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QT versus QE: who is in when the central bank is out?

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Abstract

We analyse the role of preferred habitat (PH) demand in the transmission of quantitative tightening (QT) and quantitative easing (QE) programmes. For this, we combine granular data from Bank of England QT and QE auctions with secondary market bond level transaction data. We find that when dealers traded on behalf of pension funds and insurance companies, their bidding at QE auctions was less elastic, in line with PH demand theory. In contrast, during QT auctions, there is no evidence of significant PH demand pressures. To account for the observed asymmetric demand effects during QE and QT, we build on and extend the constant elasticity demand model by Vayanos and Vila (2021), so that the PH demand elasticity can depend on available bond supply. We show that the decreased role of the PH demand channel during QT is consistent with the increased government bond issuance post the Covid-19 pandemic.

Key words: Quantitative easing, quantitative tightening, central bank auctions, monetary policy, monetary transmission mechanism, preferred habitat, gilt market.

JEL classification: E43, E52, E58, G2, G12.

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1 Introduction

In 2021, after more than a decade of unconventional monetary policy easing, major central banks around the world returned to the "old-fashioned" ways of policy making - by changing short term interest rates. And while the monetary authorities are relatively comfortable with using interest rates as a primary active tool for policy tightening, they also had to deal with Quantitative Tightening (QT).

The central banks stepped into the uncharted territory of QT without much guidance from monetary economics. Even after several years of QT implementation, which is essentially the reversal of previously implemented Quantitative Easing (QE), the literature still does not provide a clear understanding of its transmission. Little is known on how this fairly new monetary policy tool works, how it affects financial markets, notwithstanding the wider economy, and how its workings compare to the QE transmission channels.

Our paper aims to fill this gap. By analyzing the mechanics of QT and how it compares to QE, in this paper we focus on two channels, the so-called 'preferred habitat' (PH) demand channel and the 'portfolio balance' channel. These are the channels that policy makers expected a-priori to be the main operating channels during QT (see e.g. Schnabel (2023)).

The portfolio balance channel gained prominence in policy making and academic circles during the early stages of QE. During these early stages, it was assumed that for QE to lower bond yields by shrinking the supply of longer-term bonds ('portfolio balance channel') some investors must have a preference for bonds of specific maturities (see Busetto et al. (2022), for the discussion). Insurance companies and pension funds (ICPFs) are a classic example of such 'preferred habitat' investors as they have a special demand for longer maturity bonds.

However, in evaluating QE policies, the importance of PH demand has tended to be either assumed or implicitly inferred from the market structure insights (see e.g. Giese et al. (2024) or from the analyses of earlier shocks to the safe asset supply (as e.g. Duarte and Umar (2024)). The explicit role of PH demand for the transmission of QE and QT programmes has been hard to pin down, mainly because the demand is unobservable and therefore hard to measure. In this paper, we propose to overcome this obstacle by using the unique experience of the Bank of England (BoE). The active approach to QT chosen by the BoE is different to the approaches used by most other central banks (such as the Federal Reserve or the ECB), which have employed a passive QT so far, thereby letting their asset portfolio that they accumulated during QE unwind in a natural way as assets mature. The BoE, instead, has in addition been actively selling the QE assets into the secondary markets via auctions since 2022.

Our idea is to combine and analyse granular BoE auctions data jointly with the detailed transaction level data around the central bank auctions, focussing on potentially distinct patterns of trade between dealers and ICPFs during QE and QT monetary policy periods. The BoE auctions data provide rich insights into the bidding behaviour of auction participants, allowing us to study the bidding behaviour of dealers during auctions and investigate whether the auction bidding has been affected by the identity and type of the dealers' trading counter-parties around the auctions. Therefore, ours is the first study to use central bank proprietary auctions data in order to estimate the role of PH demand in QE/QT transmission during specific programmes.

Our results indicate that higher sales to dealers by ICPFs lead to relatively less elastic bidding at the QE auctions, or in other words, higher auction bid prices, consistent with PH demand theory. These findings provide direct evidence for the importance of the PH demand coming from ICPFs during QE implementation. Instead, during the QT phase, we do not detect any special role of ICPF investors in the policy transmission. The results therefore also imply that while QE puts downward pressure on gilt yields at the times when PH demand was strong, there seems to be no effects of excess PH demand on gilt yields during QT.

The empirical results on the asymmetric effects of the PH demand channel during QT versus QE remain robust when we account for the potentially asymmetric roles of interest rate volatility and dealer intermediation capacity during the two periods. Moreover, we also provide further empirical evidence on the relative weakness of the PH demand channel in the post COVID-19 state of the world by analysing net purchases of long maturity gilts from PH investors following primary UK government gilt auctions by Debt Management Office (DMO) during QT and pre-QT periods.

At the same time, our empirical findings present a challenge to the current views established in the theoretical literature. According to the seminal PH demand model by Vayanos and Vila (2009, 2021), the impacts of the equally sized purchases and sales on the yield curves are symmetric, and so QE and QT are expected to be mirror images of one another. Vayanos and Vila (2009, 2021) make some specific and simplistic assumptions about PH demand, however. Namely, their model is built on the assumption of a constant demand elasticity, which turns out to be key for determining the implied symmetric nature of QT and QE impacts.

We propose to build on and extend Vayanos and Vila (2021) to a more generalized demand elasticity model, so that the elasticity of PH demand can depend on the bond supply available to investors. As a result, we show that the decreased role of the PH demand channel during QT can be explained by the increased government bond issuance since the COVID-19 pandemic.

Our empirical and theoretical findings thus reaffirm the importance of the state-dependent nature of the transmission of unconventional monetary policy. The portfolio balance channel comes out as asymmetric during the two phases of unconventional monetary policies. Specifically, its role relies on the overall supply of government debt and financial intermediation activity in the market.

These results are vital to policymakers, as they indicate that the monetary transmission mechanisms of QE and QT may be very different and contingent on the environment at which the policies are implemented. And while the notion of QE and QT state-contingency is not new (see eg Bailey et al. (2020), and Haldane et al. (2016), on the importance of different states of financial market conditions, or Gertler and Karadi (2013), and Cantore and Meichtry (2024) on the role of zero lower bound for policy rates), the nature of the state dependence uncovered in this paper is different to the alternatives already available in the literature. Importantly, we show that state dependence could arise through the changing size of the government debt issuance. Therefore, our findings highlight an additional feature of the state of the economy and financial markets to be considered to inform monetary policy decisions and the conduct of unconventional monetary policies.

The remainder of the paper is organized as follows. Section 2 reviews the recent literature on the role of investors' demand for the monetary policy transmission. The institutional background on Bank of England QE and QT and the data are described in Section 3 and Section 4, respectively. We subsequently present our testable hypotheses, estimation methodology and main empirical findings in Section 5. The theoretical model with time-varying elasticity of demand is presented in Section 6. Finally, Section 7 concludes our analysis.

2 Related literature

An increasingly large body of the monetary and finance literature is dedicated to studying the effects of official asset purchases and their unwind. Our work also belongs to this literature. However, there are some important distinguishing features that set us apart from the existing studies. In particular, our paper makes three main contributions to the literature.

First, ours is the first paper to explicitly evaluate the role of the preferred habitat demand in the QE and QT transmission mechanism.

The Preferred Habitat hypothesis of interest rates was developed by Modigliani and Sutch (1966); it suggests that market participants have a preferred habitat as they match the term structure of their assets and liabilities. For example, ICPFs are often thought to have a preference for bonds of specific longer maturities, because they tend to hold long-term assets in order to match their liabilities.

Several previous studies analysed this type of 'preferred habitat' investors. Giese et al. (2024) showed that the UK government bond (gilt) market is characterised by the significant presence of PH investors (including ICPFs), whose gilt holdings are less sensitive to changes in the price of gilts, in line with the idea that such investors value these assets for non-pecuniary reasons. They found that PH behaviour in the gilt market exists across the term structure and that foreign central banks (at shorter maturities) and ICPFs (at longer maturities) make up some of the PH investor groups. They also showed that some of these investors – including insurance companies – reduced their gilt holdings more than proportionately during the 2016 QE4 programme, in line with these investors playing a key role in the transmission of QE. Similarly, Joyce et al. (2017) showed that ICPFs were selling gilts to the Bank of England as part of the QE1 and QE2 programmes. However, although these studies do find the results consistent with the preferred habitat type of demand for gilts, they are unable to say if this type of behaviour was explicitly manifested during the QE auctions or whether it had significant impact on QE transmission to the gilt market as a result.[1]

Ours is the first study to address this question by using the granular QE auctions data. The Bank of England auctions data provide rich insights into the bidding behaviour of auction participants and hence are most suited for the analysis and evaluation of the portfolio balance channel of QE.[2] In this spirit, our paper is close to Ray et al.

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[1] Some studies tried to shed light on the role of portfolio balance by analysing how the impact of QE announcements varies across individual gilts, based on the presumption that if QE lowers gilt yields by shrinking the supply of gilts, then those gilts more likely to be purchased by the central bank should see larger drops in yields after announcements. For example, using this approach, McLaren et al. (2014) find that this was the case for the first two QE programmes. From their estimates, they calculate that this 'local supply' effect explains around half of the total impact of the QE1 and QE2 announcements on medium and long-term gilt yields.

[2] The Bank of England QE auctions data was used previously to study other questions, eg the

(2024), who exploit the structure of the primary market for U.S. Treasuries to proxy for QE transmission and, as a result, they are able to isolate and evaluate demand shocks that are transmitted solely through PH demand channels. The advantage of our paper is the direct use of granular QE auctions data. This enables us to explicitly estimate the effects of preferred habitat demand during QE transmission.

Our second main contribution is the comparative empirical analysis of the QE and QT transmissions. Various studies have investigated the impact of QE. Generally, the findings document meaningful effects of QE on financial markets (see, e.g., among many others, the evidence on the yield impact of QE announcements by Krishnamurthy and Vissing-Jorgensen (2012), Christensen and Rudebusch (2012), Swanson (2021)). In contrast, evidence on the impact of QE unwinding is scarce, mainly because there have to date only been a few attempts to actively do it. A couple of existing papers, such as Du et al. (2024) and D'Amico and Seida (2024), focus on the general impact of QT announcements by the Federal Reserve and other central banks on financial markets.[3] Joyce and Lengyel (2024) take a different approach and infer the effect of the Bank's initial QT programme from an analysis of the yield curve impact of individual debt security announcements by the UK's debt management office. By exploiting the longer history of debt issuance, they are able to quantify the role of the local supply and duration risk channels in explaining the reaction of yields under different market stress conditions. They then apply their estimates to the Bank's first QT programme, which unusually has involved both passive unwind and active sales. They find the local supply transmission channel to be important at the short and the long end of the yield curve, which is an indirect evidence for market segmentation and bond demand coming from preferred habitat investors.

Instead, given that the Bank of England is the first among the central banks to actively reduce its balance sheet in the form of asset sales back to the secondary market, we can focus exclusively on QT sales, zooming in on particular QT channels. This is a cleaner approach than disentangling the announcement affects of QT from all other policy and information effects communicated at the same time. Moreover, not only do we provide the first study of direct effects from active QT sales on gilt markets, we also examine the role of the state dependency in the asymmetric effects of QE and QT.

The third contribution of this paper is theoretical. While recently there have been several notions in the literature advocating the important role of the limited asset supply for QE transmission[4], the theory of PH demand for safe bonds has been guided so far by the seminal work of Vayanos and Vila (2009, 2021). Their model features a very simple PH demand function though. Crucially, they assume a constant demand

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QE liquidity impacts. For example, Boneva et al. (2022) use the granular offer-level data from the Corporate Bond Purchase Scheme auctions to construct proxy measures for the Bank of England's demand for bonds and auction participants' supply of bonds in order to control for any reverse causality from liquidity to purchases.

[3] While here we focus on the asset side of the central bank balance sheet and on the impacts of asset purchases and sales on financial markets and real activity, there is a recent complementary study of QE/QT by Kumhof and Salgado-Moreno (2024), who develop a theoretical framework to focus on the liability side, i.e. on the effect of reserve issuance and policy rules for reserves on macroeconomic and financial stability.

[4] For example, Jappelli et al. (2023) focus on the supply channel of QE. The non-linear transmission mechanism of QE is shown to be driven by demand/supply of special bonds, which could be elastic to quantities

elasticity, which is not consistent with the empirical results we find. In this paper we propose to build on and extend the PH demand model of Vayanos and Vila (2009, 2021). Our model is based on a more generic demand function, where the elasticity can depend on the quantity of the assets available to investors. This approach delivers non-linear and asymmetric market responses to asset purchase programmes, which turns out to be key for understanding the monetary policy transmission mechanism post-2009.

3 Institutional background: the BoE's QE and QT Programmes

The Bank of England switched to the unconventional monetary policy of gilt purchases in the aftermath of the Global Financial Crisis of 2008, when policy rates hit the effective lower bound (ELB). In about four years, from March 2009 to November 2012 (QE1-QE3), the BoE removed £375 billion of gilts from the market. The asset purchases were financed by the creation of central bank reserves and formally carried out by the Bank of England's Asset Purchase Facility Fund Limited which is a subsidiary of the BoE. (For more details on the structure of APF, see **?**.) On August 4, 2016, as part of a package of monetary policy measures, the BoE announced an extra £60 billion of government bond purchases (QE4). Additional government bond purchases (QE5) were announced in March 2020 in response to the Covid-19 outbreak, eventually bringing the total BoE QE holdings up to over 40 percent of nominal U.K. GDP once completed. The stock of gilts held in the APF peaked at £875 billion towards the end of 2021, following the implementation of further QE in response to the aftermath of the COVID-19 crisis. Between different rounds of QE, the stock of QE purchases was maintained by reinvesting the principle amount of maturing gilts.

Finally, the MPC announced the key principles underpinning its approach to QT in August 2021. The principles set out the use of Bank Rate as the primary active tool for monetary policy tightening, the intention to conduct sales so as not to disrupt the functioning of financial markets, and conducting sales in a relatively gradual and predictable manner. The BoE put the principles into practice in February 2022, initially via passive QT (i.e. through ending the reinvestment of maturing bonds) and eventually announcing active gilt sales in September 2022, when the MPC voted to reduce the stock of gilts held in the APF by £80 billion in the first year. Subsequently, at its September 2023 meeting, the MPC voted to reduce the stock of gilts held in the APF for monetary policy purposes by £100 billion over the period from October 2023 to September 2024, to a total of £658 billion. After around two years of implementation, QT reduced the size of the total APF by approximately 20 percent. It should be noted though, that although the reduction in the APF is substantial, the QT policy has been implemented in the environment of the much larger universe of the outstanding gilts due to the post-Covid increase in the gilt issuance. Figure 1 displays the nominal value of conventional gilts, which as of June 2024 account for over 75% of debt issued by the DMO (£1.9tr), with index-linked gilts accounting for the rest (£600bn). Since the start of active QT, the nominal free-float of conventional gilts has increased by 44% (£803bn to £1.15tr).

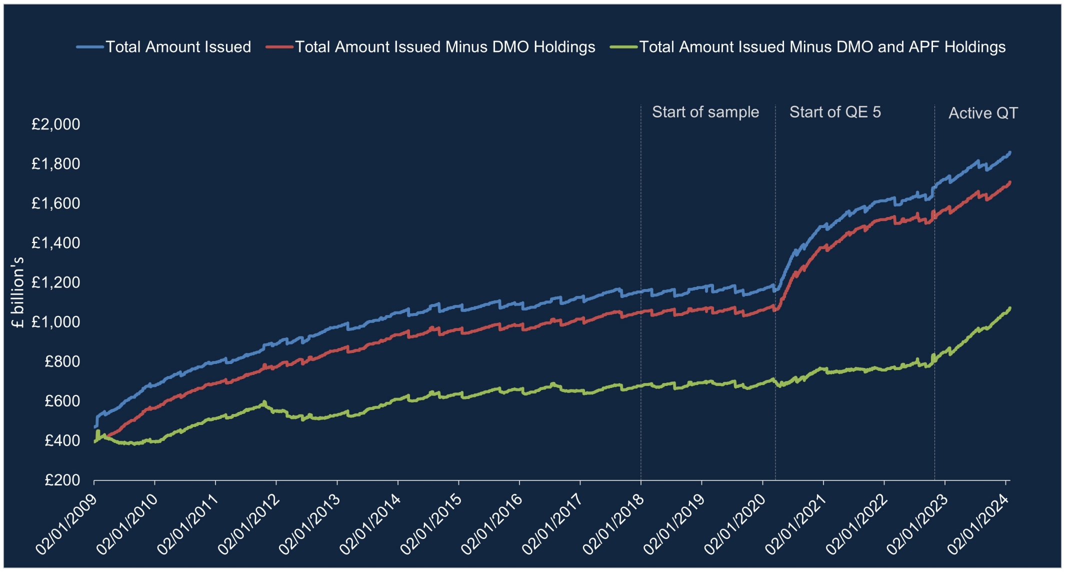

Figure 1: UK nominal gilts in circulation

Note: This figure plots the total UK nominal gilt issuance, total issuance minus DMO holdings, and total issuance minus DMO and APF holdings, in £ billions's since 2009.

3.1 BoE Auctions

The Bank of England implemented QE through a series of ‘reverse auctions’ with a multi-object, multi-unit, discriminatory price auction format. In this subsection we briefly outline how the auctions were conducted.

For each auction, participants were allowed to submit an unlimited number of offers containing a price, quantity, and the bond identifier (ISIN). Information about the offers is private. Eligible participants include the participants in the BoE’s gilt-purchase open market operations (OMOs) and the Gilt-Edged Market Makers (GEMMs), also known as ‘dealers’, as listed on the website of the U.K.’s Debt Management Office (DMO).[5] The BoE ran separate auctions for different maturity buckets and these auctions typically took place on different days of the week. Since the QE2 programme, the BoE normally ran three auctions per week, for 3-7, 7-15, and 15-50 year buckets. In the week ahead of each QE auction, the BoE published a list of eligible bonds. On auction days, dealers were expected to submit their bids to sell eligible gilts to the BoE between 14:15 to 14:45 (London time). In March 2020, when the Covid pandemic shook the UK’s economy and the markets, the maturity buckets and schedule were redefined so that the Bank could undertake three auctions per day, purchasing gilts with a residual maturity of 3-7 years at 12:15; 7-20 years at 13:15; and over 20 years at 14:15. The total amount purchased was aimed to be allocated evenly between the maturity sectors.[6] In

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[5] Market Participants (dmo.gov.uk)

[6] See also the most recent market notice for details on the design of the QE and QT auctions, available at: Asset Purchase Facility: Gilt Purchases - Market Notice 5 August 2021 — Bank of England and Asset Purchase Facility: Gilt Sales – Market Notice 21 June 2024 — Bank of England correspondingly.

general, the purchases conducted by the APF excluded gilts with residual maturity less than three years, gilts of which the BoE already holds more than 70 percent of free float, index-linked gilts, and gilts with an issue size of £4 billion or less. Gilts that were newly issued by the DMO in the week preceding the auction or those re-opened by the DMO either one week before or after the auction were also excluded. After the auction close, the received offers were ranked according to the spread between the offered yield and the secondary market yield prevailing at the auction close. The BoE accepted the most attractive bids until the announced volume was reached. Successful auction participants received their offer price, meaning that all purchases were undertaken on a discriminatory price basis. After the close of each auction, the BoE published aggregate auction results including quantities offered and allocated. Individual offers remain private to bidders and the BoE. Before and during each auction, the BoE closely monitored the developments in the secondary market and reserved the right to exclude a gilt from the auction should unusual price developments occur.

The QT auctions have been conducted in a symmetric way to the QE format. The BoE set a schedule of auctions aiming to reduce the APF as evenly as possible across maturity sectors. Similarly to QE auctions, the QT sectors are defined as gilts with a residual maturity between: 3-7 years (short), 7-20 years (medium) and over 20 years (long). In line with the MPC's approach and given the principle that QT should be gradual, QT auctions have been less frequent than QE; typically, there has been one auction per week (Monday), focusing on one maturity sector only. For more details on the BoE's approach to gilt sales see Asset Purchase Facility: Gilt Sales – Market Notice 1 September 2023 — Bank of England.

4 Data

The UK bond transactions data used for the analysis are reported under the Markets in Financial Instruments Regulation (EU), as set out in Article 26 of UK MiFIR, and made available to the BoE by the Financial Conduct Authority (FCA). The transactions dataset begins in January 2018 when the MiFID II framework was implemented and is the successor to the Zen data set, which is maintained by the FCA. The data set contains transaction level data for every bond trade including price, quantity, buyer identity, and seller identity. Given the transaction data are available from 2018, we have restricted our sample period to be from January 2018 to June 2024.

The innovative part of our paper comes from the novel use of the QE and QT auctions data obtained from the Bank of England Markets desk, which carries out bond auctions. This data set contains all individual bid prices and quantities for each dealer for each bond at each auction, as well as the bid's spread to the benchmark yield (established by the BoE at each auction). These data, in combination with the secondary market transaction data, enables us to analyse the role of the PH demand in the implementation of QE and QT.

Matching the two data sets allows us to link the amount of offers made by GEMMs at the BoE auctions to the trade flows between GEMMs and other investors around the auctions. In particular, we analyze the data by splitting transactions by different types of investors, such as dealers, hedge-funds, ICPFs (aka preferred habitat investors), and others. Finally, we also collect data on DMO auctions from the website of the DMO, which includes auction dates, auctioned bonds, as well as the issued amounts.

4.1 A closer look at the auctions data

Our sample covers 526 gilt auctions run by the BoE between January 2018 and June 2024, of which there are 447 QE auctions (including 75 reinvestment auctions before the new round of QE launched in March 2020) and 79 QT auctions.[7]

Table 1 provides summary statistics on all auctions in our sample, split into QE and QT phases. Focusing on the auction participation, we observe that the number of participating GEMMs was relatively stable over the sample, with 17 and 15 active during QE and QT auctions correspondingly. Each of them was successful in their bids at least once. The average number of eligible gilts per auction is 8, this was roughly the same for QE5 and QT auctions, although the number of auctioned bonds was smaller on average for the reinvestment auctions (just 5). On average, the maturity of auctioned gilts was slightly lower during QT sample than during QE sample (14.94 years versus 17.22 years). The bid-to-cover ratio is on average reasonably stable over different subsamples, although it tends to be lower for QT auctions. Nonetheless, as reflected in a good participation (same as during QE5) and cover ratio (of around 2), QT auctions have been attracting strong demand.

The bottom of Table 1 shows the same statistics focussing on long maturity bucket auctions only. Most of the participating dealers have been active in this maturity segment (the number of participating dealers in long maturity QT auctions and all maturity QT auctions is the same). In our sample, which consists of 143 QE auctions for long maturity gilts (out of 447 QE auctions) and 23 long maturity QT auctions (out of 79), the average auction size (*Allocated Amount Proceeds*) has been typically smaller for the long maturity auctions. The average number of eligible gilts per longer maturity auctions is also typically higher, ranging from 7 for the reinvestment auctions to 13 during QE5, comparing to 10 during QT. Correspondingly, we observe that the bid frequencies and sizes seem to differ across the QE and QT auctions. In the long maturity segment auctions, there was substantially higher average number of bids during QE rather than QT, and the average bid was also larger during QE.

4.2 A preliminary data analysis of secondary market activity

Before going into the details of our approach, here we share some stylised facts about the ICPFs and dealer activity around the auctions.

An initial data analysis suggests that ICPFs were actively trading with dealers in secondary markets around the times of QE auctions (both during reinvestment and active purchase phases) and QT auctions. The trading volumes by ICPF investors are displayed in Figure 2, which compares the trades on auction days to non-auction days.[8]

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[7] Since our focus is to analyse purchases for monetary policy implementation purposes, we excluded from the sample the BoE asset purchase auctions aimed to restore markets functioning during the LDI crisis in 2022. As Bandera and Stevens (2024) note, the 2022 intervention aimed to be temporary so that the monetary policy spillovers were as small as possible.

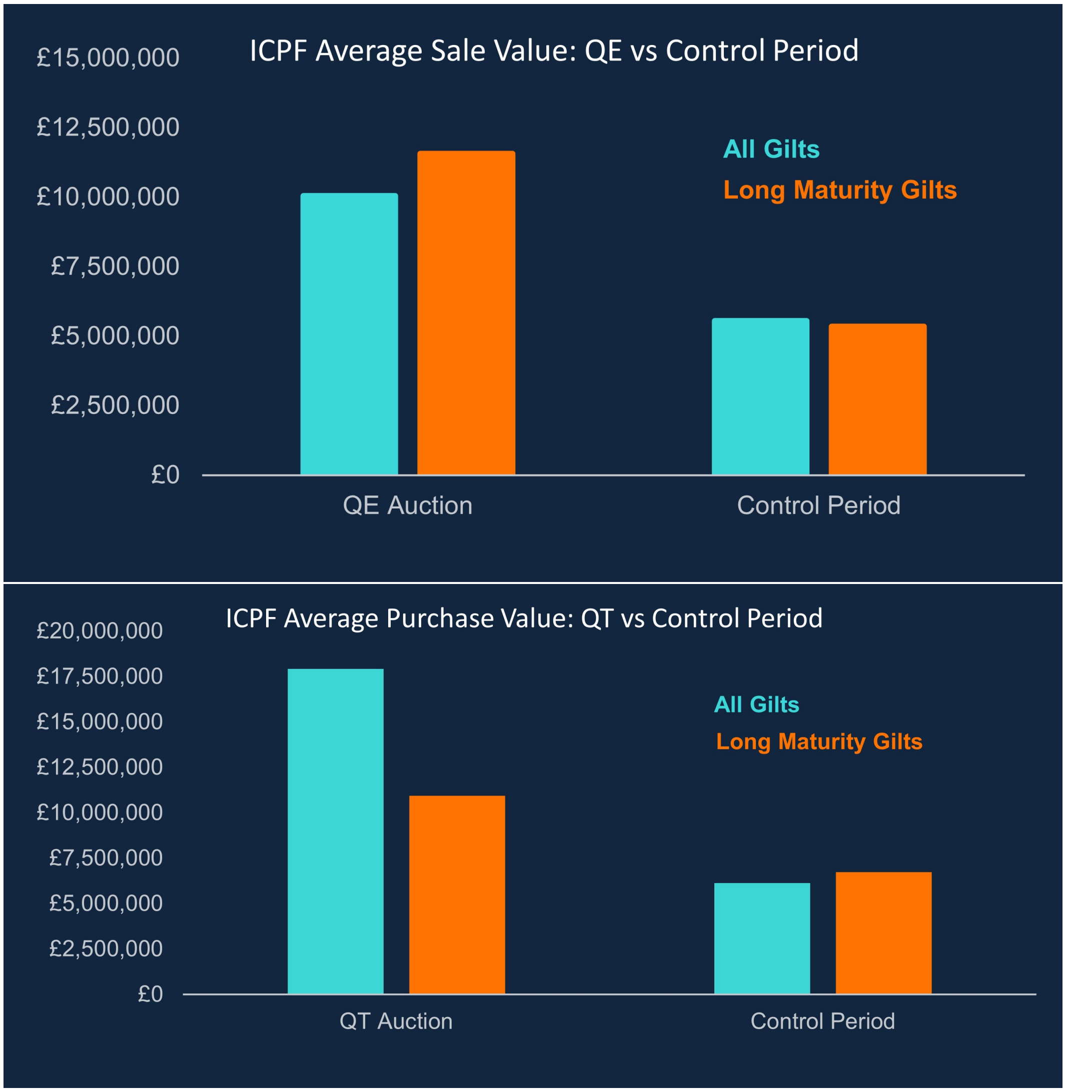
[8] As a control period for both the QE and QT comparison, we use transactions which took place between 2018 and 2020 before the start of QE 5, and in months where no reinvestment's took place, which is a total of 14 months.

Table 1: Summary Statistics of the auctions data

Note: This table displays the summary statistics for the main variables used in the regression analysis for the QE sample (2018-2021) and QT sample (2022-2024) separately. PH refers to Preferred Habitat investors, and HF refers to Hedge Funds.

	QE Sample			QT Sample
All Maturity Auctions	All QE	QE Reinvestments	QE5	All QT
Number of Auctions	447	75	372	79
Number of Participating Dealers	17	17	15	15
Total Number of Auctioned Bonds	54	36	50	44
Average Number of Auctioned Bonds	8	5	8	9
Bond Maturity, Yrs	17.22	15.98	17.35	14.94
Bid Amount, £m	58.26	75.39	56.48	-46.82
Allocated Amount Nominal, £m	18.14	22.67	17.67	-28.02
Allocated Amount Proceeds, £m	20.66	26.16	20.09	-20.30
Cover Ratio	3.42	6.46	2.81	2.29
Number of Auction Bids	61.91	34.72	67.39	35.22
Spread to Benchmark Yield, %	-0.02	-0.03	-0.02	0.01
Long Maturity Auctions	All QE	QE Reinvestments	QE5	All QT
Number of Auctions	143	19	124	23
Number of Participating Dealers	16	16	15	15
Total Number of Auctioned Bonds	24	18	22	19
Average Number of Auctioned Bonds	12	7	13	10
Bond Maturity, Yrs	31.21	34.25	30.98	31.24
Bid Amount, £m	40.42	62.66	38.68	-32.81
Allocated Amount Nominal, £m	13.16	12.99	13.18	-39.39
Allocated Amount Proceeds, £m	16.96	15.68	17.06	-19.14
Cover Ratio	3.57	12.47	2.28	1.72
Number of Auction Bids	74.21	40.63	79.35	35.52
Spread to Benchmark Yield, %	-0.02	-0.05	-0.02	0.01

The chart indicates the QE auctions were associated with higher trading activity from preferred habitat investors. Indeed, the average transaction value of gilts sold by ICPF investors to primary dealers on QE auction days is twice their normal amount when compared to the control period (i.e. months without auctions). A similar increase in transactions is observed during QT, suggesting that part of the market trading can be related to central bank auctions.



ICPF Average Sale Value: QE vs Control Period

ICPF Average Purchase Value: QT vs Control Period

Figure 2: ICPF trades with GEMMs around QE and QT auctions

Note: This figure plots the average purchase value of ICPF investors for QE and QT auctioned bonds on auction days, alongside the corresponding values during the control period when no APF auctions were held. Average values are provided for all gilts auctioned and longer maturity gilts (over 20 years time to maturity) separately.

As it can be seen from Figure 3, the secondary market trades on auction days and the dealers' trades at the APF auctions are closely matching, justifying our assumption on the link between them. These patterns are also consistent with the dealers' intermediary role; indeed, rather than being buy-and-hold investors, GEMMs tend to buy gilts from other investors in order to sell at QE auctions and tend to sell the purchased gilts after the QT auctions.[9] Finally, we also note that the trades between ICPFs and GEMMs at longer maturities, although relatively small, were nevertheless sizeable. We formally explore the relationship between the two in the next section.

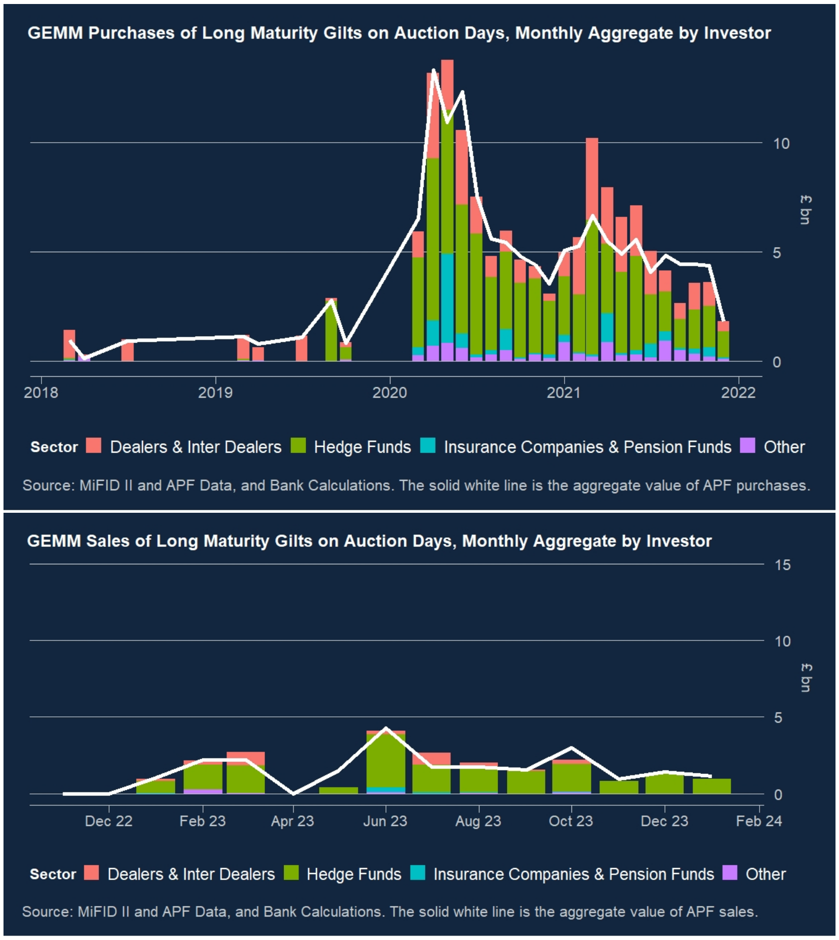


Figure 3: APF auctioned amounts and ICPF trades around the auctions

Note: This figure plots the aggregate value of APF purchases during QE auctions (top chart) and APF sales during QT auctions (bottom chart) for long maturity (over 20 years) bonds, alongside stacked bars which decompose the volumes bought from dealers by investor type, aggregated across months.

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[9] In fact, the choice of the U.K. primary dealers is based on their vital role in the secondary gilt market. For example, they provide liquidity to market participants on a continuous basis in all market conditions. In return, they are eligible to participate in the U.K. DMO primary auctions and related BoE operations.

5 Testable Hypotheses, Estimation Methodology and Results

In this section, we investigate how the trading volume of ICPFs investors with dealers affects the bidding behaviour of dealers during auctions. For this, we first provide testable hypotheses that would guide our empirical analysis.

Our first hypothesis is inspired by the literature that argues that ICPFs belongs to the preferred habitat group of investors because they have a strong and less elastic preference for government bonds than other investors (see, for example, Giese et al. (2024); Vayanos and Vila (2021)1; Krishnamurthy and Vissing-Jorgensen (2012). Our second hypothesis proposes that this effect would be higher for longer maturities, especially for very long maturities, where ICPFs display strongest preferred habitat (see Giese et al. (2024), and Vayanos and Vila (2021)). Correspondingly, we formulate the hypotheses as:

Hypothesis 1: The higher the trading volume between preferred habitat investors and dealers around the QE (or QT) auction day, the higher the dealer bid will be.

Hypothesis 2: The magnitude of the effect described by Hypothesis 1 will be larger for longer maturity bonds.

5.1 Estimation Methodology

In this subsection, we test our hypotheses and analyse the relationship between dealer bids at the APF auctions and the dealer trades with ICPFs with the help of panel regressions.

Let i refer to the individual dealer, b refer to the specific bond, and t to the auction date. Our dependent variable is the average yield spread to benchmark yield, $Y_{i,b,t}$, calculated as the average offer yield across all bids for bond b made by dealer i at a given auction minus the corresponding benchmark yield established by the BoE for that bond at that auction. The main variable of interest is $PHRatio_{i,b,t}$, calculated as the ratio of a gilt b volume bought (sold) by a dealer i from ICPFs relative to the total volume of that gilt b bought (sold) by a dealer i on the secondary market on the QE (QT) auction date t. Another variable of interest is $HFRatio_{i,b,t}$, similarly defined for the dealer i as her share of secondary market trades with Hedge Fund (HF) investors in the gilt b relative to total secondary market trade by the dealer i in gilt b on the day of the auctions, which would capture the key role of arbitragers activity in absorbing supply and demand shocks in the gilt market (as in Vayanos and Vila (2021) and Greenwood and Vayanos (2014)).

To investigate the role played by the PH investors in shaping dealers' bidding behaviour, we estimate the following panel data regression:

$$\mathrm{Y}_{i,b,t} = \beta_1 PHRatio_{i,b,t} + \beta_2 HFRatio_{i,b,t} + \beta' Z_{i,b,t} + \beta_0 + \xi_i + \mu_b + \psi_t + \epsilon_{i,b,t} \qquad (1)$$

where $Z_{i,b,t}$ is a vector of bond-, dealer-, and bond/dealer-specific control variables, including total bid quantity for a bond by a dealer, dealer balance sheet constraints (measured by the total amount of gilts accumulated by a dealer during three days prior to the auction), and a bond-specific liquidity control (calculated as the total amount of that bond bought and sold by all investors relative to the total free float available). Finally, ξ_i refers to dealer fixed effects, μ_b to bond fixed effects, and ψ_t time fixed effects.

To estimate the regressions we focus on the most relevant trades in the secondary markets. In particular, for QE, we narrow the trades to only those in which GEMMs were the buyers. For QT, we narrow the trades to only those in which the dealer was the seller. We use all bids and do not restrict to only successfully allocated bids because ex ante dealers did not know if their bids would be successful. We restrict our observations to only those in which preferred habitat investors traded with the dealers within the specific time horizon. To estimate dealer balance sheet constraints, we calculate the amount of the specific bond that the dealer had purchased up to two days before the auction. For bond liquidity, we calculate the gross trading volume (buying and selling) for a given bond for all investors using the same time periods. We also include the associated bid quantity to control for any price affects associated with the size of bid.

Table 2 contains summary statistics of the variables used for the regressions on our QE and QT samples. The main variable of interest, $PHRatio_{i,b,t}$, which is the ratio of ICPFs trades on the auction dates, was higher during QE (12 percent) than during QT (8 percent), suggesting that ICPFs were more active around QE auctions, confirming the aggregate trend discussed in Data section. The relative role of HFs was relatively stable over the two samples, accounting for 27 and 24 percent during QE and QT correspondingly, although on average hedge funds trades with dealers were larger during QT than during QE. Finally, the average maturity of the auctioned gilts have naturally been higher during QE (around 18 years) than during its subsequent unwind (around 14 years).

Turning to our second hypothesis, we constrain the regression in Equation 1 to be estimated only on long maturity bonds, i.e. on bonds with time to maturity exceeding 20 years:

$$Y_{i,b,t|m>20y} = \beta_1 PHRatio_{i,b,t} + \beta_2 HFRatio_{i,b,t} + \beta' Z_{i,b,t} + \beta_0 + \xi_i + \mu_b + \psi_t + \epsilon_{i,b,t} \quad (2)$$

The estimated regression coefficients from Equations (1) and (2) are shown in Table 3.

5.2 Estimation Results

We first discuss the estimation output for the case of QE auctions, including the estimated regression results for various specifications of Equations (1) and (2) over several subsamples. Then, in the following subsection, we examine the significance of preferred-habitat demand pressures on the sample covering QT auctions.

5.2.1 QE Results

Before turning to each specification, we start by noting that the coefficients of interests, that is loadings on PH demand variables, are statistically significant (see Table 3 Columns 1-4) over the QE subsample. The coefficient β_1 is estimated to be negative in Equation 1, which implies that increased preferred-habitat demand (or, equivalently,

Table 2

Table 2: Summary Statistics of the Regression Variables

Note: This table displays the summary statistics for the main variables used in the regression analysis for the QE sample (2018-2021) and QT sample (2022-2024) separately. PH refers to Preferred Habitat investors, and HF refers to Hedge Funds.

QE	**Mean**	**Min**	**Median**	**Max**	**Stan. Dev.**	**N**
Individual Bond Issuance, £m	27,937	4,037	28,385	41,896	8,111	8,829
Individual Bond Free Float, £m	15,902	1,234	14,921	28,481	5,420	8,829
PH Amount Sold, £m	3	0	0	1,408	25	8,829
HF Amount Sold, £m	34	0	0	2,559	124	8,829
Total Volume Traded, £m	1,292	0	652	18,917	1,814	8,829
Volume Purchased Dealer, £m	2,184	52	1,797	18,285	1,865	8,829
Time To Maturity	17.79	3.00	14.35	53.25	12.77	8,829
Bond Specialness, bps	-7.88	-53.30	-6.75	50.00	8.52	8,754
Bond Return Volatility	0.58%	0.02%	0.33%	26.57%	0.87%	8,790
Duration	14.55	2.93	11.99	38.81	9.31	8,829
PH Ratio	0.12	0	0	1	0.29	8,002
HF Ratio	0.27	0	0	1	0.41	8,002
Dealer Ratio	0.38	0	0.07	1	0.44	8,002

QT	**Mean**	**Min**	**Median**	**Max**	**Stan. Dev.**	**N**
Individual Bond Issuance, £m	33,030	12,854	32,890	43,651	6,448	1,199
Individual Bond Free Float, £m	15,862	4,564	14,233	29,624	5,632	1,199
PH Amount Bought, £m	2	0	0	430	17	1,199
HF Amount Bought, £m	51	0	0	1,800	156	1,199
Total Volume Traded, £m	1,273	0	730	9,425	1,515	1,199
Volume Sold Dealer, £m	177	0	130	1,432	193	1,199
Time To Maturity	14.31	3.01	10.20	48.73	11.55	1,199
Bond Specialness, bps	-20.98	-118.19	-7.69	5.92	27.11	1,199
Bond Return Volatility	0.53%	0.04%	0.41%	2.79%	0.41%	1,146
Duration	10.67	2.89	8.45	31.42	7.04	1,199
PH Ratio	0.08	0	0	1	0.25	1,096
HF Ratio	0.24	0	0	1	0.40	1,096
Dealer Ratio	0.42	0	0.17	1	0.44	1,096

Table 3

Table 3: Estimates of the PH demand impact during QE and QT auctions

Note: This table displays the coefficient estimates of Equation 1 for QE auctions in columns one to four, and QT auctions in columns five to seven. The dependent variable for all specifications is the average bid to benchmark yield spread. Column 1 contains just the PH Ratio alongside all controls, column 2 uses all bonds with a time to maturity over 20 years, column 3 uses all bonds but includes the hedge fund ratio (HF ratio), and column 4 includes all bonds but only auctions where the HF ratio was below 5%. Column 5 for QT auctions includes only the PH ratio, column 6 includes the PH and HF ratios, and column 7 is the only specification where the condition to only include PH ratio more than 0 is dropped. *** p <0.01, ** p <0.05, * p <0.1.

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

larger share of gilts sold to the Bank by ICPFs investors) is associated with lower average bid spread to benchmark yield at the QE auctions. The result holds for the full sample of QE purchased bonds (see Column 1), and for bonds with a time to maturity over 20 years (see Column 2). The findings confirm the importance of the demand from institutional investors during QE: higher ICPFs investor sales to dealers leads to less elastic bidding during QE auctions, consistent with Preferred Habitat demand theory (Hypothesis 1). The magnitude of the effect is larger when we look at longer maturity bonds, also in-line with the second hypothesis (Hypothesis 2).

Next, analyzing the role of hedge funds (columns 3 and 4), we find that the coefficient of hedge fund trade volumes is positive and strongly statistically significant. The preferred habitat demand effect remains negative and statistically significant, but the magnitude and significance is smaller (compare columns 1 and 3), which highlights the important role that hedge funds play during QE auctions and therefore policy transmission.

Because it could take some time for dealers to procure gilts for QE auctions and to sell gilts after QT auctions, we also estimate the regression where the right hand side variables of interest, *(PH Ratio)* and *(HF Ratio)*, are estimated over a wider window covering the adjacent days. Table 4 shows the coefficient estimates for these specifications. Similar to our baseline results, when we estimate the impact of trades with PH investors over a wider window, capturing not only the day of the auction but also the previous day, the coefficient on *(PH Ratio)* remains significant, although the significance is weaker. Finally, when we widen the window further, the significance fades away, which is understandable given that the wider window would capture a larger share of trades unrelated to the QE auctions.

In summary, the estimation results over the QE sample do not reject the PH demand channel hypotheses stated in the beginning of the section. Higher preferred habitat trade flows with dealer around auction dates lead to lower average spreads to benchmark prices relative to other dealers, or in other words, higher auction bid prices, consistent with the hypothesis that preferred habitat investors value the bonds they invest in more than other investors such as hedge funds (arbitrageurs).

5.2.2 QT Results

Our QT sample covers more than a year of active sales by the BoE. Over that period the APF portfolio has been unwound by around 20 percent. Therefore the estimation results using the QT sample should not be treated as final. And, in terms of comparison with the QE, we should also remember that there have been relatively few observations (79 so far comparing to 317 QE auctions during 2018-2022).

On the available QT sample, which is based a on comparatively small number of observations, the coefficient of interest *(PH Ratio)* is statistically insignificant (Columns 5-7), implying a weaker role of ICPF investors during the QT auctions. As a result this suggests that the preferred habitat demand part of portfolio-balance channel is not key for the policy transmission during this phase of the unconventional monetary policy. The dealers' willingness to buy at the QT auctions instead seems to be more driven by hedge fund activity (*(HF Ratio)* in Column 7).

In summary, we find that insurance companies and pension funds have been less active in QT auctions compared to QE auctions, while hedge funds have absorbed

Table 4

Table 4: Estimates of the PH demand impact using alternative samples
Note: This table displays the coefficient estimates of Equation 1 for QE auctions in columns one to four, and QT auctions in columns five to seven. The dependent variable for all specifications is the average bid to benchmark yield spread. The PH Ratio is estimated over alternative windows: Column 1 and 4 cover only trades on the day of the auctions, column 2 uses all trades with PH investors over the day of the QE auction and the preceding day, column the 3 uses all trades during the QE auction day and preceding two days; Column 5 includes the PH ratio calculated for the trades on day of the QT auction and a following day, column 6 includes the PH trades over the QT auction day and two subsequent days. *** p <0.01, ** p <0.05, * p <0.1.

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

in proportion more gilts than during QE. This could be suggestive of smaller local supply effects given a reduced presence of preferred habitat investors in the current environment. We can think of various reasons why this might be the case, with a potential primary reason being the increased supply of gilts in the post-Covid period (See Figure 1), for which ICPF investors may have stronger preference than for APF held gilts.[10]

5.3 Robustness

5.3.1 Robustness: Accounting for Interest Rate Risk

Our analysis of QE and QT covers the sample between 2018 and 2024. This period was characterised by changing interest rate environment. While QE was implemented when the policy rates were held close to the ELB, the QT programme has been launched at the time of rising policy rates, i.e. at the time of the elevated interest rate risk. Dealers, who typically lend long term and borrow short term, are vulnerable to interest rate risk, which could affect their bidding behaviour in QE and QT auctions. Furthermore, pension funds with long-term liabilities are highly sensitive to fluctuations in interest rates as well (see e.g. Jansen et al. (2024)).

Therefore, to analyse the robustness of our results to changing interest rate risk, we introduce two additional controls. First, we include the standard deviation of bond specific yield changes from the previous five days on a rolling basis across the sample in order to capture bond specific volatility. Second, we account for the price sensitivity to interest rate risk as captured by a duration measure. (Figure 4 plots the average modified duration of the APF bond portfolio since 2018, the start of our sample.)

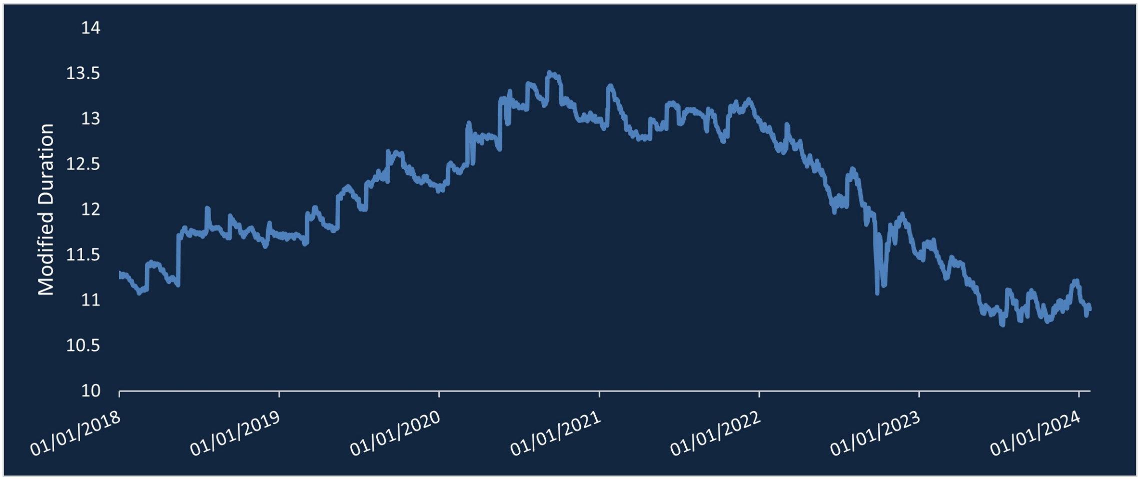

Figure 4: The average modified duration of the APF bond portfolio since 2018

Table 5 builds on the regression results in Table 3 by adding the modified duration and interest rate volatility measures. The first and main observation is that neither measure is statistically significant at the 90% confidence interval in any specification.

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[10] The relatively less appealing nature of holding gilts in the current higher inflation environment, or an overhang effect from the LDI crisis are two other potential explanations. Alternatively, newly issued gilts will have higher coupons which ICPF investors might prefer.

This suggests that any role of interest rate risk is either not statistically significant in affecting the bidding behaviour of dealers, or that the effects are already being captured in the other controls and fixed effects. Another observation is that the statistical significance of the PH Ratio and HF Ratio is reduced when these measures are included, driven by a slight reduction in the size of the coefficient estimates, which along with the increased adjusted R squared suggests interest rate risk can help to explain the auction bidding behaviour of dealers.

5.3.2 Robustness: Dealer Intermediation Capacity and Hedge Funds

The importance of dealer intermediation capacity and its effects on market liquidity and functioning is well known (e.g. see Adrian et al. (2017), Duffie (2023); or, closer to our case, Boneva et al. (2024), who study dealers behaviour at the earlier BoE QE auctions). Since only GEMM's are able to participate in APF auctions, the ability and willingness of these primary dealers to purchase gilts in the auctions and intermediate in secondary markets is of foremost importance, and therefore very relevant to our empirical study.

To investigate the importance of dealer intermediation capacity in dealer auction bids, we calculate a ”Dealer Ratio”, following the same methodology used to calculate the PH Ratio and HF Ratio. We then include this variable in our panel regression to investigate if the PH Ratio is still a significant predictor of dealer bidding behaviour during auctions, or if this variable had simply been capturing dealer's willingness to intermediate in gilt markets. In other words, the economic rationale for including the Dealer Ratio is to test whether the preferred habitat demand effect we have documented is in fact just capturing the reluctance (or inability) of dealers to warehouse gilts and intermediate in secondary markets.

Table 6 includes the Dealer Ratio alongside the PH Ratio, and we observe that the PH Ratio remains statistically significant at the 99% significance level in column 1, the baseline specification. The Dealer Ratio variable is also not statistically significant. This result suggests that at least during QE and QT auctions considered, the balance sheet capacity of dealers did not affect their gilt bidding behaviour, which is therefore more likely driven by their clients' demand for the gilts being auctioned. [11]

5.4 Additional Evidence: DMO Auctions

To further corroborate our presumption about the role of the increased supply of gilts for the asymmetric PH demand impacts during QE and QT, in this section we investigate DMO gilt absorption by preferred habitat investors in the increasing gilt free float environment (Figure 1). For this, we compare the ratio of net purchases to auctioned gilt amount from Debt Management Office (DMO) auctions between the pre-QE period (April 2018 to March 2020), and the ongoing QT period (January 2023 onwards for this

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[11] As a further check, we also investigated the link between the Dealer Ratio and the GEMM's Liquidity Coverage Ratio (LCR), a measure of the GEMM's ability to withstand a liquidity shock. The higher the liquidity ratio, the more able banks are to cope with a large shock. We find that the LCR does indeed significantly predict the Dealer Ratio, and hence their willingness to intermediate in gilt markets in-line with Boneva et al. (2024), with a higher LCR predicting a higher dealer ratio, which is intuitive.

Table 5

Table 5: Estimates of the impacts of PH demand and Interest Rate Risk

Note: This table displays the coefficient estimates of Equation 1 for QE auctions in columns one to four, and QT auctions in columns five to seven. The dependent variable for all specifications is the average bid to benchmark yield spread. Column 1 contains just the PH Ratio alongside all controls, column 2 uses all bonds with a time to maturity over 20 years, column 3 uses all bonds but includes the hedge fund ratio (HF ratio), and column 4 includes all bonds but only auctions where the HF ratio was below 5%. Column 5 for QT auctions includes only the PH ratio, column 6 includes the PH and HF ratios, and column 7 is the only specification where the condition to only include PH ratio more than 0 is dropped. Bond and time specific proxies for interest rate risk are captured by modified duration ('Duration'), and the standard deviation of daily bond yield changes over the previous five days ('IR Vol'). *** p <0.01, ** p <0.05, * p <0.1.

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**	-0.009*	-0.005*	-0.008**	0.009	0.004	0.000
	(0.003)	(0.005)	(0.003)	(0.003)	(0.011)	(0.022)	(0.004)
HF Ratio	-	-	0.007*	0.193	-	-0.010	-0.010***
			(0.003)	(0.130)		(0.026)	(0.002)
Duration	0.002	0.001	0.002	0.002	0.008	0.010	0.015*
	(0.002)	(0.004)	(0.002)	(0.003)	(0.035)	(0.031)	(0.008)
IR Vol	0.097	0.032	0.106	0.164	-5.156	-5.229	0.558
	(0.093)	(0.143)	(0.093)	(0.132)	(5.815)	(5.839)	(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

Table 6

Table 6: The Effect of Primary Dealer Trades

Note: This table displays the coefficient estimates of Equation 1 for QE auctions in columns one to three, and QT auctions in columns four to five, with the inclusion of Dealer Ratio in the place of HF Ratio. The dependent variable for all specifications is the average bid to benchmark yield spread. Column 1 contains the PH Ratio and Dealer Ratio alongside all controls, column 2 uses all bonds with a time to maturity over 20 years, and column 3 includes all bonds but only auctions where the Dealer ratio was below 5%. Column 4 for QT auctions includes the PH ratio and Dealer Ratio, column 5 is the only specification where the condition to only include PH ratio more than 0 is dropped. *** p <0.01, ** p <0.05, * p <0.1.

Dependent Variable: Average Bid Spread to Benchmark Yield					
		QE		QT	
	(1)	(2) TTM > 20	(3) Dealer Ratio < 5%	(4)	(5)
PH Ratio	-0.009*** (0.003)	-0.013** (0.005)	-0.012* (0.006)	0.004 (0.008)	0.005 (0.004)
Dealer Ratio	-0.004 (0.003)	-0.007 (0.005)	0.069 (0.169)	-0.002 (0.020)	0.006** (0.003)
Controls & FE's	✓	✓	✓	✓	✓
Clustered SE's	✓	✓	✓	✓	✓
PH Ratio > 0	✓	✓	✓	✓	×
Observations	1,901	1,110	798	153	1,095
Adj R-squared	0.231	0.357	0.171	-0.207	0.139

specific exercise). We focus on nominal gilts only (i.e. we exclude auctions for index-linked gilts) and consider both regular and syndicate auctions.[12]

First, 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. We then estimate the following dynamic difference-in-difference:

$$\text{Gilt Absorption Ratio}_{i,\tau} = \sum_{d=1}^{22} \beta_d \, \mathbb{1}[\tau = d] \times \text{QT Period} + \alpha_i \; + \; \alpha_t \; + \; \epsilon_{i,\tau}, \tag{3}$$

where Gilt Absorption $\text{Ratio}_{i,\tau}$ is the ratio of net volumes to auctioned amounts for auctioned bond i, τ days after the auction where $\tau = 0 : 22$, QT Period is a dummy variable which equals one if the DMO auction was held from January 2023 onwards, $beta_d$ measures the trading day specific difference between the QT period ratio relative to the pre-QE5 period, α_i capture bond specific fixed effects, α_t is a date fixed effect, and $\epsilon_{i,\tau}$ a residual.

In line with the evidence presented from the auctions data in Section 5.2, Figure 5 shows that the ratio of absorbed gilts from preferred habitat investors 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 three weeks after the auction date, after which the coefficent estimate finishes negative but not statistically significant from zero. This provides very clear evidence that preferred habitat investor demand for nominal gilts is relatively less than when the free float of gilts was smaller.

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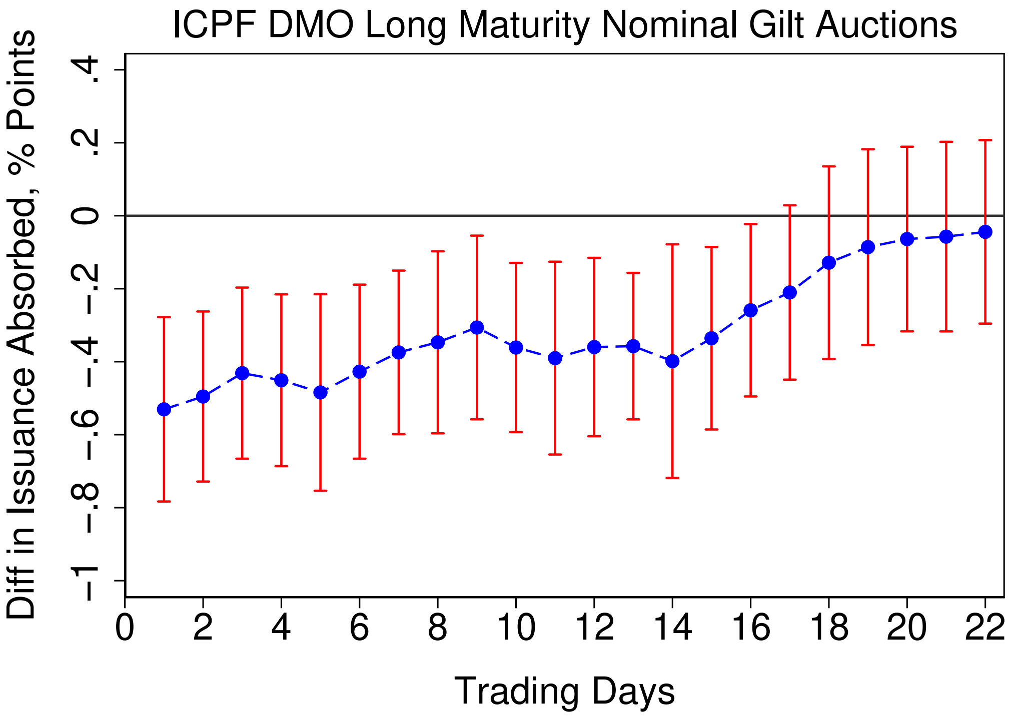
[12] A detailed list of auction dates and issued amounts are available on the DMO website: www.dmo.gov.uk/calendars/.

Figure 5: Difference in Gilt Absorption Ratio by ICPFs during QT and QE

Note: This figure plots the coefficient estimates of Equation 3 for ICPF investors and long maturity gilts only. The control period is pre-QE5 and the treatment period is since January 2023. Bond and date fixed effects are included, and 95% confidence intervals are included vertically alongside coefficient estimates.



On the other hand, in Figure 6, we see that hedge fund net volumes are substantially larger during the QT period, with a difference of around 65% after one month. This is consistent with our APF auction results which show that hedge funds are more active in QT auctions than they were during QE auctions, especially for long maturity gilts.

In summary, our analysis of DMO auctions data and the relative net volumes absorbed by various investor groups one month after the auction date confirms that the PH demand has been significantly lower post COVID-19 than it was before gilt free-float increased to record amounts. Instead, a different type of investors - hedge funds, who are less traditional but more flexible and less regulatory constrained, are taking a more prominent role. [13]

To understand how a relatively weaker PH demand and a larger role of the hedge fund activity would impact monetary policy transmission mechanism, in the next section we present a reduced form equilibrium yield curve framework for analyzing the interaction between PH investors, arbitrageurs and the size of government debt.

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[13] The increased role in trading activity is also visible in the euro case, see https://www.ecb.europa.eu/press/blog/date/2024/html/ecb.blog20240923 d859db790b.en.html

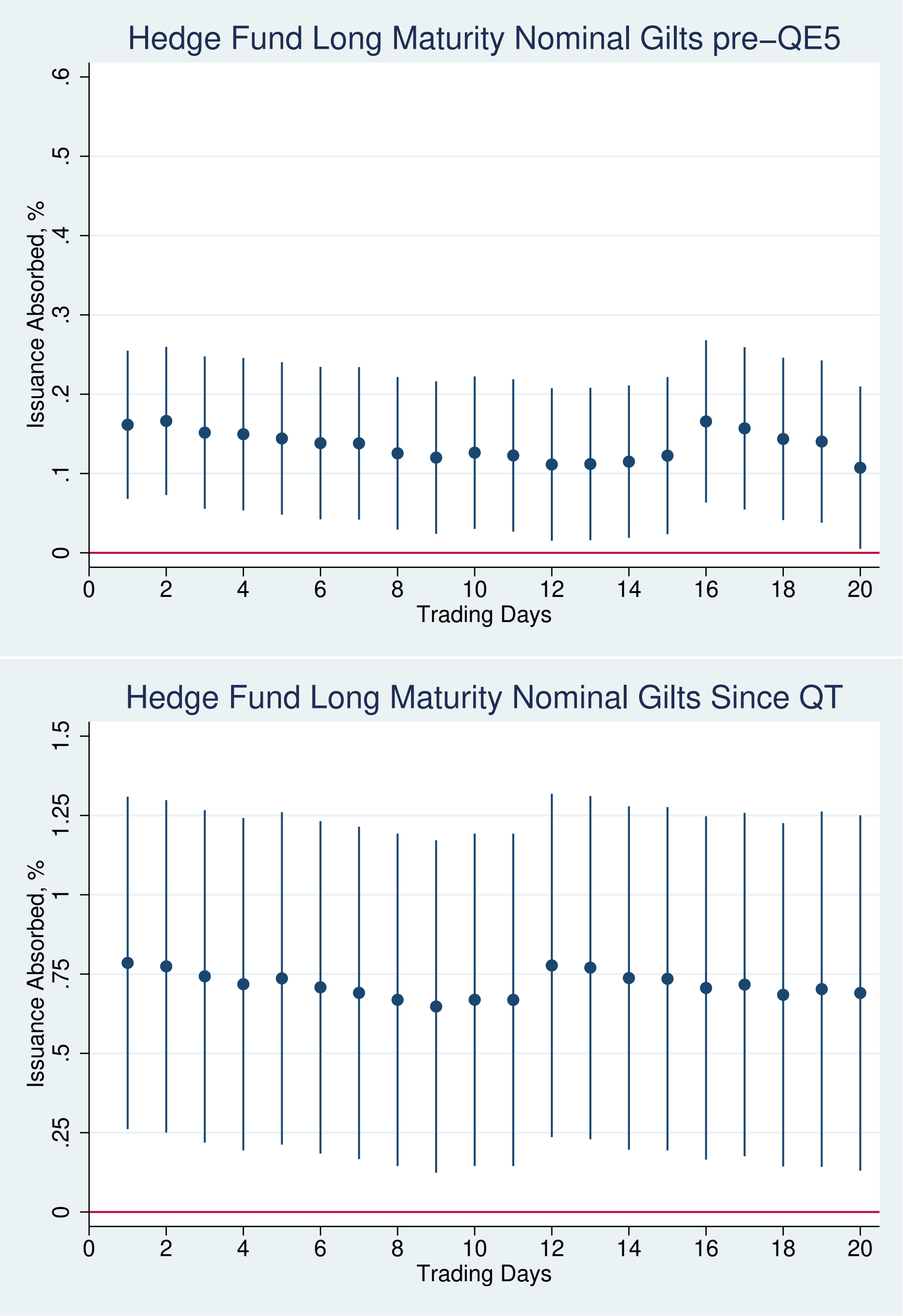

Figure 6: Gilt Absorption Ratio by Hedge Funds during QT and QE

Note: This figure plots the average gilt absorption expressed as a ratio of net volumes to DMO auctioned bonds between April 2018 to March 2020 (pre-QE5 period, Top) and since January 2023 (QT period, Bottom) for hedge fund investors for gilts with a time to maturity equal to above twenty years, up to twenty trading days after the auction date.

6 Theoretical Model

In order to make sense of our empirical findings, we model the determination of interest rates as arising from the interaction between fixed income arbitrageurs and preferred habitat investors. Arbitrageurs trade bonds of all maturities in order to satisfy a mean-variance portfolio allocation problem. Preferred habitat investors instead specialize in bonds of specific maturities, with elastic demand increasing in the yield of the specific bond. Our setup is identical to that of Vayanos and Vila (2021), except we allow for the demand elasticity of preferred habitat investors to vary over time as a function of the outstanding supply of bonds.

Formally, we assume there are a continuum of zero-coupon bonds with price $P_t^{(\tau)}$, yields $y_t^{(\tau)} \equiv -\frac{1}{\tau}\log P_t^{(\tau)}$ and maturities $0 \leq T \leq \infty$. The instantaneous nominal short rate is given by $r_t \equiv \lim_{\tau\to 0} y_t^{(\tau)}$.

Arbitrageurs solve the following portfolio allocation problem:

$$\max_{\{X_t^{(\tau)}\}} E_t \,\mathrm{d}W_t - \frac{a}{2} V_t \,\mathrm{d}W_t \tag{4}$$

$$\text{subject to: } \mathrm{d}W_t = W_t r_t \,\mathrm{d}t + \int_0^T X_t^{(\tau)} \left[\frac{\mathrm{d}P_t^{(\tau)}}{P_t^{(\tau)}} - r_t \,\mathrm{d}t \right] \mathrm{d}\tau \,. \tag{5}$$

As is clear from the budget constraint (5), arbitrageurs may always invest all of their wealth in the instantaneous risk-free rate. Relative to this case, arbitrageurs may seek out higher returns by investing a portion of their wealth $X_t^{(\tau)}$ in the bond carry trade across any maturity τ. The realized returns are represented by the integral term in the budget constraint. The risk aversion parameter a governs the trade-off between expected returns and the price risk inherent in such conducting such carry trades.

Preferred-habitat demand is assumed to follow

$$Z_t^{(\tau)} = -\alpha_t(\tau) \log P_t^{(\tau)} - \beta_t^{(\tau)}. \tag{6}$$

The elasticity $\alpha_t(\tau) > 0$ is a function of maturity τ. Additionally, habitat elasticities vary over time. Time-variation arises as a function of the outstanding stock of bonds; in particular, we model the elasticity function in such a way that demand elasticities shrink towards zero as the outstanding stock of bonds increases. We make this assumption to capture the idea that habitat investors become "satiated" when the market is flooded with bonds. The term $\beta_t^{(\tau)}$ represents additional sources of variation in habitat demand which are independent of movements in prices ("noise" demand).

In general, the dynamics of the economy are governed by a set of risk factors $\mathbf{q}_t \in \mathbb{R}^J$ which evolve according to the vector Ornstein-Uhlenbeck process

$$\mathrm{d}\mathbf{q}_t = -\mathbf{\Gamma}\mathbf{q}_t \,\mathrm{d}t + \boldsymbol{\sigma} \,\mathrm{d}\mathbf{B}_t \,, \tag{7}$$

where the dynamics and diffusion matrices $\mathbf{\Gamma}, \boldsymbol{\sigma}$ are primitives of the model. The vector $\mathbf{B}_t$ is a set of standard independent Brownian motions. For simplicity, we assume that the risk factors $\mathbf{q}_t$ are in terms of deviations from steady state. The short rate $r_t \equiv \mathbf{e}_r^\top \mathbf{q}_t$ is a function of the risk factors (and may be included in the set of risk factors, in which case the vector $\mathbf{e}_r$ is a standard normal basis vector).

The outstanding stock of bonds with maturity τ is given by

$$S_t^{(\tau)} \equiv \hat{\boldsymbol{\Theta}}(\tau)^\top \mathbf{q}_t, \tag{8}$$

where the vector function $\boldsymbol{\Theta}(\tau)$ governs how movements in risk factors lead to changes in the supply of bonds with maturity τ. Market clearing is therefore given by

$$\begin{aligned} S_t^{(\tau)} &= X_t^{(\tau)} + Z_t^{(\tau)} && (9) \\ \implies X_t^{(\tau)} &= \alpha(\tau, \mathbf{q}_t) \log P_t^{(\tau)} + \boldsymbol{\Theta}(\tau, \mathbf{q}_t)^\top \mathbf{q}_t, && (10) \end{aligned}$$

where in (10) we have written the habitat demand slope and intercept as functions of risk factors $\mathbf{q}_t$, by defining $\boldsymbol{\Theta}(\tau, \mathbf{q}_t)$ so that $\boldsymbol{\Theta}(\tau, \mathbf{q}_t)^\top \mathbf{q}_t = \beta(\tau, \mathbf{q}_t) + \hat{\boldsymbol{\Theta}}(\tau)^\top \mathbf{q}_t$.

6.1 Equilibrium

Because demand elasticities vary over time, unlike in Vayanos and Vila (2021) our model is no longer consistent with a time-homogenous (log) affine solution. Nevertheless, it is useful to decompose bond prices as

$$-\log P_t^{(\tau)} = \mathbf{A}(\tau, \mathbf{q}_t)^\top \mathbf{q}_t + C(\tau). \tag{11}$$

The coefficient functions $\mathbf{A}(\tau, \mathbf{q}_t)$ and $C(\tau)$ are endogenous; in this section, we characterize the equilibrium as the solution for these coefficient functions.

To simplify notation, we suppress notational dependence on maturity τ and risk factors $\mathbf{q}_t$; we use subscripts to denote partial derivatives: for instance, $\mathbf{A}_\tau \equiv \frac{\partial \mathbf{A}(\tau, \mathbf{q}_t)}{\partial \tau}$ and $\mathbf{A}_q \equiv \nabla_{\mathbf{q}} \mathbf{A}(\tau, \mathbf{q}_t)$. Without loss of generality, we assume that log prices $\log P_t^{(\tau)}$ in the model are measured in terms of deviations from steady state, so that $C(\tau) = 0$ for all maturities. With an appropriate definition of the demand intercept function $\beta(\tau, \mathbf{q}_t)$, we therefore have that in steady state ($\mathbf{q}_t = \mathbf{0}$), supply $S(\tau, \mathbf{0}) = 0$ and habitat demand $Z(\tau, \mathbf{0}) = 0$.

Applying Ito's Lemma to (11) gives

$$\begin{aligned} \frac{\mathrm{d}P_t^{(\tau)}}{P_t^{(\tau)}} &= \mu(\tau, \mathbf{q}_t)\, \mathrm{d}t + \boldsymbol{\sigma}(\tau, \mathbf{q}_t)\, \mathrm{d}\mathbf{B}_t && (12) \\ \text{where } \mu(\tau, \mathbf{q}_t) &= \left(\mathbf{A}_\tau + \boldsymbol{\Gamma}^\top \left[\mathbf{A} + \mathbf{A}_q^\top \mathbf{q}_t \right] \right)^\top \mathbf{q}_t + \frac{1}{2} \mathcal{T}_t, && (13) \\ \boldsymbol{\sigma}(\tau, \mathbf{q}_t) &= -\left[\mathbf{A} + \mathbf{A}_q^\top \mathbf{q}_t \right] \boldsymbol{\sigma}. && (14) \end{aligned}$$

We make one minor approximation and assume that the convexity term $\mathcal{T}_t \approx 0$.[14]

The arbitrageur optimality conditions imply that

$$\begin{aligned} \mu(\tau, \mathbf{q}_t) - r_t &= \boldsymbol{\sigma}(\tau, \mathbf{q}_t) \boldsymbol{\Lambda}_t, && (15) \\ \text{where } \boldsymbol{\Lambda}_t^\top &= a \int_0^T X_t^{(\tau)} \boldsymbol{\sigma}(\tau, \mathbf{q}_t)\, \mathrm{d}\tau\,. && (16) \end{aligned}$$

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[14] One way to formalize this is to assume that physical risk $\boldsymbol{\sigma} \to \mathbf{0}$ in (7), but that arbitrageur risk aversion $a \to \infty$ in (4), such that the product of risk aversion and risk remains finite and bounded. Intuitively, we study a version of the model where risk is small but that arbitrageur risk-bearing capacity is also small.

Note that the market price of risk $\mathbf{\Lambda}_t$ depends on arbitrageur risk aversion, and the total quantity of risk exposure (captured by the integral terms). This expression is the same as in Vayanos and Vila (2021). The difference is that, through market clearing, the risk exposure of arbitrageurs will depend on time-variation in demand elasticities.

Combining arbitrageur optimality conditions with market clearing (10), we can characterize the equilibrium as follows:

$$\mathbf{0} = \mathbf{A}_\tau + \mathbf{M}\left[\mathbf{A} + \mathbf{A}_q^\top \mathbf{q}_t\right] - \mathbf{e}_r, \tag{17}$$

$$\text{where } \mathbf{M} \equiv \mathbf{M}(\mathbf{q}_t) = \mathbf{\Gamma}^\top - \int_0^T \left[-\alpha \mathbf{A} + \mathbf{\Theta}\right]\left[\mathbf{A} + \mathbf{A}_q^\top \mathbf{q}_t\right]^\top \mathrm{d}\tau\, \hat{\mathbf{\Sigma}}, \tag{18}$$

and where $\hat{\mathbf{\Sigma}} = a\boldsymbol{\sigma}\boldsymbol{\sigma}^\top$. As in Vayanos and Vila (2021), through market clearing, the risk-adjusted dynamics matrix $\mathbf{M}$ solves a complicated fixed-point problem which balances arbitrageur optimality conditions and habitat demand curves. Two additional complexities arise in our setting. First, the matrix $\mathbf{M}$ is not time-homogenous, but instead depends on the value of risk factors $\mathbf{q}_t$ through the demand functions $\alpha(\tau, \mathbf{q}_t)$ and $\mathbf{\Theta}(\tau, \mathbf{q}_t)$. Second, equilibrium is characterized by a set of PDEs, rather than ODEs (after imposing the initial conditions $\mathbf{A}(0, \mathbf{q}_t) = \mathbf{0}$).

6.2 Stylized Parameterization

Equations (17)-(18) characterize the equilibrium of our model, but solving this set of equations in general must be done numerically. In order to extract intuitive insights from these complicated sets of expressions, we instead focus on a stylized parameterization of the model. First, we assume that

$$\mathbf{\Theta}(\tau, \mathbf{q}_t)^\top \mathbf{q}_t = \alpha(\tau, \mathbf{q}_t)\mathbf{q}_t^\top \mathbf{A}_q \mathbf{q}_t + \tilde{\mathbf{\Theta}}(\tau, \mathbf{q}_t)^\top \mathbf{q}_t.$$

Second, we assume that the demand and supply functions take the form of dirac delta functions:

$$\alpha(\tau, \mathbf{q}_t) = \delta(\tau - T)\alpha(\mathbf{q}_t),$$
$$\tilde{\mathbf{\Theta}}(\tau, \mathbf{q}_t) = \delta(\tau - T)\tilde{\mathbf{\Theta}}(\mathbf{q}_t),$$

and take the limit as $T \to \infty$. Although these stylized assumptions remove some of the richness of the model described above, we derive a significantly simpler characterization of equilibrium below.

Let $\mathbf{B} \equiv \mathbf{B}(\tau, \mathbf{q}_t) = \mathbf{A} + \mathbf{A}_q^\top \mathbf{q}_t$ (which captures the entire reaction of log bond prices to changes in the risk factors). Define the scalar

$$z \equiv z(\mathbf{q}_t) = \mathbf{B}^\top \hat{\mathbf{\Sigma}} \mathbf{B}. \tag{19}$$

Then with the above assumptions in place, equations (17)-(18) become

$$\left[\mathbf{\Gamma}^\top + \alpha z \mathbf{I}\right]\mathbf{B} = \mathbf{e}_r + z\tilde{\mathbf{\Theta}}. \tag{20}$$

Conditional on the value of the scalar z (and the set of risk factors $\mathbf{q}_t$, which enter through the demand and supply functions), this is a simple linear system of equations which characterizes $\mathbf{B}$. Thus, for a given level of the risk factors $\mathbf{q}_t$, we can solve the equilibrium of the model as the solution to a scalar fixed point problem using (19) and (20).

6.3 Numerical Example

To explore the implications of the model, we consider a simple two-factor version. We assume that the risk factors $\mathbf{q}_t$ consist of the short rate r_t and a supply factor s_t (thus, we abstract from habitat noise demand risk). We assume that these factors are independent (so $\mathbf{\Gamma}$ and $\boldsymbol{\sigma}$ in (7) are diagonal). We choose the mean reversion of short rate and supply shocks to be $\gamma_r = 0.5$ and $\gamma_s = 0.2$, respectively. Volatilities are set to $a \cdot \sigma_r^2 = 0.05$ and $a \cdot \sigma_s^2 = 0.1$ (note that for the purposes of studying how bond prices react, we do not need to separately calibrate physical risk and risk aversion).[15]

We assume that the demand elasticity varies as a function of the supply factor according to the top panel of Figure 7. The elasticity function α varies from values of 2.0 (when supply s_t is low) to 0.2 (when supply s_t is high).

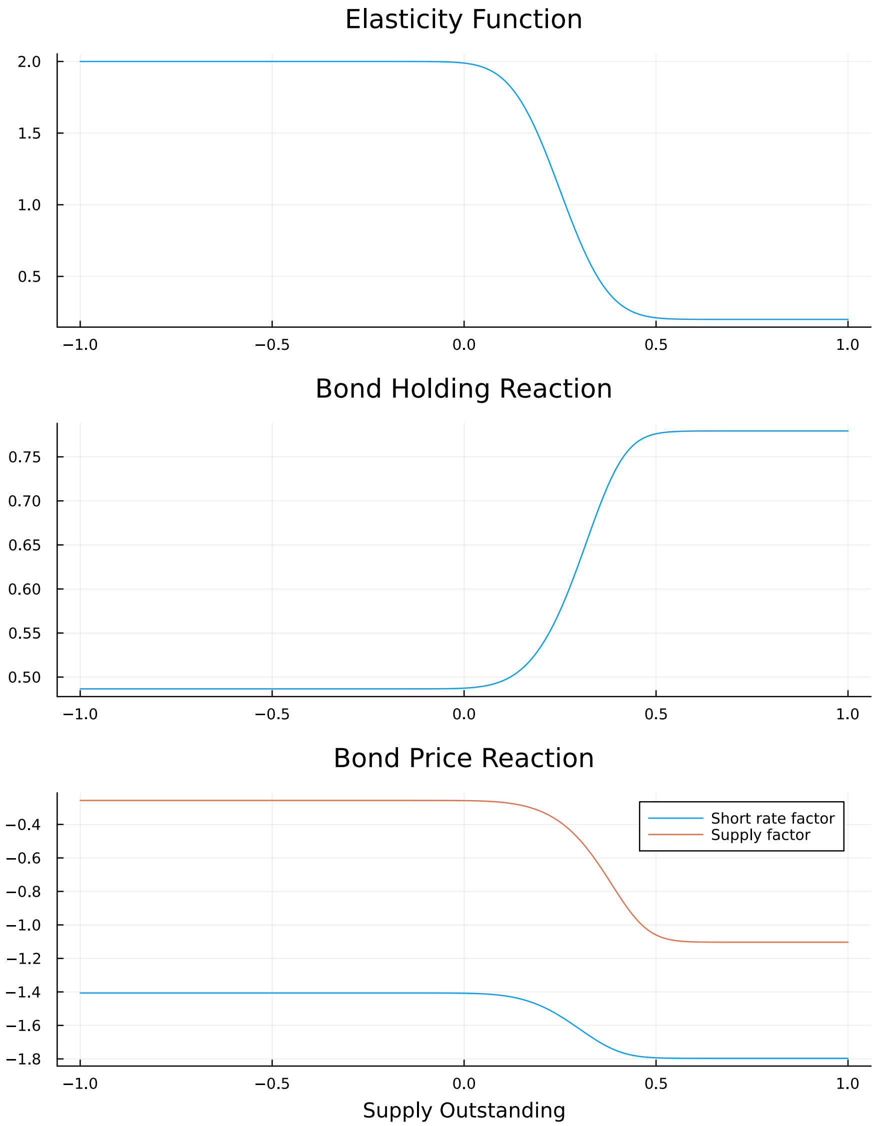

Figure 7: Two-Factor Model

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[15] Our calibration is meant to be illustrative.

The second panel of Figure 7 shows how equilibrium arbitrageur holdings of bonds reacts to increases in supply. Regardless of the level of outstanding supply, when additional bonds are issued, arbitrageurs in equilibrium increase their holdings of bonds. Preferred habitat investors also increase holdings: an increase in bond supply leads to a decrease in bond prices, which incentivizes habitat investors to buy a portion of the increase in bonds. But the strength of this channel is governed by habitat elasticity. When the outstanding supply of bonds increases, habitat elasticities decrease and therefore arbitrageurs end up holding a larger fraction of the increase in issuance.

Thus, in states of the world where bonds are scarce, an increase in supply is absorbed by both arbitrageurs and preferred habitat investors. However, when we enter a regime of saturated bond markets, only arbitrageurs absorb additional increases in supply.

The final panel of Figure 7 shows what this mechanism implies for the equilibrium response of (log) bond prices to changes in the short rate factor (blue line) or the supply factor (red line) as a function of the supply outstanding. We find that, as expected, increases in the short rate or supply decrease the price of bonds regardless of the total supply outstanding. However, as supply increases into the region in which the demand elasticity falls, the responsiveness of bond prices to these factors increases (in absolute magnitude). This change in responsiveness is much more salient for the supply factor: bond prices become more than twice as sensitive to changes in supply.

Thus, our findings suggest a note of caution for central banks pursuing balance sheet normalization through quantitative tightening (QT), when the preferred habitat investors play a key role in the market. Policymakers have stated that QT will be uneventful: like "watching paint dry." Figure 7 shows that the response to QT may be consistent and uneventful while outstanding bond supply remains low. However, once habitat investor demand is highly satiated, a decline in demand elasticities would lead to significantly larger price reactions to continued unwinding, implying potential disruptions in bond markets.

7 Conclusion

In this paper we studied and contrasted behaviour of preferred habitat investors around QE and QT auctions.

Using granular offer-level Bank of England auctions data and UK government bond transactions data, we find that increased trade volumes from preferred habitat investors to dealers during QE periods lead to stronger dealer bidding behaviour at the auctions, with lower offer spreads to benchmark yields. During QT period, preferred habitat investors have played a less significant role; instead, QT transmission has been more affected by a larger role for hedge fund activity. Therefore, our empirical results imply that the transmission mechanism of the unconventional monetary policy is potentially asymmetric and state dependent.

To explain the empirical findings, we build a theoretical model (an extension and generalisation of Vayanos and Vila (2021)) and show how the available supply of the government debt could drive the results on the asymmetric and state contingent role of demand for bonds. At the time of large debt supply, and hence relatively smaller role of buy-and-hold/preferred habitat investors, the bond price reactions to QT become more susceptible to the conditions of financial markets and capacity of intermediaries to absorb the debt supply, highlighting the importance of “gradual and predictable” approach.

Our results have important policy implications. The strength of the portfolio balance channel depends on the overall supply of government debt and financial intermediation activity in the market, and so these factors have to be considered ahead of policy implementation decisions.

In sum, although there is still much to learn, QT is not an uncharted territory anymore. After several years of active asset sales, granting us with useful data to analyse the experience, we have deepened our empirical and theoretical understanding of QE and QT. Based on this knowledge, however, our recommendation for optimal exit from QE would not be very different to the principles announced when the QT was still considered to be a novelty. The exit from unconventional monetary policy should be implemented gradually and in a predictable manner.

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