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Francis Breedon[1]

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 from private sector intermediaries rather than directly from the government. This paper estimates the cost of this round-trip transaction – government issuance of liabilities and central bank purchases of those liabilities in the secondary market – for the UK. I estimate that this cost amounts to about 0.5% of the total value of QE (over £1.8 billion in my sample). I also find some evidence that this figure is inflated by the unusual design of UK QE operations.

Keywords: Quantitative Easing, Auctions, Government Bonds

JEL Classification: G12, E58

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1. Introduction

Although quantitative easing (QE) programmes vary in design, the four major ones – those of the US, Euro-Area, Japan and the UK – have primarily involved the creation of central bank reserves in return for government bonds. In all four cases this has involved purchasing bonds from private sector intermediaries despite the fact that significant government bond sales to the same intermediaries took place over the same period. A seemingly simpler procedure would be the direct acquisition of these liabilities from the government through the creation of reserves, thus removing the need for the government to issue these liabilities to the market in the first place. In both cases the end result would be the creation of reserves backed by central bank holdings of government liabilities and so the overall impact would be almost identical. So the round-trip approach of selling bonds to private sector intermediaries and then buying them (or, in fact, similar ones) back shortly afterwards has an almost identical impact to not selling the bonds to the private sector in the first place. Probably the key difference is that the round trip approach involves a debt sale and a debt purchase – both of which incur transaction costs.

Whilst it is hard to establish exactly why the round trip approach has been adopted in all cases, many argue that the direct financing approach is cosmetically worse in the sense of making the operation of quantitative easing look more like the type of monetary financing that occurs when the fiscal authority forces the central bank to finance government spending. Thus direct financing might undermine the perception of central bank independence even though the end result (central bank acquisition of government liabilities in return for central bank reserves) is the same. This issue is discussed in more detail in the next sub-section, but the main objective of this paper is to estimate the total transactions costs involved in the round trip approach in the case of the UK's QE programme.

As well as this broad policy question, this paper looks in detail at how UK debt sales and purchases are conducted in practice and highlights some important design issues in how the Bank of England's

debt purchases are conducted. I find that the small number of bidders per bond and the fact that the auction allocation is based on market prices the bidders themselves have a significant role in creating, opens up the process to uncertainty and potential manipulation. I find some evidence that these design issues have resulted in higher transactions costs relative to alternative reverse auction design used by most other Central Banks such as the Federal Reserve.

1.1. Central Bank direct acquisition of Government Liabilities

Although the first Central Banks were created to help finance government, this role has diminished to such an extent that about two-thirds of Central Banks surveyed by Jácome et al (2012) are expressly forbidden from funding the government directly or are limited to short term loans[2]. The reason for this change is clearly related to the increased role of Central Bank's in creating fiat money and the temptations this role created for government. Thus as Ricardo (1824) notes "It is said that Government could not be safely entrusted with the power of issuing paper money; that it would most certainly abuse it.…There would, I confess, be great danger of this, if Government--that is to say, the ministers--were themselves to be entrusted with the power of issuing paper money."

However, as Ricardo's quotation implies, it is not direct acquisition of government liabilities that is the key concern but the fear that the government can *require* the central bank to create money in order to acquire those liabilities. So, as Central Banks have become increasingly independent from government the risks associated with direct financing have diminished. In a key work on the topic, Cotterelli (1993) notes, so long as the Central Bank is independent of government and any direct financing (that the Central Bank might want to initiate) occurs at market (not subsidised) rates and involves marketable securities (so the Central Bank can sell them to the private sector if necessary) then a prohibition on primary market purchases by the Central Bank has no economic impact and simply serves as an 'institutional signal' of the separation of Government and Central Bank. The

[2] Indeed the subject of this study, the UK is, at the time of writing, legally restricted from direct government finance by Article 123 of the Lisbon Treaty on the Functioning of the European Union.

Central Bank Governance Group (BIS(2009)) reaches a similar conclusion, arguing that prohibitions on direct financing can be seen as a 'belt and braces' policy in the presence of Central Bank independence and market determined interest rates.

It is also worth noting that a limitation on direct financing does not stop government's forcing Central Banks to finance them indirectly if those Central Banks are not independent. Stasavage(1997) describes an example of this in the case of the CFA Franc Zone where, in the face of restrictions on direct financing, a number of governments required their Central Bank to make subsidised loans to a number of commercials and development banks who then became a major source of finance to governments and related public entities This form of financing was a key factor behind the fiscal indiscipline that characterised the Zone over this period.

It is arguable that, although limitations on direct financing are neither a necessary nor sufficient condition to stop governments requiring their Central banks to finance them, they have, historically at least, been a relatively costless measure that has some signalling benefit. However, in recent years where unconventional monetary policy has resulted in the dramatic expansion in several Central Banks' balance sheets, the cost of these limitations has increased since government debt has generally been the key asset acquired in those expansions. Indeed, it is interesting that the Central Bank of Brazil, which until it was overtaken by the Bank of Japan in 2012, had the largest balance sheet in the G20 (in terms of gross central bank assets as a share of GDP) and holds a large portfolio of relatively short maturity government debt has created a clear demarcation whereby it is constitutionally prohibited from direct lending to the government, but may purchase government securities in the primary market for monetary policy purposes. This provision allows it to roll over its stock of government debt without incurring secondary market transactions cost. It is also instructive that Jácome et al (2012) classify arrangements like Brazil's as being in the group that prohibit direct financing since such countries make a clear demarcation between direct financing for government

purposes and what is required for monetary policy purposes. This demarcation by purpose is also highlighted by the Central Bank Governance Group (BIS(2009)).

The Brazilian example suggests that when Central Bank balance sheets grow based on acquiring government debt, the transactions costs incurred in acquiring that debt mean that the benefits of allowing Central Bank participation in the primary market for government debt may outweigh the costs of abandoning the 'belt and braces' approach – particularly if the demarcation between government financing and monetary policy purposes is made clear. This paper aims to estimate those transactions costs in the case of the UK.

Thus this paper aims to establish if the round-trip approach to quantitative easing undertaken by the UK involves significant transactions. If such costs were small then a 'belt and braces' approach seems relatively harmless. If, on the other hand, significant transactions costs were incurred (which is what I find) then the question of why a prohibition on primary market purchases is required at a time of significant Central Bank government debt acquisition and holdings[3] becomes a policy relevant one.

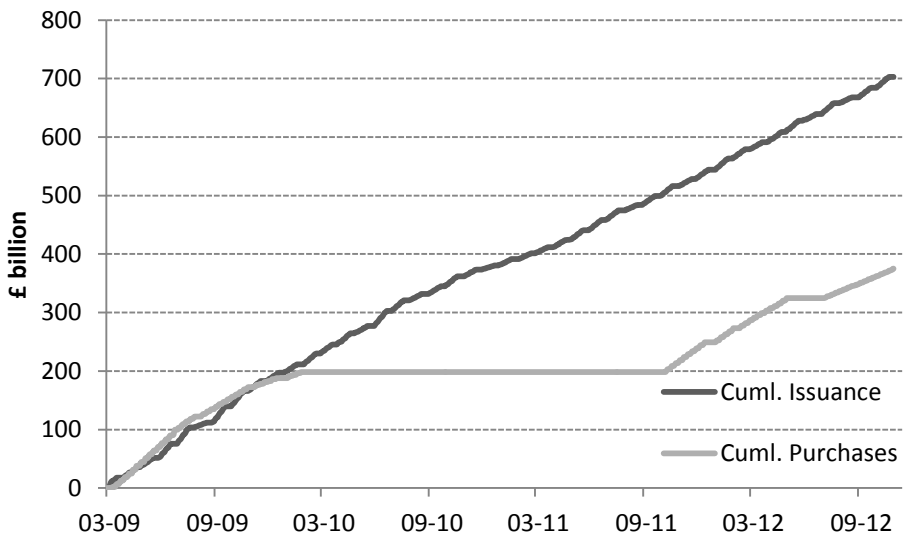
[3] Particularly since a number of authors argue that Central Banks should maintain these large portfolios indefinitely. e.g. Greenwood et al. (2016)

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 direct financing rather than a round-trip approach, namely that either the scale or maturity profile of QE purchases could not be matched by new issuance.

Between March 2009 and October 2012 (the period I analyse in this paper) there were two distinct periods of Bank of England bond purchases (QE1 March 2009-December 2009 and QE2 September 2011-October 2012[4]), Figure 1 shows cumulative conventional bond issuance and bond purchases over this period.

Figure 1: Cumulative Gross Issuance and Purchases 12/3/09 to 31/10/12



Source DMO and APF

As Figure 1 shows, over the whole period there were significantly more sales than purchases and that over the two sub-periods when purchases occurred the rate of purchases was almost identical to the rate of sales (see Table 1). Thus, relatively small changes in timing could have allowed the rate

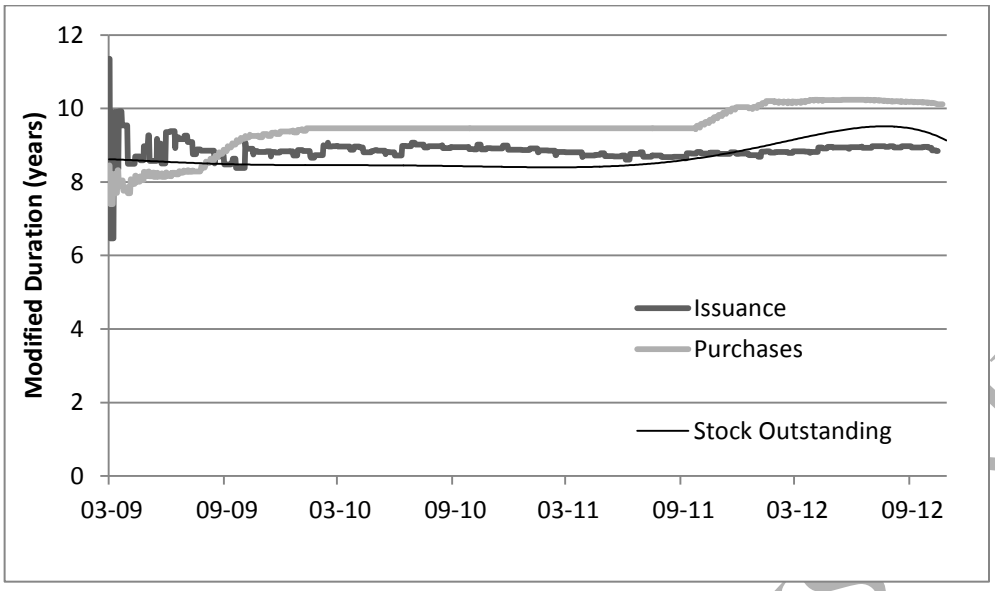
[4] The period from July to October 2012 is sometimes referred to as QE3 but I have merged this period into QE2 to make the two periods large enough to analyse separately

of purchases and sales to be exactly aligned. It is also noteworthy that neither the Bank of England Monetary Policy Committee nor the Treasury gave a precise indication on the timing of purchases and issuance respectively and so the timing of actual auctions was an operational rather than strategic decision for both institutions.

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 maturity of existing debt. This would be akin to 'operation twist' where purchases of longer maturity debt are funded by sales of short term debt with the express intention of shortening the average maturity of outstanding debt (and potentially lowering long term yields – see Swanson (2011)). In order to assess the difference in maturity of debt purchases and sales over this period, Figure 2 shows the cumulative average duration (a more precise measure of the timing of cash flows than maturity) [5] of conventional debt sales and purchases as well as the duration of outstanding conventional debt over the QE period (table 1 below focuses on the two QE periods in more detail) . Whilst it is true that the average duration of purchases (10.2 years) was somewhat longer than that of sales (8.9 years, over the whole period), the difference was not large and so the same impact on the average duration of outstanding debt could easily have been achieved with direct financing by reducing the duration of residual issuance (i.e. issuance still required between the two QE periods) to about 6 years. Again since neither the Bank of England Monetary Policy Committee nor the Treasury gave maturity targets for either purchases or issuance, it is hard to argue that either purchases or sales were strongly focussed on reducing the average duration of outstanding debt over this period.

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

Figure 2: Cumulative Duration of Conventional Purchases and Issuance and Duration of Outstanding Stock of Debt 12/3/2009 31/10/12



Source DMO and APF

2.1 Matching Sales and Purchases

Since, when calculating transactions costs, this paper implicitly assumes that all secondary market transactions associated with QE could have been replaced with primary market ones it is worth spending a little time judging if this could in fact have been done in practice.

Table 1: Value and Duration of Sales and Purchases over the two QE periods

	QE1 period		QE2 period	
	Purchases	**Sales**	**Purchase**	**Sales**
Value (£bn)	**198.3**	**200.6**	**176.7**	**198.5**
Duration (years)	**9.2**	**8.8**	**10.8**	**9.4**

Value and average duration of sales and purchases over QE1 period (March 2009-December 2009) and QE2 period (September 2011-October 2012)

Table 1 shows both the value and duration of issuance and purchases over the two periods of quantitative easing, they confirm impression from the charts above, in both periods the total value of sales was larger than the value of purchases, but the sales were generally at a slightly shorter duration. In the analysis below I allow for this duration effect by calculating transactions costs on the assumption that the duration of sales was adjusted in order to keep the average duration of debt

held in private sector hands at the end of the QE period was identical to that which occurred in practice

Thus although many of the precise details of issuance and purchases over this period were somehow different (e.g. issuance auctions tended to be larger than purchases one, the same bond was never sold and purchased in the same week) small changes which would not have materially changed the overall stock or duration of debt or effected the overall strategy of either the Treasury or the Bank of England would have allowed purchases and issuance to be perfectly aligned.

2.2 Debt Sale and Purchase Techniques in detail

Before measuring transactions costs it is useful to summarise how government bonds were sold and purchased over the period I study (March 2009 and October 2012).

Over this period the Debt Management Office (DMO) adopted three issuance techniques to sell Conventional Debt; Auctions, Syndications and Tenders

- *Auctions.* Over this sample, the vast majority of debt (about 86% by value) was sold at auction. The average amount sold per auction was about £3.5 billion. At such auctions the exact amount and details of the bond 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[6]
- *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 are appointed who, over the period of the offer, build

[6] 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.

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 the estimate of auction concession.

- *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.

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

- *QE Operations.* The Bank of England announced a maturity range (for most of this period there were three ranges - short, medium or long) and a total value of bonds (average of £1.9 billion in our sample) in that range it offered to buy at the operation. Thus market participants could offer any eligible bond in the announced range for that operation (on average about 5 different bonds were offered). 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 itself GEMMs had half an hour (14:15 to 14:45) to submit offers (bond, offer yield and amount) to sell. After receiving these offers the Bank of England would then calculate the difference between each offer yield and the market yield of the relevant 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). So for example, if the Bank of England received offers of both a 10-year and 9-year bond at 3% yield and observed that the 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 the market yield 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 paper I measure transactions costs as the difference between the bond yield received at the market operation (either sale or purchase) and the prevailing yield on that bond in the days surrounding the auction (I use yields rather than prices for reasons explained below and in appendix 2). This measure is widely used in the auction underpricing literature (see for example Simon (1994), Nyborg et al.(2002)) as it allows for the fact that the market yield tends to change around an auction so ,for example, yields tend to rise (prices fall) in the run up to a sale and then fall back after the sale has taken place. The extent to which bond sales receive a yield above the prevailing yield in the surrounding days (and purchases receive a yield above the prevailing level) is commonly termed the auction 'concession' since it is a measure of how different the auction yield was from the prevailing market yield in the days surrounding the auction. Thus my focus is on the full transactions cost of the operation including the short term movements in the secondary market price rather than an analysis of auction behaviour at the moment of the operation itself as is undertaken by Song and Zhu (2017)

Equally, it is important to note that my measure focuses on the short term impact of the operation rather than the long run effect. Thus in the case of QE operations, a key policy objective of the operation is to lower bond yields over an extended period, so the operation actually aims to influence the prevailing level of bond yields over the medium to long term. However, short term impacts spanning just a few days are not an objective of the operation and can be thought of as a

pure transaction cost (the difference between the auction yield and the prevailing market yields around the auction). In that sense the approach taken here is very different to 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, instead this paper focuses 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.

Overall my approach is most similar to Lou et al (2013) who study US Treasury auctions, in a similar way and find similar results both in terms of 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.

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 the auction concession is less correlated with maturity allowing a cleaner estimate that is comparable across maturities (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, thus, 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[7]. 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

[7] as well at the fact that concession effects are insignificant beyond the two day window for both purchases and sales, the fact that QE operations tended to occur once a week means a longer window would be contaminated by the impact of other operations.

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[8] to the results so the more straight forward un-adjusted concessions are used throughout this paper.

In the case of QE bond purchases, since the operation involves purchasing a range of bonds in a single operation, the yield concession is calculated as the average concession across all the bonds purchased in a given operation rather than treating each bond purchased as an individual event. 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.

In Table 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. Table 2 simply measures average transaction costs by type of operation, a more detailed analysis of the determinants of these transactions costs in presented in Appendix 2.

[8] I adjusted for the trend in yields in the 10 days before each operation window and found similar results as the trends were largely insignificant.

Table 2: Estimated Transactions Costs (in yield basis points).

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. 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. *,**,*** 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.

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

As Table 2 shows, there is evidence of significant over pricing for total purchases on all comparisons whilst 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 US 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, I 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 quantitative easing. Using the average yield concessions and assuming that the issuance that would not have been undertaken (due to direct sales to the government) was conducted in the same proportion of auctions, syndications and tenders that occurred over this period but was at a significantly shorter duration (around 6 years) so that the average duration of outstanding debt remains the same as actually occurred. This 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.

Table 3: Estimated Costs of QE Programme (in £million).

Using the yield concession results, this table estimates the total transactions costs involved in the UK's quantitative easing programme. It adjusts for differences in both the in amount and duration of sales and purchases so that the costs are consistent with leaving a stock of debt in public hands that is equal in amount and duration to the stock currently held. Duration Adj is the reduced cost of issuing shorter duration debt that would have left the duration of outstanding debt the same as occurred after QE.

	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. Investigating 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. First, that purchases are intrinsically more expensive to undertake than sales since they require existing holders to offer their bonds for sale, and second that the particular design of the quantitative easing programme was at fault. Although it is hard to distinguish between these explanations, two considerations suggest that poor design was responsible. First, an analysis based on 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 1998-99 to 2000-01 the UK 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 of these reverse auction operations conducted from July 2000 to February 2001. The design of these reverse auctions 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 where 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[9].

Table 4: Average Yield Concession for Reverse Auctions

	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 Whitney Mann 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 2000's 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.

Table 5: Average end of day t yield concession for other QE programmes

Breedon Bank of England	Schlepper et al. (2017) ECB (bunds)	D'Amico & King (2013) Federal Reserve	Song and Zhu (2017) Federal Reserve
0.79	0.12	0.31	0.30

All figures converted to give yield concession at average duration of UK QE to make the figures comparable to Table 2. Schlepper et al (2017) based on their specification 1 which is the most comparable to my approach

Table 5 presents comparable end of auction day concessions from other studies for the ECB and Federal Reserve (comparisons for other days where not undertaken in these studies). In the case of the Federal Reserve, QE auctions are conducted in a very similar way to the UK reverse auctions of the early 2000's described above where allocation is based on pricing relative to the Federal Reserve's estimated yield curve model. The ECB programme is based simply on purchasing

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

government debt directly in the market rather than through scheduled auctions[10] Results presented in this studies have been converted to yield effects at 10.2 year duration to make them comparable with my UK results and show that in both the Fed and ECB case the transactions costs are substantially smaller than in the UK[11] though there are of course many differences between the QE programmes and government bond markets in these countries (most notably the difference in liquidity, with the UK market being the least liquid) so it is not possible to ascribe these differences simply to auction design. Notwithstanding, it is interesting that Lou et al (2013) find similar transactions costs for US issuance to the ones I find for the UK, since UK and US issuance techniques are very similar this could be interpreted as suggesting that QE operation design is important.

4.2 UK QE Auction Design

In terms of design there are two potential problems with UK quantitative easing operations

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 (2017)), there is a literature (e.g. 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 to the extent that the yield can be influenced by the actions of market participants over the operation period (i.e. 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

[10] There are no comparable studies of Bank of Japan auctions, but the allocation is based on yield spreads like to Bank of England approach, but in their case yield are judged again pre-announced benchmark rates rather than end of auction rates.

[11] Statistically significantly smaller on the basis of z-tests using published standard errors – an admittedly weak test.

and thus raise the likelihood and/or improve the terms at which that bond would be purchased. With a maximum of 20 GEMMs 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. Although there is little public information on bidding, the fact that over 86% of bond purchases were fully allocated at a single price (i.e. almost certainly to a single bidder) suggests that competition in individual bonds was limited[12]. 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, a case of deliberate price manipulation was investigated by the Financial Conduct Authority (FCA) whereby 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 and 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[13]. So, for example,

[12] Certainly, full allocation at a single price did not occur in any of the issuance auctions in my sample, nor did it occur in any US QE auction(Song and Zhu(2017))

[13] In the US, 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).

price/yield quotes displayed by GEMMS are indicative rather than firm (i.e. GEMMs are not bound to trade at the displayed quotes) and the price/yield details of recent trades are generally not revealed to other market participants. This makes establishing the precise secondary market yield problematic – particularly at the end of an auction (before the results announcement) when market activity is likely to be subdued[14]. In the case of QE operations, the 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 for a given bond, the price it publishes "is not intended to give a market price at which it could or has been traded" (See DMO (2011)). Indeed, it is surprising that the Bank of England did not attempt to avoid the possibility of quote manipulation given the on-going LIBOR fixing scandal that first came to light in 2008 just before QE operations began.

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, although the evidence is not strong, it seems plausible to argue that the higher transactions costs associated with QE operations were due to their design.

5. Conclusion

This paper has shown that there was a small (as a percentage of the total amount) but significant transaction cost involved in the round trip approach to quantitative easing, and although it is hard to

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

identify the recipients of these transactions costs it is unlikely to be entities that the government would wish to subsidise. Given this cost, it seems, therefore, that the question posed at the beginning of this paper – why is a round trip approach necessary? – is of more than 'academic' interest. Although ½% is small, it is important in the context of such large operations and would seem to justify at least some discussion of the benefits of the round-trip approach given that the outcome (Central Bank acquisition of Government Liabilities) is identical in both the direct and round-trip approaches. This question has broad relevance given the dramatic increase in the size of several Central Banks' balance sheets in recent years

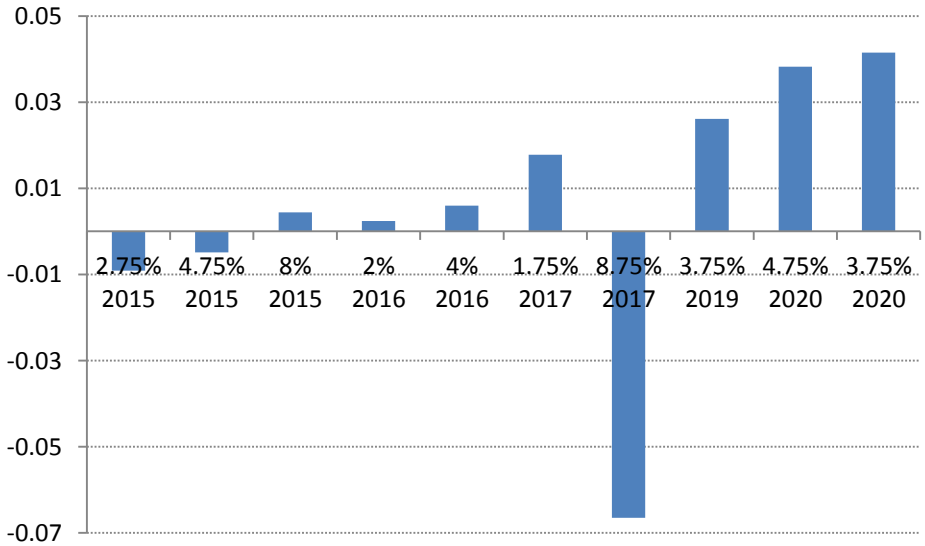
As well as this broad conclusion, the results in this paper highlight the importance of careful auction design in reducing the transactions costs of debt issuance and purchases. The results in this paper suggest that unusual operation design may have been responsible for transactions costs for QE purchases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

APPENDIX 1: SUMMARY OF EVENTS SURRONDING THE CANCELLED AUCTION OF THE 8.75% 2017 BOND ON 10/10/2011

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

The first QE auction of QE2 took place on the10th 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 9am and 2.30pm when the reverse auction took place (bids can be submitted from 2.15pm to 2.45pm). 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 figure A1.1).

Figure A1.1: Percentage point yield difference between end of day price on business day before 10/10/11 reverse auction and average yield accepted at auction
(8.75% 2017 based on submitted bid)

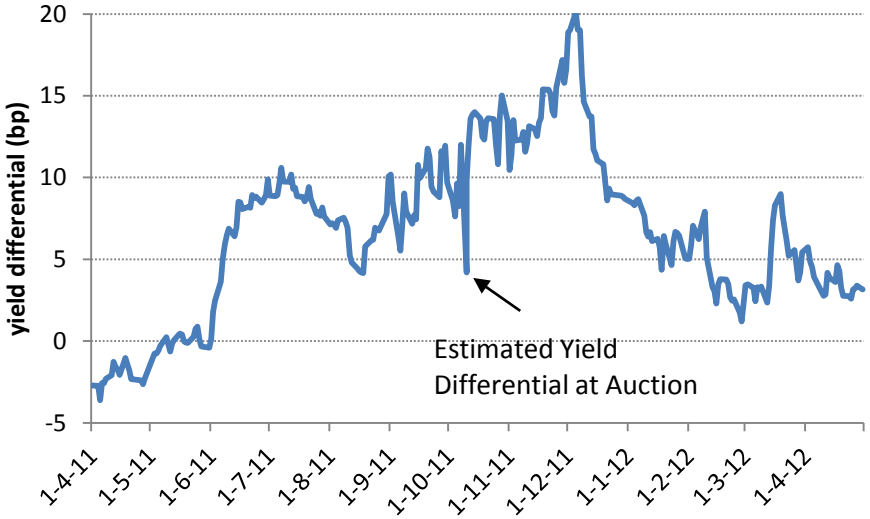


At the auction itself, the trader offered a large amount of the bond for sale (£1.2 billion) at a yield significantly lower than the secondary market yield on the previous business day, but higher than the secondary market yield at the end of the auction period itself (given the significant price movement 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 bond rose back – in relative value terms (as measured by a standard butterfly spread defined in figure A1.2 below) – above the price offered in the failed auction (see figure A1.2). 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.

Figure A1.2: Relative Value of the 8.75% 2017 based on butterfly spread

Figure 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[15]). 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



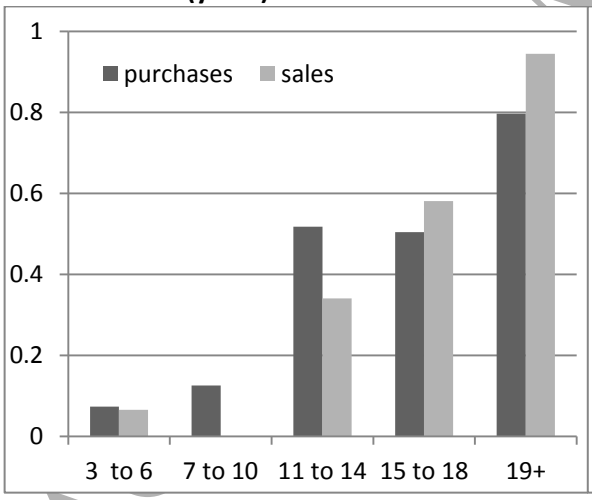
[15] Since the 1.75% 2017 was only created in August 2011 it was not used in this chart. However results using the 1.75% 2017 instead of the 5% 2018 over the shorter sample gives very similar results.

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, figures A2.1-2.2 show how the yield/price concession measured relative to t-2 varies with duration. They show a clear tendency for the price concession to rise with the duration of bond being purchased/sold whilst in yield terms the concession is more consistent across durations though even in yield terms there does appear to be a tendency for the concession 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.

A2.3: Price Concession (t-2 to auction) by bond duration (years)



A2.4: Yield Concession (t-2 to auction) by bond duration (years)

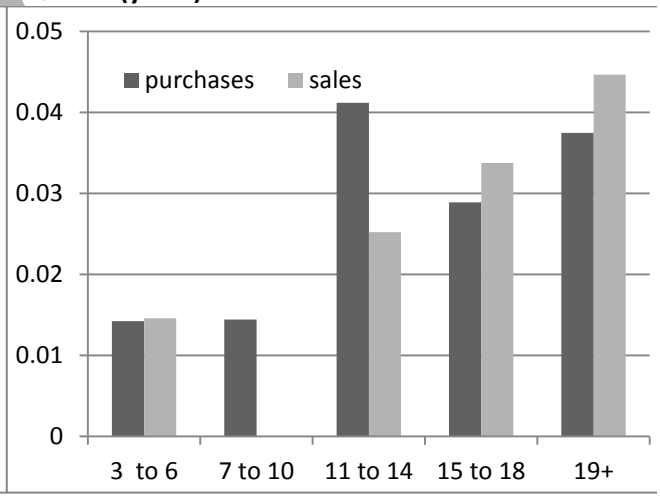


Table A2.1 explores the determinants of the yield concession in more detail. It presents the results of estimating the relationship between operation yield concessions (both sales and purchases) measured at the five different horizons (t-2 through to t+2) and some potential determinants. The first of those determinants - the size of the operation itself (i.e. 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 since 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 free float, 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 Estimated Determinants of Operation Concessions

Table 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. Total sample = 353

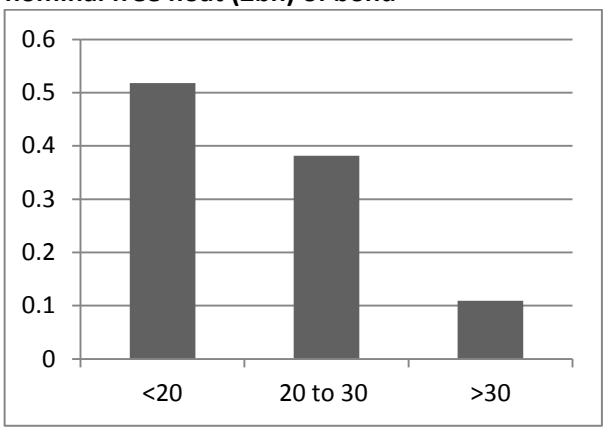
	t-2	***t-1***	***t***	***t+1***	***t+2***
Log(Value)	0.705 (1.248)	1.913** (0. 764)	1.068* (0.641)	3.300*** (1.119)	3.279** (1.585)
Duration	0.153** (0.075)	0.094** (0.046)	-0.023 (0.038)	0.082 (0.067)	0.108 (0.095)
Log(Free Float)	-0.311 (0.628)	-0.217 (0.384)	0.645** (0.323)	0.672 (0.564)	0.852 (0.796)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

Standard Error in brackets. *,**,*** indicates coefficient significantly different from zero at the 10%, 5% and 1% level based on standard t-test

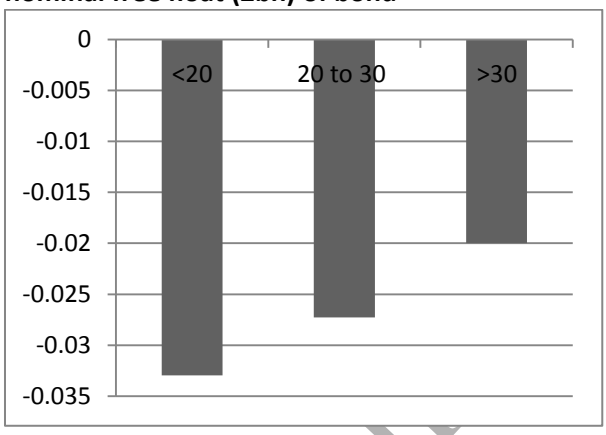
Variable Definitions
Log(Value) = log of the total size of the operation (i.e. amount sold or purchased at the operation)
Duration = duration of the instrument sold/purchased. For QE operations this is the average duration of bonds purchased at each operation.
Log(Free Float) = Existing Free Float of 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 Figures A2.3-2.4 show how the price/yield concession for QE purchases measured relative to t-2 varies with the liquidity of the bond at the individual bond level. 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.

A2.3: Price Concession (t-2 to auction) by nominal free float (£bn) of bond

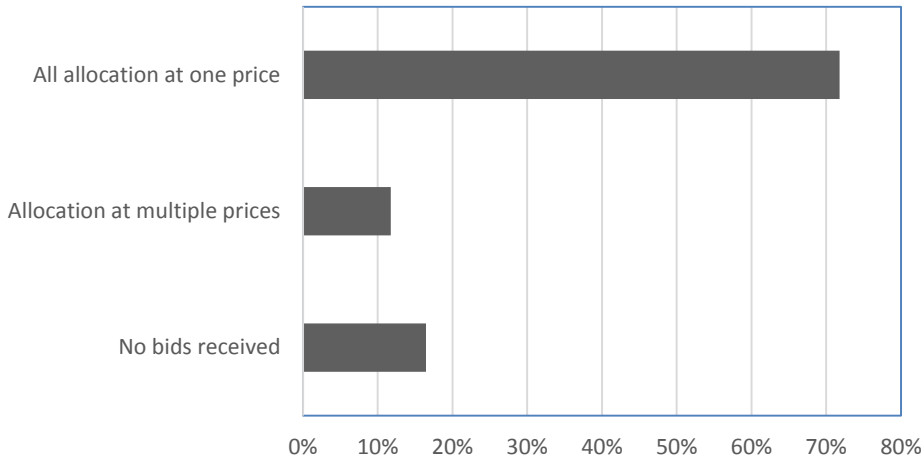


A2.4: Yield Concession (t-2 to auction) by nominal free float (£bn) of bond



As is noted in the text, the large auction concessions for QE operations could be related to the limited number of bidders for each bond. Figure A2.5 gives an indication of this by showing that, for all bonds eligible for each QE operation 16% were not bid for at all, 72% were allocated at a single price (almost certainly indicating a single bidder) and 12% were allocated at multiple prices (which could still indicate only a single bidder as each bidder is allowed to make more than one bid)[16].

A2.5 QE Auction allocations by bond



[16] Thus 86% of allocations were at a single price.

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