Innovations in the Bank's provision of liquidity insurance via Indexed Long-Term Repo (ILTR) operations

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- The Bank's liquidity insurance facilities have been consistently improved since the onset of the financial crisis. The most innovative of these facilities is the Indexed Long-Term Repo (ILTR).
- In designing the ILTR, the Bank has drawn on lessons from auction theory. A key feature is that the provision of liquidity via the ILTR adjusts automatically to increases in demand caused by liquidity stresses in the financial system.

Overview

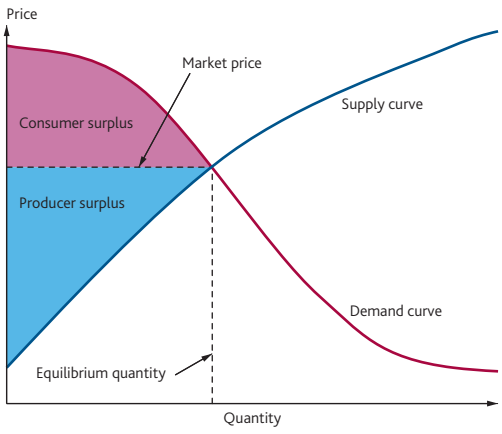
The provision of liquidity insurance is a core function of the Bank of England. It directly supports the Bank's mission to promote the good of the people of the United Kingdom by maintaining monetary and financial stability. The financial crisis illustrated that, in times of stress, market participants' demand for liquidity insurance and the price they are willing to pay for it increases. The Bank, like other central banks, faced the challenge of needing to respond by providing large-scale liquidity insurance against a wide range of collateral.

Part of the Bank's response included redesigning its existing long-term repo operations, with the objective of increasing the availability and flexibility of liquidity insurance provision. The operations now offer liquidity at longer maturities against the full range of Sterling Monetary Framework eligible collateral and at cheaper (auction-determined) rates.

Two automatic responses are now built into each Indexed Long-Term Repo (ILTR) operation. First, if the prices and quantities bid in the operation indicate that there are signs of increased stress on a particular set of collateral, a greater proportion of the liquidity made available by the Bank is lent against that set. Second, the operation is no longer limited to supplying a fixed quantity of liquidity. Instead, as the pattern of bids observed in the operation suggests a greater overall demand, the total quantity of liquidity made available is automatically increased. The allocation process achieves this by maximising the combined 'surplus' of both producer and consumers as illustrated in the **summary figure** and explained further in the annex.

Since the launch of the updated ILTR, demand for central bank liquidity has been principally met with the reserves supplied by the Monetary Policy Committee's asset purchases, known as quantitative easing. However, as unconventional operations are wound down over time, the flexibility of the ILTR to respond to increased demand for liquidity, particularly in a market stress, is likely to prove a valuable addition to the Bank's liquidity insurance toolkit.

Summary figure The combined consumer and producer surplus



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The Bank of England's mission is to promote the good of the people of the United Kingdom by maintaining monetary and financial stability. The Bank's operations in the sterling money markets, known as the Sterling Monetary Framework (SMF), serve that mission. They are designed to implement monetary policy and to support financial stability by acting as a backstop provider of liquidity in order to reduce the cost of disruption to critical financial services.

This article provides a brief overview of how the Bank's primary market-wide liquidity insurance tool, the Indexed Long-Term Repo (ILTR), has evolved from pre-crisis to the present day. It considers the liquidity risk that is a standard feature of the banking system, and why central banks are well placed to act as backstop providers of liquidity. It then describes the steps that the Bank has taken to develop its liquidity insurance operations, culminating in the reforms made to the ILTR in February 2014. The article then goes on to demonstrate the two key features of the ILTR using an illustrative example.

Liquidity risk in the banking system

Banks, building societies and broker-dealers (henceforth 'banks') are subject to liquidity risk: the risk that a material part of their funding is withdrawn before the assets they hold can be realised at their true economic value. Liquidity risk is a standard feature of banking, and responsibility for managing normal day-to-day fluctuations should fall to banks themselves.

However, it is inefficient for banks to have to self-insure against extreme or 'tail' liquidity risks such as those caused by sudden market dysfunction. In such circumstances, central banks are well placed, as the monopoly suppliers of the most liquid asset — central bank reserves — to act as backstop providers of liquidity to solvent banks: so-called 'liquidity insurance'.

The Bank's liquidity insurance facilities have been consistently improved through a series of major reforms since the onset of the financial crisis. The most innovative of these facilities is the Bank's ILTR, a regular auction of central bank reserves which provides banks with an opportunity to obtain liquidity against a wide range of collateral.

In designing the ILTR the Bank has drawn on lessons from auction theory. A key feature is that the provision of liquidity via the ILTR adjusts automatically to increases in demand, for example in the event of liquidity stresses in the financial system.

Evolution of the Bank's liquidity insurance provision

Prior to the financial crisis, the Bank offered a limited amount of liquidity via monthly Long-Term Repo operations (LTRs) at a range of maturities. These fixed-size LTR auctions were primarily designed as a tool for the Bank to manage its balance sheet, by reducing the 'churn' of shorter-term liquidity supplying operations used to implement monetary policy. The stock of lending via LTRs represented a relatively small proportion of the overall quantity of liquidity supplied by the Bank.

The auctions utilised a so-called 'single-good' auction format. Participants were able to bid to borrow central bank reserves secured against a single pool of highly liquid sovereign debt securities. A discriminatory pricing format was used, with each successful bidder required to pay their bid price. Participants' bids were ranked in descending order by price. Bids at the highest price were accepted first, followed by bids at successively lower prices until all bids had been allocated in full, or the fixed total quantity of liquidity made available by the Bank had been reached.

The first step towards the present ILTR operations was taken towards the end of 2007. In response to strains in funding markets, demand for liquidity increased, particularly against less liquid collateral. In response, the Bank announced a significant expansion of its existing three-month Long-Term Repo operations, increasing the fixed total quantity of liquidity available and expanding the range of collateral accepted to include a wider range of less liquid, non-sovereign securities for the first time.

These Extended Collateral Long-Term Repos (ELTRs) retained the same discriminatory price and single-good format used in the earlier LTRs. However, in order to reflect the difference in liquidity between different types of collateral, a higher minimum bid rate was introduced for those participants wishing to borrow against the newly eligible, less liquid securities. As the crisis evolved, these ELTRs were offered in greater size, at a greater frequency, and against a wider range of collateral. At their peak during January 2009, the stock of outstanding ELTRs reached £190 billion.

In June 2010 the ELTRs were replaced with ILTR operations, as part of a move to make the eligibility of a broader range of collateral a permanent part of the SMF. Two ILTR auctions with a three-month maturity and one with a six-month maturity were offered in each calendar quarter.

At this point a 'multi-good' auction format was adopted, with the single pool of eligible collateral split into two distinct sets to better reflect their different liquidity characteristics — a

'narrow' set consisting of the highest quality sovereign securities, and a 'wider' set containing a broader class of high-quality but less liquid debt securities.

The allocation method also switched from a discriminatory to a uniform pricing format, in which each successful bidder paid the clearing price for the chosen collateral set. All bids above the respective clearing price were allocated in full, while bids below the clearing price were unallocated. Bids at the clearing price may have been partially allocated. In a discriminatory price auction, participants may face incentives to submit bids at prices below those they may be willing to pay in order to avoid paying a higher price than would have been necessary to receive an allocation. In contrast, bidders in a uniform price auction are further incentivised to bid the maximum price they are willing to pay, in the knowledge that their bid will be accepted at that price or a better one.

Each auction continued to offer a fixed total quantity of liquidity, but the proportion allocated to the two collateral sets was allowed to vary based on the pattern of bids received and the Bank's pre-determined preferences for allocating between them. If the quantity and price of bids received against the wider collateral set were high relative to those on the narrow collateral set — taken to be indicative of increased market stress — the auction automatically allocated more funds to the wider collateral set.

The interest rates charged to successful bidders in these auctions were indexed to Bank Rate. Indexing removes the interest rate risk that would otherwise exist for both the Bank and its counterparties. Risk to the Bank's balance sheet was managed by comprehensive risk management and monitoring of the securities accepted, including the application of 'haircuts' on the value of collateral.(1)

The current ILTR framework

The Bank introduced a further set of amendments to its ILTR operations in February 2014.(2) These amendments formed part of a series of reforms to the SMF made following an external review of the Bank's operating framework by Bill Winters, commissioned by the Court of the Bank in 2012.(3) The changes were designed to increase the availability and flexibility of the Bank's liquidity insurance provision, providing liquidity at longer maturities, against an even wider range of collateral, at a lower cost and with greater predictability of access.

Participants are now able to borrow for a six-month term against the full range of SMF eligible collateral,(4) which is grouped into three sets in descending order of expected market liquidity. Level A collateral comprises certain high-quality, highly liquid sovereign securities; Level B collateral includes a broader range of securities, including other sovereign, supranational, mortgage-backed and corporate bonds; and Level C comprises less liquid securitisations, own-name securities and portfolios of loans. Level C collateral was not previously eligible in the ILTR. The addition of a third collateral set means each auction now produces three clearing prices, one for each set.

Two automatic responses are now built into each ILTR operation. First, as in the original ILTR, if the prices and quantities bid in the operation indicate that there are signs of increased stress on a particular collateral set, a greater proportion of the liquidity available is lent against that set. Second, the operation is no longer limited to supplying a fixed quantity of liquidity. Instead, if the pattern of bids observed in the operation suggests a greater overall demand for liquidity, the total quantity made available automatically increases in response.

The outcome of each ILTR operation is determined by the interaction between participants' demand for funding, and the Bank's pre-determined supply preferences for the amount of liquidity supplied, both across collateral sets and in aggregate.

Participant demand

Participants express their demand for liquidity insurance through the bids they submit. During each ILTR operation, each participant may submit bids against one or more collateral sets. Each bid specifies the price (expressed as a spread to Bank Rate) the participant is willing to pay for a desired quantity of liquidity, along with the collateral set they wish to deliver in exchange.

There are no restrictions on the number of bids submitted or the quantity of liquidity requested. However, bids must be submitted at spreads that are at or above the minimum spreads for each collateral set as published by the Bank. Those minimum spreads are currently set at 0 basis points, 5 basis points, and 15 basis points over Bank Rate for Levels A, B and C respectively.

The Bank's supply preferences

The Bank's preference for supplying liquidity against each of the three collateral sets is expressed through two upward-sloping supply curves that are specified in advance of each operation. These define the premium that bidders will need to pay to borrow more of the available liquidity against a particular collateral set. The first specifies the Bank's preference for the proportion of the available liquidity

(1) Alphandary, A (2014), 'Risk managing loan collateral at the Bank of England', *Bank of England Quarterly Bulletin*, Vol. 54, No. 2, pages 190–201; www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2014/qb14q208.pdf.
(2) See www.bankofengland.co.uk/markets/Documents/money/publications/liquidityinsurance.pdf.
(3) See www.bankofengland.co.uk/about/Pages/courtreviews/default.aspx.
(4) Further details on the range of eligible collateral is available at www.bankofengland.co.uk/markets/Pages/money/eligiblecollateral.aspx.

allocated to the less liquid collateral sets (Levels B and C combined). The second determines the split of this combined quantity between Level B and Level C. The higher the prices and quantities bid against Levels B and C relative to those on Level A, the higher the proportion of the liquidity allocated to bids against Levels B and C. Similarly, the higher the prices and quantities on Level C relative to those on Level B, the higher the allocation to Level C.

With the exception of published minimum bid spreads for each collateral set, the exact specification of the Bank's supply preferences is not publicly disclosed, and the Bank is able to alter its supply preferences over time. However, illustrative supply preferences are shown in **Figures 1** and **2**. Two general principles underpin the Bank's supply preferences. First, the Bank sees merit in making a limited proportion of the amount offered available to each collateral set at the published minimum spreads, which is represented by the horizontal section of the illustrative curves. Second, the operation should respond to stress by allowing more of the available liquidity to be provided against a particular collateral set as demand for liquidity against that set increases.

Figure 1 Supply preferences between Level A and Levels B and C combined

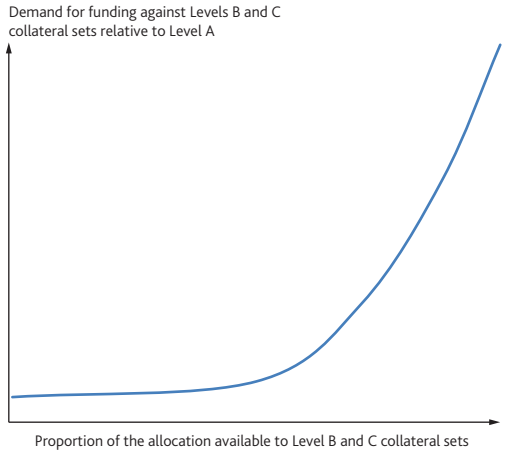
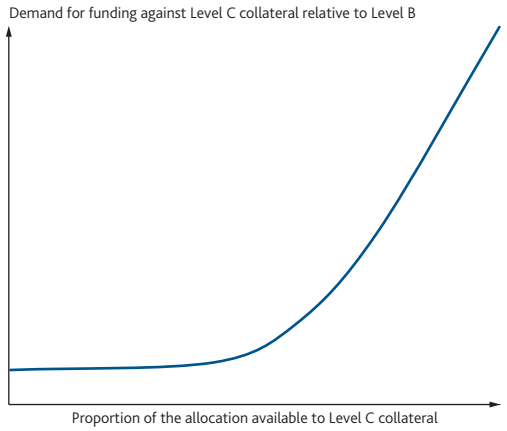


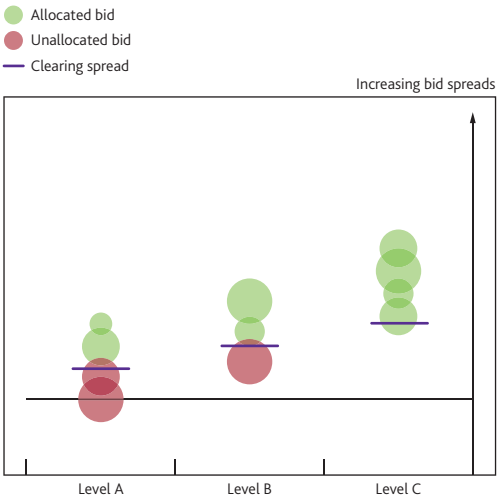
Figure 2 Supply preferences between Levels B and C



The ILTR allocation process

The ILTR's innovative allocation process is perhaps best illustrated through an example. Consider the hypothetical set of bids for a fixed auction size shown in **Figure 3**. Each bid is displayed as a circle, where the size of the circle represents the size of the bid, and the vertical position of the centre of the circle represents the bid spread to Bank Rate. Bids in each auction should provide accurate information on individual participants' demand for liquidity and the prices they are willing to pay for it. Taken together, the pattern of bids in each auction therefore provides an indication of the degree of market stress against each collateral set. In this case, bids are relatively well dispersed across each collateral set and at low spreads, suggesting no sign of market stress.

Figure 3 Allocation in a fixed-size auction

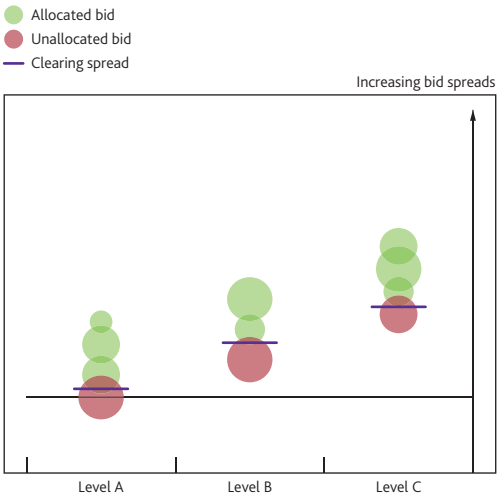


The outcome of each ILTR auction is a set of three clearing spreads which are determined by the interaction between participants' demand for liquidity and the Bank's preferences for supplying it. One way to find the auction result is to begin with an arbitrarily selected set of clearing spreads and iterate until the single set of clearing spreads consistent with both sets of preferences is identified. For example, choosing the clearing spreads shown in purple on **Figure 3** would result in the bids shaded green receiving a full allocation, while those shaded red fall below the chosen clearing spreads and are therefore unallocated.

At these clearing spreads the auction allocation is skewed towards the less liquid Level B and Level C collateral sets, with all of the Level C bids being allocated in full. This outcome is inconsistent with the Bank's preference to not increase the allocation to the less liquid collateral sets until demand for those sets increases materially.

It is therefore necessary to adjust the clearing spreads and rebalance the allocation by decreasing the clearing spread on Level A, allowing more bids to be allocated, and increasing the

Figure 4 Allocation in a fixed-size auction following adjustment of the clearing spreads



clearing spread on Level C to reduce the proportion of the auction allocated to that set. **Figure 4** illustrates the results of such an adjustment.

The outcome shown in **Figure 4** is more evenly split across the three collateral sets, which is closer to the principles behind the Bank's supply preferences. In theory, it is possible to test every possible combination of clearing spreads, calculating the resulting allocation and comparing it with the Bank's supply preferences. However, instead of manually iterating towards a solution, the allocation can be specified as an optimisation problem with a set of constraints. This can then be solved using linear programming techniques, as described in the annex.

Introducing a variable auction size

The example described above iterated towards a final allocation on the basis of a fixed auction size and a set of bids which represented relatively low demand. In the event of a market stress, participants' demand for liquidity and the price they are willing to pay for it is likely to increase. With a fixed auction size, as demand increases, an increasing quantity of bids must go unallocated — only those willing to pay the highest prices receive liquidity. This can be illustrated as a vertical supply curve, where a pre-determined amount of liquidity is supplied irrespective of the level of demand (**Figure 5**).

Figure 6 illustrates what might happen in a fixed-size auction when market stress increases. More bids are received, at higher spreads, and some at larger sizes than before. However, the auction is only able to allocate the same total quantity of liquidity, which means most of the bids are unallocated and the clearing spreads are much higher as a result.

This would be a good result for an auctioneer seeking only to increase the value they obtain from the auction for themselves. However, consistent with its policy objectives, the Bank's desire is to respond to market stress by increasing the provision of liquidity. In the ILTR, this is achieved by incorporating an upward-sloping supply curve like that shown in blue in **Figure 5**.

Figure 5 Fixed versus variable quantity supply curves

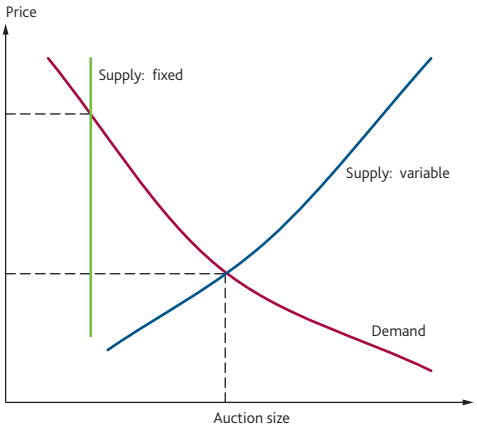
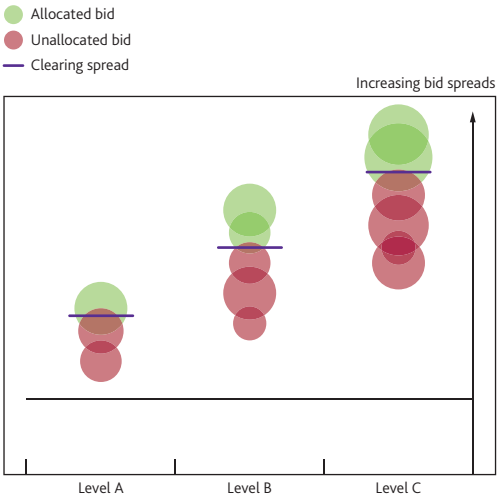
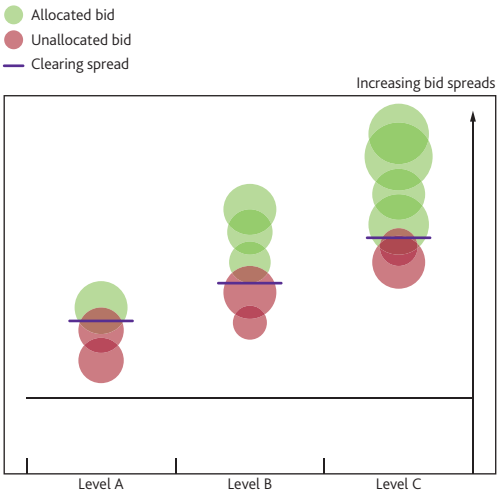


Figure 6 Allocation in a fixed-size auction during market stress



The variable quantity response is incorporated in each ILTR operation by running a large number of discrete fixed-size auctions, with the size gradually increased for each iteration. The results of each individual auction can then be used to construct a downward-sloping demand curve: as the auction size increases, more bids can be allocated, and the clearing spreads in the auction fall. This result is illustrated in **Figure 7**. The auction size which is consistent with the Bank's pre-determined preferences for the quantity of liquidity it will supply at the given clearing spreads is determined by the intersection between the demand curve and the Bank's upward-sloping supply curve (**Figure 5**).

Figure 7 Allocation in a variable-size auction during market stress



Conclusion

The provision of liquidity insurance is a core function of the Bank of England. It directly supports the Bank's mission to promote the good of the people of the United Kingdom by maintaining monetary and financial stability.

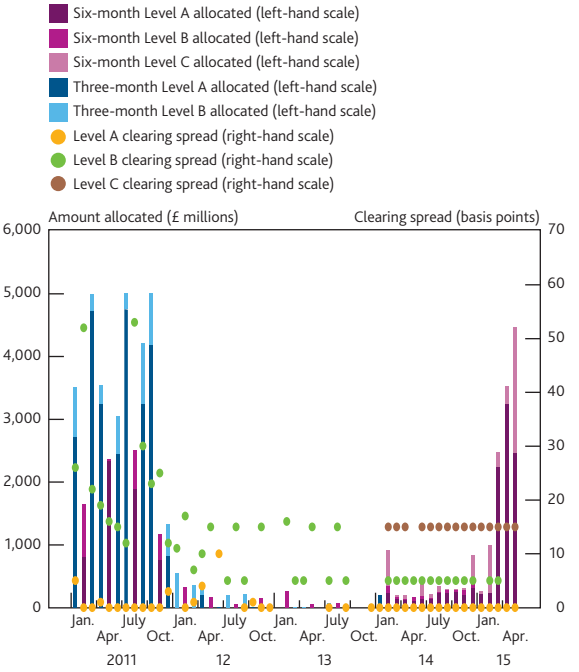
During the financial crisis, the Bank, like other central banks, faced the challenge of needing to provide large-scale liquidity insurance against a wide range of collateral. Part of the Bank's response included redesigning its existing Long-Term Repo operations to incorporate a more flexible response to stress and repositioning the ILTR as a specific liquidity insurance facility.

The latest version of the Bank's ILTR operation builds on the lessons of the financial crisis. The operation now offers liquidity insurance at longer maturities against the full range of SMF eligible collateral and at cheaper (auction-determined) rates.

As the crisis illustrated, in times of stress, financial market participants' demand for liquidity insurance and the price they are willing to pay for it increases. The auction mechanism outlined in this article allows the Bank to respond to unforeseen changes in the demand for liquidity insurance by automatically adjusting both the quantity of liquidity supplied and the allocation of that liquidity against different types of collateral.

The Bank has conducted ILTRs in the revised format since February 2014. During this time, demand for central bank liquidity has been principally met with the reserves supplied by the Monetary Policy Committee's asset purchases, known as quantitative easing. Consequently, demand for liquidity insurance in the ILTRs has been relatively low, as shown in **Chart 1**. However, as unconventional operations are wound down over time, the flexibility of the ILTR to respond to increased demand for liquidity, particularly in a market stress, is likely to prove a valuable addition to the Bank's liquidity insurance toolkit.

Chart 1 Usage of ILTR operations over time



Annex
Finding the auction equilibrium

This annex explains how an auction outcome consistent with the preferences of both the consumers and the producer of a good can be derived for a fixed-size auction by transforming their preferences into an optimisation problem that can be solved using linear programming techniques.

The problem can be specified with the intention of maximising the combined 'surplus' of all participants (both the consumers and the producer) subject to a set of constraints. For a single good, this is equivalent to the shaded area between the supply and demand curves, as shown in the summary chart.

In the ILTR, the consumers are the bidders, the producer is the Bank and the goods represent the quantity of liquidity allocated to each collateral set. As the ILTR is an auction of liquidity against three distinct collateral sets, the total surplus can be thought of as the sum of the combined surpluses for each individual collateral set.

Defining the consumer surplus

In a uniform price auction like the ILTR, the total consumer surplus can be thought of as the sum of the differences between the price each bidder would have been willing to pay for the good (represented by the bid price, referred to below as p) and the price actually paid (the auction clearing price, c), multiplied by the quantity received (x).

Consumer surplus on an individual bid = (bid price - clearing price) × quantity allocated

Consumer surplus on the i^{th} bid on collateral set j

$$= \left(p_i^j - c_j\right) x_i^j$$

$$\text{Total consumer surplus} = \sum_{j=A}^{C} \sum_{i} \left(p_i^j - c_j\right) x_i^j$$

$$= \sum_{j=A}^{C} \sum_{i} P_i^j \; x_i^j - \sum_{j=A}^{C} \sum_{i} c_j \; x_i^j$$

Defining the producer surplus

The producer surplus is equivalent to the revenue generated by the auction minus the cost of supply.

Producer surplus = total revenue received – total cost of supply

In the case of the ILTR, total revenue received by the Bank is exactly equal to the total amount paid by the bidders, as described by the final term in the equation for total consumer surplus. The total cost of supply across the three collateral sets can be derived as follows:

$$\text{Cost of supply} = cost_A \times quantity_A + cost_B \times quantity_B + cost_C \times quantity_C$$

In the ILTR, the Bank's supply preferences can be thought of as specifying the 'cost' to the Bank of supplying a given quantity of funds against each collateral set. In the absence of competition from bids on the other sets, the Bank is willing to allocate up to 100% of the auction against Level A bids without charging a premium over Bank Rate — this is equivalent to setting the cost of supplying liquidity against Level A at zero. For other collateral sets, the supply preferences specify the incremental cost I_B of supplying liquidity against Level B collateral versus Level A, and the incremental cost I_C for supplying liquidity against Level C collateral versus Level B. The total cost of supply is therefore:

$$\text{Cost of supply} = I_B \times quantity_B + (I_B + I_C) \times quantity_C$$

$$= I_B \times (quantity_B + quantity_C) + I_C \times quantity_C$$

The first term in the equation above is equivalent to the area below the Bank's supply preference curve between Level A and Levels B and C combined, as illustrated in **Figure 1** in the main text of the article. The second term is equivalent to the area below the Bank's second supply preference curve, between Levels B and C, as in **Figure 2**.

In order to rewrite this equation in terms of the earlier notation, the upward-sloping supply preference curves can be approximated by a number of discrete steps, where each supply preference consists of q steps, the term μ_q denotes the marginal cost per unit supplied at each step and y_q denotes the quantity supplied along each step. The area under the curve can then be calculated by summing the areas under each individual step, as follows:

$$\text{Cost of supply} = \sum_{q} \mu_q^B y_q^B + \sum_{q} \mu_q^C y_q^C = \sum_{j=B}^{C} \sum_{q} \mu_q^j y_q^j$$

The cost of supply can then be subtracted from the total revenue received, to calculate the overall producer surplus:

$$\text{Producer surplus} = \sum_{j=A}^{C} \sum_{i} c_j \; x_i^j - \sum_{j=B}^{C} \sum_{q} \mu_q^j \; y_q^j$$

Total economic surplus

The consumer surplus and producer surplus equations can then be combined to derive the objective function to be maximised.

Total economic surplus
= Consumer surplus
+ Producer surplus

Total economic surplus = Consumer surplus + Producer surplus

$$= \left(\sum_{j=A}^{C} \sum_{i} P_i^j \, x_i^j - \sum_{j=A}^{C} \sum_{i} c_j \, x_i^j \right) + \left(\sum_{j=A}^{C} \sum_{i} c_j \, x_i^j - \sum_{j=B}^{C} \sum_{q} \mu_q^j \, y_q^j \right)$$

$$= \sum_{j=A}^{C} \sum_{i} P_i^j \, x_i^j - \sum_{j=B}^{C} \sum_{q} \mu_q^j \, y_q^j$$

Auction constraints

In seeking to maximise the total economic surplus in the ILTR, it is necessary to adopt the following three constraints:

(i) The amount allocated to an individual bid must be between 0% and 100% of the bid amount. For bids above the clearing spread, the allocation is 100%. For bids below the clearing spread, the allocation is 0%. For bids at the clearing spread, the allocation can be between 0% and 100%, inclusive.

(ii) The amount allocated to each collateral set must not exceed the amount the Bank as auctioneer is willing to supply to that collateral set, at the given spread.

(iii) The total amount allocated across all three collateral sets must not exceed the auction size.

The final result of the linear program

Linear programming techniques can be used to maximise the objective function described above. This results in a set of clearing spreads which can be used to determine the allocation to each individual bid based on a fixed-size auction. The variable quantity element of the ILTR is implemented by running a series of independent auctions at different fixed sizes, then selecting the single auction size which matches the Bank's supply preferences.