Area
Borrower measure	χ_b	0.492	N	2014 ES fraction of renters & mortgaged homeowners
Labor disutility	ι	0.752	Y	$N_{SS} = 1$
Inverse Frisch elasticity	ϕ	0.5	N	Same as Euro Area
Housing preference	ξ	0.407	N	Same as Euro Area
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
		Housing and Mortgages		
Share of ARMs	$1-\alpha$	0.896	N	2014 ES share of adjustable rate mortgages
Mortgage amortization	ν	0.435%	N	Same as Euro Area
Income tax rate	τ	0.24	N	Same as Euro Area
Max LTV ratio	θ_{LTV}	0.85	N	ES Median LTV
Housing depreciation	δ	0.005	N	Same as Euro Area
Refinancing rate	ρ	0.034	N	Same as Euro Area
Housing stock	$\bar{H}$	21.727	N	Same as Euro Area
		Labor Market		
Elasticity subst. tasks	φ	21	N	Same as Euro Area
Disutility wage changes	ψ	279.135	Y	Implies standard value for wage flexibility: 0.1
		International Finance		
Home bias	λ	0.187	N	Burriel, Fernández-Villaverde, and Rubio-Ramirez (2010)
Elasticity subst. consumpt.	η	7.671	N	Burriel, Fernández-Villaverde, and Rubio-Ramirez (2010)

Back

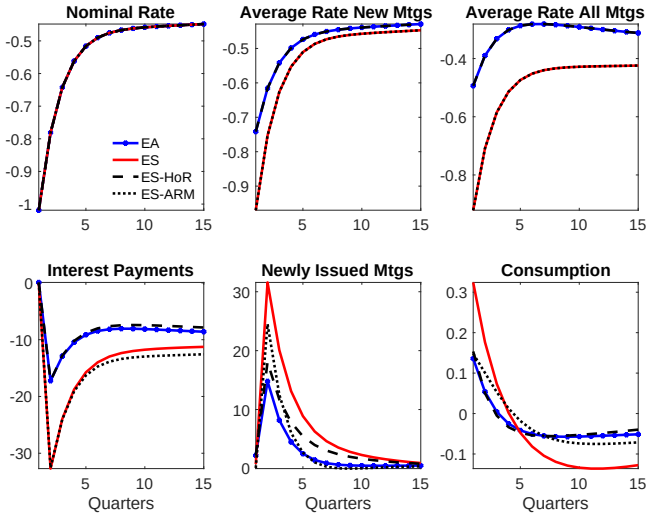
MP shock Generates Little Heterogeneity

Back



HoR & ARM Amplify Each Other

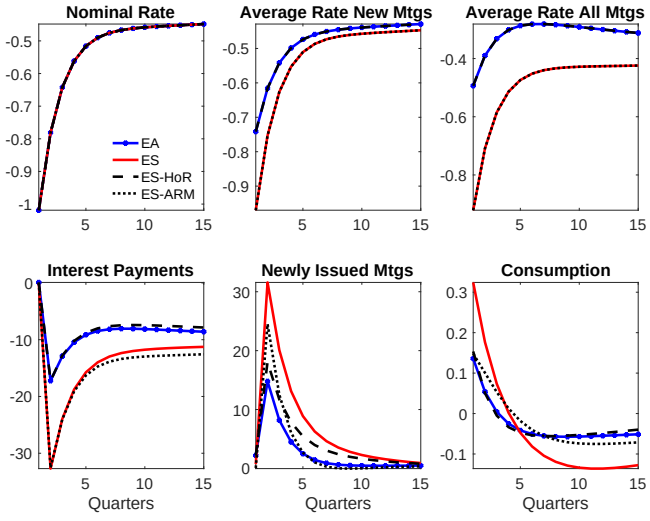
Back Prices



- ARM share explains pass-through & short-term mtg issued
  - Via cheaper mtg payments (cash flow effect)

HoR & ARM Amplify Each Other

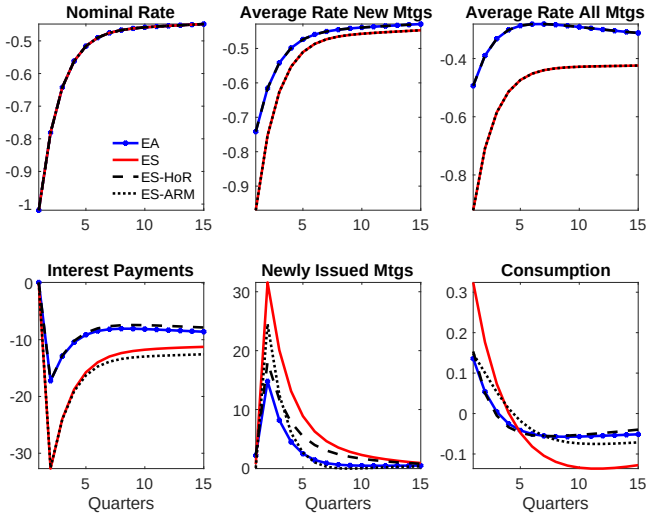
Back Prices



- ARM share explains pass-through & short-term mtg issued
  - Via cheaper mtg payments (cash flow effect)
- HoR increases new mtgs and tenure changes
  - More mortgaged homeowners active (level effect)

HoR & ARM Amplify Each Other

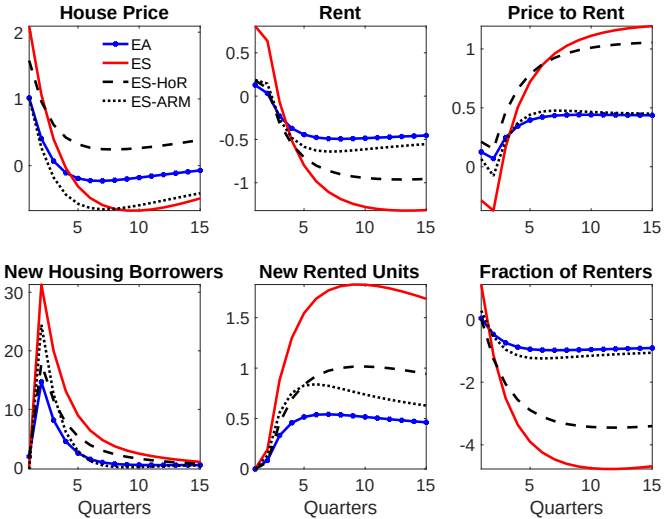
Back Prices



- ARM share explains pass-through & short-term mtg issued
  - Via cheaper mtg payments (cash flow effect)
- HoR increases new mtgs and tenure changes
  - More mortgaged homeowners active (level effect)
- Both channels at work interact to ↑ aggregate consumption

↑HoR Dominates Price-to-Rent

Back



- House prices most strongly linked to borrower housing demand
- Rent linked to renting demand
- Price-to-rent reflect movements in fraction of renters
- A smaller borrower family makes it easier for renters to become homeowners

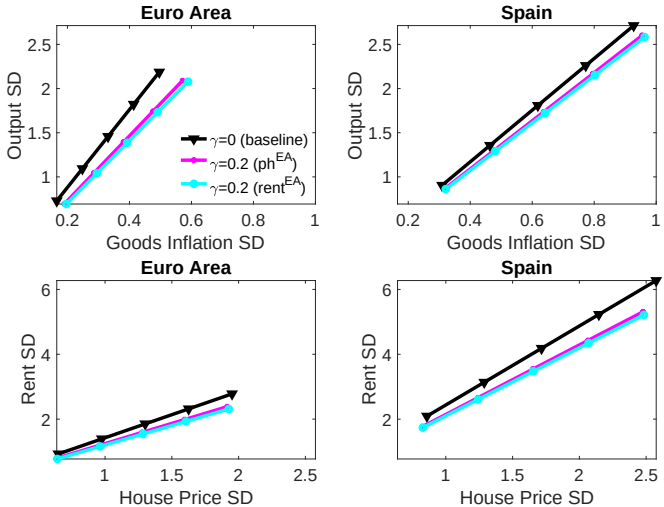
Strategy Review: Weighting House Prices in Price Index

Back

- "To further enhance the representativeness of the HICP and its cross-country comparability, the Governing Council has decided to recommend a roadmap to include owner-occupied housing (OOH) in the HICP" ECB (July 2021)
  - Net acquisition approach preferred method: include transaction prices
- In US instead, such expenditures are accounted for through "imputed rents"
- Define Strategy Review (SR) price index: $P_t^{*,SR} = p_{k,t}^{*,\gamma} P_t^{*,1-\gamma}; \quad k = h, r$
- Modify Taylor rule to include the different inflation object: $\pi_t^{SR} = \pi_{k,t}^{\gamma} \pi_t^{1-\gamma}$

Trade-Off Between Stabilizing Output and Inflation

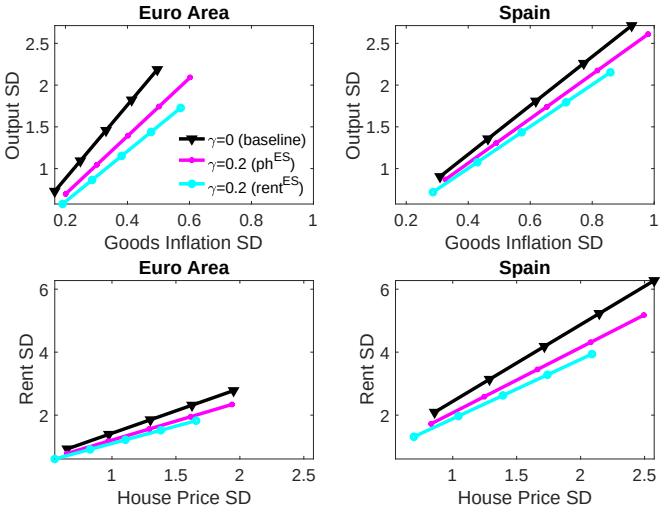
Weight ES



- Weighting prices that react more leads ECB to react less (Taylor rule)
- House price and rent inflation react more than goods inflation
  - $\Longrightarrow$ ECB stimulates the economy less
  - But goods inflation less stable as it's weighted less!

Weighting ES Rent Leads to Better Trade-Off

Back



- EA & ES house price very similar
- ES rent reacts more $\Longrightarrow$ more stable output
- Lesson: MP sensitivity of weighting prices crucial to stability