BANK FOR INTERNATIONAL SETTLEMENTS

BIS Working Papers

No 571

On the transactions costs of quantitative easing

by Francis Breedon and Philip Turner

Monetary and Economic Department

July 2016

JEL classification: D44, E42, E52, E58, G12

Keywords: Quantitative Easing, auctions, bond interest rates, central bank balance sheets, exit strategy

This publication is available on the BIS website (www.bis.org).

ISSN 1020-0959 (print)
ISSN 1682-7678 (online)

On the transactions costs of quantitative easing*

Francis Breedon and Philip Turner

Abstract

Most quantitative easing programmes primarily involve central banks acquiring government liabilities in return for central bank reserves. In all cases this process is undertaken by purchasing these liabilities in the secondary market rather than directly from the government. Yet the only practical difference between secondary market purchases and bilateral central bank/Treasury operations is the transactions costs involved in market operations. This paper quantifies the significant cost of this round-trip transaction – government issuance of liabilities and then central bank purchase of those liabilities in the secondary market.

JEL classification: D44, E42, E52, E58, G12

Keywords: Quantitative Easing, auctions, bond interest rates, central bank balance sheets, exit strategy

* Views expressed are our own and do not necessarily reflect the views of our respective institutions. The affiliations and email addresses of the authors are Queen Mary University of London (f.breedon@qmul.ac.uk) and Bank for International Settlements (Philip.turner@bis.org). Thanks are due to participants at seminars at the BIS and the Bank of England. We are also grateful for comments from Michael Chui and Andrew Filardo. Sonja Fritz, Cissy Mak and Amy Wood provided very efficient help in preparing this paper.

Contents

1. Introduction: direct finance versus monetary financing

Although quantitative easing (QE) programmes vary in design, the four major ones – those of the Bank of England, the Bank of Japan, the European Central Bank and the Federal Reserve – have involved the secondary market purchase of government bonds by the central bank and the associated creation of bank reserves.

Such policies have had two main objectives. The first is to put downward pressure on longer-term interest rates by reducing the average maturity of government debt to sell on the market (ie not held within the central bank). In an open economy, lower domestic interest rates relative to those abroad tend to induce non-residents to sell local bonds (ie capital outflows). The currency depreciates. The second objective is to increase bank reserves and make the domestic banking system more liquid in the hope that bank lending conditions ease. Many studies have shown that QE has had a large measure of success in meeting these objectives.

The question we ask in this paper is one of implementation: why in all these cases has the government issued debt in the open market for its own central bank to then purchase in the secondary market? Would it not be simpler, and cheaper, for the government to issue the bonds directly to the central bank and avoid round-tripping via the markets?[1] This question needs to be asked as central bank reinvestment of maturing government bonds is very large. And it would also be relevant during the exit phase.

Simple macroeconomic theory suggests that the two approaches are identical. The monetary and real effects of official balance sheet policy depend only on changes in the **consolidated** balance sheet of what used to be called the monetary authorities – that is the government and the central bank combined. Transactions involving only the government and the central bank have no direct effect on the private sector.

The simplest demonstration of this is to suppose the government issues bonds for its central bank to hold and puts the proceeds on deposit with the central bank. The central bank's balance sheet rises (government bonds as assets and government deposits as a liabilities) but there has been no change in the consolidated balance sheet of the authorities (that is, central bank plus government). It is simply a matter of intra-public sector accounting with no direct economic effects – unless the behaviour of the government or of the central bank is altered (or perceived to be altered) by this transaction.

It is this qualification – that the behaviour of the public sector entity is not affected by accounting conventions – which is key. Much of the controversy about balance sheet policies revolves around different views about how they could affect government fiscal decisions (eg central bank finance could mean bigger deficits) or central bank policy rate decisions (eg large short-term government debt might force the central bank to set its policy rate too low). In addition, there can be political constraints on governments and central banks that are not captured by the consolidated balance sheet of the authorities (Ueda (2003)).

How has recent QE changed the consolidated balance sheet of the monetary authorities? Stripped to its essentials, it has changed their liabilities – from long-term government bonds to very short-term bank reserves (i.e. banks' deposits with the central bank). The effect on this consolidated position of any change in the central

1 This process is somewhat more complicated in the euro case where there is one central bank and multiple governments.

bank holdings of government bonds could have been replicated by a comparable change in government debt issuance. Consider the two key objectives mentioned above – lowering the long-term interest rate and expanding bank reserves.

(a) *The long-term interest rate*. Even assuming expected future short-term rates are given, central bank purchases of longer-dated government paper can drive down the term premium (ie that part of the long-term rate not explained by expected future short-term rates) through portfolio balance effects. QE has spurred a revival of James Tobin's work on this mechanism (as well as the old preferred-habitat models, such as Modigliani and Sutch (1967)). Vayanos and Vila (2009) have developed a preferred habitat model to explain the term structure of interest rates. Gertler and Karadi (2013) have established that changes in the term premium play a significant role in US monetary policy transmission. Iwata et al (2016) develop a similar analysis for Japan.

    There is hardly anything new in this. Buying long-term government debt was central to Keynes's analysis in *Treatise on Money* of how central banks could combat slumps (Tily, (2010)). Worried that a central bank acting alone could run the risk of provoking excessive currency depreciation, he argued that the newly established BIS could encourage internationally coordinated central bank efforts to reduce long-term interest rates. Per Jacobsson, Economic Adviser at the BIS from 1931, strongly supported coordinated policies aimed at reducing long-term interest rates.

    The Treasury could achieve exactly the same effects by issuing fewer long-term bonds and more short-term bonds. In the 1930s, HM Treasury was unconvinced by Keynes's advice, and actually lengthened the maturity of gilts issued. By the mid-1930s, 86% of UK government bonds had a maturity in excess of 15 years. Susan Howson's (1975) study of British monetary policy in the 1930s found that this limited the effectiveness of the cheap money policy instituted once Britain had left the gold standard: debt management policy ran counter to the monetary policy intent of low short-term rates.

    US experience since the 1970s clearly demonstrates how issuing shorter-dated debt lowers long-term interest rates. A recent study over the period 1976 to 2006 (that is, **before** QE) found that lowering the average maturity of US Treasuries held outside the Federal Reserve – mainly in this period brought about by changes in US Treasury issuance because Federal Reserve purchases were small – reduced the yield of long-term US Treasuries by a significant amount (Chadha et al, 2013).

    Since early 2009, the US Treasury's policy of lengthening the average maturity of gross issuance has worked in the opposite direction as QE. Larry Summers argued recently that the Federal Reserve's QE policies reduced dollar long-term rates by 1.37 percentage points while the increase in the average maturity of Treasury debt issuance added back 0.48 percentage points (Greenwood et al, 2014). Iwata and Fueda-Samikawa (2013) show how the rise in the average maturity of JGBs has at times run counter to the Bank of Japan's QE policies.

(b) *Expanding bank reserves*. The government issuing bonds directly to the central bank with a given price – rather than having the central bank buy such bonds in the secondary market – would generate government deposits with the central bank equal in value to the price put on the bonds. It is only if the government draws down such deposits to finance its domestic spending that there would be monetary implications. As the government spends more, commercial bank deposits would rise leading to an expansion in bank reserves.

As already noted, the macroeconomic equivalence between bilateral central bank/Treasury operations and round-tripping through the markets depends on the assumption that the behaviour of the government or the central bank is not altered by the alternative financing arrangements. This assumption can of course be challenged. Fiscal discipline could be eroded if the Treasury were able to force the central bank to directly finance government spending *at interest rates dictated by the Treasury* ("direct finance"). Monetary policy independence would be undermined.

Nonetheless, simply banning direct purchases of government debt by the central bank would not, in itself, prevent such an outcome. If the Treasury could force the central bank to buy government debt in the secondary market, it would be relatively easy to find willing buyers for that debt in the primary market who could then quickly sell to the central bank. Indeed, other financing arrangements could equally undermine fiscal discipline – such as forcing commercial banks to finance the government (financial repression). In all cases, it is the ability of the Treasury to influence the behaviour of potential holders of government debt that is the key – not the mechanics of how that debt is sold.

The monetary financing of government deficits can take place without any direct finance. Indeed, the standard measure of monetary financing does not depend on the intentions of either government or the central bank. Rather it is based on the short-term liabilities on the consolidated balance sheet of the central bank and the government: currency, other central bank liabilities and short-term government debt. The short-hand view was that Treasury issuance of short-term debt was monetary finance, and therefore subject to limits.

For this reason, the Deutsche Bundesbank had for many years a veto on short-term debt issuance by the German government. Many central banks paid close attention to measures of monetary financing. Hoogduin et al (2010), for instance, describe the case of the Netherlands: "In the 1980s, government debt finance was an explicit part of the monetary analysis of De Nederlandsche Bank … when the government financed part of its debt in the money market, it was considered monetary financing, which would increase the amount of liquidity in the economy." Treasury bills are close to money because their holders can cash close to the nominal value of the bill – which cannot be counted upon in the case of bonds. Implicit understandings that only the central bank should issue debt at the short-end of the market while government issued longer-dated paper took root in many countries, often to avoid having two official issuers "competing" in the same maturity tenor.

The definition of monetary financing in Table 1 follows Tobin (1963). Tobin argued that the monetary impact of government debt depends on the composition of the public's holdings of government debt (that is, net of central bank holdings). He showed that, in 1969, it was the increasing reliance by the Treasury on short-term debt (not increased Federal Reserve obligations) that had made the economy more liquid.

Monetary financing was accordingly defined as currency, Federal Reserve liabilities plus US Treasuries with a maturity of less than one year. Non-monetary financing is simply longer-dated US Treasuries held outside the central bank – this can be altered either by the central bank buying bonds in the open market or by the Treasury issuing more short-term bills and fewer longer-term bonds. Likewise, according to this view, monetary financing can take the form of Treasury issuance of short-term bills.

Table 1 shows that such issuance in the United States was large in FY 2008 and FY 2009. Under the Supplementary Financing Program (SFP), the US Treasury did increase its issuance of Treasury bills – "separate from its current borrowing program" as its September 2008 press release put it – and put the proceeds on deposit with the Federal Reserve (which purchased mortgage-backed securities).

Composition of marketable US Federal government debt held by the public

$ billion — Table 1

End of fiscal year (Sept)	Marketable securities		Currency & Federal Reserve obligations	Total	Money, Federal Reserve obligations and short-term debt
	(<or = 1 year)	(> 1 year)			
	(a)	(b)	(c)	(d)	= (a+c) % d
1955	43	113	51	207	45.4%
1969	80	82	73	235	65.1%
1990	527	1668	306	2501	33.3%
2001	735	2180	638	3553	38.6%
2007	955	3474	834	5262	34%
2008	1484	3726	1087	6297	40.8%
2009	1986	5002	1780	8768	43%
2010	1784	6692	1896	10372	35.5%
2011	1476	8129	2683	12287	33.8%
2012	1613	9117	2541	13271	31.3%
2013	1528	10049	3410	14988	32.9%
2014	1410	10862	3796	16067	32.4%
2015	1355	11477	3556	16388	30%

Sources: This is an update of that in Tobin (1963) using US Treasury Bulletin; Federal Reserve Flow-of-Funds. In this table, "by the public" means outside the central bank.

Although these terms are sometimes confused, monetary financing is not the same as direct financing by the central bank of the government *on terms decided by the government*. The central bank which purchases government bonds in open markets may protect itself from such pressure – but it is still engaged monetary financing. Central banks have historically been active in bond markets in implementing monetary policy. As Truman (2005) put it well before recent QE policies, "the proposition that a central bank should limit its purchases of long-dated government obligations in the open market because not to do so would impair its balance sheet and de facto independence [is incorrect]… as long as the central bank purchases long-dated government obligations in the open market and has no obligation to roll them over, the central bank should have no legislated or self-imposed limit on the amount of such obligations it may purchase." Equally a government engaged in significant and regular market issuance in primary markets – so that market-determined new issue prices exist – can place new issues with the central bank at prices determined by the market. It can entirely avoid the traps that Truman warned about without the roundabout strategy of selling bonds in open markets that it knows the central bank – for its own monetary policy purposes – plans to purchase. This roundabout strategy is costly.

Of course, in the case of EU countries direct financing is legally problematic given the Lisbon Treaty on the Functioning of the European Union. Article 123 of the Treaty states:

> "Overdraft facilities or any other type of credit facility with the European Central Bank or with the central banks of the Member States (hereinafter referred to as 'national central banks') in favour of Union institutions, bodies, offices or agencies, central governments, regional, local or other public authorities, other bodies governed by public law, or public undertakings of Member States shall be prohibited, as shall the purchase directly from them by the European Central Bank or national central banks of debt instruments."

Some have argued this Treaty does not preclude direct central bank/Treasury operations, Bossone (2013), for example, suggests that such financing could be undertaken under the Emergency Liquidity Assistance (ELA) scheme. Such legal arguments are however beyond the scope of this paper which has a more limited objective – to examine whether the round-trip approach to quantitative easing involves significant transactions costs. If such costs are not incurred, then a further analysis of why the round-trip approach is undertaken would have little policy relevance. If, on the other hand, significant transactions costs are incurred (which is what we find), then the benefits of the round-trip approach that offset this cost need to be identified.

In this paper we take the UK QE programme as an example and estimate the transactions costs involved in that programme. We analyse the movements in bond yields around each type of operation (debt sales and debt purchases) to measure short-term underpricing of sales and overpricing of purchases – commonly termed the 'concession' – over the period when quantitative easing was in operation. In approach it is most similar to Lou et al (2013) who study US Treasury auctions, in a similar way and find similar results in terms of both the size and length of the concession window. On the QE purchase side, it is also similar to D'Amico and King (2013), though they use a somewhat different approach and a shorter window. In some senses, the approach taken here is also comparable with that adopted in a number of QE studies (see, for example, Krisnamurthy and Vissing-Jorgenson (2011) and Joyce et al (2010)) to measure the long-run and announcement effects of the policy. But the focus of this paper is very much on the short-run liquidity impact of individual operations (what D'Amico and King (2013) call 'flow effects') as a way of gauging the difference between the price government bonds could be sold at and the price they could be purchased at in large scale official operations over the QE period.

2. UK debt issuance and Quantitative Easing

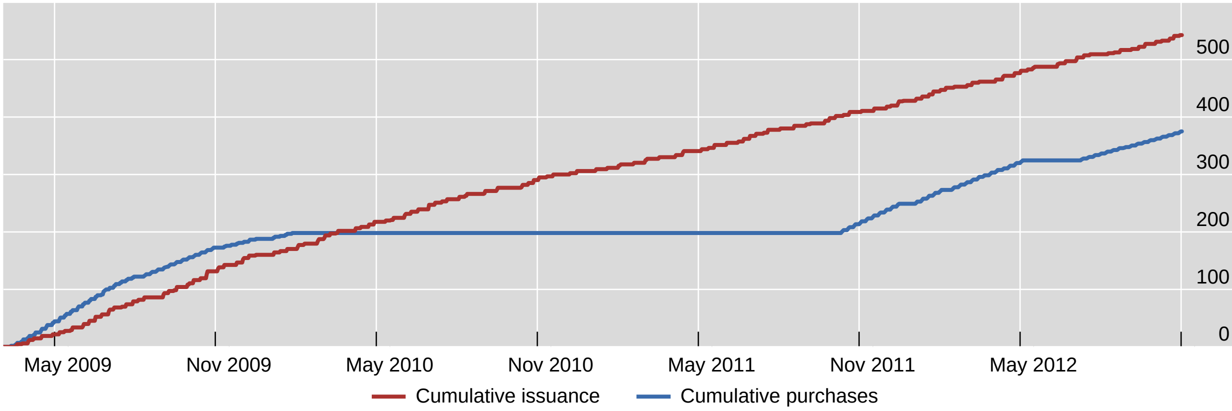
As a preliminary analysis, it is useful to look at two aspects of QE that might have precluded a bilateral central bank/Treasury transaction rather than a round-trip approach, namely that either the scale or the duration of QE purchases could not be matched by new issuance.

Between March 2009 and October 2012, there were two distinct periods of Bank of England bond purchases. QE1 covers the period from March 2009 to December

2009, and QE2 covers that between September 2011 and October 2012[2]. Graph 1 shows cumulative conventional bond issuance and bond purchases over this period.[3]

Cumulative issuance and purchases of conventional bonds since 12 March 2009

£ billions Graph 1



Sources: DMO; APF.

As Graph 1 shows, over the whole period there were significantly more sales than purchases but that over the two sub-periods when purchases occurred the rate of purchases was somewhat faster than sales. Overall, however, relatively small changes in timing could have allowed the rate of purchases and sales to be exactly aligned, and MPC minutes do not seem to indicate that the exact timescale of purchases was seen as a key aspect of QE policy. This suggests that the round-trip approach was not required due to lack of government primary issuance during the QE period.

One other possible explanation for a round-trip approach to QE transactions could be that the secondary objective of the programme was to substantially alter the average duration of existing debt. This would be akin to 'operation twist' where purchases of longer duration debt are funded by sales of short duration with the express intention of shortening the average duration of outstanding debt (and potentially lowering long term yields – see Swanson (2011)).

In order to assess the difference in duration of debt purchases and sales over this period, Graph 2 shows the cumulative average duration[4] of conventional debt sales and purchases as well as the duration of outstanding conventional debt over the QE period. Whilst it is true that the average duration of purchases (10.2 years) was somewhat longer than that of sales (8.9 years), the difference was not large and so the same impact on the average duration of outstanding debt could have been achieved by a direct central bank/Treasury operation. The same effect could have been achieved by reducing the duration of residual issuance (that is, issuance still required after direct sales to the Bank of England) to about 6 years. For a similar analysis of the duration of US Treasuries held by the public, see Chadha et al (2014).

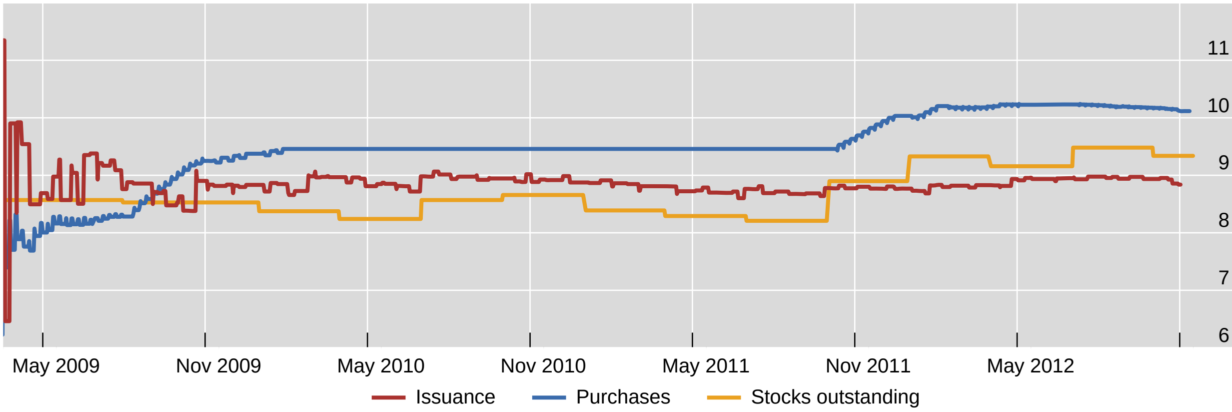
[2] The period from July to October 2012 is sometimes referred to as QE3 but we have merged this period into QE2 to make the two periods large enough to analyse separately.

[3] We exclude index-linked debt throughout this paper since it was not eligible for QE operations.

[4] The value-weighted duration of debt sold/purchased from March 2009 up to the date on the x-axis.

Cumulative duration of conventional purchases and issuance and duration of outstanding stock of debt

Modified duration (years) Graph 2



Source: DMO.

2.1 Debt issuance and QE purchase operations

Before measuring transactions costs, it is useful to summarise how government bonds were sold and purchased. Over this period, the Debt Management Office (DMO) adopted three issuance techniques to sell Conventional Debt: Auctions, Syndications and Tenders.

- *Auctions.* Over our sample, the vast majority of debt (about 86% by value) was sold at auction. Over this period, the average amount sold per auction was about £3.5 billion. At such auctions, the exact amount and details of the gilt for sale are announced about a week before the auction. At the auction itself, Gilt-Edged Market Makers (GEMMS) submit bids (price and amount) to purchase the bond and the bids are filled from the highest down on a bid price basis until the full amount is allocated.[5]

- *Syndications*. Given the scale of bond issuance required over recent years, the DMO has begun to conduct a few large-scale syndications (average size in our sample was £5.6 billion). At a syndication, lead managing banks, appointed over the period of the offer, build a book of demand through ongoing dialogue with investors. The book closes and the deal is priced when the Lead Managers and issuer agree. Thereafter the Lead Managers and issuer agree the allocation of bonds to investors. Syndications also involve the payment of fees to the Lead Manager. These fees are not included in our estimates.

- *Tenders.* These are small-scale auctions (average size about £1 billion) arranged at short notice (minimum of one hour) which are used when the DMO 'judges there to be excess demand' in a particular bond. The allocation process is the same as at standard auctions.

[5] Other entities are allowed to submit bids at auction – including non-competitive bids that are filled at the average accepted auction yield. However, in practice the non-GEMM contribution to bidding is insignificant.

The method by which the Bank of England purchased bonds over this period is a little more involved.

- *QE Operations*. The Bank announced a maturity range and total value of bonds (average of £1.9 billion in our sample) in that range it offered to buy at the operation. The final details of each operation were normally announced on the Thursday of the preceding week, though the general pattern was fairly predictable. On the operation day, GEMMs would then have half an hour (14:15 to 14:45) to submit offers (bond, price and amount) to sell. After receiving these offers, the Bank of England would then calculate the difference between each offer yield and the secondary market yield of the bond at the end of the operation (14:45). Given these differences, the Bank then purchased whatever bond had been offered at the highest yield relative to the market yield at the end of the auction period and then worked down through the offers until the full amount had been allocated (see Bank of England Market Notice 100108). For example, if the Bank of England received offers of both a 10-year and a 9-year bond at 3% yield and observed that the secondary market yield of the 10-year bond at the end of the operation was 3.01% and the 9-year bond was 2.99% it would purchase the 9-year bond first since that had a higher offered yield (lower price) relative to that observed at the end of operation. As discussed in Section 4, this allocation method is unusual (probably unique) and presents a number of practical problems.

Although the precise details of the operations (maturity range of bonds purchased, timing of operations etc.) changed several times over the QE period (see McLaren et al (2014) for details), the underlying purchase method remained as described above.

3. The transactions costs of debt sales and QE purchases

In this section, we report estimates of the cost of purchase and sales operation by comparing the yield received at each operation with the end-of-day yield[6] for the same instrument in the surrounding days. This approach is widely used in the auction underpricing literature (see for example Simon (1994), Nyborg et al (2002)). This approach is generally preferred to the alternative (comparing auction yields with yields on comparable bonds) because comparable bonds are also influenced by the auction process (see for example D'Amico and King (2013)) particularly since QE operations involve a whole range of bonds. The extent to which the sale price is lower than the prevailing market price around the operation and the purchase price is higher is then a measure of what is termed the *auction concession*[7].

6 End-of-day yields are collected and checked by the DMO from the GEMMs. The checking process allows the DMO to censure any GEMM who submits unrealistic prices and so is superior to the 'live' DMO price discussed below. However even these prices are simply indicative and may not relate to actual trades that have occurred.

7 The term "auction concession" is most often used to describe underwriting spreads in equity and bond underwriting agreements. As there are no underwriters in these auctions, however, the concession is defined in this paper as the difference between the auction price and the prevailing market price before and after the auction.

Perhaps two aspects of the auction concession measure used in this paper are unusual. First, the concession is measured in terms of yield rather than price, this is because the auction concession in price terms rises significantly with bond maturity as might be expected given the higher price volatility of longer maturity bonds. In yield terms it is less correlated with maturity allowing a cleaner estimate (see Appendix 2). Second, the calculation of the concession is calculated up to 2 days before and after the auction. This is because there is clear evidence that bond yields move significantly over this period. For example, the auction concession is significantly larger when using t-2 and t+2 as comparator than with t-1 and t+1 though there is no significant effect beyond t-2 and t+2 for either sales or purchases.[8] Whilst such a long window is rarely used in the government auction underpricing literature, an even more extended period of yield impact is found by Lou et al (2013) in the case of US Treasury Auctions. In the UK case, the infrequent trading in the more illiquid bonds could be also help explain the extended window of yield impact. Nath (2003) estimates that, although the top 5 most heavily traded gilts average almost 40 public trades per day, outside the top 30 the average is less than 1 per day. Certainly, other studies of auction concessions for UK government bonds have also found a longer window is required (see Breedon et al (2012) and Ahmed and Steeley (2008)). One disadvantage of the longer window is that more general movements in the bond market may influence the results for the overall concession. However, adjustments for the general trend in yields around auctions make very little difference[9] to the results so the more straightforward un-adjusted concessions are used throughout this paper.

QE bond purchases involve purchasing a range of bonds in a single operation. Hence the yield concession is calculated as the average concession across all the bonds purchased in a given operation. This approach is consistent with the standard approach used in event studies (starting with Jaffe (1974)) since it eliminates correlation across the event and is also consistent with the idea that each operation should be viewed as a single event (rather than multiple ones). However, treating each bond purchased as a single event and using the ADJ-BMP statistic that adjusts for the cross-event correlation (as described in Kolari and Pynnonen (2010)) gives similar results.

Table 2 simply measures average transaction costs by type of operation. The five columns show end-of-day yields from 2 days before to 2 days after, relative to average accepted yield at operation in basis points for all operations between March 2009 and May 2012. For sales, the concession is end-of-day yield minus operation yield; for purchases it is operation yield minus end-of-day yield. A more detailed analysis of the determinants of these transactions costs in presented in Appendix 2. We use both standard t-tests and the Mann Whitney U test to check for the significance of transactions costs. The latter non-parametric test is used as it is more efficient in the presence of non-normal distributions which may be an issue in this case given the range of different bonds analysed.

8 Not only are concession effects insignificant beyond the two-day window for both purchases and sales, but there is also a risk that a longer window would be contaminated by the impact of other operations since QE operations tended to occur once a week.

9 We adjusted for the trend in yields in the 10 days before each operation window and found similar results as the trends were largely insignificant.

Estimated transactions costs

In yield basis points — Table 2

	t-2	*t-1*	*t*	*t+1*	*t+2*
Purchases	**2.58**	**1.43**	**0.72**	**1.43**	**2.22**
N=192, (1338)	**(***,†††)**	**(***,†††)**	**(***,†††)**	**(***,†††)**	**(***,†††)**
QE1	2.66	1.66	1.10	2.53	2.86
N=92, (576)	(***,†††)	(***,†††)	(***,†††)	(***,†††)	(***,†††)
QE2	2.51	1.21	0.31	0.42	1.65
N=100, (762)	(***,†††)	(**,††)			(**,†)
Sales	**1.64**	**0.70**	**0.79**	**0.71**	**1.47**
N=161	**(***,†††)**	**(**,†††)**	**(***,†††)**	**(†)**	**(**,††)**
Auctions	1.62	0.51	0.82	0.59	1.41
N=139	(***,†††)	(*,††)	(**,†††)		(*,††)
Tenders	0.16	1.49	0.42	0.59	0.61
N=13					
Syndications	6.31	3.87	0.95	2.69	3.56
N=9	(*)			(*)	(*)
Difference	0.94	0.71	0.07	0.72	0.79
(Purchase–sales)	(*,††)	(**,†)			(*)

Notes:

(1) N is number of operations. In the case of QE the first figure is the total number of QE operations and the second figure is the total number of bond purchases (since there are several bonds purchased at each operation). Smaller QE operations of less than £1bn, such as those used to offset redemptions, are excluded.

(2) *, **, *** indicates significant at the 10%, 5% and 1% level based on standard t-test, †, ††, ††† indicates significant at the 10%, 5% and 1% level based on Mann-Whitney U test.

As Table 2 shows, there is evidence of significant overpricing for total purchases on all comparisons. For sales, the results are somewhat weaker with the clearest evidence of underpricing occurring at the t-2 and t horizons. The results for sales are similar to those of Lou et al (2013) for the United States who find about a 2bp concession for 10-year bonds over a somewhat longer (5-day) window Looking in detail at different types of operation, there is some evidence that QE operations in QE1 had a higher concession, though not significantly so. On the sales side, the 9 syndications seem to have a very high average concession though the sample is too small and variable to draw strong conclusions. Perhaps the most interesting result is that at t-2, t-1 and t+2 QE purchases have a significantly larger average concession than sales. We return to this result in Section 4.

Given the results in Table 2, it is possible to estimate the total transactions cost involved in a round-trip approach to QE. First, we estimate the average saving from not conducting sale and purchase operations by assuming that the issuance not undertaken (due to direct sales to the government) was conducted in the same proportion of auctions, syndications and tenders that occurred over this period. We then adjust this cost to allow for the fact that remaining issuance would have to have been of significantly shorter duration (around 6 years) in order to leave the average duration of outstanding debt in private sector hands the same as actually occurred. This duration adjustment makes issuance somewhat cheaper (since the estimated auction concession is in yield terms).

Results for this exercise are shown in Table 3. The total figure comes out at £1.85 billion (on the t-2 comparison) which is close to ½% of the total value of QE operations (£375 billion). The figure is smaller on other comparisons though t+2 is similar at about £1.69 billion.

As noted above, the cost of sales was appreciably lower than that of purchases (about 40% less on average) even though the high cost of the small number of syndications was a substantial contributor to the overall cost of sales.

Estimated costs of the QE programme

In £million

Table 3

	t-2	*t-1*	*t*	*t+1*	*t+2*
Purchases	1182	726	181	660	974
QE1	563	421	164	543	589
QE2	620	305	17	117	385
Sales	668	293	277	380	716
Auctions	425	150	216	224	489
Tenders	36	18	4	–1	–1
Syndications	199	122	53	154	221
Duration Adj.	8	3	4	3	7
Total	**1850**	**1019**	**458**	**1040**	**1690**
(% of QE)	**(0.49%)**	**(0.27%)**	**(0.12%)**	**(0.28%)**	**(0.45%)**

4. The transactions costs of QE operations

Section 3 showed that there seems to be a significantly higher transactions cost involved in purchasing bonds in QE operations relative to the average cost of sales. Arguably, there are two possible explanations for this difference. One explanation would be that purchases are intrinsically more expensive to undertake than sales since they require existing holders to offer their bonds for sale. Another explanation would be that the particular design of the QE programme was at fault. Although it is hard to distinguish between these explanations, two considerations suggest that poor design was responsible. First, the small sample of official bond purchases conducted using other methods does not show evidence of significant overpricing and, second, there are some clear design issues with these QE operations which could explain the high level of overpricing.

4.1 Evidence from other official purchases

From 1998/9 to 2000/1, the United Kingdom ran a series of large fiscal surpluses that resulted in the decision to conduct a series of reverse auctions to reduce outstanding debt. Overall there were six such reverse auction operations conducted from July 2000 to February 2001. Their design was in many ways similar to QE operations in the sense that a range of bonds were purchased at each auction based on offers from GEMMs. The key difference is that the allocation was based on yield deviations from an estimated yield curve model rather than the yield on each bond at the end of the auction. Thus, auction allocation was on the basis of each bond's position relative to an estimated yield curve. Offers of bonds by GEMMs were therefore allocated starting with the offer at the highest yield relative to the estimated curve and working down through the offers until the full amount has been purchased. This relative value approach, arguably, helps mitigate the problems of allocation discussed below.[10,11]

Average yield concession for reverse auctions — Table 4

	t-2	t-1	t	t+1	t+2
Reverse Auctions N=6,(12)	0.62	1.46	0.38	–1.60	–0.29
Difference (QE-reverse auctions)	1.97 (*)	–0.05	0.21	3.04 (†)	2.52 (†)

*, **, *** indicates significant at the 10%, 5% and 1% level based on standard t-test, †, ††, ††† indicates significant at the 10%, 5% and 1% level based on Mann-Whitney U test

Table 4 shows that the average yield concession for the small sample of reverse auctions was remarkably small, so much so that the concession is significantly smaller, at the 10% level, at t-2 and t+1 and t+2 (based on the Mann-Whitney U test) than for QE operations. Although it is hard to draw firm conclusions from such a small sample, the evidence from the reverse auctions conducted in the early 2000s does not suggest that the concession for official purchases is greater than that for sales and therefore the particular design of QE operations may have been an important factor in explaining the larger concession in that case.

4.2 QE auction design

There are two potential design problems with QE operations. One arises because bidders may act to influence the secondary market yields used to allocate bonds. The other problem stems from the fact that the secondary market yields used are indicative, and not based on firm offers to buy.

1) *Potential interaction between bidder behaviour and final allocation*. Although these operations are too complex to be adequately analysed using standard auction theory (see Song and Zhu (2014)), there is a literature (eg Bond, Goldstein and Prescott (2009)) that indicates that allocation rules based on market prices that can be influenced by market participants are potentially problematic. In this particular case, the fact that the allocation of purchases across bonds was based on the market yield at the end of the operation itself could create an indeterminacy. This is because the yield can be influenced by the actions of market participants over the operation period (ie significant purchases may lower the market yield – at least temporarily – and vice versa for significant sales). Thus a market participant purchasing bonds in the secondary market in order to on-sell to the Bank of England could inadvertently, or deliberately, lower the secondary market yield of that bond and thus raise the likelihood and/or improve the terms at which that bond would be purchased.

10 US QE operations also mainly refer to the yield curve as a reference for allocation, though other factors such as the secondary market yield can also be used (see Song and Zhu (2014)).

11 It should also be noted that these auctions were somewhat smaller in scale (average £0.66bn), which is about half the size of the average QE operation in real terms.

With a maximum of 20 market makers in gilts participating in the auction and up to 14 bonds eligible, competition between participants is unlikely to eliminate this effect – especially for the less frequently traded bonds. Certainly, the fact that over 86% of bond purchases were allocated at a single yield (indicating that there was probably only one successful bidder) suggests that competition in individual bonds was limited. Such an effect could also explain why the yield concession on individual bonds was appreciably larger for more illiquid bonds (see Appendix 2) where the price impact of secondary market purchases or sales would presumably be larger.

Indeed the Financial Conduct Authority (FCA) recently investigated a case of deliberate price manipulation. A trader purchased a significant amount of the 8.75% 2017 bond (one of the least liquid) on the day of a QE operation and then offered them, plus a large position he had acquired beforehand, for sale at the operation itself. The price of this bond rose strongly against its near comparators during the day due to these purchases but then fell back when the Bank of England announced it was not accepting offers in this bond due to its unusual price movements during the day. The trader was later found guilty of market abuse and fined £662,700. Ironically the Bank of England did eventually accept offers in this bond at a higher price, relative to its near comparators, than it rejected at this operation. See Appendix 1 for further details.

2) *Use of indicative secondary market yields*. Compared with most major bond markets, the UK secondary market for government bonds has a low level of transparency.[12] So, for example, price/yield quotes displayed by GEMMS are indicative rather than firm (i.e. GEMMs are not bound to trade at the displayed quotes). This makes establishing the precise secondary market yield problematic – particularly at the end of an auction before the results announcement when secondary market activity is likely to be subdued.[13] In the case of QE operations, the secondary market yield at the end of the auction was established with reference to the 'live DMO price'. This price is in fact simply a mechanical average of screen quotes offered by GEMMs with the highest and lowest quote removed. Although there is no evidence that this took place, it is clear that GEMMs participating in the operation would have an incentive to change their quotes around the end of the auction in order to improve their chances in the final allocation. Indeed, it is notable that the DMO itself states that the price it publishes for a given bond "is not intended to give a market price at which it could or has been traded" (See DMO (2011)).

As well as having a direct impact on QE operation prices, it seems likely that these two issues would have raised the level of uncertainty at these operations and thus added to the concession demanded by risk-averse GEMMs and/or final purchasers. Thus it seems plausible to argue that the higher transactions costs associated with QE operations were due to their design.

12 In the United States, general access to interdealer prices through GovPx and more general price information through other platforms such as Espeed and brokerTec makes the market highly transparent. Similarly, access to interdealer information though Euro MTS and other MTS platforms make the major European government bond markets more transparent (though recent events have disrupted the normal functioning of this market).

13 Although there is no evidence for the UK bond markets, evidence from other markets suggests that little secondary market trading takes place during a primary operation. See, for example, Lease et al. (1992).

5. The mechanics of reinvestment and of exit

The choice between bilateral central bank/Treasury operations and transactions in the secondary market for government bonds will remain live for years. Both the Federal Reserve and the Bank of England have ceased new asset purchases on a net basis, but continue to reinvest the proceeds of maturing debt. Such proceeds could be just as well reinvested via bilateral central bank/Treasury operations priced according to a current market-clearing price, not affected by central bank market operations.

Both the Federal Reserve and the Bank of England have indicated that the initial steps of monetary policy normalisation will take the form of policy rate increases, rather than sales of assets. The Bank of England has explained its logic of sequencing by indicating "it is likely to defer sales of assets at least until the Bank Rate has reached a level from which it could be cut materially, were more stimulus to be required." But when and how fast central banks will reduce their holdings of bonds beyond the next couple of years, once policy rates are well clear of zero, is unknown. The option of just allowing bonds to mature – apparently the easy option because it avoids contentious decisions about actual sales – would not be a neutral policy choice. It would mean central bank balance sheets remain large beyond 2020. And it would also mean that the timing of shrinking – which would have effects on financial markets and the macroeconomy – would depend only on the pattern of past purchases and be quite independent of future economic conditions.

The corollary of the argument developed above is that the macroeconomic effects of central bank sales of bonds in the market could also be achieved by some combination of a bilateral central bank/Treasury transaction (eg the Treasury could swap long-dated fixed-rate government bonds on the central bank's balance sheet for floating-rate debt) and a change in the government's debt management strategy.

The options for exit are wider than just the central bank selling in the open market the government bonds it holds. For instance, Stella (2015) points out that the Treasury could design "more efficient and less costly" exit by a single financing strategy for the consolidated public balance sheet (that is, central bank and Treasury combined). The central bank could be given the opportunity to swap the government bonds it holds for short-term government bills.

The widely noted contradiction in recent QE policies in which the central bank seeks to take duration out of the market while the government lengthens the average maturity of gross issuance should be recalled in any consideration of the exit strategy. As Fukunaga et al (2015) note, "…[currently] the BoJ extends the maturity of its holding of JGBs to achieve the price stability target…while the government extends the maturity of its debt to reduce the risks associated with refinancing…however, there might be some room to improve the situation by pursuing better coordination among these entities."

6. Conclusion

This paper has argued that the monetary and real effects of QE (eg reduced holdings of long-term government bonds by the market and increased bank reserves) depend on the changes in the consolidated balance sheet of the monetary authorities. The mechanism used recently – government issuance of bonds and central bank purchases of those bonds in secondary markets – involves significant market transaction costs, even if small as a percentage of the total amount. In the case of the United Kingdom, these costs are estimated at 0.5% of the total value of QE or over £1.8 billion. Although it is hard to identify the recipients of these transactions costs, it is unlikely to be entities that the government would wish to subsidise.

The question posed at the beginning of this paper – why is a round-trip approach necessary? – is of more than 'academic' interest given the large market operations involved. It remains live as central bank reinvestment of maturing government bonds continues even if net holdings are no longer increasing. It would be relevant once (or if) central banks wish to sell bonds ("Quantitative Tightening"). Any bilateral central bank/Treasury operation would have to be designed in such a way that avoids compromising central bank autonomy.

The results in this paper also highlight the importance of careful auction design in reducing the transactions costs of debt issuance and purchases. Poor operation design may have been responsible for transactions costs for UK QE purchases that were significantly higher than those for sales over the same period. Similarly, results for larger debt sales, like syndications, suggest that the concession is larger (as a percentage of amount sold) the larger the amount sold. This result, which was also found for the United States by Lou et al (2013), suggests that smaller and more frequent issuance could reduce costs.

References

Ahmad, F and J Steeley (2008): "Secondary market pricing behaviour around UK bond auctions", *Applied Financial Economics, 18*(9), pp 691–699.

Bank for International Settlements (2012): "Threat of fiscal dominance?" *BIS Papers*, no 65, May.

Bond, P, I Goldstein and E Prescott (2009): "Market-Based Corrective Actions", *The Review of Financial Studies*, vol 23, issue 2, pp 781–820.

Bossone, I (2013): "Time for the Eurozone to shift gear: issuing euros to finance new spending", 8 April *voxEU.org*.

Blommestein, H and P Turner (2012): "Interactions between sovereign debt management and monetary policy under fiscal dominance and financial instability", in BIS (2012).

Breedon, F, J Chadha and A Waters (2012): "The financial market impact of UK quantitative easing", *Oxford Review of Economic Policy*, vol 28(4), pp 702–728.

Cai, N, J Helwege and A Warga (2007): "Underpricing in the corporate bond market", *The Review of Financial Studies*, vol 20, issue 6, pp 2021–2046.

Chadha, J S (2014): "The impact of the maturity of US government debt on forward rates and the term premium: new results from old data", VOX CEPR's Policy Portal, 4 November.

Chadha, J S, P Turner and F Zampolli (2013): "The interest rate effects of government debt maturity", *BIS Working Papers*, no 415, June.

D'Amico, S and T King (2013): "Flow and stock effects of large-scale Treasury purchases: evidence on the importance of local supply", *Journal of Financial Economics,* vol 108, issue 2, pp 425–448.

DMO (2011): "A guide to the roles of the DMO and Primary Dealers in the UK government bond market", DMO, August.

Fukunaga, I, N Kato and J Koeda (2015): "Maturity structure and supply factors in Japanese government bond markets", Bank of Japan, *IMES Discussion Paper*, no 2015-E-10.

Gertler, M and P Karadi (2013): "Monetary policy surprises, credit costs and economic activity", NBER conference, Boston, 18–19 October.

Goodhart, C (2010): "The changing role of central banks", *BIS Working Papers,* no 326.

Greenwood, R, S G Hanson, J S Rudolph and L H Summers (2014): "Government debt management at the zero lower bound", Working Paper, no 5, September, Hutchins Center on Fiscal and Monetary Policy.

Hoogduin, L, B Öztürk and P Wierts (2010): "Public debt managers' behaviour: interactions with macro policies", Banque de France and BETA Workshop New Challenges for Public Debt in Advanced Economies, Strasbourg, 16–17 September. (Reprinted as DNB Working Paper, no 273).

Howson, S (1975): *Domestic monetary management in Britain 1919-38*. University of Cambridge. Department of Applied Economics. Occasional Paper 48.

Iwata, K, I Fueda-Samikawa, E Takahashi and T Kimotsuki (2016): "Risks from extending the QQE policy – Bank of Japan's JGB purchases to reach limits in June 2017", Japan Center for Economic Research, Tokyo, January.

Iwata, K and I Fueda-Samikawa (2013): "Quantitative and qualitative monetary easing effects and associated risks", Japan Center for Economic Research.

Jaffe J (1974): "Special information and insider trading", *The Journal of Business,* vol 47, no 3, pp 410–428.

Joyce, M, A Lasaosa, M Tong and I Stevens (2011): "The financial market impact of quantitative easing in the United Kingdom", *International Journal of Central Banking*, 7(3), pp 113–161.

Kolari, J and S Pynnonen (2010): "Event study testing with cross-sectional correlation of abnormal returns", *Review of Financial Studies*, vol 23, no 11, pp 3996–4025.

Krishnamurthy, A and A Vissing-Jorgensen A (2011) "The effects of quantitative easing on interest rates" *Brookings Papers on Economic Activity*, pp 3–43

Lease, R, R Masulis and J Page (1992): "Impacts of seasoned equity offerings on market microstructure and the stock return generating process", *Vanderbilt University working paper.*

Lou, D, H Yan and J Zhang (2013): "Anticipated and repeated shocks in Liquid Market", *Review of Financial Studies,* vol 26, no 8, pp 1891–1912.

McLaren, N, R Banerjee and D Latto (2014): "Using changes in auction maturity sectors to help identify the impact of QE on Gilt yields", *The Economic Journal*, vol 124, issue 576, pp 453–479.

Mogdigliani, F and R Sutch (1967): "Debt management and the term structure of interest rates: an empirical analysis of recent experience", *Journal of Political Economy*, 75:4, pp 569–589.

Nath, P (2003): "Interdealer trading in the UK government bond market", London Business School, *SSRN Electronic Journal*, October.

Nyborg, K, K Rydqvist and S Sundaresan (2002): "Bidder behavior in multiunit auctions: evidence from Swedish Treasury auctions", *Journal of Political Economy*, vol 110, no 2, pp 394–424.

Song, Z and H Zhu (2014): "QE auctions of Treasury bonds", *Federal Reserve Board Finance and Economics Discussion series,* 2014-48.

Stella, P (2015): "Exiting well", http://stellarconsultllc.com/blog/wp-content/uploads/2016/01/1-Exiting-Well-v_December-31_2015.pdf

Simon, D (1994): "The Treasury's experiment with single-price auctions in the mid-1970s: winner's or taxpayer's curse?", *The Review of Economics and Statistics,* pp 754-760.

Swanson, E (2011): "Let's twist again: a high-frequency event-study analysis of Operation Twist and its implications for QE2", *Brookings Papers on Economic Activity*, vol 42 (Spring), pp 151–207.

Tily, G (2010): *Keynes betrayed: the General Theory, the rate of interest and 'Keynesian' economics*, Palgrave Macmillan.

Tobin J (1963): "An essay on the principles of debt management", *Fiscal and debt management policies,* Prentice-Hall, Reprinted in James Tobin *Essays in Economics: Volume 1 (*1971). Markham Publishing Company, Chicago.

Truman, E (2005): "Comment on Charles A E Goodhart *Beyond current policy frameworks",* in Goodhart (2005).

Turner, P (2015): "The consequences of exit from non-conventional monetary policy." *Journal of Financial Perspectives*, vol 3, issue 2, pp 43–59.

Ueda, K (2003): "The role of capital for central banks", Fall Meeting of the Japan Society of Monetary Economics, 25 October.

Vayanos, D and J L Vila, (2009): "A preferred-habitat model of the term structure of interest rates", *NBER Working Paper*, no 15487.

Appendix 1: Summary of events surrounding the cancelled auction of the 8.75% 2017 bond on 10 October 2011

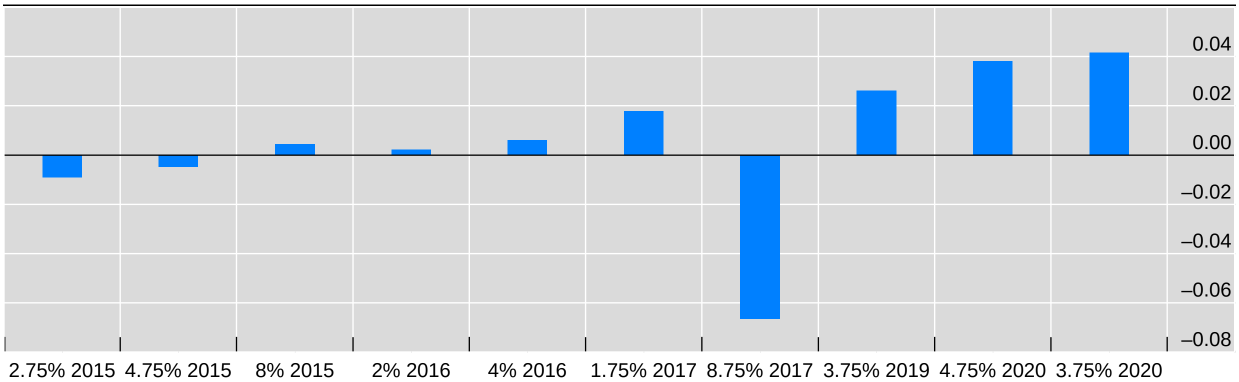
This appendix summarises the events surrounding the QE auction on 10 October 2011 which subsequently resulted in the FCA fining of the trader involved.

The first QE auction of QE2 took place on 10 October 2011. The Bank of England invited offers for a range of short maturity bonds ranging in maturity from 2015 to 2020 using the auction method described above. A trader at one of the GEMMs had already acquired a significant position in the 8.75% 2017 bond that was eligible for the auction and on the day of the auction aggressively bid for more of that bond acquiring £331.1 million between 09:00 and 14:30 when the reverse auction took place (bids can be submitted from 14:15 to 14:45). As a result of those continued purchases, the price of the bond rose appreciably during the day even though other comparable bonds had actually fallen slightly in price – see Graph A1.1).

Percentage point difference between end-of-day price on business day before 10 October 2011 reverse auction and average yield accepted at auction

8.75% 2017 bond based on submitted bid, in percent

Graph A1.1



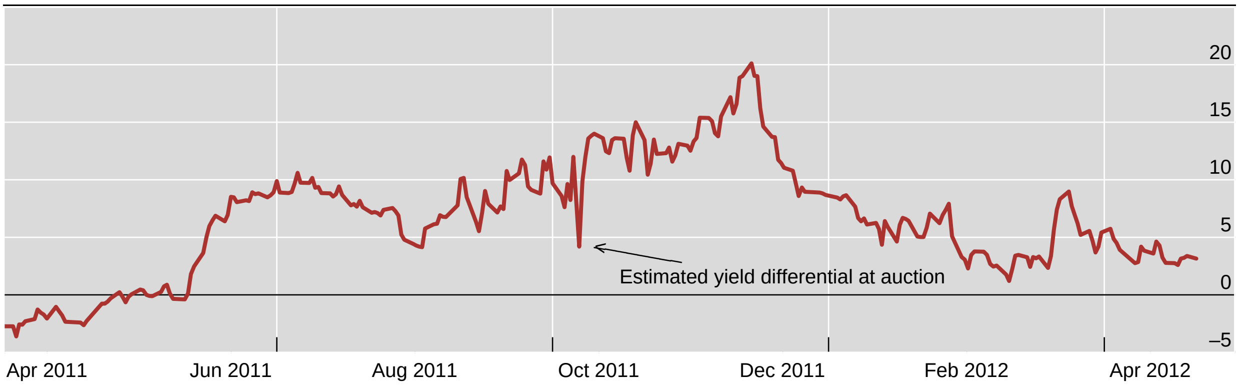
At the auction itself, the trader offered a large amount of the bond for sale (£1.2 billion) at a yield significantly lower than the secondary market yield on the previous business day, but higher than the secondary market yield at the end of the auction period itself (given the significant price movement that had occurred during the day). Having seen the unusual movements in the price of that bond, the Bank of England announced that it would not be accepting offers for that bond in the auction. Subsequent investigation by the FCA found the trader guilty of deliberate price manipulation.

Ironically after a few months the price of the bond rose back – in relative value terms (as measured by a standard butterfly spread defined in Graph A1.2 below) – above the price offered in the failed auction. In fact, the Bank of England subsequently (at February and March 2012 auctions) accepted offers of this bond at a higher relative value than it had rejected at the disputed auction, perhaps because the low level of liquidity (the 8.75% 2017 bond had the second lowest nominal outstanding of all bonds eligible for QE at the time) made it particularly strongly influenced by QE purchases.

Graph A1.2 shows the difference between the yield on the 8.75% 2017 and the yield predicted by a linear interpolation between its two nearest equivalents in terms of duration (the 4% 2016 bond and the 5% 2018).[14] The estimated yield differential at auction is based on the accepted yield at auction of the two nearest equivalents and the rejected offer yield for the 8.75% 2017.

Relative value of the 8.75% 2017 bond based on butterfly spread

Basis points Graph A1.2



[14] Since the 1.75% 2017 was only created in August 2011 it was not used in this chart. However, using the 1.75% 2017 instead of the 5% 2018 over the shorter sample gives very similar results.

Appendix 2: Some detailed results on operation concessions

This appendix gives some further evidence on the determinants of the yield concession on both sales and purchases.

As a preliminary analysis to check that it is appropriate to measure the concession in yield rather than price terms, Graph A2.1 shows how the yield and price concessions measured relative to t-2 varies with duration. It shows a clear tendency for the price concession to rise with the duration of bond being purchased/sold. In yield terms, the concession – albeit more consistent across durations – does appear to rise with duration. Table A2.1 confirms that this rise in concession yield as duration increases is significant at two horizons (t-2 and t-1). However, at all horizons the relationship between duration and yield concession is less significant than that between duration and price concession.

Measures of price/yield concessions

Graph A2.1

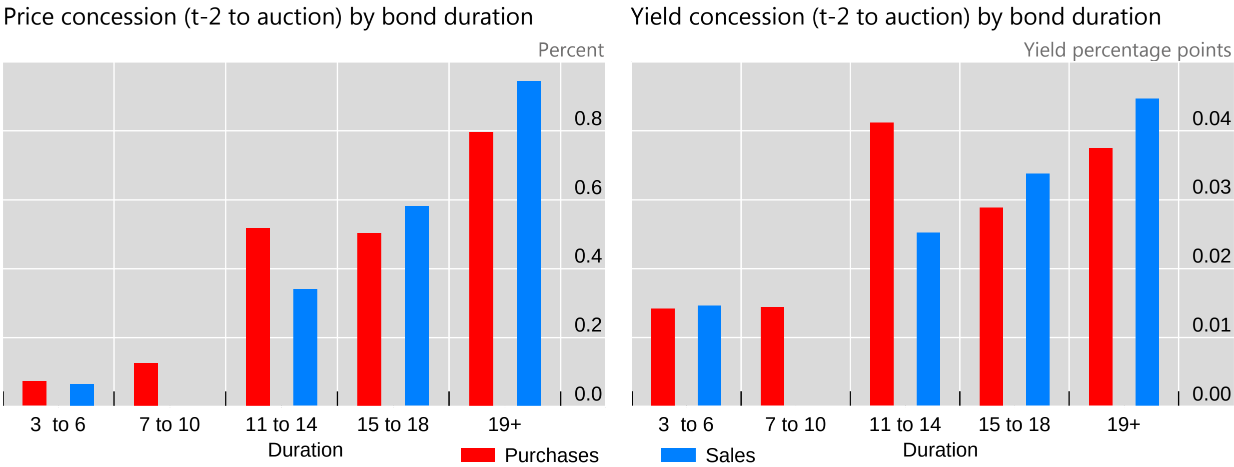


Table A2.1 explores the determinants of the yield concession in more detail. It presents the results of the empirical relationship between operation yield concessions (both sales and purchases) measured at the five different horizons (t-2 through to t+2) and some potential determinants. The first of those determinants – the size of the operation itself (ie, the log of the total amount of bonds bought/sold at each operation) – appears to have quite a strong relationship with the auction concession at most horizons indicating that larger operations tend to generate a larger concession.

The duration of the bonds purchased/sold, as discussed above, tends to have a positive relationship with the yield concession – most notable at the t-2 and t-1 horizons. This is perhaps a little surprising. Although longer duration implies more price volatility, this is not generally the case with yield volatility – which tends to decline slightly with duration. Thus the lower yield volatility of long duration bonds might be expected to be associated with a lower rather than higher yield concession.

Free Float is a measure of the value of each bond in private sector hands just prior to the operation (i.e. the total value of the bond already issued minus the amount held by the government and the Bank of England). Other than at horizon t (which has the surprising result that a higher free float increases the concession), this variable seems to have no strong relationship with the yield concession. However, in the case of QE operations it seems likely that, if free float does have a relationship with the auction concession, this would be more apparent at the individual bond level rather than in the average of each operation as used in Table A2.1. Results at the individual bond level are presented below.

The three dummy variables give an indication of the average concession for the three types of bond sale (auctions, syndications and tenders) relative to QE purchase operations. The results show a significantly smaller concession for auctions relative to QE operations at t–1, t+1 and t+2 whilst the small sample of tenders and syndications means that results for these two types of operation are inconclusive.

Table A2.1 shows estimated coefficients of five regressions of operation concession in yield basis points (both purchases and sales) calculated at different horizons (2 days before through to 2 days after) against potential determinants of that concession.

Estimated determinants of operation concessions — Table A2.1

	t-2	*t-1*	*t*	*t+1*	*t+2*
Log(Value)	0.705	1.913**	1.068*	3.300***	3.279**
	(1.248)	(0. 764)	(0.641)	(1.119)	(1.585)
Duration	0.153**	0.094**	–0.023	0.082	0.108
	(0.075)	(0.046)	(0.038)	(0.067)	(0.095)
Log(Free Float)	–0.311	–0.217	0.645**	0.672	0.852
	(0.628)	(0.384)	(0.323)	(0.564)	(0.796)
Auction	–1.157	–2.093***	–0.293	–2.566***	–2.424*
	(1.047)	(0.641)	(0.538)	(0.940)	(1.326)
Syndication	1.46	–0.523	–0.591	–3.623	–2.077
	(3.431)	(2.111)	(1.762)	(3.079)	(4.345)
Tender	–1.920	1.263	0.540	0.468	–0.970
	(1.914)	(1.172)	(0.983)	(1.718)	(2.424)

Note: The total sample was 353. Standard errors in brackets. *, **, *** indicates coefficient significantly different from zero at the 10%, 5% and 1% level based on standard t-test.

Variable definitions

Log(Value) = Log of the total size of the operation (i.e. amount sold or purchased at the operation)

Duration = Duration of the instrument sold/purchased. For QE operations this is the average duration of bonds purchased at each operation.

Log(Free Float) = Existing Free Float of the instrument sold/purchased, where free float is the total value of the instrument in private sector hands prior to the operation. For QE operations this is the average free float of bonds purchased at each operation.

Auction = Dummy variable that equals 1 if the operation was a sale by auction.

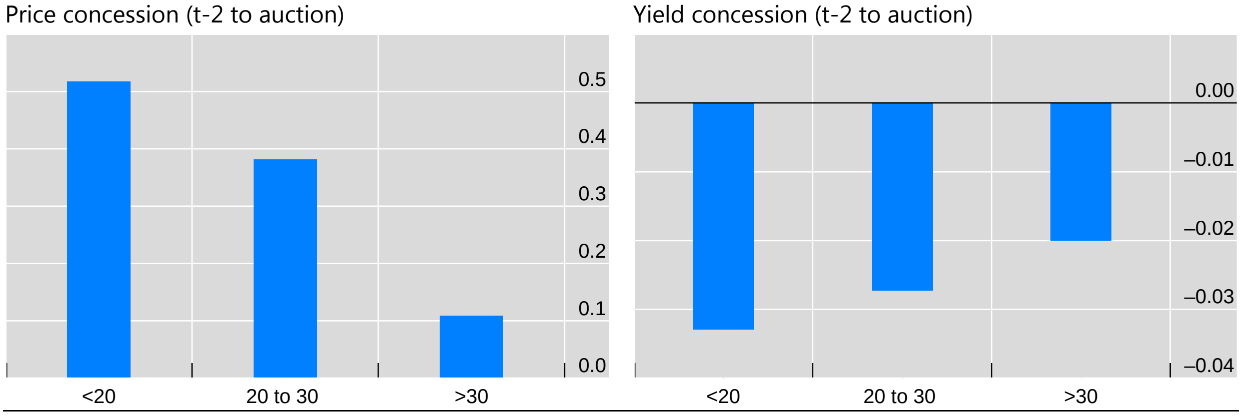
Syndication = Dummy variable that equals 1 if the operation was a sale by syndication.

Tender = Dummy variable that equals 1 if the operation was a sale by tender.

As discussed above, the relationship between free float (a measure of the liquidity of an existing bond) and the auction concession is probably best measured at the individual bond level rather than averaging free float for each operation (as is done in Table A2.1 in the case of QE operations). Thus Graph A2.2–2.4 shows how the price/yield concession for QE purchases measured relative to t-2 varies with the liquidity of the individual bond. At this level there is a clear tendency for the concession to fall as free float rises in both price and yield terms. This effect is statistically significant.

Price and yield concession by nominal free float of bond

£ billions Graph A2.2



Previous volumes in this series

No	Title	Author
570 July 2016	Unconventional monetary policies: a re-appraisal	Claudio Borio and Anna Zabai
569 July 2016	Monetary policy, the financial cycle and ultra-low interest rates	Mikael Juselius, Claudio Borio, Piti Disyatat and Mathias Drehmann
568 June 2016	Output gaps and policy stabilisation in Latin America: the effect of commodity and capital flow cycles	Enrique Alberola, Rocio Gondo, Marco Lombardi and Diego Urbina
567 June 2016	Understanding the changing equilibrium real interest rates in Asia-Pacific	Feng Zhu
566 May 2016	Monetary facts revisited	Pavel Gertler and Boris Hofmann
565 May 2016	The Collateral Trap	Frédéric Boissay and Russell Cooper
564 May 2016	Moore's Law vs. Murphy's Law in the financial system: who's winning?	Andrew W Lo
563 May 2016	Who supplies liquidity, how and when?	Bruno Biais, Fany Declerck and Sophie Moinas
562 May 2016	Expectations and investment	Nicola Gennaioli, Yueran Ma and Andrei Shleifer
561 May 2016	Mobile collateral versus immobile collateral	Gary Gorton and Tyler Muir
560 May 2016	Has the pricing of stocks become more global?	Ivan Petzev, Andreas Schrimpf and Alexander F Wagner
559 April 2016	A comparative analysis of developments in central bank balance sheet composition	Christiaan Pattipeilohy
558 April 2016	Why bank capital matters for monetary policy	Leonardo Gambacorta and Hyun Song Shin
557 April 2016	How Does Bank Capital Affect the Supply of Mortgages? Evidence from a Randomized Experiment	Valentina Michelangeli and Enrico Sette
556 April 2016	Threat of Entry and Debt Maturity: Evidence from Airlines	Gianpaolo Parise
555 March 2016	The causal effect of house prices on mortgage demand and mortgage supply: evidence from Switzerland	Christoph Basten and Catherine Koch
554 March 2016	Can a Bank Run Be Stopped? Government Guarantees and the Run on Continental Illinois	Mark Carlson and Jonathan Rose

All volumes are available on our website www.bis.org.