QT vs QE: Who is In When the Central Bank is Out?

Iryna Kaminska (BoE), Alex Kontoghiorghes (BoE), Walker Ray (Chicago Fed)

Monetary Policy Transmission, 2025 AEA San Francisco

4th January 2025

Disclaimer

The views expressed in this paper are solely those of the authors and should not be taken to represent the views of the Bank of England or the Federal Reserve Bank of Chicago (or any of its committees).

Motivation

- Major central banks have recently returned to the conventional way of policy tightening - raising policy rates.

Motivation

- Major central banks have recently returned to the conventional way of policy tightening - raising policy rates.
- At the same time many monetary policy makers have also had to deal with Quantitative Tightening (QT), which is the reversal of previously implemented Quantitative Easing (QE).

Motivation

- Major central banks have recently returned to the conventional way of policy tightening - raising policy rates.
- At the same time many monetary policy makers have also had to deal with Quantitative Tightening (QT), which is the reversal of previously implemented Quantitative Easing (QE).
- But how do QT and QE compare?
  - *Policy makers: they are not the same!* Expect any QT effects to be limited under normal market conditions and weaker than those observed during QE (e.g. Schnabel (2023)).

Motivation

- Major central banks have recently returned to the conventional way of policy tightening - raising policy rates.
- At the same time many monetary policy makers have also had to deal with Quantitative Tightening (QT), which is the reversal of previously implemented Quantitative Easing (QE).
- But how do QT and QE compare?
  - *Policy makers: they are not the same!* Expect any QT effects to be limited under normal market conditions and weaker than those observed during QE (e.g. Schnabel (2023)).
  - *Theory: they are the same!* QE and QT are mirror images of one another (Vayanos and Vila (2009, 2021)).

Motivation

- Major central banks have recently returned to the conventional way of policy tightening - raising policy rates.
- At the same time many monetary policy makers have also had to deal with Quantitative Tightening (QT), which is the reversal of previously implemented Quantitative Easing (QE).
- But how do QT and QE compare?
  - *Policy makers: they are not the same!* Expect any QT effects to be limited under normal market conditions and weaker than those observed during QE (e.g. Schnabel (2023)).
  - *Theory: they are the same!* QE and QT are mirror images of one another (Vayanos and Vila (2009, 2021)).
  - *Evidence: not much!* QE affects the yield curves via multiple channels, but for QT there is more uncertainty about it's channels.

This Paper

Our Research Question:

- What can we learn about the Preferred Habitat demand channel of QE and QT by combining auction and transaction level data?

This Paper

Our Research Question:

- What can we learn about the Preferred Habitat demand channel of QE and QT by combining auction and transaction level data?

Our Approach:

- Using a novel blend of APF auctions data with bond level transactions data, we compare the gilt trading volumes of Preferred Habitat investors (insurance companies and pension funds, or ICPFs) and arbitrageurs with dealers around QE and QT auction days.

This Paper

Our Research Question:

- What can we learn about the Preferred Habitat demand channel of QE and QT by combining auction and transaction level data?

Our Approach:

- Using a novel blend of APF auctions data with bond level transactions data, we compare the gilt trading volumes of Preferred Habitat investors (insurance companies and pension funds, or ICPFs) and arbitrageurs with dealers around QE and QT auction days.
- We use this information to understand auction bidding behaviour during QE and QT auctions, and test a number of hypotheses which Preferred Habitat models depend on.

This Paper

Our Research Question:

- What can we learn about the Preferred Habitat demand channel of QE and QT by combining auction and transaction level data?

Our Approach:

- Using a novel blend of APF auctions data with bond level transactions data, we compare the gilt trading volumes of Preferred Habitat investors (insurance companies and pension funds, or ICPFs) and arbitrageurs with dealers around QE and QT auction days.
- We use this information to understand auction bidding behaviour during QE and QT auctions, and test a number of hypotheses which Preferred Habitat models depend on.
- We propose a state-dependent Preferred Habitat demand model to reconcile our empirical results, by building on Vayanos & Vila (2021).

Preview of Main Findings

1) Higher ICPF investor sales to dealers leads to higher bid prices during QE auctions, consistent with Preferred Habitat demand theory. The effect decreases as available bond supply increases.

Preview of Main Findings

1) Higher ICPF investor sales to dealers leads to higher bid prices during QE auctions, consistent with Preferred Habitat demand theory. The effect decreases as available bond supply increases.

- Our findings confirm the importance of the demand from institutional investors during QE auctions, and highlights the role of bond supply.

Preview of Main Findings

1) Higher ICPF investor sales to dealers leads to higher bid prices during QE auctions, consistent with Preferred Habitat demand theory. The effect decreases as available bond supply increases.

- Our findings confirm the importance of the demand from institutional investors during QE auctions, and highlights the role of bond supply.

2) The share of Preferred Habitat trade volumes has decreased during QT auctions relative to QE auctions, and even more so for long maturity bonds. Conversely, the role of arbitrageurs has increased.

Preview of Main Findings

1) Higher ICPF investor sales to dealers leads to higher bid prices during QE auctions, consistent with Preferred Habitat demand theory. The effect decreases as available bond supply increases.

- Our findings confirm the importance of the demand from institutional investors during QE auctions, and highlights the role of bond supply.

2) The share of Preferred Habitat trade volumes has decreased during QT auctions relative to QE auctions, and even more so for long maturity bonds. Conversely, the role of arbitrageurs has increased.

- During QT, we find no significant Preferred Habitat demand effects.

Preview of Main Findings

1) Higher ICPF investor sales to dealers leads to higher bid prices during QE auctions, consistent with Preferred Habitat demand theory. The effect decreases as available bond supply increases.

- Our findings confirm the importance of the demand from institutional investors during QE auctions, and highlights the role of bond supply.

2) The share of Preferred Habitat trade volumes has decreased during QT auctions relative to QE auctions, and even more so for long maturity bonds. Conversely, the role of arbitrageurs has increased.

- During QT, we find no significant Preferred Habitat demand effects.

3) Empirical findings are consistent with the extension of a theoretical Vayanos-Vila model, in which Preferred Habitat demand elasticities are not constant but depend on the scarcity of supply.

Preview of Main Findings

1) Higher ICPF investor sales to dealers leads to higher bid prices during QE auctions, consistent with Preferred Habitat demand theory. The effect decreases as available bond supply increases.

- Our findings confirm the importance of the demand from institutional investors during QE auctions, and highlights the role of bond supply.

2) The share of Preferred Habitat trade volumes has decreased during QT auctions relative to QE auctions, and even more so for long maturity bonds. Conversely, the role of arbitrageurs has increased.

- During QT, we find no significant Preferred Habitat demand effects.

3) Empirical findings are consistent with the extension of a theoretical Vayanos-Vila model, in which Preferred Habitat demand elasticities are not constant but depend on the scarcity of supply.

- Results point to the state-dependency of the preferred habitat channel during the two phases of unconventional monetary policy.

Related Literature and Contribution

Theory:

- Preferred Habitat (PH) demand, *Modigliani & Sutch (1966)*.
- Financial market implications of PH theory and Portfolio Balance channel of QE, e.g. *Vayanos & Vila (2009, 2021), Greenwood & Vayanos (2014), King (2019)*.

Related Literature and Contribution

Theory:

- Preferred Habitat (PH) demand, *Modigliani & Sutch (1966)*.
- Financial market implications of PH theory and Portfolio Balance channel of QE, e.g. *Vayanos & Vila (2009, 2021), Greenwood & Vayanos (2014), King (2019)*.

Empirics:

- Existence of PH investors in gilt markets, *Giese et al (2021)*.
- Indirect analysis of PH demand role during QE1-2, *Joyce et al (2017)*.
- Analysis of auctions data to capture PH demand shocks: *Ray, Droste, Gorodnichenko (2023), Joyce & Lengyel (2024)* .

Related Literature and Contribution

Theory:

- Preferred Habitat (PH) demand, *Modigliani & Sutch (1966)*.
- Financial market implications of PH theory and Portfolio Balance channel of QE, e.g. *Vayanos & Vila (2009, 2021), Greenwood & Vayanos (2014), King (2019)*.

Empirics:

- Existence of PH investors in gilt markets, *Giese et al (2021)*.
- Indirect analysis of PH demand role during QE1-2, *Joyce et al (2017)*.
- Analysis of auctions data to capture PH demand shocks: *Ray, Droste, Gorodnichenko (2023), Joyce & Lengyel (2024)* .

This Paper's Contribution:

- We use a novel blend of QE/QT auction and transaction data to create an observable measure of PH demand.
- We propose a new model of PH demand with state dependent elasticities, allowing for the asymmetric transmission of QT/QE.

Institutional Background: BoE's QE and QT Programmes

- Between 2009-2012, the BoE purchased £375 billion of gilts (QE1-QE3) financed by the creation of central bank reserves.
- In August 2016, the BoE announced an extra £60 billion (QE4).
- QE5 in March 2020. The stock of gilts peaked at £875 billion.
- Between different rounds, the stock of QE purchases was maintained by reinvesting the principle amount of maturing gilts.
- The MPC announced the key principles for its approach to QT in August 2021: Bank Rate as the primary active tool for monetary policy tightening, the intention not to disrupt market functioning, sales in a relatively gradual and predictable manner.
- In February 2022 passive QT (i.e. ending the reinvestment) began, and active gilt sales commenced in September 2022
- As of October 2024, QT has reduced the size of the BoE gilt stock by over 25 percent.

Institutional Background: BoE Auctions

- The Bank of England implemented QE through a series of 'reverse auctions' with a multi-object, multi-unit, discriminatory price auction format.
- The QT auctions have been conducted in a symmetric way to the QE format.
- The BoE set a schedule of auctions aiming for an even implementation across maturity sectors: 3-7 years (short), 7-20 years (medium) and over 20 years (long).

Data

We merge the following two in-house datasets by date, primary dealer, and bond:

- **APF Auctions Data:** individual dealer bid-level data by auction date, dealer LEI, and bond ISIN including bid spread to benchmark yield and bid quantity. Latest auctions data as of end June 2024.
- **Mifid 2 regulatory data:** gilt transactions data by date, counterparty identities and sectors, bond ISINs, transaction prices and quantities. Sample begins Jan 2018.

Data

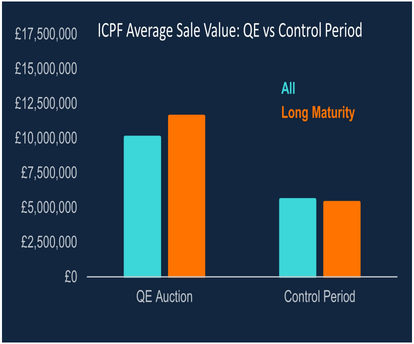
We merge the following two in-house datasets by date, primary dealer, and bond:

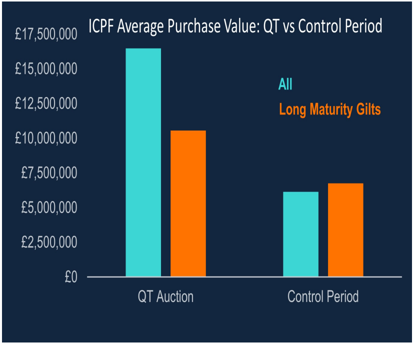
- **APF Auctions Data:** individual dealer bid-level data by auction date, dealer LEI, and bond ISIN including bid spread to benchmark yield and bid quantity. Latest auctions data as of end June 2024.
- **Mifid 2 regulatory data:** gilt transactions data by date, counterparty identities and sectors, bond ISINs, transaction prices and quantities. Sample begins Jan 2018.

Bond specific data:

- Free-float data from the UK DMO.
- Specialness (difference between the repo rate and the general collateral (GC) repo rate).

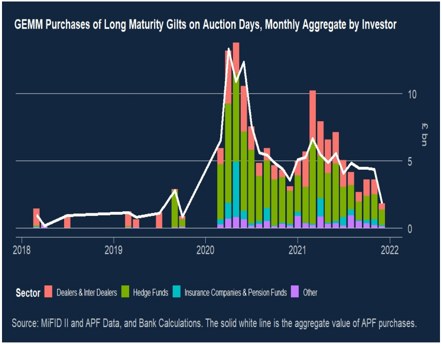
ICPF Trade Volumes on Auction Days vs Non-Auction Days

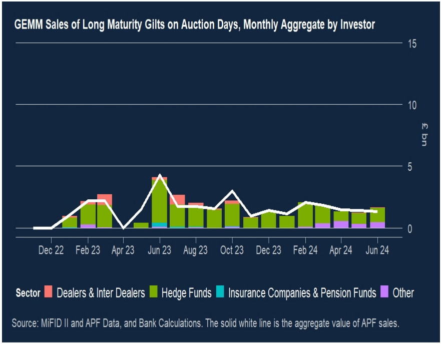




- The control period is between 2018 and 2020 when no QE re-investments or DMO auctions took place.
- As intended, QE and QT auctions stimulate trading activity from ICPFs. But average volumes do not reveal their participation rate.

Matching Auctions Data with Mifid Data





- Other includes: asset managers, retail, trading services, foreign official, trading venue, etc.

Testing Key Predictions of Preferred Habitat Theory

$$
\begin{aligned}
&(\text{Av. Spread to Benchmark Yield})_{i,b,t} = \\
&\quad = \beta_1 \left(\frac{\text{Preferred Habit Amount Sold to Dealer}}{\text{Total Amount Sold to Dealer}} \right)_{i,b,t} \\
&\quad + \beta_2 \left(\frac{\text{Hedge Fund Amount Sold to Dealer}}{\text{Total Amount Sold to Dealer}} \right)_{i,b,t} \\
&\quad + \beta_3 \text{ Bid Quantity}_{i,b,t} + \beta_4 \text{ Dealer Constraint}_{i,t} + \Xi \text{ Bond Controls}_{b,t} \\
&\quad + \beta_0 + \xi_i + \mu_b + \psi_t + \epsilon_{i,b,t}
\end{aligned} \tag{1}
$$

Testing Key Predictions of Preferred Habitat Theory

$$
\begin{aligned}
&(\text{Av. Spread to Benchmark Yield})_{i,b,t} = \\
&\quad = \beta_1 \left(\frac{\text{Preferred Habit Amount Sold to Dealer}}{\text{Total Amount Sold to Dealer}} \right)_{i,b,t} \\
&\quad + \beta_2 \left(\frac{\text{Hedge Fund Amount Sold to Dealer}}{\text{Total Amount Sold to Dealer}} \right)_{i,b,t} \\
&\quad + \beta_3 \text{ Bid Quantity}_{i,b,t} + \beta_4 \text{ Dealer Constraint}_{i,t} + \Xi \text{ Bond Controls}_{b,t} \\
&\quad + \beta_0 + \xi_i + \mu_b + \psi_t + \epsilon_{i,b,t}
\end{aligned} \tag{1}
$$

- Hypothesis 1: For QE auctions, $\beta_1 < 0$ as Preferred Habitat investors value bonds more than other investors.

Testing Key Predictions of Preferred Habitat Theory

$$
\begin{aligned}
&(\text{Av. Spread to Benchmark Yield})_{i,b,t} = \\
&\qquad = \beta_1 \left(\frac{\text{Preferred Habit Amount Sold to Dealer}}{\text{Total Amount Sold to Dealer}} \right)_{i,b,t} \\
&\qquad + \beta_2 \left(\frac{\text{Hedge Fund Amount Sold to Dealer}}{\text{Total Amount Sold to Dealer}} \right)_{i,b,t} \\
&\qquad + \beta_3 \text{ Bid Quantity}_{i,b,t} + \beta_4 \text{ Dealer Constraint}_{i,t} + \Xi \text{ Bond Controls}_{b,t} \\
&\qquad + \beta_0 + \xi_i + \mu_b + \psi_t + \epsilon_{i,b,t}
\end{aligned} \tag{1}
$$

- Hypothesis 1: For QE auctions, $\beta_1 < 0$ as Preferred Habitat investors value bonds more than other investors.
- Hypothesis 2: The magnitude of the effect will increase for longer maturity bonds.

Testing Key Predictions of Preferred Habitat Theory

$$
\begin{aligned}
&(\text{Av. Spread to Benchmark Yield})_{i,b,t} = \\
&\quad = \beta_1 \left(\frac{\text{Preferred Habit Amount Sold to Dealer}}{\text{Total Amount Sold to Dealer}} \right)_{i,b,t} \\
&\quad + \beta_2 \left(\frac{\text{Hedge Fund Amount Sold to Dealer}}{\text{Total Amount Sold to Dealer}} \right)_{i,b,t} \\
&\quad + \beta_3 \text{ Bid Quantity}_{i,b,t} + \beta_4 \text{ Dealer Constraint}_{i,t} + \Xi \text{ Bond Controls}_{b,t} \\
&\quad + \beta_0 + \xi_i + \mu_b + \psi_t + \epsilon_{i,b,t}
\end{aligned} \tag{1}
$$

- Hypothesis 1: For QE auctions, $\beta_1 < 0$ as Preferred Habitat investors value bonds more than other investors.
- Hypothesis 2: The magnitude of the effect will increase for longer maturity bonds.
- Hypothesis 3: The effect will be state dependent and larger when arbitrageurs are trading less.

Panel Regression Results

Main takeaway: preferred habitat demand channel is significant and negative, in-line with null hypothesis.

Dependent Variable: Average Bid Spread to Benchmark Yield							
	QE				QT		
	(1)	(2) TTM > 20	(3)	(4) HF Ratio < 5%	(5)	(6)	(7)
PH Ratio	-0.008***	-0.011**	-0.005*	-0.008**	0.004	0.000	0.000
	(0.003)	(0.005)	(0.003)	(0.003)	(0.009)	(0.018)	(0.004)
HF Ratio	-	-	0.007**	0.385	-	-0.007	-0.009***
			(0.003)	(0.271)		(0.023)	(0.002)
Controls & FE's	✓	✓	✓	✓	✓	✓	✓
Clustered SE's	✓	✓	✓	✓	✓	✓	✓
PH Ratio > 0	✓	✓	✓	✓	✓	✓	✗
Observations	1,901	1,110	1,901	1,368	153	153	1,095
Adj R-squared	0.231	0.356	0.233	0.192	-0.185	-0.204	0.189

Panel Regression Results: Interest Rate Risk

Main takeaway: interest rate risk does not meaningfully change the results.

Dependent Variable: Average Bid Spread to Benchmark Yield							
	QE				QT		
	(1)	(2) TTM > 20	(3)	(4) HF Ratio < 5%	(5)	(6)	(7)
PH Ratio	-0.007** (0.003)	-0.009* (0.005)	-0.005* (0.003)	-0.008** (0.003)	0.009 (0.011)	0.004 (0.022)	0.000 (0.004)
HF Ratio	-	-	0.007* (0.003)	0.193 (0.130)	-	-0.010 (0.026)	-0.010*** (0.002)
Duration	0.002 (0.002)	0.001 (0.004)	0.002 (0.002)	0.002 (0.003)	0.008 (0.035)	0.010 (0.031)	0.015* (0.008)
IR Vol	0.097 (0.093)	0.032 (0.143)	0.106 (0.093)	0.164 (0.132)	-5.156 (5.815)	-5.229 (5.839)	0.558 (0.779)
Controls & FE's	✓	✓	✓	✓	✓	✓	✓
Clustered SE's	✓	✓	✓	✓	✓	✓	✓
PH Ratio > 0	✓	✓	✓	✓	✓	✓	✗
Observations	1,897	1,107	1,897	1,365	136	136	1,044
Adj R-squared	0.246	0.381	0.247	0.207	-0.123	-0.143	0.146

Panel Regression Results Checks: Larger Event Window

Main takeaway: preferred habitat demand effects are strongest on the day of the auction.

Dependent Variable: Average Bid Spread to Benchmark Yield						
	QE			QT		
	(1)	(2)	(3)	(4)	(5)	(6)
PH Ratio	-0.008***			0.004		
	(0.003)			(0.009)		
PH Ratio + 1 Day		-0.006*			-0.008	
		(0.003)			(0.010)	
PH Ratio + 2 Days			-0.004			-0.003
			(0.003)			(0.007)
Controls & FE's	✓	✓	✓	✓	✓	✓
Clustered SE's	✓	✓	✓	✓	✓	✓
PH Ratio Window > 0	✓	✓	✓	✓	✓	✓
Observations	1,901	1,973	1,979	153	165	165
Adj R-squared	0.231	0.236	0.224	-0.185	-0.151	-0.160

What Does Market Intelligence Say?

FINANCIAL TIMES

HOME WORLD UK COMPANIES TECH MARKETS CLIMATE OPINION LEX WORK & CAREERS LIFE & ARTS HTSI

Gilts Added

UK told to issue more short-dated debt as pension fund demand wanes

Bond dealers and investors highlight 'structural shift' in gilt buying

Share Save

The UK's large private pensions industry has long been a cornerstone of the gilt market © Bloomberg

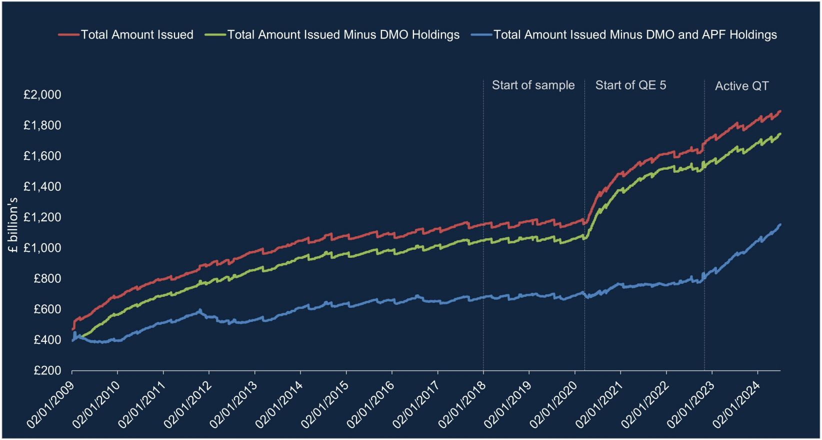
Mary McDougall in London JANUARY 30 2024 63

Get ahead with daily markets updates. **Join the FT's WhatsApp channel**

The UK government has been told to scale back its issuance of long-dated and inflation-linked bonds as pension funds' appetite for such debt wanes in a "significant structural change" to demand.

Gilt issuance plans for the 2024-25 financial year should take into account a reduction in demand of longer maturity gilts, "in particular from the domestic pension fund sector", the minutes of an annual meeting between the UK's Debt Management Office, bond dealers and investors showed on Tuesday.

The Backdrop: UK Government Bond Issuance



- Chart displays nominal value of conventional gilts, which account for $>75\%$ of debt issued (£1.9tr), with index-linked the rest (£600bn).
- Since start of active QT, nominal free-float of conventional gilts has increased by over 44% (£803bn to £1153bn).

Panel Regression Results: Bond Supply

Main takeaway: a higher bond free float reduces the preferred habitat demand effect.

Dependent Variable: Average Bid Spread to Benchmark Yield			
		QE	
	(1)	(2)	(3)
PH Ratio	-0.008***	-0.011***	-0.008**
	(0.003)	(0.004)	(0.003)
High Free Float	-	0.005	0.001
		(0.002)	(0.004)
PH Ratio × High Free Float	-	0.005**	0.005**
		(0.002)	(0.002)
HF Ratio	-	-	0.008**
			(0.003)
Controls & FE's	✓	✓	✓
Clustered SE's	✓	✓	✓
PH Ratio > 0	✓	✓	✓
Observations	1,901	1,901	1,901
Adj R-squared	0.231	0.231	0.233

A Model of State-Dependent Habitat Demand

- To make sense of our empirical findings, we extend the preferred habitat model of Vayanos & Vila (2021).

A Model of State-Dependent Habitat Demand

- To make sense of our empirical findings, we extend the preferred habitat model of Vayanos & Vila (2021).
- In the model, interest rates are determined by the interaction of:
  - Bond intermediaries (*arbitrageurs*) with limited risk-bearing capacity.
  - Clientele investors, specializing in specific maturities (*preferred habitat*).

A Model of State-Dependent Habitat Demand

- To make sense of our empirical findings, we extend the preferred habitat model of Vayanos & Vila (2021).
- In the model, interest rates are determined by the interaction of:
  - Bond intermediaries (*arbitrageurs*) with limited risk-bearing capacity.
  - Clientele investors, specializing in specific maturities (*preferred habitat*).
- In our extension, preferred habitat demand depends on prices *and* the available supply of bonds.

Model Details: Arbitrageurs

- Continuum of zero-coupon bonds: price/yields $y_t^{(\tau)} \equiv -\frac{1}{\tau}\log P_t^{(\tau)}$ and maturities $0 \leq T \leq \infty$. Short rate $r_t \equiv \lim_{\tau \to 0} y_t^{(\tau)}$ (exogenous).
- Arbitrageurs problem:

$$\max_{\{X_t^{(\tau)}\}} E_t \, \mathrm{d}W_t - \frac{a}{2} V_t \, \mathrm{d}W_t$$

$$\text{subject to: } \mathrm{d}W_t = W_t r_t \, \mathrm{d}t + \int_0^T X_t^{(\tau)} \left[\frac{\mathrm{d}P_t^{(\tau)}}{P_t^{(\tau)}} - r_t \, \mathrm{d}t \right] \mathrm{d}\tau$$

- Arbitrageurs invest $X_t^{(\tau)}$ in bond carry trade of maturity τ.
- Remainder of wealth W_t invested at the short rate.
- Risk-return trade-off governed by a
  - Formally: risk aversion coefficient.
  - More generally: proxies for any limits to risk-bearing capacity or intermediation frictions.

Model Details: Habitat Demand

- Habitat bond demand (exogenous) for maturity τ:

$$Z_t^{(\tau)} = -\alpha_t(\tau) \log P_t^{(\tau)} - \beta_t^{(\tau)}$$

- Elasticity $\alpha_t(\tau) > 0$ depends on maturity τ and varies over time, as a function of outstanding stock of bonds.
- We model elasticities such that $\alpha_t(\tau) \to 0$ as the outstanding stock of bonds increases ("satiation").
- "Noise demand" captured by $\beta_t^{(\tau)}$.

Model Details: Equilibrium

- Time-variation in demand elasticities $\implies$ no longer consistent with time-homogenous (log) affine solution (as in Vayanos & Vila 2021).
- Can still decompose bond prices as

$$
\begin{aligned}
-\log P_t^{(\tau)} &= \mathbf{A}(\tau, \mathbf{q}_t)^\top \mathbf{q}_t + C(\tau) \\
\implies \frac{\mathrm{d}P_t^{(\tau)}}{P_t^{(\tau)}} &= \mu(\tau, \mathbf{q}_t)\,\mathrm{d}t + \boldsymbol{\sigma}(\tau, \mathbf{q}_t)\,\mathrm{d}\mathbf{B}_t
\end{aligned}
$$

- Arbitrageur optimality conditions imply that

$$
\mu(\tau, \mathbf{q}_t) - r_t = \boldsymbol{\sigma}(\tau, \mathbf{q}_t)\boldsymbol{\Lambda}_t, \quad \boldsymbol{\Lambda}_t^\top = a \int_0^T X_t^{(\tau)} \boldsymbol{\sigma}(\tau, \mathbf{q}_t)\,\mathrm{d}\tau
$$

Equilibrium Intuition

- Market price of risk

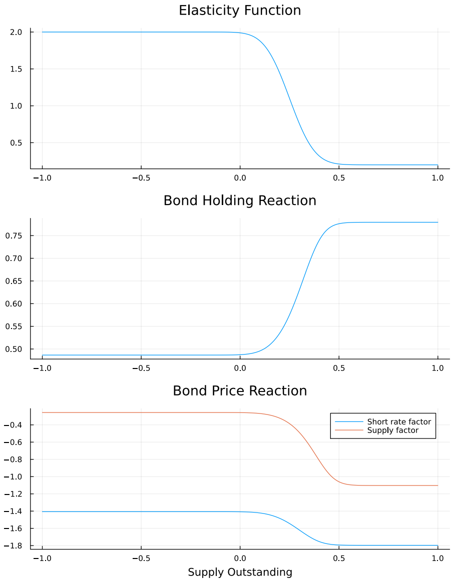
$$\mathbf{\Lambda}_t^\top = a \int_0^T X_t^{(\tau)} \boldsymbol{\sigma}(\tau, \mathbf{q}_t)\, \mathrm{d}\tau$$

- Function of:
  - Arbitrageur risk aversion (a)
  - Risk exposure (holdings $X_t^{(\tau)}$ and endogenous volatility $\boldsymbol{\sigma}(\tau, \mathbf{q}_t)$)
- Through market clearing, risk exposure and volatility depend on time-variation in demand elasticities. Intuition:
  - Increase in supply shock $\implies \uparrow S_t^{(\tau)}$
  - In order to hold more bonds, arbitrageurs must be compensated $\implies \uparrow y_t^{(\tau)}$
  - If outstanding supply is low, then $\alpha_t(\tau) \gg 0 \implies \uparrow Z_t^{(\tau)}$
  - If not, then $\alpha_t(\tau) \approx 0 \implies \uparrow X_t^{(\tau)}$

Numerical Example

- Numerically explore the implications in a simple two-factor version of our model.
- Illustrative calibration:
  - Independent factors $\mathbf{q}_t$ consist of short rate r_t and a supply factor s_t.
  - Mean reversion of short rate and supply shocks: $\gamma_r = 0.5$ and $\gamma_s = 0.2$, respectively.
  - Volatilities: $a \cdot \sigma_r^2 = 0.05$ and $a \cdot \sigma_s^2 = 0.1$ (for the purposes of studying how bond prices react, we do not need to separately calibrate physical risk and risk aversion).
  - Approximation: dirac supply function $\theta(\tau) = \delta(\tau - \tau^*)$ for $\tau^* \gg 0$.
  - Habitat demand elasticities vary from 2.0 (when supply s_t is low) to 0.2 (when supply s_t is high).

Numerical Example



Implications

- Thus, our model delivers richer and more intuitive yield curve model features.
- As in Vayanos & Vila, following an increase in supply:
  - Arbitrageurs increase bond holdings
  - Yields increase
- In addition, when outstanding stock of bonds is large:
  - Increase in arbitrageur bond holdings is larger
  - Yield reaction to supply change is larger and more volatile
- Note of caution for policymakers who hope that QT will be like "watching paint dry": response to QT may be uneventful while outstanding bond supply remains low, but once habitat investor demand is highly satiated, a decline in demand elasticities could lead to significantly larger price reactions.

Conclusions

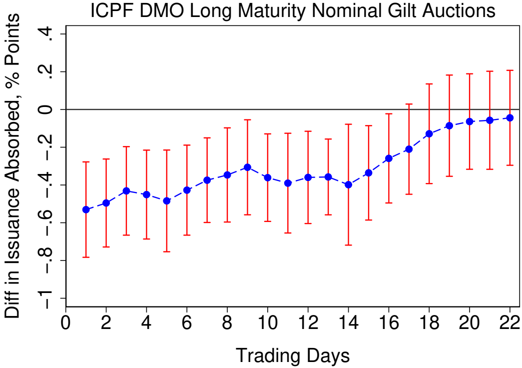
- Findings clearly show the existence of Preferred Habitat demand during QE. This is a vital requirement for the portfolio rebalancing channel to operate.
- On QT auction days, we find no significant Preferred Habitat demand effects.
- Results point to the state-dependency and the asymmetric role of the portfolio rebalance channel during the two phases of unconventional monetary policy.
- We propose a new model of Preferred Habitat demand, with state-dependent elasticities, which is consistent with these findings.

Conclusions and Policy Implications

- The size of the government bond debt is fundamental for the portfolio balance mechanism of the unconventional monetary policy, and thus have to be considered ahead of policy implementation decisions.
- Based on new empirical and theoretical understanding of QE and QT, our recommendation for optimal exit from QE would not be very different to the principles announced when the QT was still considered to be novelty.
- The exit from unconventional monetary policy should be implemented gradually and in a predictable manner.

Evidence From DMO Auctions

$$\text{Gilt Absorption Ratio}_{i,\tau} = \sum_{d=1}^{22} \beta_d \, \mathbb{1}[\tau = d] \times \text{QT Period} + \alpha_i + \alpha_t + \epsilon_{i,\tau}. \tag{2}$$



Net purchases of auctioned nominal gilt from DMO auctions between the pre-QE5 period (April 2018 to March 2020), and the ongoing QT period.

Evidence From DMO Auctions

- We calculate net volumes (total purchase volumes minus sales) relative to the auctioned bond amount, across a range of investor groups up to 22 trading days (approximately one month) after a given DMO auction for long maturity gilts only.
- Preferred habitat demand for long maturity nominal gilts is significantly less in the QT period than during the pre-QE5 period, by as much as 50 percentage points in the immediate aftermath of the auction.
- This reduction persists even up to 3 weeks after the auction date, after which the coefficient estimate finishes negative but not statistically significant from 0.

Model Details: Dynamics and Market Clearing

- In general, dynamics are governed by risk factors $\mathbf{q}_t \in \mathbb{R}^J$ which evolve according to

$$\mathrm{d}\mathbf{q}_t = -\boldsymbol{\Gamma}\mathbf{q}_t\,\mathrm{d}t + \boldsymbol{\sigma}\,\mathrm{d}\mathbf{B}_t$$

- Dynamics and diffusion matrices $\boldsymbol{\Gamma}, \boldsymbol{\sigma}$ are primitives
- Outstanding stock of bonds with maturity τ and market clearing:

$$S_t^{(\tau)} \equiv \hat{\boldsymbol{\Theta}}(\tau)^\top \mathbf{q}_t$$
$$S_t^{(\tau)} = X_t^{(\tau)} + Z_t^{(\tau)}$$

  - Function $\boldsymbol{\Theta}(\tau)$ governs how movements in risk factors lead to changes in the supply of τ-maturity bonds