



BANK OF ENGLAND

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## Pricing central bank liquidity through product-mix auctions – the first anniversary of the Bank of England’s indexed long-term repo operations

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### Abstract

The objectives of central banks’ operating frameworks typically involve implementing monetary policy and supporting financial stability via the provision of liquidity insurance to the banking system. Prior to the crisis, many central banks aimed to provide liquidity insurance through facilities that had primarily been designed for the implementation of monetary policy. One lesson the Bank has learnt from the crisis is that there are advantages to separating the implementation of monetary policy from the provision of liquidity insurance. This approach has been incorporated in new developments in the Bank’s permanent operating framework – the Sterling Monetary Framework (SMF). One manifestation of this is the evolution of the Bank’s long-term repo operations from a facility primarily designed to aid monetary policy implementation to one with the primary objective of providing liquidity insurance without distorting commercial banks’ incentives for prudent liquidity management, and while minimising the risks being taken by the Bank. In designing these indexed long-term repo operations (ILTRs) the Bank has drawn on the lessons from auction theory. A feature of the ILTRs – which we believe to be a first in central bank auction design – is that the provision of liquidity insurance adjusts automatically to increases in demand caused by liquidity stresses in the banking system. This paper describes the design of the ILTRs and reports on the Bank’s experience with the new auction design during its first year of operation.

**Key words:** Auction design, liquidity insurance, central bank

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## 1 Introduction

1. The specific objectives of central banks' operating frameworks differ from central bank to central bank. But they typically involve implementing monetary policy and supporting financial stability via the provision of liquidity insurance to the banking system.
2. Prior to the crisis, many central banks, including the Bank of England (henceforth 'the Bank'), aimed to provide liquidity insurance through the same facilities that had been primarily designed for the implementation of monetary policy. For example, bilateral standing facilities were designed primarily to assist in controlling overnight interest rates as well as helping to deal with temporary frictional payment shocks.
3. One lesson the Bank has learnt from the crisis is that there are advantages to separating the implementation of monetary policy from the provision of liquidity insurance. This lesson has since been incorporated into the Bank's permanent operating framework – the Sterling Monetary Framework (SMF). Clews, Salmon and Weeken (2010) describe how this is reflected in the various elements that make up the SMF. These includes its operating system, policies on access rights to the Bank's facilities and collateral policy.
4. The Bank's collateral policy plays an important role in the separation between monetary policy implementation and the provision of liquidity insurance. Operations aimed at implementing monetary policy decisions provide reserves only against a narrow range of high-quality collateral that is reliably liquid in private markets. Such operations are unlikely to alter the risk characteristics of banks' balance sheets to such a degree as to prompt any behavioural changes. By contrast, the Bank stands ready to provide liquidity insurance against a broader range of less liquid assets. When providing such liquidity insurance, the Bank charges higher fees to provide incentives for banks to manage their liquidity prudently.<sup>1</sup>
5. The evolution of the Bank's long-term repo operations (LTRs) is one manifestation of its response to the crisis. When it launched a reformed operational framework in 2006, weekly fixed-rate short-term repo operations (STRs) were the main tool through which the Bank supplied central bank reserves to the banking system. But the Bank also provided reserves via monthly variable-rate LTRs at maturities of three, six, nine and twelve months.
6. By providing the Bank's counterparties with central bank reserves for an extended period, LTRs already contained an element of liquidity insurance. However, prior to the financial crisis, LTRs were primarily designed as a balance sheet management tool in order to

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<sup>1</sup> The Bank's collateral policy is described in more detail in Fisher (2011a).

reduce the size of routine STRs (i.e. the ‘churn’). As such, the stock of LTRs was relatively small at £15 billion (around 19% of the Bank’s total assets at the time). And LTRs were conducted against the same pool of highly liquid sovereign or near-sovereign bonds from a small selection of countries (henceforth ‘narrow collateral’) against which the Bank lent in its STRs.

7. During the financial crisis, the Bank, like other central banks, faced the challenge of providing large-scale liquidity insurance against a wide range of collateral – both bilaterally to individual institutions and multilaterally to the banking system as a whole. The Bank’s response to this challenge is described in Cross, Fisher and Weeken (2010).

8. Part of this response included redesigning the Bank’s existing LTRs into a wider liquidity insurance facility. Specifically, the Bank increased the size and frequency of its three-month LTRs and expanded the range of collateral eligible in those operations to include high quality, but less liquid private sector securities (henceforth ‘wider collateral’). To mitigate adverse selection and moral hazard, counterparties were charged a minimum spread of 50 basis points to borrow against wider collateral. The stock of LTRs eventually reached £190 billion by early 2009 (around 74% of the Bank’s total assets at the time).

9. The temporary extension of LTRs during the crisis (henceforth ‘eLTRs’) was successful in its main objective of providing liquidity insurance to the banking system, but raised a number of operational policy challenges for the Bank. In particular (1) as was the case with LTRs, eLTRs exposed the Bank and its counterparties to significant interest rate risk since commercial banks’ reserves balances were being remunerated at Bank Rate, while the minimum bid rate in the eLTRs was equal to a fixed three-month market rate at the time of the operation (plus a spread for wider collateral); (2) it was difficult to calibrate the appropriate spread to charge for lending against wider relative to narrow collateral; (3) it was difficult to determine the required size of the eLTRs.

10. To address these challenges, the Bank replaced its eLTRs with its new permanent indexed long-term repo operations (ILTRs) in June 2010.<sup>2</sup> The primary objective of ILTRs is to provide liquidity insurance without distorting commercial banks’ incentives for prudent liquidity management, and while minimising the risks being taken by the Bank. In the ILTRs, counterparties can submit bids against narrow collateral, wider collateral or both. These bids are expressed as a spread to Bank Rate (subject to a minimum spread of zero). The Bank then allocates a proportion of the funds on offer to the bids against wider collateral, in line with a pre-determined supply schedule, so that the proportion is endogenously determined depending on the spreads offered. The remainder is allocated to bids against narrow collateral.

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<sup>2</sup> Paul Klemperer from Nuffield College, Oxford University contributed to and advised on the design issues of the ILTRs.

11. Expressing the bids as spreads to Bank Rate eliminates the interest rate risk arising from unexpected movements in Bank Rate. Moreover, the spread the Bank charges to lend against wider collateral relative to narrow collateral and the proportion lent against each collateral set are determined within the auction (as the degree of market stress increases, the clearing spread on wider collateral relative to narrow collateral would be expected to rise and the Bank would automatically, within the auction, lend a greater proportion against wider collateral). Finally, from the pattern of the bids, the Bank obtains a signal about the need to expand the overall size or frequency of future operations.

12. The remainder of this paper provides more detail on the design of the ILTRs and reports on the Bank's experience with this new auction design during its first year of operations. The next section describes the principles underlying product-mix auctions. Section 3 describes how product-mix auctions have been applied in the design of the Bank's ILTRs. The penultimate section discusses the auction results over the first year of this approach. The final section draws out our conclusions so far.

## **2 Product-mix auctions**

13. A product-mix auction allows participants to bid on multiple differentiated products (product varieties) that are subject to an overall supply constraint in a single auction. The product-mix auction on which this paper focuses was invented by Professor Klemperer of Nuffield College, Oxford, in 2007/2008 to help the Bank address the challenges described in the introduction to this paper. But product-mix auctions can be applied to any problem where both seller(s) and buyers regard the goods or services to be sold as imperfect substitutes. The remainder of this section explains the shortcomings of standard auctions for multiple differentiated products and provides a generic description of product-mix auctions.<sup>3</sup>

### ***2.1 Shortcomings of standard auctions for multiple differentiated products***

14. There are a number of ways in which standard auctions could be modified to sell multiple differentiated products. For example, the seller could (1) run a separate auction for each variety of the product or (2) set a fixed price add-on for the more desirable product variety and auction all units as if they were otherwise homogenous.

15. In separate auctions, the auctioneer has to choose in advance the amount of each product variety to offer. Bidders have to guess for how much to bid in each auction and place their bids without knowing the price difference between the different product varieties. This is likely to result in inefficient outcomes.

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<sup>3</sup> See Klemperer (2008, 2010), who also provides examples of possible extensions, including multiple sellers, variable total quantities and permitting bidders to exchange goods.

16. In auctions utilising a fixed price add-on, the auctioneer has to estimate the size of the add-on. But the auctioneer may be uncertain about the appropriate add-on and – if bidders have private information – he may suffer from adverse selection. So he may instead wish to extract information about the appropriate add-on from the bids received. Even if the auctioneer is confident about the size of the add-on, he may not want to reveal it. In addition, a fixed price add-on limits the ways in which the auctioneer can express his preferences. For example, the proportion of the different product varieties the auctioneer wishes to sell may be a function of the price differential between the varieties. The eLTRs that were described in the introduction of this paper are one example of a fixed price add-on auction and it was in part because of the shortcomings outlined above that the Bank sought to redesign its long-term repo operations.

## 2.2 *The design of product mix auctions*

17. Product-mix auctions can overcome the shortcomings of standard auctions highlighted above. In a product mix auction, each bidder can make multiple bids, both across and within product varieties. Each bid specifies the price and quantity for a specific product variety. For example, bidder A might want to purchase up to 400 units of a premium quality variety and may be prepared to pay up to £60 per unit. To do this, he could place a single bid at £60 per unit for 400 units or make multiple bids adding up to 400 units at different prices. Bidder B might also want to purchase up to 400 units but might be indifferent between the premium and standard quality variety provided that the latter is at least £20 per unit cheaper.

18. The product mix auction allows bidders with preferences like bidder B to submit a single bid that encompasses multiple, *mutually exclusive* sub-bids that each specify a price and a quantity for a specific product variety. For example bidder B might submit a single, ‘paired’ bid to purchase 400 units of the premium variety for, say, £60 per unit *or* 400 units of the standard variety for £40 per unit. This provides bidders with multiple opportunities to obtain a specific quantity whilst avoiding the risk of over allotment that might otherwise occur if single bids for the same quantity were submitted.

19. In allocating a product-mix auction, the auctioneer considers all the bids and chooses a cut-off price per unit of each product variety below which bids are rejected. All bids that match or exceed the cut-off price for the corresponding variety are accepted. The exception are the paired bids where – if more than one of the sub-bids matches or exceeds the cut-off price – the auctioneer accepts the sub-bid with the maximum distance to the respective cut-off price. For example, if the cut-off prices per unit for the premium and standard variety products were £50 and £39 respectively, bidder B would be allocated 400 units of the premium quality variety at a price of £50. This offers him £10 of ‘value’ relative to £1 of value should he have been allocated against the standard variety product.<sup>4</sup>

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<sup>4</sup> Should each mutually-exclusive sub bid be of equal distance from the corresponding cut-off price, the bidder may be allotted against either or both sub bids.

20. The auctioneer then has a choice of allocating on a discriminatory (pay your bid) or uniform (all successful bidders pay the lowest accepted price) price basis.<sup>5</sup> Uniform price auctions mean that, if the number of bidders is sufficiently large, bidders face no incentive to try to “game” the auctions, nor is there a need for them to speculate on other bidders’ behaviour. Instead, bids should reflect the true demand for the auctioned good or services since, unless a bidder is “large” relative to the market as a whole, it cannot significantly affect the prices he pays if he wins. In contrast, in a discriminatory price auction, bidders have an incentive to shade down their bids in order to avoid paying “too much” (or at least more than the bidder feels he needed to) relative to other successful bidders.

21. In the case of uniform pricing for each variety, each accepted bid pays the cut-off price. In principle, as long as the resulting allocation is consistent with the auctioneer’s overall supply constraint, these cut-off prices could be chosen arbitrarily. Alternatively, the auctioneer might choose the cut-off prices across products based on a set of rules that reflect the seller’s supply constraints and preferences.

### **3 The design of the Bank’s ILTRs**

22. In the context of ILTRs, the ‘bidders’ in the product-mix auction are the Bank’s counterparties, the ‘differentiated products’ or ‘product varieties’ correspond to loans of central bank reserves that the Bank makes against the narrow or the wider collateral set. The prices at which counterparties bid are expressed as a spread (in basis points) to Bank Rate (subject to a minimum spread of zero). The ‘overall supply constraint’ is the pre-announced quantity of central bank reserves the Bank is willing to supply through the auction. The Bank utilises a uniform price format so that all counterparties pay the lowest accepted rate (on each collateral set) regardless of their bids.

23. The remainder of this section explains the auction mechanism by way of stylised examples. It sets out how an allocation frontier can be constructed from the bids received and how the preferences of the Bank can be expressed by way of a supply curve. The final subsection shows how the intersection of these curves determines the allocation.

#### **3.1 The allocation frontier**

24. In a normal auction there will be one clearing price at which the auction will clear. But in the ILTRs there are two clearing spreads, one for each of the two types of collateral. These pairs of possible clearing spreads can be derived from the bids, and the resulting “allocation

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<sup>5</sup> Klemperer (2010) proposes uniform pricing. There is considerable debate about whether uniform or discriminatory pricing should be preferred for “standard” auctions of just a single variety, but in a product-mix auction there is a clear preference for uniform pricing. In a product-mix auction, discriminatory pricing would make it very hard for bidders to calculate optimal bids (thus also making the auction a less useful source of information about market conditions, and perhaps discouraging participation), and – even if bidders do bid sensibly- would generally lead to inefficient allocations.

frontier” which can be thought of as a demand curve mapping the difference between the two clearing spreads (known as the stop-out spread) against the proportion of the auction that would be allocated to wider collateral (and hence by implication, narrow collateral) in each case.

*Construction of the allocation frontier*

25. Table 1 shows hypothetical bids from eight counterparties. Four of the bids are against the narrow collateral set (N) and the remaining four are against the wider set (W). For simplicity, this example abstracts from paired bids (which are described in the annex to this paper) and each counterparty is assumed to only submit a single bid against either the narrow or the wider collateral set. At the end of the auction, the bids within each set are ranked from those with the highest spread to Bank Rate to those with the lowest spread (as shown in Table 1). The first stage of the allocation process is to construct the frontier of potential allocations based on the bids received. For simplicity, it is assumed that the Bank has offered to supply £100 million in this operation, that the minimum allocation is £0.1 million and that the maximum amount any participant can bid for is 30% of the total amount offered.

**Table 1: Hypothetical ILTR bids**

<b>Bidder</b>	<b>Amount (£mn)</b>	<b>Spread (bps)</b>
W1	30	19
W2	20	17
W3	25	15
W4	25	14
N1	30	12
N2	30	10
N3	20	8
N4	20	5

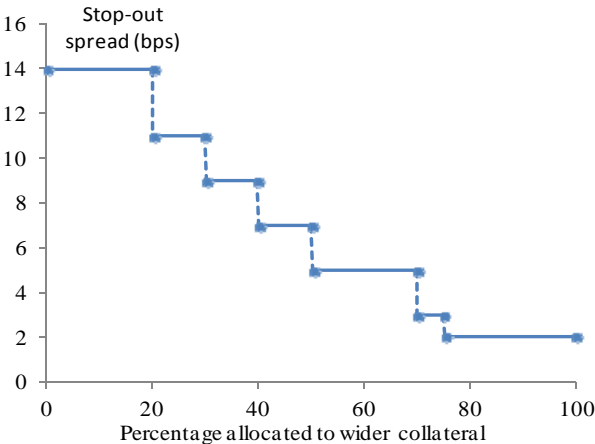
26. The most systematic way of constructing the allocation frontier is to begin at one ‘end’ – that is, where the auction is allocated to only one type of collateral.<sup>6</sup> Then by a combination of allocating less to the first type of collateral and more to the other, each possible collateral split (and its associated stop-out spread) can be mapped as a series of ‘steps’.

27. In this example, we assume this process will begin where the entire auction is allocated only to narrow collateral bids (the left-hand end of the allocation frontier). Now assume that the minimum increment (i.e. £0.1 million in this example) is allocated to the highest wider collateral bid (W1) and the lowest narrow collateral bid (N4) is rationed by the same amount. This would result in clearing spreads of 19 basis points and 5 basis points on wider and narrow collateral respectively, producing a stop out spread of 14 basis points (the first point on the blue curve in chart 1). Then, as progressively more is allocated to wider collateral, the allocation moves

<sup>6</sup> Strictly, a stop-out spread is not defined if the allocation is 100% to one type of collateral. It should also be noted that since there is a minimum allocation amount to any given bid (in this example, £0.1 million), the downward steps are not completely vertical and the allocation frontier is not completely continuous (illustrated by dashed vertical lines between steps).

horizontally along the solid line until N4 is fully rationed. At this point, the clearing spread on narrow collateral changes to the second-lowest bid spread (8 basis points). This reduces the stop-out spread to 11 basis points and creates a ‘step’. This process continues, with a step each time a narrow bid becomes fully rationed or we start allocating to the next lowest wider bid and can be extended to every possible collateral split, i.e. from allocating none of the wider bids to allocating all of them. However, a step will occur only when the clearing spread on either wider or narrow collateral (and thus the associated stop-out spread) changes. Chart 1 shows the allocation frontier based on the pattern of bids in Table 1.<sup>7</sup>

**Chart 1: Allocation frontier based on bids in Table 1**



*The allocation frontier in times of stress*

28. Consider two variants on the baseline example laid out in Table 1. In the first, a system-wide shock hits the market, reducing interbank lending volumes and impairing the mechanism by which banks transfer liquidity amongst themselves, in particular against wider collateral. This is illustrated in Table 2 as an increase in the spread banks are prepared to pay to obtain reserves from the Bank against wider collateral. In the second example, an individual counterparty suffers a liquidity shock, which leads that counterparty to bid more aggressively for reserves (bidder W2 in Table 2). Chart 2 shows the allocation frontiers associated with these shocks relative to the baseline.<sup>8</sup>

<sup>7</sup> In auctions with no wider bids, narrow bids are allocated from the highest bid spread through bids at successively lower spreads until the target size of the auction is reached or all narrow bids are fully allotted. In an auction with no narrow bids, wider bids are allocated from the highest bid spread received through successively lower spreads until an intersection with the relative supply schedule is reached or all wider bids are full allotted.

<sup>8</sup> For clarity, these examples focus on an increase in the spread against wider collateral. In reality, a system wide shock may also affect the amount of liquidity banks may try to secure from the central bank and/or the spread they would be willing to pay to obtain liquidity against narrow collateral. Similarly, a counterparty suffering an idiosyncratic liquidity shock may also demand a higher amount of central bank liquidity.

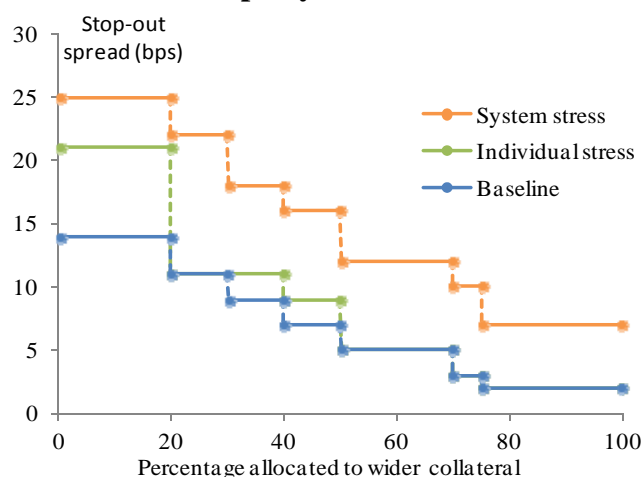


**Table 2: Hypothetical bidding patterns**

Bidder	Baseline		System wide shock		Individual counterparty shock	
	Amount (£mn)	Spread (bps)	Amount (£mn)	Spread (bps)	Amount (£mn)	Spread (bps)
W1	30	19	30	30	30	19
W2	20	17	20	26	20	26
W3	25	15	25	22	25	15
W4	25	14	25	19	25	14
N1	30	12	30	12	30	12
N2	30	10	30	10	30	10
N3	20	8	20	8	20	8
N4	20	5	20	5	20	5

Changes from the Baseline are shown in red

**Chart 2: Stylised allocation frontiers under the baseline, system-wide stress and individual counterparty stress scenarios**



29. Because bids in the auctions should provide accurate information on individual banks’ demand for liquidity and the prices they are willing to pay for it, the Bank can use the pattern of bids in each auction to assess the extent of stress in the market. These examples thus highlight how ILTRs can provide an “early warning indicator”. The Bank can use that information to inform its decisions on the size and maturity of future operations (hence solving one important problem with the eLTRs that was highlighted in the introduction) and it can engage institutions in a dialogue to understand the market’s liquidity needs.

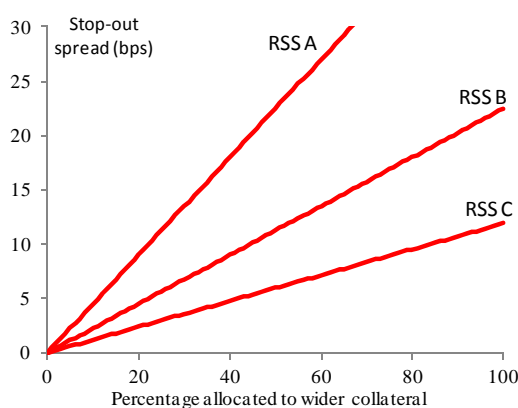
### 3.2 Relative supply schedule

30. The Bank’s supply schedule is pinned down by its objective – namely to provide liquidity insurance to the banking system at a price that does not undermine the incentive to prudently manage liquidity. The Bank summarises its preferences using a Relative Supply Schedule (RSS). A perfectly inelastic RSS would pin down the quantity of funds the Bank provides against wider collateral, regardless of the bids submitted. And with a perfectly elastic

supply curve, the Bank would, once a certain price threshold is exceeded, be prepared to allocate against all the wider collateral bids. The RSS thus dictates how the proportion of each auction allocated to the wider collateral set responds to changes in the bids submitted, and specifically the difference between the clearing spreads on the narrow and the wider collateral set (i.e. the stop-out spread).

31. Chart 3 below shows some illustrative examples of an RSS. A larger stop-out spread increases the proportion of the auction allocated to the wider collateral set, so the Bank’s ‘supply schedule’ is upward sloping. The different RSSs shown in Chart 3 are extremely simplistic, and are not realistic parameterisations of the Bank’s actual RSS. In particular, although the Bank’s supply curve should be continuous, it need not be linear. In general terms, the elasticity of the Bank’s RSS is pinned down by three broad considerations. First, the Bank sees merit in allocating some funds regularly against wider collateral, to ensure counterparties remain familiar with the auction structure and continue to participate. Second, the Bank should not undermine the incentives to manage liquidity prudently. And third, the auctions should permit an increased allocation against wider collateral to the system in the face of adverse liquidity shocks and the associated heightened demand for liquidity. While the principles underlying the Bank’s RSS are clear, the precise configuration of the RSS is not revealed to the market, further reducing any scope for firms to game the Bank, and encouraging them to bid according to need.

**Chart 3: Stylised relative supply schedules**



### 3.3 Equilibrium

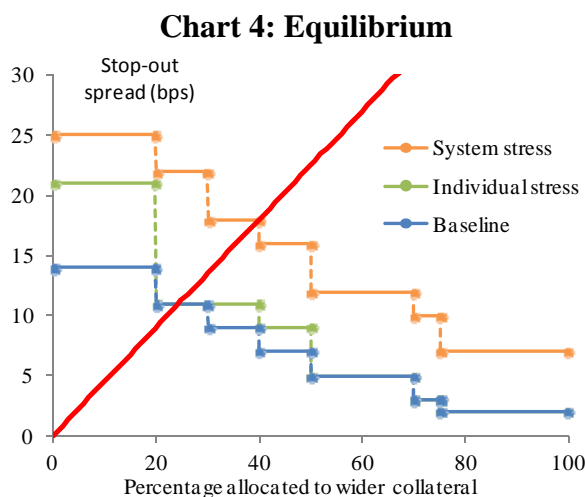
32. The equilibrium point is determined by the intersection of the observed allocation frontier, and the Bank’s RSS.<sup>9</sup> Chart 4 below illustrates this for the examples in Table 2 and the RSS A depicted in Chart 3 above.

<sup>9</sup> There can be instances where the allocation frontier and the RSS do not intersect. This is described in more detail in Fisher (2011b). When this was the case in the auctions conducted during the first year of operations considered here, the Bank has chosen to allocate at the lowest accepted bid spread. The Bank has recently moved to instead allocating on — or close to — the RSS.

33. In the baseline example, the Bank allocates 24% to wider collateral and 76% to narrow collateral at a stop out spread of 11 basis points. This means that bidder W1 receives a partial allocation of £24 million at 19 basis points. Bidders N1 and N2 are fully filled and bidder N3 receives £16 million of his £20 million bid. Since the auction uses uniform pricing and bidder N3 is the bidder with the lowest accepted bid rate, N1, N2 and N3 pay 8 basis points. The stop-out spread is thus 11 basis points.

34. Under a system-wide shock the intersection between the allocation frontier and the RSS shifts to the right relative to the baseline scenario. The auction thus automatically responds to such an increase in system-wide stress, thereby providing the intended liquidity insurance to the banking system as a whole. In this case 39% of the auction is allocated against wider collateral with the remaining 61% allocated to narrow collateral. This means that bidder W2 becomes the marginal bidder, receiving £9 million of his £20 million bid, with bidders W1 and W2 both paying a spread of 26 basis points. Bidder N3 remains the marginal bidder on narrow collateral, but receives a smaller allocation (£1 million) than previously at 8 basis points. The stop-out spread is thus 18 basis points.

35. Under the individual counterparty shock, neither the amount allocated to wider collateral, nor the stop-out spread is affected.<sup>10</sup> But by ‘bidding up’, bidder W2 has increased the share of the auction he receives from £10 million in the baseline scenario to his full bid of £20 million. Bidder W1 becomes the marginal bidder on wider collateral at 19 basis points, with bidder N3 remaining the marginal bidder on narrow collateral at 8 basis points.



<sup>10</sup> The allocation to wider collateral and the stop-out spread need not remain unaffected in response to a counterparty specific shock. For example, a steeper RSS could have led to an increase in the spread and a small increase in the proportion allocated to wider collateral.

## 4 Empirical results

36. This section summarises the results of the first year of ILTR operations, i.e. the first twelve operations held between June 2010 and May 2011. During this period, the Bank offered ILTRs on a monthly basis. In each calendar quarter, two £5 billion auctions with a three-month maturity and one £2.5 billion auction with a six-month maturity have been offered. The larger amount offered at three-month maturity reflects the fact that term liquidity in the money market has in the past been deepest at this maturity. But the Bank could adjust the frequency, size and/or maturity of ILTRs in light of evidence of system wide stress, including as revealed by demand in previous auctions.

37. Participants were able to submit multiple bids against either or both collateral sets, including paired bids. The Bank placed no restrictions on the number of bids submitted, but restricted the value of bids received from each participant to 30% of the auction size to prevent a single counterparty dominating the auction.

38. Table 3 provides a summary of key auction statistics for the first twelve operations.

**Table 3: Summary of average auction results**

	Maturity	
	3-month	6-month
Number of operations	8	4
Amount offered (£mns)	£5,000	£2,500
Total bids received (£mns)	£6,045	£3,743
Cover ratio	1.21	1.50
Stop-out spread (bps)	22	41

	Narrow	Wider	Narrow	Wider
Total bids received (£mns)	£4,958	£1,086	£2,938	£806
Amount allotted (£mns)	£3,999	£631	£1,724	£526
% of auction amount allotted	80	13	69	21
Cover ratio	0.99	0.22	1.18	0.32
Clearing spread (bps)	2	24	1	42

### 4.1 Quantities

39. Participation levels in the ILTRs have been lower than in the eLTRs at the peak of the crisis. The average level of cover (the total nominal amount of bids received relative to the total amount offered) across operations of the same maturity was higher during the first six months of ILTR operations between June and November 2010 than during the second six months between December 2010 and May 2011. Participants attributed the fall in average participation in the second six-months to the increased availability of longer-term funding in the market over the period. The majority of bids received in ILTR auctions to date, by both number and size, have been against the narrow collateral set.

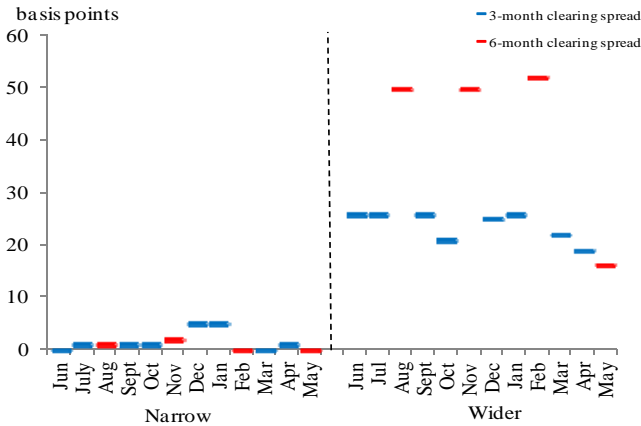
40. Two of the auctions at each maturity have been uncovered – that is the sum of bids received was less than the amount on offer. There are two points to note about uncovered auctions. First, even if there is insufficient demand, the auction mechanism functions. Second, irrespective of the cover ratio, the allocation depends on where the bids are relative to the Bank’s supply schedule. So while an uncovered auction will mean that the Bank allocates less than it had offered, a covered auction may also be under-allotted if the majority of the bids received produced stop-out spreads that were below the Bank’s supply schedule.<sup>11</sup>

41. Although the sample is small, on average, the six-month auctions appear to have generated greater demand relative to the amount on offer (higher cover) than the three-month auctions. Participants suggest that this reflects a combination of the attractiveness of securing longer-term liquidity, in part resulting from the need to comply with new regulatory liquidity requirements which aim to lengthen banks’ liquidity profiles and, particularly in the initial operations, the relative scarcity of longer maturity liquidity.

**4.2 Prices**

42. With the exception of the May 2011 six-month ILTR auction, which produced the lowest clearing spread on wider collateral across auctions to date, clearing spreads against both the narrow and the wider collateral sets have been broadly similar across operations of the same maturity (Chart 6). Furthermore, in general, clearing rates (i.e. clearing spread plus Bank Rate) have been close to market price indicators. With the exception of the May 2011 operation, auctions at the six-month maturity have commanded a significant premium compared to three-month auctions.

**Chart 5: Auction clearing spreads**



<sup>11</sup> Ordinarily, the Bank implements the interest rate decision of the Monetary Policy Committee in a system where banks set targets for the amount of central bank reserves they wish to hold over a maintenance period. In this system, the Bank uses short-term open market operations (OMOs) to adjust the level of reserves to enable the banking system in aggregate to meet its’ targets. In determining the size of these operations, the Bank needs to take account of all flows across its balance sheet, including a smaller than anticipated injection of reserves through an uncovered ILTR.

### **4.3 Operational features**

43. In contrast to the previous LTRs and eLTRs, ILTRs operate a uniform price allocation format. It is difficult to establish the extent to which this change to a uniform price allocation mechanism has affected participants' bidding strategies. This may be more easily observable during times of stresses in financial markets when the value placed on longer-term liquidity is likely to be more variable across participants.

44. Over the first year of operations, there has been limited use of the paired bidding functionality described above. But paired bids are likely to be of greater use during times of market stress when participants are more focussed on securing a specific quantity of liquidity.

## **5 Conclusion**

45. Central bank operations have evolved rapidly in recent years. Many of the changes arose as a direct consequence of the financial crisis, and the new demands for liquidity insurance that it engendered. One lesson the Bank has learnt from the crisis is that there are advantages to separating the implementation of monetary policy from the provision of liquidity insurance. As a result, the Bank has installed permanent facilities to provide liquidity insurance, without compromising its ability to meet its monetary policy objective. The Bank's ILTR operations are one manifestation of this.

46. The primary objective of the Bank's ILTR operations is to provide liquidity insurance to the banking system without distorting commercial banks' incentives for prudent liquidity management, and while minimising the risks being taken by the Bank. The most innovative aspect of ILTRs is that, as the degree of market stress increases (as the clearing spread on wider collateral rises relative to that on narrow collateral), the Bank, within the auction, automatically lends a greater proportion against wider collateral consistent with its pre-determined relative supply schedule. And it obtains a signal about the need to expand the overall size or frequency of future operations. In doing so, we believe, the Bank's ILTRs represent a global first in central bank auction design.

47. The Bank has conducted ILTRs since June 2010. The results from the operations conducted during the first year suggest that during this time, the UK banking system's demand for central bank liquidity from longer-term operations has been significantly less than during the height of the financial crisis. The new auctions have thus not been tested during times of severe stress. The Bank will continue to regularly review its operations. However, based on the operations to date, the Bank is satisfied that the operational framework meets the objectives of the ILTRs.

## Annex A: Constructing an allocation frontier including paired bids

1. Construction of the allocation frontier follows the same process as outlined in the main text. However, at some point we begin to allocate to a wide bid that has been entered as part of a pair. The total allocation to a paired bid cannot exceed the nominal amount of the bid. To deal with this, if both parts of a pair are above their respective clearing spreads (and hence eligible for a full allocation), the bidder is allotted in full against the part of the pair that offers them better value. In a uniform price auction, this can be determined by comparing the spread the bidder was prepared to pay for each half of the pair with the respective auction clearing spreads.
2. The following example is based upon the pattern of bids used in the baseline example discussed in the main text with the exception that bids N1 and W1 now represent two parts of a paired bid (shown below).

Bidder	Amount (£mns)	Spread (bps)	Pair	Bidder	Amount (£mns)	Spread (bps)	Pair
N1	30	12	P1	W1	30	19	P1
N2	30	10		W2	20	17	
N3	20	8		W3	25	15	
N4	20	5		W4	25	14	

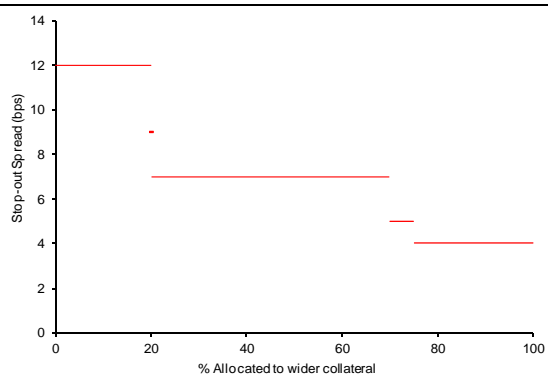
Auction size: £100mn

Minimum allocation increment: £1mn

3. As described in the main text, the allocation algorithm starts by allocating 100% of the auction to bids against the narrow collateral set. In the above auction, this results in a clearing spread on narrow collateral of 5bps. There is no allocation to wider collateral and therefore bidder (P1) receives a full allocation against narrow collateral. The second step is to ration the lowest ranked narrow bid (bid N4) and allocate this amount to the highest spread bid against wider collateral (W1). However, as W1 is the wider half of the paired bid and the narrow half of the pair (N1) is also eligible for a full allocation against narrow collateral, the algorithm must consider which collateral set the paired bidder would prefer to be allotted against. At a spread of 12bps, the narrow half of the pair exceeds the current narrow clearing spread of 5bps by 7bps, while the wider half of the pair is effectively at the wider clearing spread. Consequently, at this point, the bidder would prefer to be allotted in full against narrow collateral. The allocation process therefore skips bid W1 and starts to allocate to bid W2 at a spread of 17bps, resulting in clearing spreads of 5bps and 17bps for the narrow and wider collateral sets respectively (a stop-out spread of 12bps).

4. The allocation process continues to reduce the amount allocated to narrow collateral and increase the amount allocated to wider collateral until the point at which a change in clearing spreads causes the paired bidders preferred allocation to switch from the narrow to the wider collateral set. In this case when the clearing spreads are 10bps and 15bps for narrow and wider collateral respectively, the narrow half of the pair now exceeds the narrow clearing spread by 2bps while the wider part of the pair exceeds the wider clearing spread by 4bps (Table A1). The allocation process then continues to construct the rest of the demand schedule as shown in Chart A1.

Table A1: Summary of potential allocations					Chart A1: Demand schedule			
Potential allocations (%)		Clearing spreads (bps)		Stop-out spread (bps)	Spread of paired bid to clearing spread (bps)		Paired bid prefers allocation to	
Narrow	Wide	Narrow	Wide		Narrow	Wide		
100	0	5	-	-	7	-	Narrow	
99	1	5	17	12	7	2	Narrow	
81	19	5	17	12	7	2	Narrow	
80	20	8	17	9	4	2	Narrow	
79	21	8	15	7	4	4	Indifferent	
31	69	8	15	7	4	4	Indifferent	
30	70	10	15	5	2	4	Wider	
25	75	10	15	5	2	4	Wider	
24	76	10	14	4	2	5	Wider	
1	99	10	14	4	2	5	Wider	
0	100	-	14	-	-	5	Wider	



5. As the allocation process systematically reduces the amount allocated to narrow and increases the amount allocated to wider bids, the clearing spread on narrow will always increase while that on wider will always decrease. Consequently, once a paired bid has switched across from the narrow to the wider collateral set, the bidder will always prefer to be allocated against wider collateral.

6. The final auction clearing spreads, as determined by the intersection point between the demand schedule and the Banks RSS are used to establish which collateral set the paired bidder would prefer to be allotted against.

*Further considerations*

7. In many auctions, the allocation of paired bids where both bids are above stop-out rates will be unambiguous, since one side is likely to be further above the indicated stop-out spreads than the other (and thus the bid fully allocated to one type of collateral). But there could be occasions where one or more paired bids are equal distance from the respective stop-out rates at the prices indicated by the auction. In this case, the bidder should be indifferent as to which half of the pair they are allocated against and so (at the given prices) the auctioneer could choose to ration each side of the pair in order to reach any intermediate collateral split, so long as the paired bid is allocated its full amount



(and no more).<sup>12</sup> Such an approach is also advantageous for participants, as if they chose to be allocated against only one collateral set then they would be likely to receive a lower proportion of their bid

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<sup>12</sup> It is also possible to encounter a situation where both sides of a paired bid are at their respective stop-out rates. Again, the auctioneer may choose to ration both sides of the paired bid in order to obtain any intermediate collateral split.

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