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The yield curve impact of government debt issuance surprises and the implications for QT

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Abstract

We analyse the market reaction of yields to UK government debt auction announcements to quantify the potential impact of quantitative tightening (QT) by the Bank of England. Our results suggest that the yield reaction to debt issuance surprises comes through both duration risk and local supply channels, and depends critically on the level of market stress. Based on these estimates, a fully unanticipated announcement that mimics the Bank's first annual QT programme would raise 10-year yields by 20 basis points under low market stress, with the impact from passive unwind broadly equivalent to that from active sales.

Key words: Yield curve, government debt auctions, quantitative easing, quantitative tightening.

JEL classification: E43, E52, E58, G12, G14, G18.

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1 Introduction

Although a large literature exists exploring the impact of Quantitative Easing (QE) - central bank asset purchases financed by reserve creation - on financial markets and the macroeconomy (see, for example, reviews by Bhattarai and Neely (2022) and, for the UK specifically, Busetto et al. (2022)), much less is known about Quantitative Tightening (QT), where the central bank reduces the size of its asset portfolio. So when the Bank of England (BoE) and some other central banks announced their intention to begin unwinding their balance sheets in 2022, at a time when economic and financial conditions were beginning to normalise following the Covid pandemic, there was little evidence to draw on and considerable uncertainty about the impact this would have on monetary conditions.

There are good reasons for assuming that the absolute effects on financial markets from QT will be weaker than a similar increase in QE purchases, as some transmission channels identified as important for QE are less likely to be important in a situation where the central bank is unwinding its balance sheet. For example, once policy rates are no longer constrained at their effective lower bound and take the role of being the active tool of monetary policy, there is less chance that balance sheet reductions can be taken as a signal about future policy rates (as would be the case according to the so-called signalling channel). Other channels like confidence, liquidity or market-functioning also seem less likely to be important. This implies that any QT effects will mainly be restricted to come through a portfolio balance channel effect associated with an increase in the net supply of bonds. This would manifest initially through reduced scarcity of specific bonds (the local supply channel) or the fact that investors need to hold larger amounts of duration risk (the duration risk channel), both of which would tend to increase bond yields. Even in this case, however, it seems likely that any effects will be more muted to the extent that markets are operating normally and the forces of arbitrage are stronger.

The prediction that QT effects will be weaker seems borne out by various event studies carried out around QT announcements, which show very limited effects on yields (Smith and Valcarcel (2023), Du et al. (2024), Bank of England (2023) and Ramsden (2023)). But experience with QT is still relatively limited, and there remains the caveat that in beginning to unwind their balance sheets central banks were deliberately careful to signal their intentions well in advance, minimising the news content of the official QT announcements themselves and making it more difficult to isolate the incremental effects of the policy through event study methods.

In this paper, we study the effects of the BoE's initial annual QT plans announced by the Bank's Monetary Policy Committee (MPC) in 2022, as they relate to the Bank's portfolio of UK government bonds (gilts). But rather than attempting to infer the effects of QT from previous QE episodes (for example, by assuming QT is the mirror of QE), or by defining QT so that it includes a larger set of events (for example, as any balance sheet policy that occurs during a "tightening cycle", as in the analysis of the Fed's QT policy by D'Amico and Seida (2023)), we focus on what we can learn from the effects of previous debt issuance surprises in the UK. We argue that the experience of debt issuance provides a more appropriate benchmark for analysing QT: first, because it tells us directly about the impact of gilt sales on the yield curve rather than having to infer it from purchases during past QE programmes and, second, because the yield impact of new debt issued by the UK's Debt Management Office (DMO) is more likely to come primarily through portfolio balance effects, making it more comparable with the expected transmission through QT.

We make several contributions to the associated literature on QE and QT. First, we quantify the relationship between the price reaction of gilts and news about bond level quantities, even in the absence of survey information. In an earlier paper Lengyel (2022) uses high frequency yield data following DMO auction announcements to identify broad maturity segment debt shocks (similar to the method followed in applications to US data by Ray et al. (2024) and Phillot (2021)). By using the high frequency yield reaction to individual gilt auction announcements, we extend this identification to the bond level. Combining these shocks with the associated individual security level details, we are then able to identify the quantity surprise of the specific gilt being issued, allowing us to trace out the reaction of yields to changes in bond supply at a very granular level. Our second contribution is using these shock estimates for individual bonds to construct measures of the shocks to local supply and duration risk from each issuance announcement (components of the portfolio balance channel, see Vayanos and Vila (2021)), using a similar method to that used in the QE literature (see Cahill et al. (2013) and Altavilla et al. (2021)). This allows us to estimate the role of the local supply and duration risk channels in explaining yield reactions to changes in supply over a much richer sample going back to 2006. Using this lengthy sample containing frequent issuance announcements, we can address questions that are much more difficult using data on infrequent QE and QT events. Motivated by the Vayanos and Vila (2021) framework, we address two specific questions. Supply effects in this framework are tightly linked to arbitrageurs' risk aversion/risk-bearing capacity. We analyse how the strength of the two channels differ with the amount of market stress, which can be thought of as positively related to arbitrageur risk aversion. Moreover, we also analyse in which maturity segments the local supply channel is more important. While in a stylised model, preferred-habitat investors are distributed evenly across the yield curve, this is unlikely to be the case in practice, which has implications for the way the local supply channel operates.

A further contribution of the paper comes from using the estimated yield curve elasticities from our analysis of debt auction supply shocks to simulate the effects of the BoE's first annual QT programme. This programme for 2022/23 was provisionally announced by the

Bank's MPC in August 2022 and confirmed in September 2022.[1] Uniquely among major central banks, it involved the BoE actively selling part of its accumulated stock of gilts to the secondary market, as well as continuing to passively run off maturing gilts from its asset portfolio. There had been a lot of discussion and information on QT in the preceding months and years, making it difficult to identify the extent to which the QT annual programme was unexpected. We instead simulate the market reaction to the 2022/23 programme, assuming all the related information on it published up to the beginning of September 2022 was fully unanticipated, avoiding the issue of predicting when this market reaction occurred. This approach enables us to assess the overall effect of the programme on gilt yields under varying levels of market stress. Additionally, it allows us to compare the yield impact of active sales and passive unwind to the extent that these reflect differences in the maturity and duration profile of the bonds that the BoE actively sells and the bonds issued by DMO to refinance bonds that mature. We also apply our model estimates to explaining the sharp market reaction to the surprise announcement in October 2022 to skew QT sales initially to shorter maturities. To our knowledge the only other paper that has attempted to quantify the impact of different unwind strategies is Wei (2022), but that paper takes a rather different approach, using a calibrated Vayanos and Vila (2021)-type model for the US Treasury market to examine this issue under various hypothetical assumptions about how the Federal Reserve might undertake QT.

Our results suggest that the market reaction to debt issuance surprises comes through both duration risk and local supply channels. To the best of our knowledge, our paper is the first to document that the effects of the local supply channel channel are larger at shorter and longer yield maturities and less for intermediate maturities. This is broadly consistent with empirical evidence suggesting that preferred habitat behaviour in the gilt market is particularly evident at both short and long maturities (see Giese et al. (2024)). According to our central estimates, the Bank's 2022/23 QT programme would have increased 10-year yields by around 20 basis points, assuming low market stress over the period of the programme. In contrast, our results for high market stress imply that the reaction of yields would have been about five times larger. We also find that maturing gilts (passive unwind) have similar effects on yields as active sales, on the assumption that the DMO refinances these bonds according to the remit published in April 2022.

The rest of this paper is structure as follows. Section 2 discusses how our research fits into the broader literature on QE and QT. We then go on to describe our dataset in Section 3 and our empirical methodology in Section 4. The latter relies on using the high frequency reactions of yields to identify surprises in the quantity of debt being auctioned. Section

[1] The first QT sales were subsequently delayed until November 2022. This followed the fiscal expansion announced in the so-called mini-budget on 23 September 2022, which triggered a period of gilt market turmoil, involving forced asset sales by Liability-Driven Investment funds. We discuss this further in Section 6 of the paper.

5 describes our results and Section 6 discusses their implications for the BoE's QT policy. Section 7 provides conclusions.

2 Literature review

The theoretical underpinnings of our analysis go back to the preferred habitat model developed by Vayanos and Vila (2009) and Vayanos and Vila (2021), itself best seen as a modernised version of the theory set out originally by Modigliani and Sutch (1966). This framework provides a rationale for changes in central bank asset holdings affecting yields through both duration risk and local supply channels. The former emerges as risk-averse arbitrageurs require a larger (smaller) premium for bearing more (less) duration risk, as QT (QE) leads to them bearing more (less) long-term debt. The latter emerges as preferred habitat investors have a strong preference for certain maturity segments. The resulting imperfect substitutability between bonds means that yields adjust upwards (downwards) by more around the specific maturities being sold (purchased).

A large number of papers have used this conceptual framework as the basis for empirical work aimed at understanding the transmission of QE policies. D'Amico et al. (2012) used security level data to construct measures of duration risk and local scarcity to estimate the relative importance of these channels for explaining yield curve movements. Another influential paper by D'Amico and King (2013) uses a two stage least squares approach to explain relative yield movements in terms of instrumented asset purchases during the Fed's first LSAP programme. Cahill et al. (2013) and Altavilla et al. (2021) build on D'Amico and King (2013) by introducing, respectively, a role for duration risk and credit risk. More recently, Froemel et al. (2022) apply the approach of D'Amico and King (2013) to examine time variation in the yield curve impact of the UK's five QE programmes through the local supply channel.

Our approach is most closely related to that of Cahill et al. (2013), who test for the existence of the duration and local supply channels using data on five different FOMC large scale asset purchase announcements. Compared to their paper, we offer two contributions. First, we use a much richer dataset. Instead of using data on net supply changes due to central bank activity, we utilize data on supply changes due to security-level issuance by the debt management authority, giving us a much larger number of events. Second, the longer timespan and larger number of observations allows us to examine how the strength of these two channels vary in different market conditions, and also the maturity segments where local supply is most relevant. We find that the local supply channel is much stronger at shorter and longer bond maturities than at intermediate maturities. In this regard, our findings are complementary to Giese et al. (2024), who identify the strong presence of preferred-habitat investors in broadly the same maturity segments.

There is of course a much older literature on the effects of debt issuance on yields that goes back to the Federal Reserve and US Treasury's "Operation Twist" in the 1960s (Modigliani and Sutch (1966)), which was itself revisited in the early QE literature (by Swanson (2011)). Examples of other more recent papers that investigate the impact of debt supply on the term structure, often motivated by QE policies and/or focused on the US experience, include: Kuttner (2006), Hamilton and Wu (2012), Greenwood and Vayanos (2014), Li and Wei (2013), and Chadha et al. (2013).

We contribute to the QE and QT literature by quantifying the relationship between bond prices and quantities in the absence of survey data. To this extent our paper is also connected to papers that analyse the market reaction to government bond auction results (Ray et al. (2024) and Lengyel and Giuliodori (2022)) and government bond auction announcements (Lengyel (2022) and Phillot (2021)), in order to understand how the market absorbs unexpected changes in the demand or the supply of these assets.These studies focus on non-maturity shocks, or shocks to the short or the long-end of the curve. The novelty of our analysis, as already discussed, is that we relate yield curve movements to unexpected supply changes of individual securities.

There have thus far been relatively few papers that directly examine QT empirically, given the limited amount of data available. One approach to potentially overcome this small sample problem is to look at the cross-country evidence. Du et al. (2024), for example, provide a comprehensive analysis of the effects of QT announcements in seven advanced economies and find only moderate effects of these on yields. But, as mentioned in the introduction, event studies for QT may be less appropriate, given the different way QT has been conducted as compared to QE, with central banks preferring to communicate their intentions well in advance to avoid surprising markets and proceeding cautiously at a slower pace. This critique also applies to D'Amico and Seida (2023) who focus exclusively on local supply shocks, defining QT as balance sheet policies that occur during a "tightening cycle", which leads to them also including tapering announcements as QT events. A paper with similar aims to ours is Wei (2022), who uses a calibrated model for the US to quantify the impact of QT on Treasury yields under various hypothetical scenarios. Our paper is more empirically based and focused on what can be learned from UK debt issuance auction announcements. These are much smaller than QE announcements and may impact yields through the same economic channels as QT. Moreover, they have been carried out in a variety of economic conditions, allowing us to potentially isolate the specific contribution of market stress in amplifying the impact of net supply changes on the yield curve. Although obviously not directly analogous to the QT programmes carried out by central banks, we believe the analysis of the impact of debt issuance provides us with a better benchmark to judge the potential effects of QT on yields.

3 Institutional Details and Data

We use data on debt issuance announcements to identify unexpected bond supply changes to learn about the transmission of QT policies. In this section, we briefly describe the institutional details of the UK debt issuance and our dataset on auction announcements and high-frequency yield reactions. Figure A1 in the Appendix shows a stylized timeline of the auction process. For a detailed description see Lengyel (2022).

3.1 Institutional details around gilt issuance

The primary method of bond issuance by the DMO is through regular auctions and tenders, which is our focus. These account for around three quarters of overall gilt sales, with the remaining part issued through syndicated gilt offerings and a Post Auction Option Facility. The annual financing remit, set by the UK Treasury, outlines the gilt sales required from the DMO for the upcoming financial year, which runs from the beginning to April to the end of March. The document specifies the total amount of gilt sales and the breakdown between index-linked gilts and conventional gilts in different maturity buckets. It is published every year in mid-March alongside the Budget. The remit is often revised in April when the central government's final net cash requirement for the previous financial year is published. It is also usually revised in November or December when the UK Government publishes its Autumn Statement together with forecasts of public finances.

The annual remit contains the Gilt Auction Calendar, which sets out the dates for auctions in the next financial year. The document also provides the aggregate amount of gilts in cash terms to be issued and the number of planned auctions in four categories. The four categories are index-linked gilts, and three conventional gilt maturity buckets: short, medium, and long conventional gilts with 0-7, 7-15, and 15+ years to maturity. Therefore, the information in the remit gives investors an idea about the average size of the coming auctions in each category. The DMO announces its auction plan for the next quarter on the last business days of March, May, August, and November in the form of an operations calendar. This calendar publishes the dates of the coming auctions, mini-tenders, and syndicated issuances in the next quarter. The document also specifies the maturity year and the interest rate of the issuance. Importantly, it does not provide information about the size of the auction. This is in contrast to the US, where the Treasury gives preliminary estimates of future auction volumes every quarter.[2]

Auction announcements are published at 3:30pm, usually (but not always) on the Tuesday in the week preceding the auction, which follows 4 to 8 days afterwards (see Figure A1). The associated press release contains all the pertinent information about the issuance. Im-

[2]See the US Quarterly Refunding Press Conference: https://home.treasury.gov/policy-issues/financing-the-government/quarterly-refunding.

portantly, at this time investors learn the exact nominal value being auctioned. Additional information released in the statement are the ISIN (International Securities Identification Number), coupon payments (in the case of new bonds), and the terms and conditions of the auction.

3.2 Data

We collect gilt auction and tender announcements and information from the DMO's website. We only include days with a single conventional gilt announcement. Our sample runs from 02 May 2006 to 31 Oct 2023 and covers 424 announcements. Out of these, 43 announcements are initial offerings of new bonds, while the rest are re-issues. Our results are robust to using only re-issues. We omit auction announcement days coinciding with: BoE or ECB policy decisions; the announcement on 28 September 2022 of the BoE's gilt market intervention in response to forced selling by Liability-Driven Investment (LDI) funds; a day during the 2023 US Banking Turmoil induced volatility; and one day in 2006 and four days in 2008, due to unreliable yield data for some ISINs.

For each gilt we construct the free float supply of the gilt, by subtracting official gilt holdings from the amount outstanding. Official holding constitute BoE holdings and DMO holdings, as the DMO also holds a portion of the outstanding gilts for secondary market activities. DMO holdings data are at the monthly frequency and sourced from the DMO; BoE holdings are at the daily frequency and from the BoE.

To examine the market reaction to gilt auction announcements, we use intraday high-frequency gilt yield data across a range of different maturities, supplied by LSEG. Daily yield curve data are sourced from Tradeweb. We use the Composite Indicator of Systemic Stress (CISS) for the UK (see Hollo et al. (2012)) to proxy for the level of financial stress, sourced from the ECB's Data Portal. The macroeconomics news index is constructed using Bloomberg consensus survey data.

4 Methodology

Our goal is to estimate the relationship between the bond supply announced before each auction and changes in yields. A simple regression of yield changes on the announced quantity of issuance would not give us the elasticity of yields to supply, as the majority of the new supply is foreseen by markets, as a large portion of the issuance is either used to refinance maturing debt or to finance government spending that is known in advance. Therefore, the effect is already priced in at the time of the announcement. Instead, we proceed with the analysis in two steps. In the first step, we isolate the surprise component of the announcements using the high-frequency market yield reaction to the announcements.

Then, in the second step we study how this additional supply (the surprise component) is absorbed by the market over the day using a regression approach described below.[3] Given that we know all the characteristics of the announced gilt, we can disentangle two distinct transmission channels: the global duration risk effect and the maturity specific local scarcity or local supply effect.

4.1 Constructing the announcement surprises

In more detail, in the first step, we isolate the unexpected component of the announcement at date t ($SurpriseSupply_t$), by instrumenting the announced volume with high-frequency yield surprises. Assuming that market prices reflect all public information prior to the announcement, yield movements in a narrow event window around the announcements proxy the new information content of the announcement (see also Ray et al. (2024) and Lengyel (2022)). These yield reactions are assumed to be correlated with the true policy surprise, but uncorrelated with any other factors that drive the announced volume. We use these high-frequency yield surprises as instruments for the true policy shock. In other words, the instrumentation isolates the variation in the announced supply that is correlated with these surprises. Intuitively, stronger yield movements around the announcement indicate more surprise in the announced volume. Our first stage regression is:

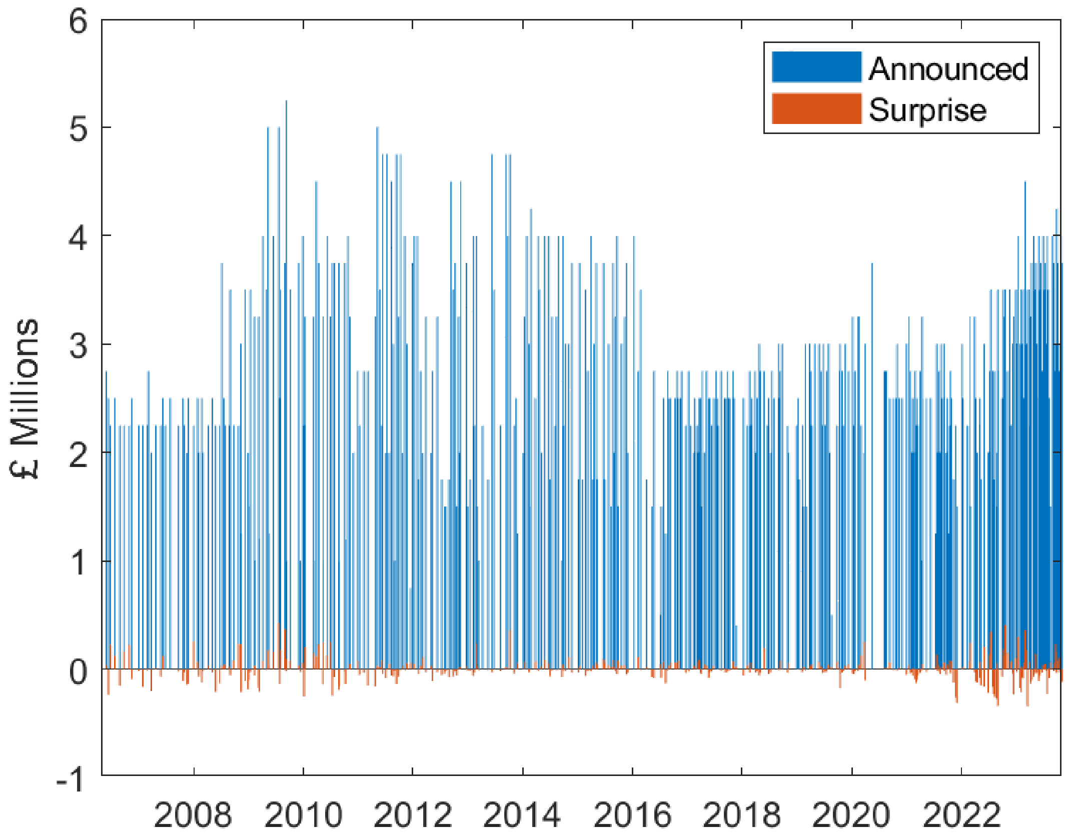
$$AnnouncedSupply_t = \alpha^{(Short)} + \alpha^{(Medium)} + \alpha^{(Long)} + \boldsymbol{\beta}\mathbf{Z_t} + \varepsilon_t \tag{1}$$

where $\alpha^{(m)}$ is a maturity bucket specific intercept, intended to capture the average issuance sizes of each maturity bucket, as the DMO targets different average issuance volumes in each bucket. We use the DMO maturity classification here, so short maturities are between 1 and 7 years, medium maturities are between 7 and 15 years, and long are above 15 years. Z_t is a vector of high-frequency yield surprises around the announcement. The $SurpriseSupply_t$ series is the part of the total volume that co-moves with the high-frequency surprises $SurpriseSupply_t = \hat{\boldsymbol{\beta}}\mathbf{Z_t}$.

We use intraday yield data at 1-minute frequency at eight maturity points: 1, 2, 3, 5, 10, 15, 10 and 30 years. Our analysis is based on an event window that runs from 5-minutes before the announcement to 10 minutes after, but our results are robust to changes in the length of the window. The series of the total announced volume and the surprise component is plotted in Figure 1. The $SurpriseSupply_t$ series has a mean of virtually zero and standard deviation of £115 million. The first stage regression results are shown in Table A1 in the Appendix.

[3]Practically, this amounts to stripping out how much of the daily moves in yields are attributable to the effects of an event that has a direct impact on yields.

Figure 1: $AnnouncedSupply_t$ and $SurpriseSupply_t$ at par value



4.2 Constructing the local supply shock

In the second step, we calculate proxies for the surprise changes in aggregate duration risk and the local supply shock at the security level for each announcement, drawing on Cahill et al. (2013). We first explain how we construct the local supply shock for each announcement and each outstanding bond. For a given bond, this is the estimated supply surprise in the maturity segment of the bond, scaled by the free float of that maturity segment. As mentioned earlier, we focus exclusively on days when a single gilt auction is announced. Hence, on announcement day t and announced bond i the local supply shock for i is given by:

$$ls_{i,t} = \frac{SurpriseSupply_{i,t}}{\sum_k \delta_{i,k} FreeFloat_{k,t}} \tag{2}$$

Where $FreeFloat_{k,t}$ is the outstanding nominal value of bond k in the hands of private investors, i.e., we subtract the holdings of the DMO and the BoE from the total outstanding stock of bonds.[4] $\delta_{i,j}$ is a substitutability weight between bond i and j, which is a decreasing function of the maturity distance between the two bonds:

$$\delta_{i,j} = \left(1 - \frac{|\tau_i - \tau_j|}{\tau_i \theta}\right) \mathbf{1}_{\{|\tau_i - \tau_j| \leq \theta \tau_i\}} \tag{3}$$

where $1_{\{|\tau_i - \tau_j| \leq \theta * \tau_i\}}$ is an indicator function that takes the value one if bond j's maturity is within θ percent of security i's maturity. For our baseline, we set θ to 0.5, i.e., bonds are substitutes if they are within 50% maturity distance from each other, as in Cahill et al. (2013).

For bonds other than the announced bond i, the local supply shock is given by:

$$ls_{j,t} = \frac{\delta_{i,j} SurpriseSupply_{i,t}}{\sum_k \delta_{j,k} FreeFloat_{k,t}} \tag{4}$$

4.3 Constructing the duration risk shock

The duration risk shock for bond j is the product of the duration risk added to the market by the issuance of bond i with the duration risk exposure of bond j (denoted as $f(d_j)$):

$$dr_{j,t} = \frac{SurpriseSupply_{i,t} \times d_i}{\sum_k FreeFloat_{k,t} \times d_k} f(d_j) \tag{5}$$

where d_i is the duration of bond i. Function $f(d_j)$ is a concave function determining the exposure of security j to aggregate duration risk and given by:

$$f(d_j) = \frac{(1 - exp(-\gamma d_j))}{\gamma} \tag{6}$$

We follow Cahill et al. (2013) and set γ to 0.2 in our baseline specification.

Figures A2 and A3 in the Appendix show examples for two auction announcements days, with the security level local supply shock, the security level duration risk shock and the yield changes for each outstanding bond. If duration risk was the only factor influencing yields on these days, one would expect yield movements that are monotonically increasing or decreasing in maturity. Instead, the figures shows stronger movements in the vicinity of the announced bond's maturity, which suggests the potential existence of local supply effects. In the next section, we quantify the effects of these two channels separately.

[4] In principle, we would ideally deduct the holdings of other private sector preferred habitat investors as well (similar to the euro area measure used by Eser et al. (2023)), but the available data for the UK do not allow us to do this reliably.

5 Results

To study the joint effect of the two shocks, we estimate panel regressions, where the outcome variable is the yield change of individual bonds relative to the day before. The independent variables are the bond level local supply and duration risk shocks. The results from the different regression specifications are displayed in Table 1. Adding a lagged dependent variable leaves the results quantitatively unchanged, so we do not report these results. All specifications include time fixed effects, which are omitted from the table. The first column shows the results when only the duration risk and local supply variables are included, i.e., for each announcement day t, we estimate:

$$\Delta y_{i,t} = \mu_t + \delta_1 ls_{i,t} + \delta_2 dr_{i,t} + \varepsilon_{i,t} \tag{7}$$

Both channels have a positive and highly statistically significant effect. The R^2 across all specification is very high, over 80%, though most of the explanatory power is attributed to the time fixed effects. Figure A4 in the Appendix illustrates that the estimated log-likelihood surface for this specification, across different values of δ and γ, is relatively flat.

The local supply channel requires there to be imperfect substitutability between different gilts, which may emerge due to the existence of preferred-habitat investors, who have strong preferences to hold bonds with specific maturities. In the Vayanos and Vila (2021) framework, these investors are evenly distributed across maturities. There is however, both narrative (Greenwood and Vayanos (2010)) and empirical (Giese et al. (2024)) evidence, that preferred-habitat investors are located at different yield curve maturity segments, specifically pension funds at the long end and foreign central banks at the short end. Although one might expect stronger local supply effects in these maturity segments, we are not aware of any previous studies that have demonstrated this. Our dataset, which includes frequent and sizable security-level shocks across the curve, can address this question. We interact our local supply variable with maturity bucket dummies to explore this further.

$$\Delta y_{i,t} = \mu_t + \sum_{m \in \{Short, MediumLong\}} I_t^m \delta_1^m ls_{i,t} + \delta_2 dr_{i,t} + \varepsilon_{i,t} \tag{8}$$

Column (2) demonstrates that in line with the theory and the empirical evidence on the location of preferred-habitat investors, changes in bond supply have more localized effects at the two ends of the term structure, with the strongest effect at maturities above 20 years. Here we use the bucket definition of the BoE, but our results are robust to alternative definitions of the buckets. These results potentially have important implications for the design of central bank balance sheet unwind programmes, suggesting that the yield curve impact is sensitive to which maturities are sold.

Demand and supply effects in the Vayanos and Vila (2021) framework are tightly linked to arbitrageurs' risk aversion/risk-bearing capacity. Yield curve effects from demand/supply shocks are predicted to be more pronounced when the capacity or the willingness to hold risk is lower, and there is abundant empirical evidence supporting this (Ray et al. (2024), D'Amico and Seida (2023), Lengyel and Giuliodori (2022), and many others). Therefore, we expect our two transmission channels to operate differently under adverse market conditions compared to normal times. Local supply effects can be stronger in stressed market conditions as arbitrageurs are less likely to intermediate between different maturity segments in such a way that they fully smooth out shocks at specific maturities. At the same time, duration risk effects may be stronger because investors require a higher compensation for holding additional risk. We test these predictions by estimating state dependent versions of equation (7), where the state variable is the level of financial market stress in the UK, proxied by the country level CISS index (Hollo et al. (2012), plotted in A5 in the Appendix) above its historical 75th percentile. Our results are robust to higher or lower values of this threshold.

$$\Delta y_{i,t} = \mu_t + I_t[\delta_1^S ls_{i,t} + \delta_2^S dr_{i,t}] + (1 - I_t)[\delta_1^{NS} ls_{i,t} + \delta_2^{NS} dr_{i,t}] + \varepsilon_{i,t} \tag{9}$$

Column (3) presents these results, revealing that both channels have stronger effects during periods of heightened market stress. While the difference for the duration risk shock is less pronounced, the effect of local supply nearly triples. This aligns with the idea that the local supply channel is driven by segmentation in the bond market along the yield curve, which becomes more prominent during times of stress when arbitrageurs are less willing or able to integrate the market. These findings may have significant implications for the design of central bank QT programmes, highlighting the importance of implementing them during stable market conditions. In the next section, we use our estimates to quantify the potential impact of the BoE's 2022/2023 QT programme.

Table 1: Regression results for Equations (7), (8) and (9)

	(1)	(2)	(3)
Local Supply	0.027***		
	(0.004)		
Local Supply - Short		0.037***	
		(0.006)	
Local Supply - Medium		0.010	
		(0.007)	
Local Supply - Long		0.032***	
		(0.010)	
Local Supply - High Stress			0.037***
			(0.006)
Local Supply - Low Stress			0.014**
			(0.007)
Duration Risk	0.014***	0.014**	
	(0.005)	(0.006)	
Duration Risk - High Stress			0.016**
			(0.007)
Duration Risk - Low Stress			0.013*
			(0.007)
R^2	0.801	0.801	0.801

Notes: Short, Medium and Long buckets indicate bonds with remaining maturities of 0-7, 7-20 and 20+ years respectively. High Stress indicates the CISS index above its historical 75th percentile. Estimated time fixed effects omitted in all columns. The sample includes 424 announcements, and the total number of observations is 18988. Standard errors in parenthesis, (*), (**), and (***) denote statistical significance at 10%, 5%, and 1%, respectively.

Finally, before we apply these elasticities to the analysis of the QT programme, we add additional control variables to test the robustness of our results. We first add variables that intend to capture the effect of macroeconomic data releases in the UK, Euro Area (EA) and the United States (US), similar to Altavilla et al. (2016) and Eguren Martin and McLaren (2015). We use the standardized difference between the first-released data and the Bloomberg (consensus) median forecast. We include GDP, CPI, PMI, and IP releases, weighted equally. For the US series, we use the previous business day's value, to control for the time zone difference. We also allow for the possibility that news has different effects across the term structure, by adding interaction terms. Lastly, we add bond level characteristics, such as the coupon, the duration, the maturity and the maturity squared. While most of these variables are statistically significant, they do not seem to have a quantitatively important effect on our estimated elasticities or the model fit, as shown in Table A2 in the Appendix.

6 Applications to the Bank of England's QT programme

In this section, we use our estimated elasticities to quantify the impact of the Bank of England's first annual QT programme. There had been a lot of discussion and information on QT in the preceding years, including a box in the August 2021 Monetary Policy Report that set out the principles the Bank would follow in unwinding the stock of assets held in the Bank's Asset Purchase Facility (APF).[5] Many of the details of the 2022/23 programme were also announced gradually over time through MPC minutes and press releases. Furthermore, one could even argue that the passive component of the program, i.e., bonds eventually maturing and rolling off the balance sheet, was already fully understood and potentially priced in at the start of QE purchases. So rather than follow an event study approach to quantify the impact of the programme, we construct a simulation of the market reaction to the 2022/23 programme, assuming all the related information on it published up to the beginning of September 2022 was fully unanticipated. This approach allows us to quantify the potential yield impact of the programme without taking a stance about when this effect might materialize, and drawing on our model estimates we can also simulate the market reaction under stressed and unstressed market conditions. In another simulation exercise, we present a separate set of estimates, which assume planned active sales were equal to the size of the passive run-off of maturing gilts, which allows us to calculate the difference between active and passive runoff under different assumptions.

As a separate exercise, we also present an actual event study of one particular QT announcement that contained information that was unanticipated by the market. After the MPC confirmed their annual QT programme on 22 September, the new government announced a mini budget which led to a sharp rise in gilt yields and severe dysfunction in the gilt market, associated with forced gilt sales by LDI funds (see Hauser (2022) and Alexander et al. (2023)). The QT sales programme which had been planned to start in October was therefore postponed. After a series of events - including interventions by the Bank, the resignation of the chancellor and prime minister and a new budget - the market turmoil came to an end, and the Bank announced on 18 October that it would resume its QT sales programme by skewing its active sales of gilts towards shorter maturities (less than 20 years), by only selling gilts from its short and medium maturity buckets. This announcement caught market participants by surprise and led to a large reaction in gilt yields. We compare the market reaction to the announcement with the yield impact implied by our estimated

[5] QE purchases were made through the APF, which is a subsidiary of the Bank indemnified by the UK Treasury.

elasticities, as a way of evaluating our empirical approach.

6.1 The 2022/23 QT plan

On 4th August 2022, the Bank of England issued[6] a provisional market notice outlining the Bank's plan for reducing the stock of its asset purchase holdings for the next year. Details were clarified in a Q&A session with market participants the next day[7] and the August plans were subsequently reaffirmed by the MPC at their September policy meeting. The planned reduction in the stock of purchased gilts amounted to £80bn in purchase proceed terms, i.e., expressed at the market value at the time of the purchase. Out of this, maturing gilts would reduce the stock by £35bn, while active sales would make a further reduction of £45 billion, allocated across three maturity buckets: 3-7 years (short), 7-20 years (medium), and over 20 years (long). We now describe how we project security level sales volumes based on this information. As in the analysis above, we work with nominal amounts (instead of the market values, used in the market notice), so we transform these quantities into nominal space.

Bonds with remaining maturity of less than one year held in the APF summed to £33.6 billions in nominal terms at the time of the announcement. For the passive QT component, we assume the DMO refinances these maturing bonds according to its remit, which was published in April of that year.[8] We take the split across the buckets published there, implying a 37.6% , 26.8% and 35.6% weight across the short, medium and long buckets respectively. Note, that the DMO defines the three buckets slightly differently. The buckets are 0-7 years (short), 7-15 years (medium), and over 15 years (long). Within buckets, we assume an even split across the outstanding ISINs. We assume no issuance of bonds with remaining maturity of less then one year. The bond level quantities are displayed in Figure 2 in blue.

For the active QT component, the 2022/23 QT plan implied the sale of £38.6 billion bonds in nominal terms, with sales allocated equally across the buckets. Within each bucket, we assume securities are sold in proportion to their APF holdings. The bond level sales quantities are displayed in Figure 2 in red, and show relatively large sales figures for bonds in the 3-7 year sector.

To obtain the elasticities for this analysis, we align the estimation sample with the date of the announcements and estimate our regressions up to 31 of August 2022. The total estimated effects of the 2022/23 QT programme for the low stress and the high stress regimes are displayed separately in Figure 3. The chart shows striking differences between

[6] https://www.bankofengland.co.uk/markets/market-notices/2022/august/asset-purchase-facility-gilt-sales-provisional-market-notice-4-august-2022.

[7] https://www.bankofengland.co.uk/minutes/2022/august/boe-call-with-gemms-on-provisional-approach-to-apf-gilt-sales-august-2022.

[8] https://www.dmo.gov.uk/media/buhbty3c/pr260422.pdf.

the low and high stress estimates. The duration risk channel is responsible for most of the impact, but the local supply channel increases in importance during periods of high stress. The estimated effect for the £80bn programme under low market stress (shown in the left panel) is around 20 basis points at the 10-year maturity point. However, under high market stress this effect reaches almost 120 basis points, underlying the importance of when QT takes place.[9] These numbers are based around our central estimates which are obviously subject to estimation and model uncertainty, although the main qualitative implications seem robust (as discussed above). The estimates should be considered against a 'no QT' benchmark, i.e., where the Bank does not reduce its balance sheet and continues to reinvest the principal payments from maturing securities. It is also important to note that these estimates would apply to a fully un-anticipated announcement. To the extent that the market gradually learns about the programme details, this effect would be priced in over a period of time. Furthermore, similar to the announcement effects of QE programmes, our announcement effects might also be expected to gradually diminish over time. In the next section we explore differences between passive roll-off of the balance sheet and active sales.

[9]For comparison, the UK's QE1 purchases of £200 billion were estimated to have reduced medium to long-term yields by about 100 basis points (see Joyce et al. (2011), which would imply there were twice as powerful as our central low stress estimates for QT1 and broadly comparable with our high stress estimates. But there is a large range of uncertainty around both sets of estimates and there are good arguments for thinking that QT is qualitatively different to QE, as discussed in the introduction.

Figure 2: Projected nominal supply volumes of each bond in the 2022/23 QT program

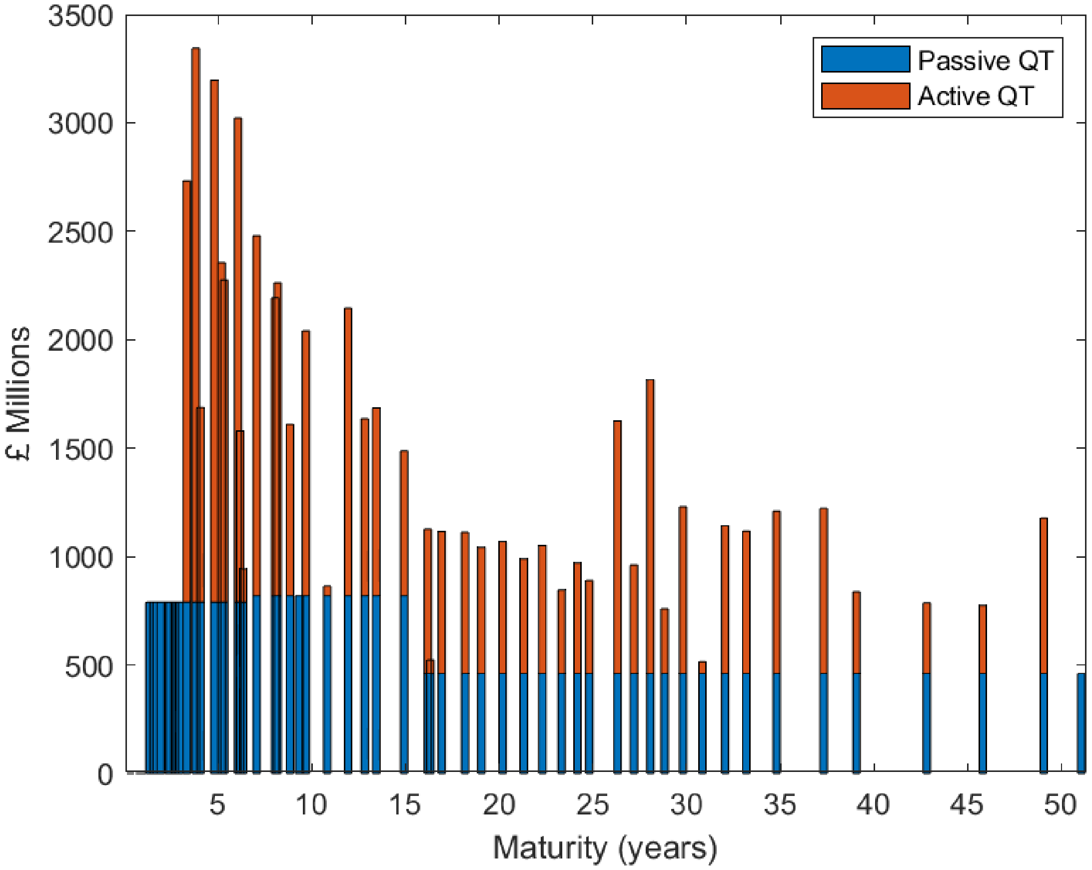
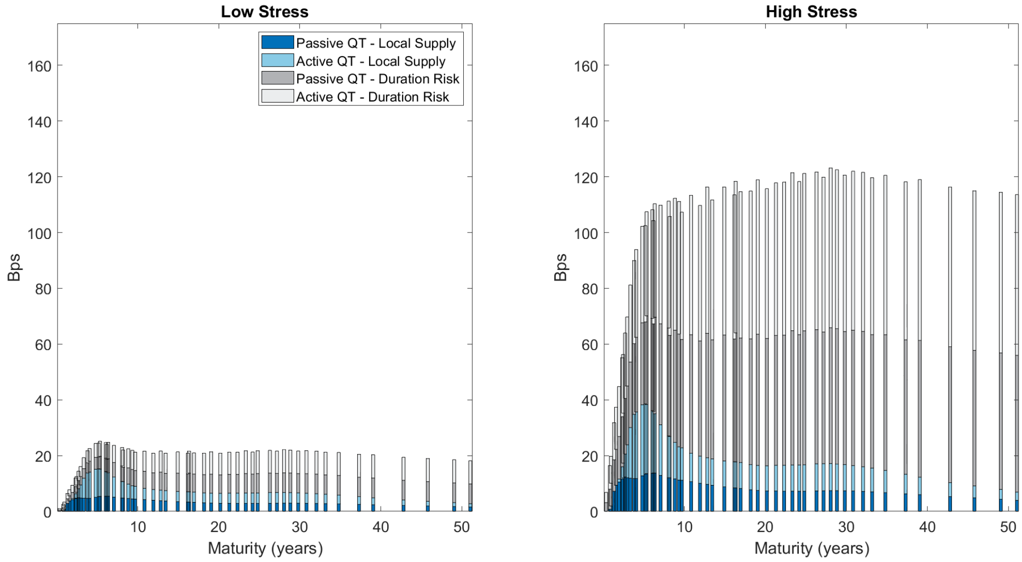


Figure 3: Total estimated effect of the 2022/23 QT programs active and passive components



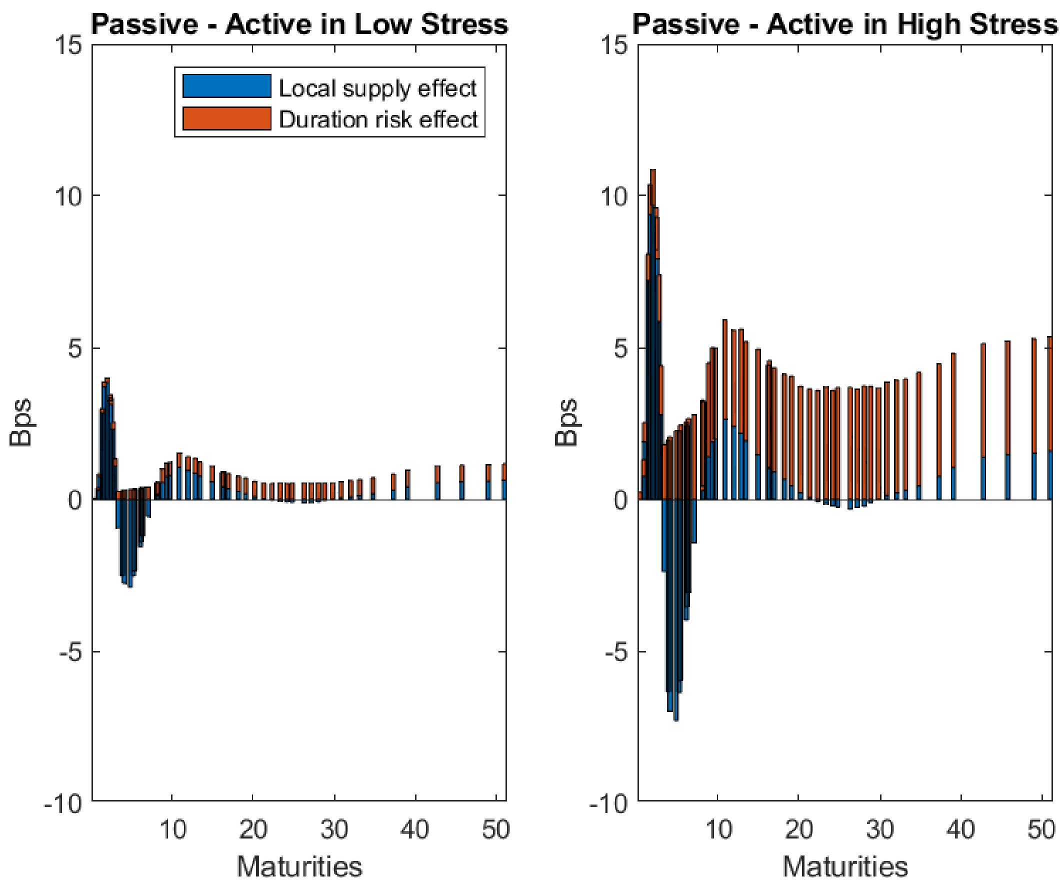
Notes: Estimated effects of the 2022/23 QT programme, using elasticities from Equation (9) estimated up to 31 August 2022. Left panel shows the results in the low stress regime, right panel shows the results in the high stress regime. High Stress is defined as the CISS index above the historical 75th percentile.

6.2 Active vs Passive

To compare the effects of active and passive QT on yields, we first scale the size of the active component to match the size of the passive, which is £33.6 billions in nominal terms, then apply the elasticities from our stress regime dependent specification. The implied bond level supply volumes are plotted in Figure A6 in the Appendix. Given that the total nominal quantities are calibrated to be the same, there are two potential factors that could drive differences in this framework. First, the specific bonds supplied to the market in the two scenarios might differ in duration. Longer maturity bonds and bonds with lower coupon rate have higher duration (all else equal), so supplying these adds more duration risk to the market. Secondly, supplying bonds in sectors with a low local free float or more potential substitutes (all else equal) will have a greater impact through the local supply channel.

The results by subtracting the estimated effects of active QT from the estimated effects from passive QT are plotted in Figure 4. The bars are almost entirely in the positive territory, indicating larger effects from passive QT. The differences are relatively small, however: at their maximum, up to 2 basis points under low stress and up to 11 basis points under high stress. These are mostly due to the overall duration supply from passive QT, which is larger than from active QT. While bond level active sales by the Bank are rather high at the 3 to 7 year segment, DMO issuance is more evenly split. This results in more duration supply from the latter. This difference in maturity allocation is also reflected in the blue bars of the local supply channel. These show that local supply is stronger for passive QT in the 1-3 year segment, consistent with the fact that the Bank does not sell there. Between 3 to 7 years the blue bars show stronger active QT effects, which is unsurprising given the heavy bond level BoE supply in this segment (see Figure 2). From 7 years and above passive QT local effects dominate again.

Figure 4: Comparing the effects of passive and active QT



Notes: Difference between the effects of £33.6 billion balance sheet reduction via passive roll-off vs. active sales. A positive value means a higher effect of passive unwind. Left panel shows the results in the low stress regime, right panel shows the results in the high stress regime. High stress is defined as the CISS index above the historical 75th percentile. Elasticities are from Equation (9), estimated up to 31 August 2022.

6.3 Alternative DMO refinancing

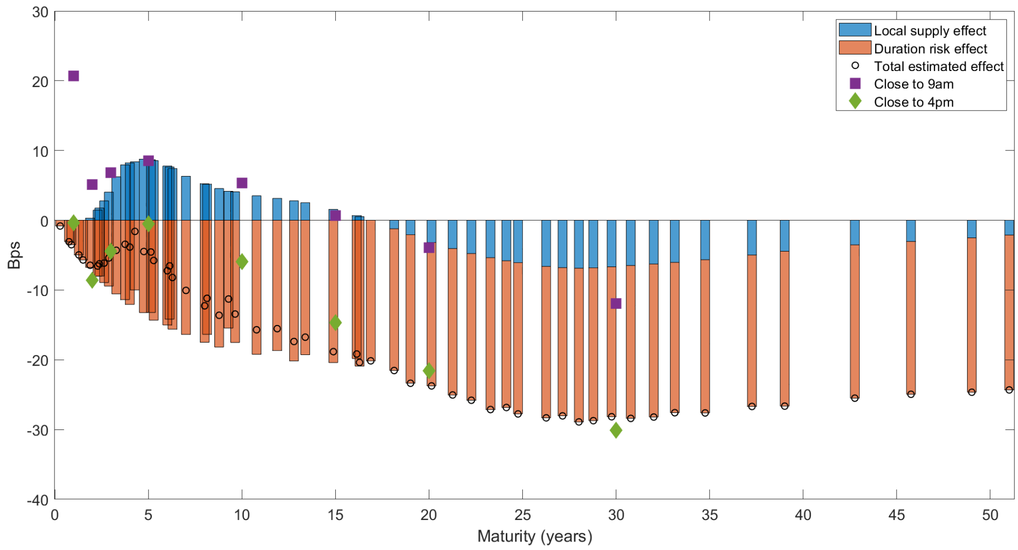
One can make alternative assumptions about how the DMO refinances the maturing bonds, which will have direct implications for the passive component of QT. Wei (2022) for example explores two scenarios. His baseline is that the Treasury refinances bonds at the initial maturity of the maturing bond. Our baseline on the other hand assumes issuance follows the DMO's remit in place at the time of the announcement. The alternative scenario in Wei (2022) is that maturing bonds are refinanced entirely with bills, yielding a much weaker effect of QT. In our framework, such a scenario would also give a lower effect overall. Refinancing maturing debt with bills instead of bonds would add considerably less duration risk to the market, yielding minimal duration risk effects. Short end rates, however, would rise significantly, due to large local supply effects.

6.4 A case study: the decision to skew towards short and medium maturity buckets

In this subsection, we describe a case study of one particular BoE QT announcement. On 28 September 2022, the Bank postponed the start of QT sales in light of deteriorating market conditions after the announcement of the 2022 Mini-Budget. Then, on 18 October 2022 after trading hours, the Bank issued a statement that confirmed that sales would commence on 1 November, but with the modification that sales during Q4 would be distributed only across the short and the medium maturity buckets. Markets reacted unusually strongly to this announcement after the market opened on the 19th. By 9am short-end yields rose by around 10 basis points, while the 30-yield yield dropped by 10 basis points compared to the previous day's close (see Figure 5). By 4pm, all yield changes were in negative territory, with 30-year yields down by 30 basis points. In this section, we try to reconcile these moves with our estimated elasticities.

We first calculate the local supply and duration risk implications of the bond level sales changes. The announcement referred to a skew in the sales only for the remaining part of 2022, but the strong market reaction suggests that investors interpreted the announcement as if it referred to the whole of the 2022/2023 QT plan. Therefore, we calculate the bond level sales implications of the skew for the entire active component of the QT plan, which are shown in Figure A7 in the Appendix. Then, we estimate Equation (9) up to 17 October 2022 and use the high stress regime elasticities for the analysis, as the CISS index was at a highly elevated level during this period (see Figure A5 in the Appendix). Our estimated effects are shown in Figure 5, predicting an overall decline across the curve. When compared to the actual market reaction on the day, yield movements up to 9am closely align with the local supply component of the announcement, suggesting that duration risk had not yet been priced in. Then, over the day the entire curve shifted down, and the movements by 4pm appear to closely match our estimated total effect, including both the local supply and duration risk components.

Figure 5: Intraday yield changes following the 18 October 2022 announcement and the estimated effects



Notes: Estimated effects of the 18 October 2022 QT skew announcement. We use the high stress regime coefficients from Equation (9), estimated on a sample up to 17 October 2022. Markers show intraday yield changes at 1, 2, 3, 5, 10, 15, 20 and 30 years between 18th October close and 19th 9am (purple squares), and 4pm (green diamonds).
Source: Intraday yields from LSEG.

7 Conclusions

In this paper we analyse how surprises in the amount of individual gilts issued by the UK's DMO affect the yield curve, in order to quantify the potential impact of the BoE's first annual QT programme.

Our empirical analysis focuses on the effects of two distinct transmission channels associated with portfolio balance effects: the duration risk channel and the local supply channel. We find that both channels are important and substantially stronger in times of heightened market stress. In addition, we find some evidence suggesting that the local supply channel is more pronounced at shorter and longer maturities, and weaker at intermediate maturities, which is broadly consistent with recent research on preferred-habitat investors in the gilt market.

Our estimated yield elasticities imply that a fully unanticipated announcement that mimics the BoE's 2022 QT programme would raise 10-year yields by 20 bps under conditions of low market stress. But under highly stressed market conditions these estimates are five times larger. The model estimates under high market stress allow us to explain the unprecedented market reaction to the announced resumption of QT sales with a maturity skew, that occurred on 18 October 2022, providing some support for our empirical approach.

Our results can also be used to help shed light on the potential difference between passive balance sheet roll-off and active sales, to the extent that the specific bonds supplied to the market may carry different duration risk and can differ in their relative scarcity. However, based on our analysis of the BoE's 2022/23 QT plan and the DMO's 2022/23 remit, the impact from passive unwind is broadly equivalent to that from active sales on a pound for pound basis.

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A.1 Additional figures and tables

Figure A1: Auction timeline

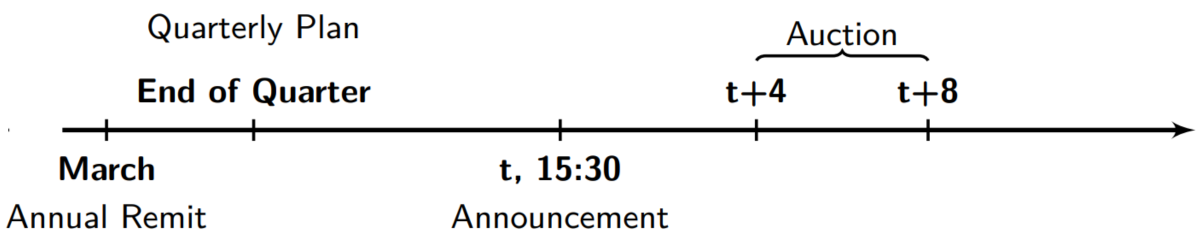
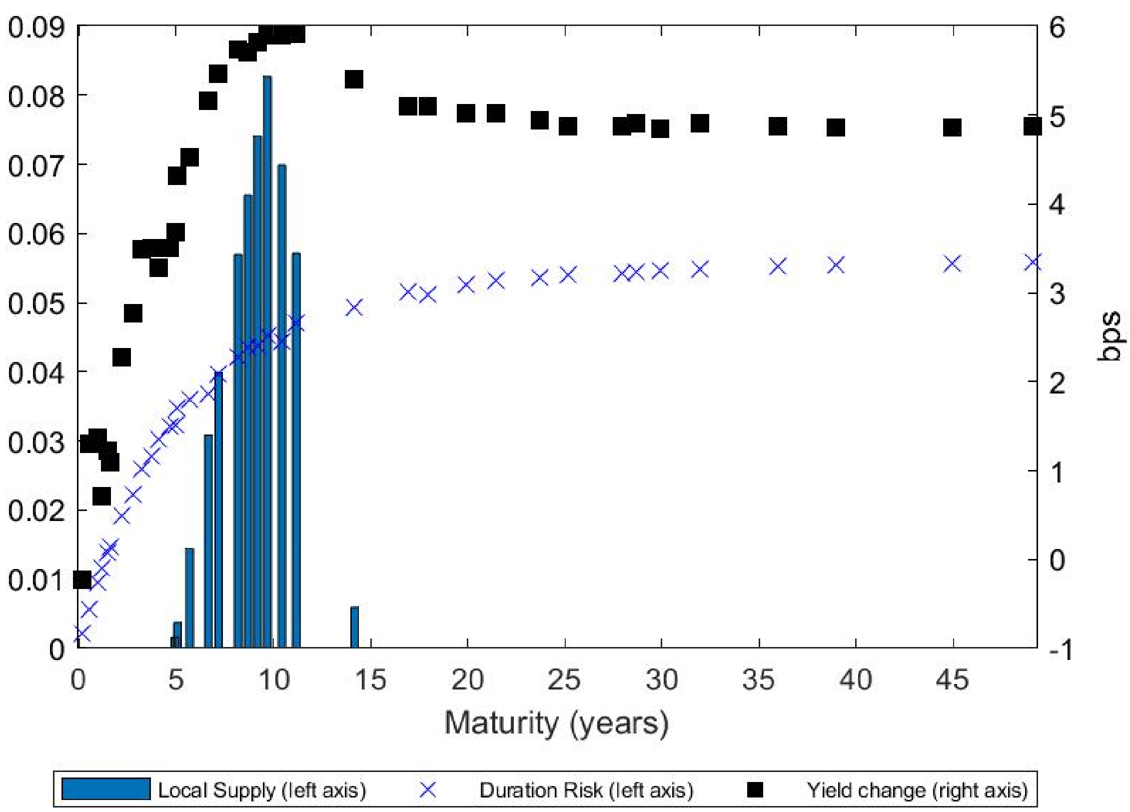
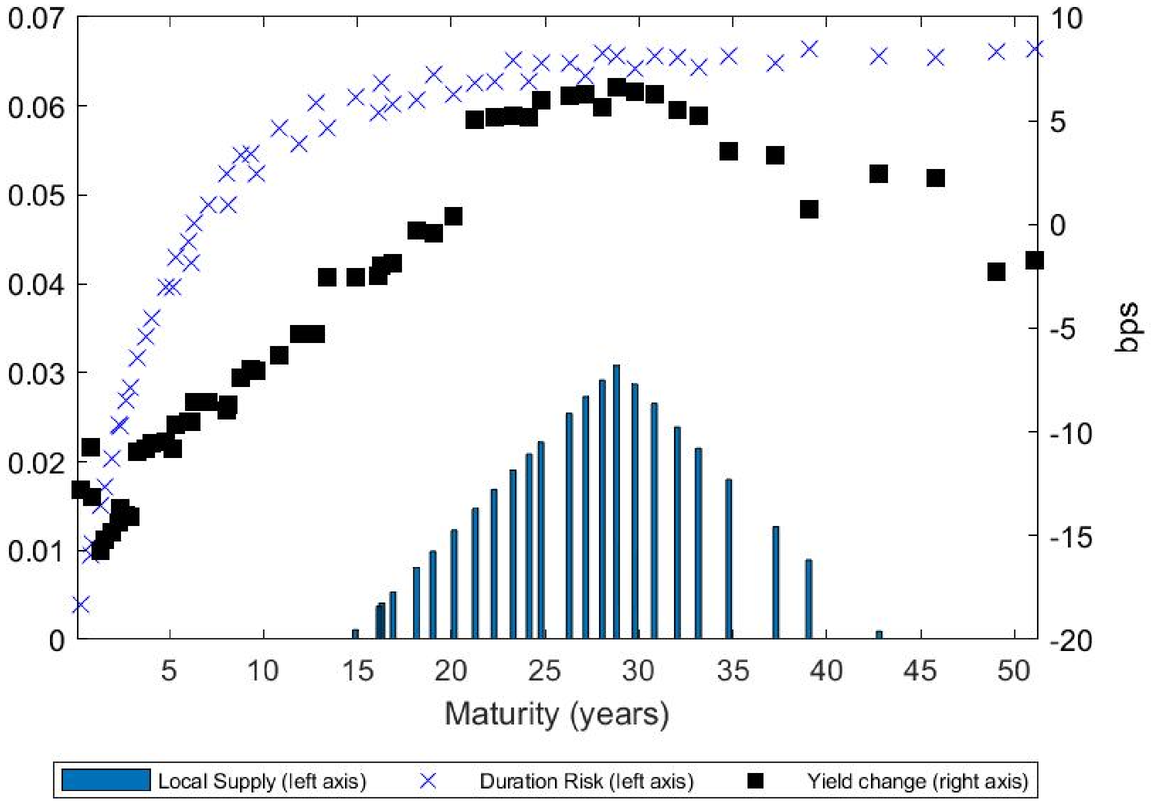


Figure A2: Local supply shock, duration risk shock and daily yield changes on 29-Dec-2010



Source: Daily yields from Tradeweb.

Figure A3: Local supply shock, duration risk shock and daily yield changes on 11-Oct-2022



Source: Daily yields from Tradeweb.

Figure A4: The estimated log likelihood of Equation (7) with different values of θ and γ

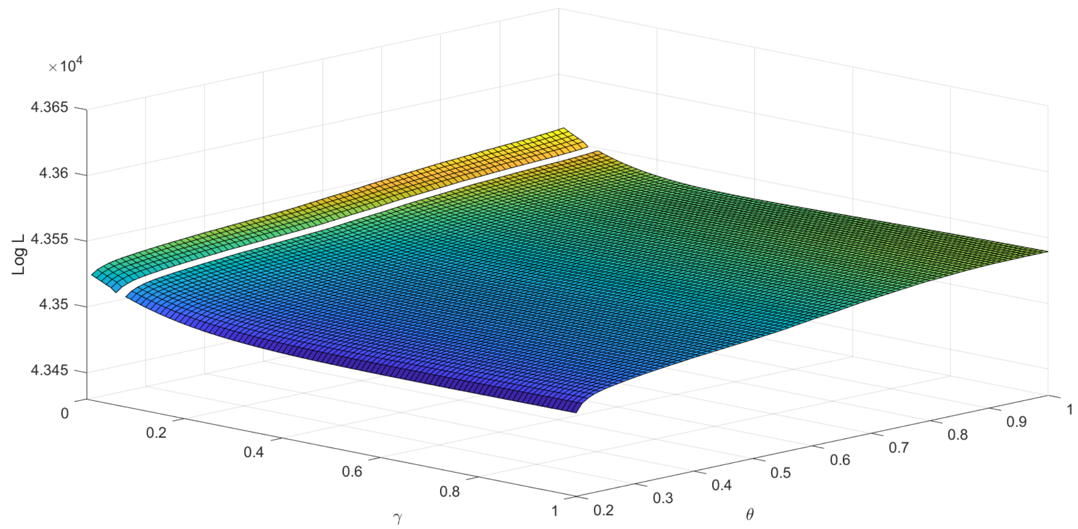
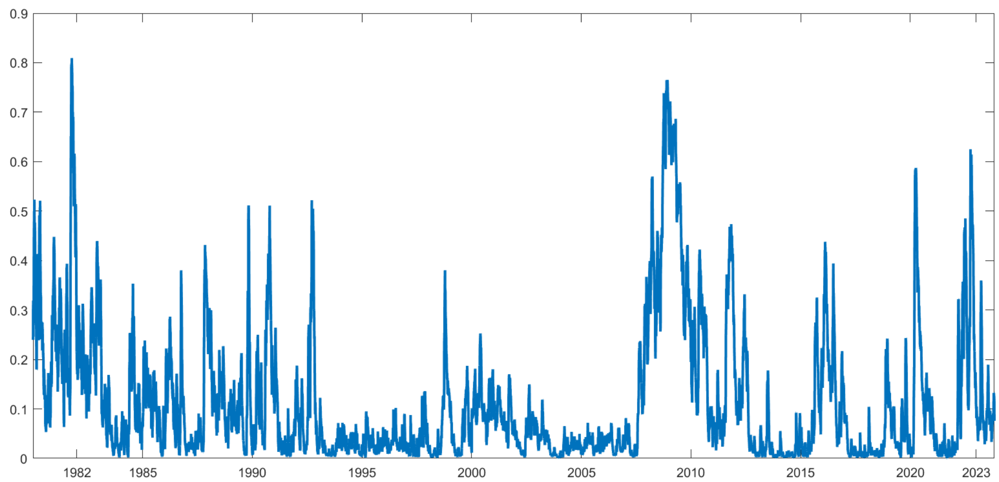


Figure A5: The CISS index of Hollo et al. (2012)



Source: ECB Data Portal.

Figure A6: Nominal supply volumes of passive QT and active QT with equal size

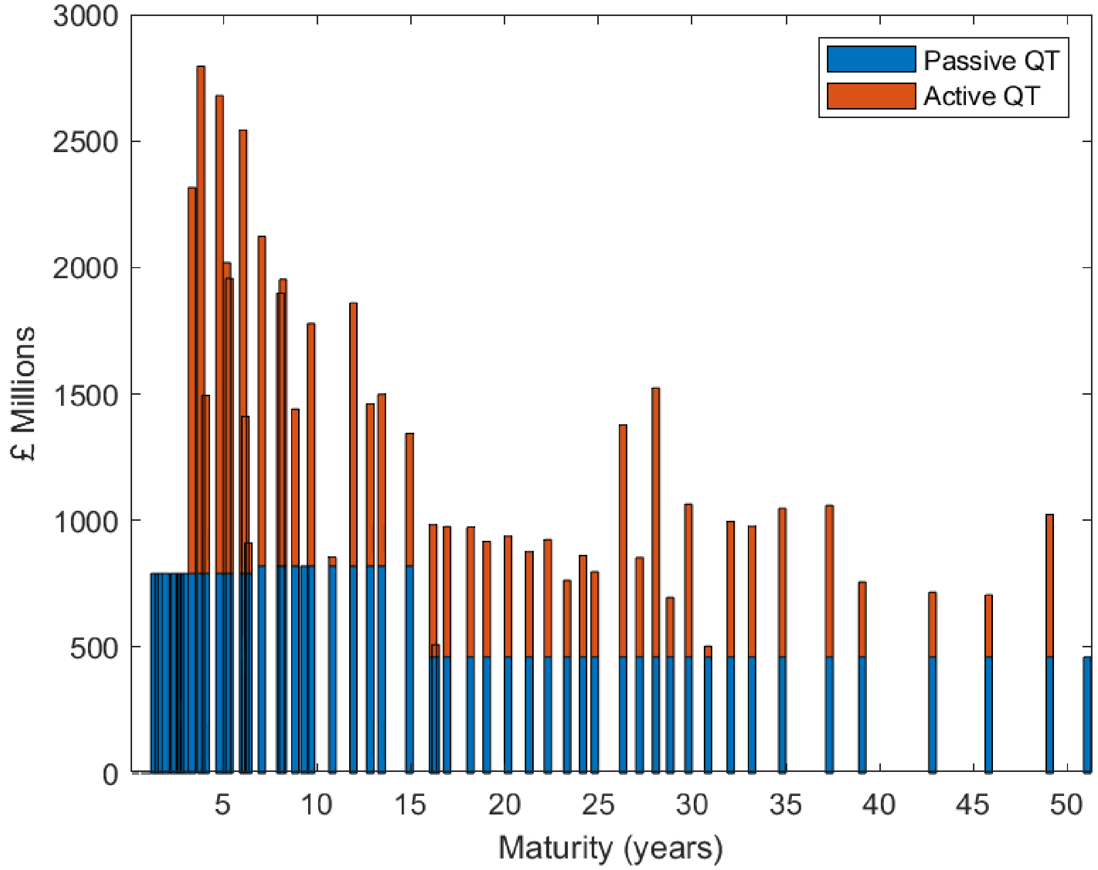


Figure A7: Bond level sales implications of the 18 October 2022 QT skew announcement

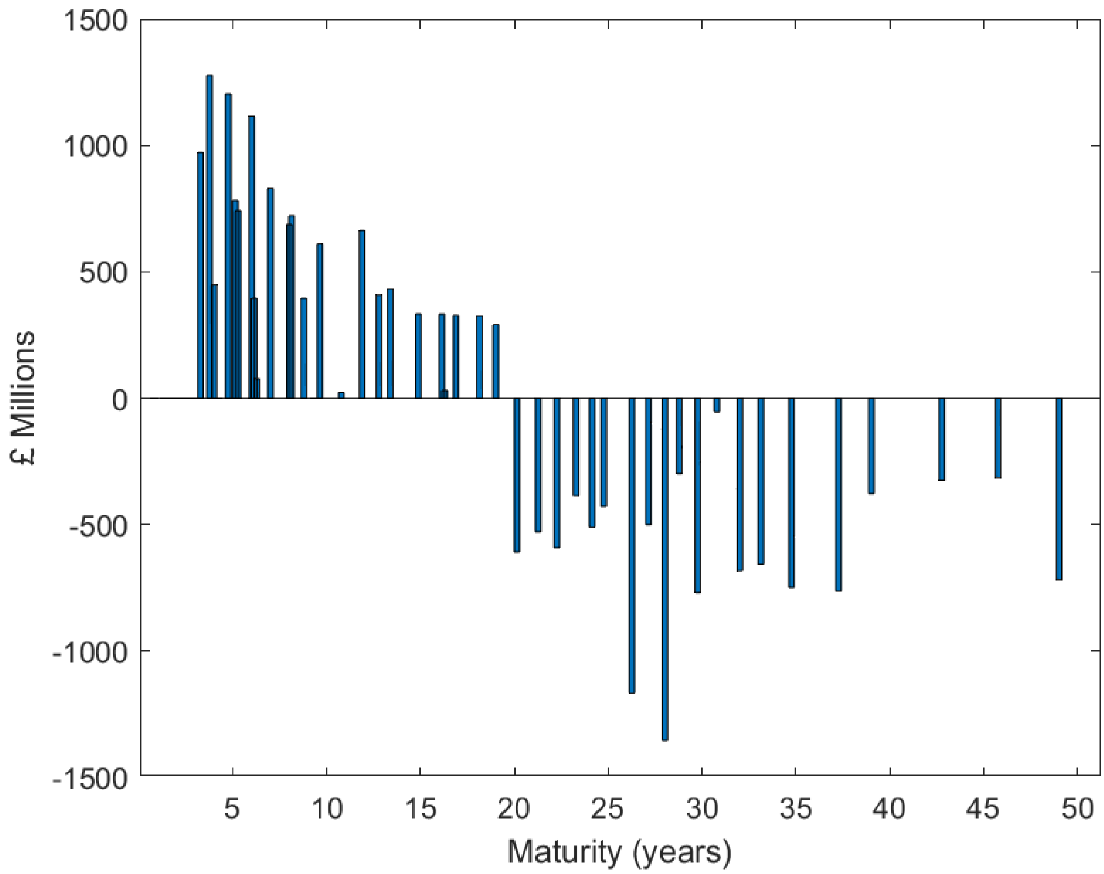


Table A1: First stage regression results

	Estimate
$\alpha^{(Short)}$	3432.875***
	(54.945)
$\alpha^{(Medium)}$	2643.732***
	(50.135)
$\alpha^{(Long)}$	1970.764***
	(59.589)
$Z_{1,t}$	58.619
	(42.523)
$Z_{2,t}$	-75.843
	(54.681)
$Z_{3,t}$	43.883
	(58.191)
$Z_{4,t}$	-28.048
	(70.837)
$Z_{5,t}$	-205.297**
	(82.216)
$Z_{6,t}$	179.090*
	(108.304)
$Z_{7,t}$	28.727
	(74.283)
$Z_{8,t}$	-18.557
	(78.069)
N	424
F-test	31.847***
R^2	0.459

Notes: Regression results from Equation (1). Standard errors in parenthesis, (*), (**), and (***) denote statistical significance at 10%, 5%, and 1%, respectively.

Table A2: Robustness results with control variables

	(1)	(2)	(3)	(4)
Local Supply - High Stress	0.037***	0.037***	0.037***	0.038***
	(0.006)	(0.006)	(0.006)	(0.006)
Local Supply - Low Stress	0.014**	0.014**	0.013**	0.013**
	(0.007)	(0.007)	(0.007)	(0.007)
Duration Risk - High Stress	0.016**	0.015**	0.016**	0.015**
	(0.007)	(0.008)	(0.008)	(0.008)
Duration Risk - Low Stress	0.013*	0.013*	0.012*	0.012*
	(0.007)	(0.007)	(0.007)	(0.007)
UK news	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
EA news	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
US news	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
UK news$\times\tau$		-0.004***	-0.015***	-0.015***
		(0.001)	(0.003)	(0.003)
EA news$\times\tau$		0.001*	0.008***	0.008***
		(0.001)	(0.002)	(0.002)
US news$\times\tau$		-0.001***	-0.005***	-0.005***
		(0.000)	(0.001)	(0.001)
UK news$\times\tau^2$			0.000***	0.000***
			(0.000)	(0.000)
EA news$\times\tau^2$			0.000***	0.000***
			(0.000)	(0.000)
US news$\times\tau^2$			0.000***	0.000***
			(0.000)	(0.000)
Coupon				-0.028**
				(0.011)
Duration				-0.001***
				(0.000)
τ				0.000***
				(0.000)
τ^2				0.000***
				(0.000)
R^2	0.801	0.802	0.802	0.803

Notes: High Stress indicates the CISS index above its historical 75th percentile. The sample includes 424 announcements, and the total number of observations is 18988. News index constructed as the standardized difference between the data release and the Bloomberg consensus. US news are lagged by one business day. τ denotes maturity. Standard errors in parenthesis, (*), (**), and (***) denote statistical significance at 10%, 5%, and 1%, respectively.
Source: LSEG, Bloomberg, ECB Data Portal.