Quantitative easing and the price-liquidity trade-off

Marien Ferdinandusse, Maximilian Freier, Annukka Ristiniemi[1]

European Central Bank and Sveriges Riksbank

October 2018

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Introduction

Motivation

- **Asset purchases part of unconventional monetary measures** of central banks in most advanced economies
- With limited downward space for interest rates **might remain important**
- But such purchases are **theoretically irrelevant under standard assumptions**

Introduction

Motivation

- Large and growing empirical literature providing **evidence for effectiveness of quantitative easing**
  - e.g. Krishnamurthy and Vissing-Jorgensen (2011); Swanson (2017); Luck and Zimmermann (2018) on the United States
  - e.g. Altavilla et al. (2015, 2016); Andrade et al. (2016); Blattner and Joyce (2016) on the euro area
  - e.g. Joyce et al. (2012); Meaning and Warren (2015) on the United Kingdom
  - e.g. De Rezende (2017); De Rezende and Ristiniemi (2018) on Sweden
  - e.g. Haldane et al. (2016); Weale and Wieladek (2016) for a comparative study
- **Theoretical foundations relatively less developed** for these findings
  - Term structure model most widely used (Vayanos and Vila, 2009; Hamilton and Wu, 2012)
  - Search models for liquidity (De Pooter, Martin and Pruitt, 2015)

Introduction

Motivation: also short term yields fall

Term structure models rely on presence of preferred habitat investors

- Preference of certain maturity segment

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Figure: German government bond, 3 month yield (solid). Eonia rate (dashed)

Introduction

Motivation: Puzzling results on liquidity

Theory:

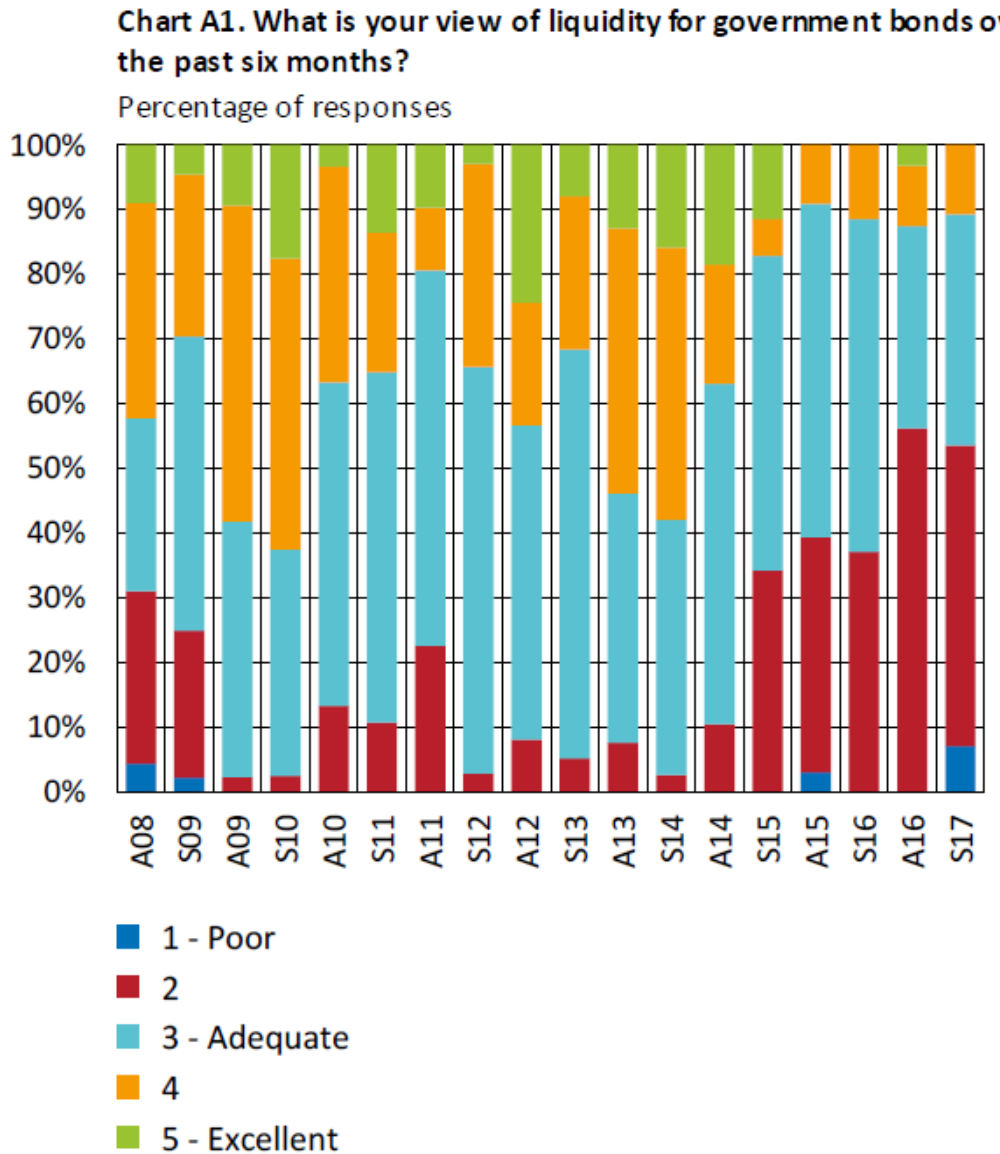
- QE leads to improved liquidity De Pooter, Martin and Pruitt (2015)

Empirics not conclusive:

- QE improved liquidity of TIPS (Christensen and Gillan, 2013), vs. reduced Coroneo (2015)
- Purchases of MBS lead to decline in their liquidity (Kandrac, 2013)
- ECB asset purchases lead to scarcity of German bunds (Schlepper, Riordan, Hofer and Schrimpf, 2017)

Introduction

Investors complain of reduced liquidity



Source: Riksbank Risk Survey Spring 2017

Introduction

Standard theory would question that

Definition:
Liquid assets are more certainly realisable at short notice without incurring a loss (Keynes, Treaties)

- Central bank is a large buyer on the market
- Hence, liquidity should improve with purchases

Introduction

Main contributions

- Model sovereign bond markets in **a search-theoretic framework of over-the-counter debt**
  - Quantitative easing affects bond prices and market liquidity through demand and supply effects
  - Reflects the practice of investors in (some) sovereign bond markets to scout the market, which delays the time to transaction
- Calculate a new **Preferred Habitat Index** (PHI) for the euro area from the ECB Securities Holdings Database
- Run **model simulations for the euro area**
  - Quantitative easing reduces yields more in countries with more preferred habitat investors
  - Liquidity initially improves more in countries with fewer preferred habitat investors, but then deteriorates more than in countries with more preferred habitat investors.

A search-theoretic framework of over-the-counter debt

Sovereign bond markets modelled in a search-theoretic framework of over-the-counter debt

- Model is based on a search theoretic model of over-the-counter debt by Duffie, Garleanu and Pedersen (2005)
- Extended by (i) default risk to bonds, (ii) a central bank, (iii) preferred habitat investors and (iv) endogenous entry of buyers as in (Afonso, 2011)

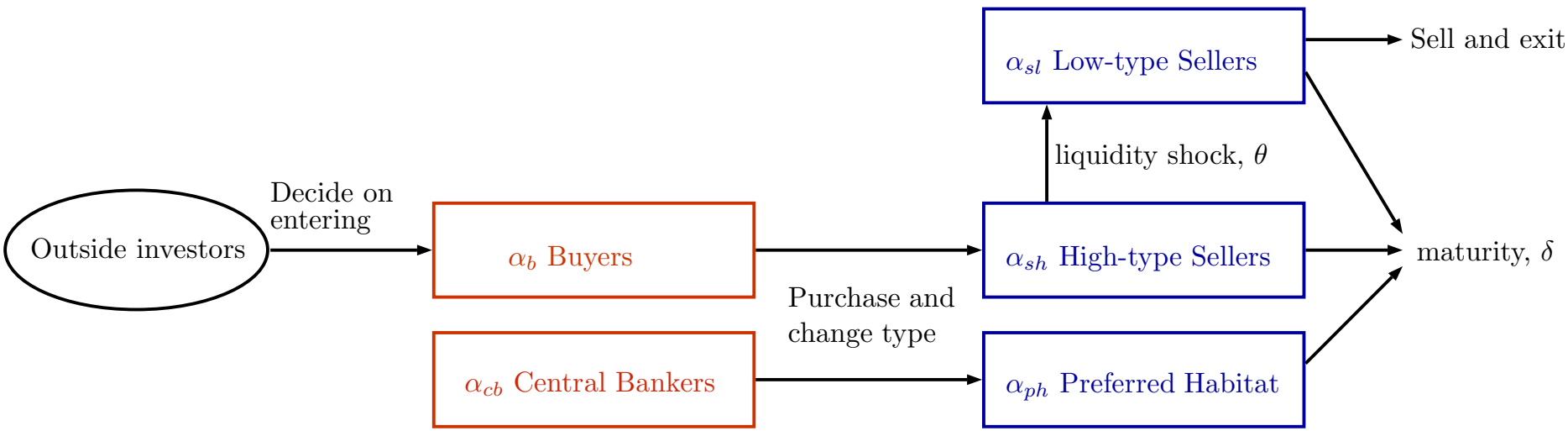


Figure: Flows of investors, with measures α_i, $i = b, sl, sh, cb, ph$

Model set up

- Government has issued an amount D of debt
- Each investor can hold only one bond at a time
- Bond pays 1 at maturity
- Buyers, central bankers, and outside investors are endowed with a unit of the consumption good that they can use to purchase a bond
- There are many central bankers, each holding one unit of the consumption good

Model set up

Value functions of buyer and sellers

Expected returns of buyers and sellers depend on the prevalence of counterparties Buyer, and central bank:

$$V_b = -e + \lambda\alpha_{sl}(V_{sh} - P) + (1 - \lambda\alpha_{sl})V_b$$

$$V_{cb} = -e + \lambda\alpha_{sl}(V_{phi} - P) + (1 - \lambda\alpha_{sl})V_{cb}$$

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Low-type (impatient) seller

$$V_{sl} = \frac{1}{(1+\rho)}\left[\delta(1-q) + \delta\gamma q + (\lambda\alpha_b + \lambda\alpha_{cb})P + (1 - \delta - \lambda\alpha_b - \lambda\alpha_{cb})V_{sl}\right]$$

Model set up

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Low-type (impatient) seller

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High-type (patient) seller, and preferred habitat investor:

$$V_{sh} = \delta(1-q) + \delta\gamma q + \theta V_{sl} + (1 - \delta - \theta)V_{sh}$$

$$V_{phi} = \delta(1-q) + \delta\gamma q + \theta V'_{phi} + (1 - \delta - \theta)V_{phi}$$

Price and liquidity in a simple model

With QE, bond prices and liquidity affected by increases in central bank demand (flow) and reduction in supply of bonds (stock)

Nash bargaining over surpluses:

$$\begin{aligned} P &= \beta V_{sl} + (1-\beta)(V_{sh} - V_b) \\ &= \beta V_{sl} + (1-\beta)(V_{phi} - V_{cb}) \end{aligned}$$

Solution:

$$P = \underbrace{\frac{(\delta(1-q)+\delta\gamma q)}{\rho+\delta}}_{\text{Fundamental value}} + \underbrace{\frac{(1-\beta)}{\beta}\frac{e(\lambda\alpha_b+\lambda\alpha_{cb}+\rho+\delta)}{\lambda\alpha_{sl}(\rho+\delta)}}_{\text{Market premium}}$$

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Price and liquidity in a simple model

With QE, bond prices and liquidity affected by increases in central bank demand (flow) and reduction in supply of bonds (stock)

Liquidity is defined as a measure of transactions:

$$\mathcal{L} = \lambda \alpha_{sl} \alpha_b + \lambda \alpha_{sl} \alpha_{cb}$$

- A share $\lambda \alpha_{sl}$ of buyers, and central bankers meet a seller and transact

Price and liquidity in a simple model

With QE, bond prices and liquidity affected by increases in central bank demand (flow) and reduction in supply of bonds (stock)

Liquidity:

$$\mathcal{L} = \underbrace{\boxed{\lambda\alpha_{sl}}}_{\text{Supply}}(\alpha_b + \overbrace{\boxed{\lambda\alpha_{cb}}}^{\text{Demand}})$$

Price:

$$P = \underbrace{\frac{(\delta(1-q)+\delta\gamma q)}{\rho+\delta}}_{\text{Fundamental value}} + \underbrace{\frac{(1-\beta)}{\beta}\frac{e(\lambda\alpha_b + \overbrace{\boxed{\lambda\alpha_{cb}}}^{\text{Demand}} + \rho + \delta)}{\underbrace{\boxed{\lambda\alpha_{sl}}}_{\text{Supply}}(\rho+\delta)}}_{\text{Market premium}}$$

Price and liquidity in a simple model

Effect of QE on prices depends on the share of preferred habitat investors

$$\frac{\partial P}{\partial \alpha_{cb}} = \frac{(1-\beta)e}{\beta(\rho+\delta)\lambda(D \boxed{-\alpha_{phi}} - \alpha_{sh})}$$

Model with endogenous market entry

Where the market entry of buyers is endogenous, QE crowds out buyers from the market: price effects muted, liquidity declines more

Inflows of outside investors g:

- who compare the value of their outside option K to the value of becoming a buyer V_b.
- The last one to enter is the marginal investor, for whom $V_b = K_m$:

$$g = \int_{\underline{K}}^{K_m} f(K)dK = F(K_m) \quad \Leftrightarrow \quad g = F(V_b) \tag{1}$$

At equilibrium, $K_m = V_b$.

Model with endogenous market entry

Liquidity effect at the end of purchases

Once central bank stops demanding bonds, but continues to hold them on the balance sheet, then liquidity can be worse that before the start of the purchases//

$$\mathcal{L} = \lambda \alpha_{sl}(\alpha_b + \alpha_{cb})$$

- $\alpha_{cb} = 0$
- α_b potentially lower than before
- α_{sl} lower as central bank purchases have moved bonds from active investors to preferred habitat investors

QE in the euro area

ECB PSPP broadly symmetric asset purchases in heterogeneous national sovereign bond markets.

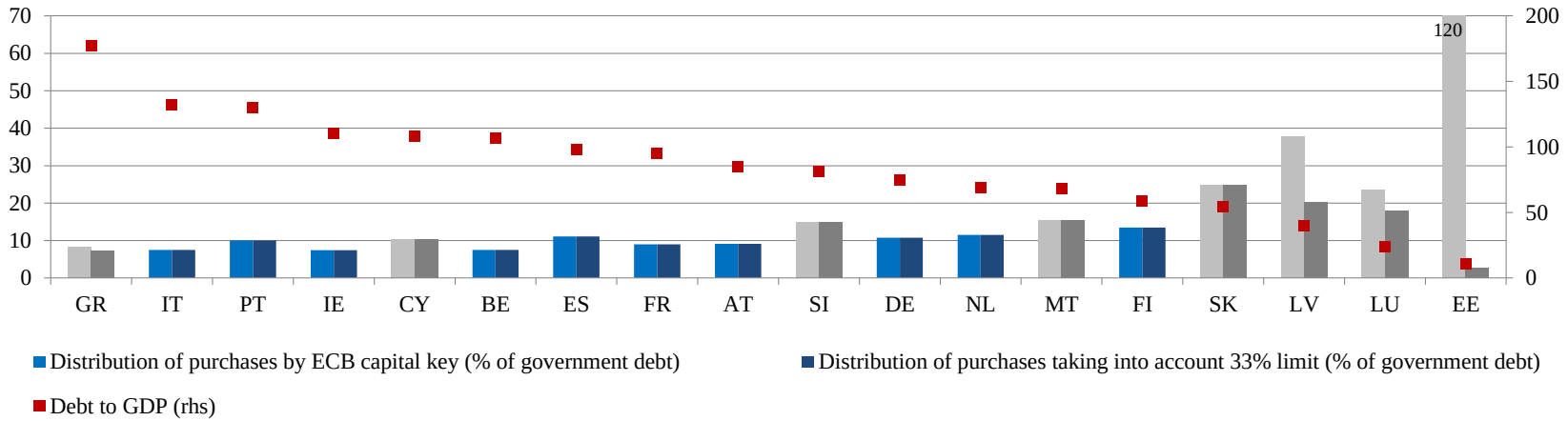

Figure: Announced purchases of outstanding debt under the ECB Public Sector Purchase Programme (PSPP), March 2015 to September 2016. Central banks are able to purchase only 33% of each country's bonds without becoming a senior debt holder. SK, SI, LV, LU and EE outliers on account of their low levels of public debt. These countries as well as the EU/IMF programme countries at the start of the ECB PSPP are excluded from the model simulations.

A preferred habitat index for the euro area

New Preferred Habitat Index (PHI) shows significant differences across euro area countries

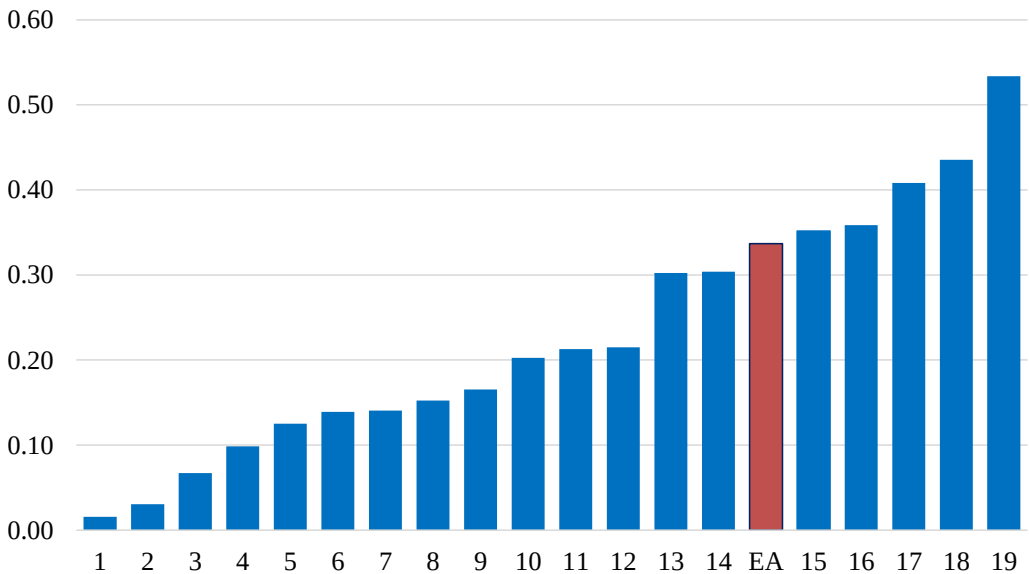

Figure: Preferred habitat investor index per euro area country, 2014. The PHI is calculated on the basis of the ESCB securities holdings statistics. It is a composite indicator, consisting of the bond holdings of central banks and general governments outside the euro area, insurance companies and pension funds (both in and outside the euro area), as a share of the total government debt securities issued by euro area countries.

A preferred habitat index for the euro area

Preferred Habitat Index (PHI) by sectors

Measure the share of each EA country government bonds held by preferred habitat investors from ECB confidential securities holding statistics

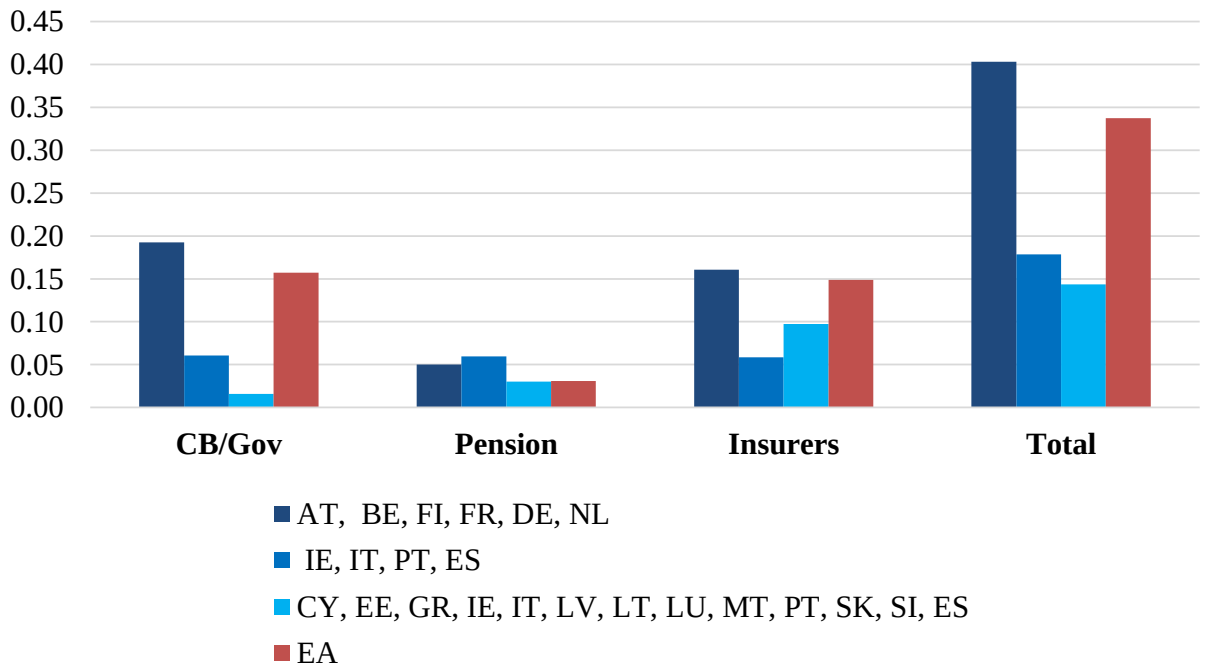

Figure: Preferred habitat investors index per sector, 2014 average.

Model simulation

Model calibrated with new PHI

	High PHI	Low PHI
Preferred habitat	40%	17%
Default probability	0.2%	2.1%
Purchases % longterm bonds	13.3%	13.8%
Average maturity	6.7 years	7.5 years

Table: Calibration of groups.

Model simulation

Simulations show QE leads to a lower decline in yields in countries with a lower PHI

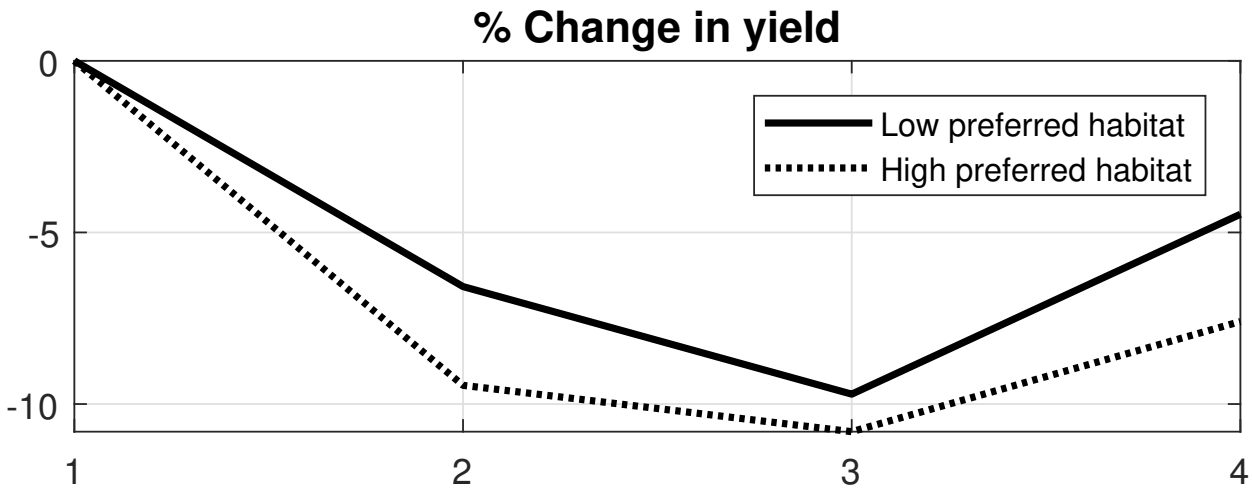

Figure: Price impact from the calibrated model:
Period 1: initial setting
Period 2: central bank purchase of 13% of bonds
Period 3: central bank purchases plus reduced bond supply
Period 4: purchases ended, bonds held.

Model simulation

Liquidity initially improves more, but then declines below pre-purchase levels

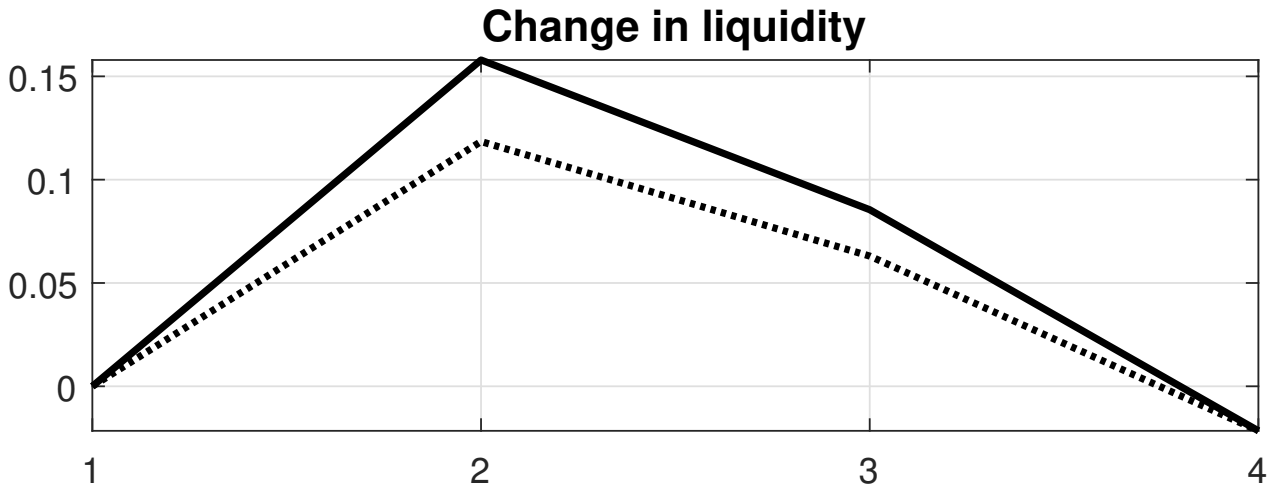

Figure: Price impact from the calibrated model:
Period 1: initial setting
Period 2: central bank purchase of 13% of bonds
Period 3: central bank purchases plus reduced bond supply
Period 4: purchases ended, bonds held.

Conclusions

Summary

- Sovereign bond markets are modelled in a search-theoretic framework of over-the-counter debt. Expected returns of buyers and sellers depend on the prevalence of counterparties.
- With QE, bond prices and liquidity are affected by increases in central bank demand (flow). The effect of QE on prices and liquidity depends on the share of preferred habitat investors.
- Where the market entry of buyers is endogenous, QE crowds out buyers from the market: price effects are muted, liquidity declines more.
- The ECB PSPP are broadly symmetric asset purchases in heterogeneous national sovereign bond markets.
- A new Preferred Habitat Index (PHI) shows significant differences across euro area countries.
- Model simulations show two results: (1) equal purchases by central bank lead to a lower decline in yields in countries with a lower PHI. (2) Liquidity initially improves more, but then declines below pre-purchase levels.

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Investor flows

Flows of high-type sellers:

$$\begin{aligned}\dot{\alpha_{sh}} &= \lambda\alpha_{sl}\alpha_b - (\delta+\theta)\alpha_{sh} = 0\\ \lambda\alpha_{sl}\alpha_b &= (\delta+\theta)\alpha_{sh}\end{aligned}$$

Flows of low-type sellers:

$$\begin{aligned}\dot{\alpha_{sl}} &= \theta\alpha_{sh} - \lambda\alpha_{sl}(\alpha_b+\alpha_{cb}) = 0\\ &= \theta\alpha_{sh} - (\delta+\theta)\alpha_{sh} + \lambda\alpha_{sl}\alpha_{cb}\\ \lambda\alpha_{sl}\alpha_{cb} &= \delta\alpha_{sh}\\ \lambda\alpha_{sl}\alpha_{cb} &= \delta(D-\alpha_{ph}-\alpha_{sl})\\ (\lambda\alpha_{cb}+\delta)\alpha_{sl} &= \delta(D-\alpha_{ph})\\ \alpha_{sl} &= \frac{\delta(D-\alpha_{ph})}{(\lambda\alpha_{cb}+\delta)}\end{aligned}$$

Results

Increase in demand

α_{cb} increases:

- Effect: price increases, liquidity improves, but α_{sl} declines, and price effect is larger, and liquidity effect is muted
- Crowding out: V_b declines, g declines, if α_b declines, then P increases less and liquidity improves less

$$\alpha_{sl} = \frac{\delta(D - \alpha_{ph})}{(\lambda\alpha_{cb} + \delta)}$$

$$V_b = -\frac{e}{\lambda\alpha_{sl}} + \frac{(\delta(1-q) + \delta\gamma q)\rho - \theta k(\rho+\delta) - \delta k(\rho + \delta + \lambda\alpha_b + \lambda\alpha_{cb})}{(\delta+\theta)(\rho+\delta)}$$

$$g = F(V_b)$$

$$\alpha_b = \frac{g}{\lambda\alpha_{sl}}$$

$$P = \frac{\delta(1-q) + \delta\gamma q}{\rho+\delta} + \frac{(1-\beta)}{\beta}\frac{e(\lambda\alpha_b + \lambda\alpha_{cb} + \rho + \delta)}{\lambda\alpha_{sl}(\rho+\delta))}$$

$$\mathcal{L} = \lambda\alpha_{sl}(\alpha_b + \alpha_{cb})$$

Results

Reduction in supply

α_{ph} increases:

- Effect: α_{sl} declines, price increases, liquidity declines
- Crowding out: V_b declines, g declines, if α_b declines, then P increases less, liquidity improves less

$$\alpha_{sl} = \frac{\delta(D - \alpha_{ph})}{(\lambda\alpha_{cb} + \delta)}$$

$$V_b = -\frac{e}{\lambda\alpha_{sl}} + \frac{(\delta(1-q) + \delta\gamma q)\rho - \theta k(\rho + \delta) - \delta k(\rho + \delta + \lambda\alpha_b + \lambda\alpha_{cb})}{(\delta + \theta)(\rho + \delta)}$$

$$g = F(V_b)$$

$$\alpha_b = \frac{g}{\lambda\alpha_{sl}}$$

$$P = \frac{\delta(1-q) + \delta\gamma q}{\rho + \delta} + \frac{(1-\beta)}{\beta}\frac{e(\lambda\alpha_b + \lambda\alpha_{cb} + \rho + \delta)}{\lambda\alpha_{sl}(\rho + \delta))}$$

$$\mathcal{L} = \lambda\alpha_{sl}(\alpha_b + \alpha_{cb})$$