Institution: University of Oxford

Unit of Assessment: 16 – Economics and Econometrics

Title of case study: Designing auctions to improve central bank operations

Period when the underpinning research was undertaken: 2000-2010

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Paul Klemperer	Professor in Economics	1985 - Present

Period when the claimed impact occurred: 2013 – 31 July 2020

Is this case study continued from a case study submitted in 2014? Y

1. Summary of the impact (indicative maximum 100 words)

Since 2010, the Bank of England's Indexed Long-Term Repo (ILTR) operations have been a key component of the Bank's toolkit for ensuring sufficient liquidity for the financial system at times of stress. The ILTR is based on Professor Klemperer's 'product-mix' auction design and was developed in collaboration with him **[E1]** as described in a 2014 REF Impact case study. Following an external review in 2012, Professor Klemperer worked with the Bank to refine and extend the ILTR to improve further the flexibility of the Bank's liquidity insurance provision. Implemented in 2014, the redesign provided liquidity at longer maturities, against an even wider range of collateral, at a lower cost and with greater predictability of access. This has led to practice changes not only in the UK central bank, but in all UK clearing banks, investors, industry regulators and other organisations. Similar work has been undertaken by Klemperer with the Central Bank of Mexico.

2. Underpinning research (indicative maximum 500 words)

Professor Klemperer's research on auction theory and the insights that it provides for our understanding of the operation of market economies has been at the forefront of the subject for more than two decades. His earlier work focused on the problems inherent in multi-unit, multi-product auctions including issues of collusion and the fact that the seller has to decide how much to sell before she knows the prices **[R1, R4]**. This work played a major role in the design of the auction for British 3G Telecom licenses in 2000 **[R1, R3]**. This was followed by a study on the benefits of competitive auctions as a mechanism for sale and procurement **[R2]**.

A major challenge for auction design is how to sell goods that both sellers and buyers view as imperfect substitutes when multi-round auctions are impractical. This was the problem facing central banks at the time of the 2007 financial crisis: given an urgent need to inject liquidity into the financial system, central banks were willing to accept a wider than usual range of collateral against loans, but wanted the interest rate charged to vary with the quality of the collateral. Klemperer's proposed solution - the product-mix auction - permits different but related goods to be traded and individually priced in a single-round auction **[R5]**. Each bidder can make one or more bids, and *each* bid contains a *set* of mutually exclusive offers. Each offer specifies a price for a quantity of a specific "variety". The auctioneer looks at all the bids and then selects a price for each "variety". The idea is that the menu of mutually exclusive bids allows each bidder to approximate a demand function, so bidders can, in effect, decide how much of each variety to buy *after* seeing the prices chosen. Meanwhile the auctioneer can look at demand *before* setting the prices. Importantly, offers for each variety provide a competitive discipline on the offers for the other varieties, because they are all being auctioned simultaneously.

The 'product-mix' auction can be understood as a proxy version of a 'simultaneous multiple round auction' (SMRA), with a number of enhancements. Because the auction is "sealed bid" it runs instantaneously (important in the financial-market context), and therefore is less vulnerable to collusion. Another important feature is that while standard SMRA implementations fix the quantity of each type of each good to be sold in advance, the auctioneer in the 'product-mix' auction can specify how the quantities of different varieties to be sold will depend upon the auction prices (the overall supply constraint). The product-mix auction yields better "matching" between suppliers and demanders, reduced market power, greater liquidity, and therefore also improved efficiency, revenue, and quality of information than feasible alternatives.

3. References to the research (indicative maximum of six references)

R1. Binmore, K. and P. Klemperer (2002), "The Biggest Auction Ever: the Sale of the British 3G Telecom Licences," *Economic Journal*, Royal Economic Society, vol. 112, 478, pp C74-C96, March. DOI:10.1111/1468-0297.00020 [output type: D]

R2. Bulow, J and P. Klemperer (2009) "Why Do Sellers (Usually) Prefer Auctions?" *American Economic Review,* American Economic Association, vol. 99 ,4, pp 1544-75, September. DOI: 10.1257/aer.99.4.1544 [output type: D]

R3. Klemperer, P. (2002). **"**What Really Matters in Auction Design," *Journal of Economic Perspectives*, American Economic Association, vol. 16, 1, pp 169-189, Winter. DOI: 10.1257/0895330027166 [output type D[

R4. Klemperer, P. (2004) *Auctions: Theory and Practice*, Princeton University Press, Princeton: US. [output type: A - Available on Request]

R5. Klemperer, P. (2010) **"**The Product-Mix Auction: A New Auction Design for Differentiated Goods," *Journal of the European Economic Association,* 8, 2-3, pp 526-536. DOI:10.1111/j.1542-4774.2010.tb00523.x [output type: D]

4. Details of the impact (indicative maximum 750 words)

The provision of liquidity insurance to commercial banks (i.e. surety that liquidity is obtainable by solvent banks as and when needed) is a core function of the Bank of England and key to maintaining financial and economic stability within the UK. The financial crisis of 2007/8 illustrated that in times of stress, demand for liquidity insurance, and consequently the price that market participants are willing to pay for it, escalates. The challenge for the Bank of England, as for all central banks, was to provide liquidity insurance at far larger scale and at minimal cost to the taxpayer, which could only be achieved by ensuring that banks adequately collateralise their borrowings from the central bank.

In response to the financial crisis, the Bank of England developed a set of permanent liquidity insurance tools, specifying for the first time the detailed terms of a suite of facilities to deal with both market-wide and institution-specific liquidity shocks. The most innovative of these is the Bank's Indexed Long Term Repo (ILTR) operations, a monthly auction of Bank reserves for three or six months, which provides the commercial banks with an opportunity to obtain liquidity against collateral **[E3, p.182]**. The ILTR is based on Professor Klemperer's 'product-mix' auction design and was developed in collaboration with him as described in a 2014 REF Impact case study **[E1]**. A key feature of liquidity provision via the ILTR is that it provides regular liquidity insurance to the banking system and adjusts automatically to increases in demand caused by liquidity stress. Since its introduction in 2010, the ILTR has played a central role in the Bank's Sterling Monetary Framework **[E3]**.

The ILTR, along with other reforms to the Sterling Monetary Framework, were the subject of an external review in 2012, and the subsequent report (known as the 'Winters report') encouraged

the Bank to consider whether more could be done to improve the usability and flexibility of its facilities **[E2]**. In this context, Professor Klemperer was invited to redesign the auctions, and the resultant changes to ILTR operations, as implemented in February 2014, are the basis for this continued impact case study. **[E1]**

Improving the Bank of England's Liquidity Insurance Facility: Implementation of Indexed Long-Term Repo Operations (ILTR)

The ILTR is a permanent market-wide facility that until 2014 only accepted a relatively narrow range of collateral. The Winters report also noted that the stigma attached to seeking liquidity and risk of consequent reputational damage led to banks taking the minimum amount of liquidity believed adequate for their needs. These factors, combined with the sub-three month term of ILTRs, led to limited take-up of the facility, which potentially exacerbated liquidity problems in the market **[E2, pp.55-57]**. Banks needing emergency liquidity provision that could not meet the narrow collateral requirements for ILTRs risked having to use the BoE's Extended Collateral Term Repo (ECTR) facility, which it only provided in times of peak stress and at a cost of Bank Rate plus 125 basis points **[E2, p.104]**. The step up, the report observed, between ILTR and ECTR was large, both because of uncertainty around ECTR activation and the potentially large step up in pricing between ILTRs and ECTRs. Klemperer's redesign of the monthly market-wide ILTR auctions, outlined in the Bank of England's 'Developments in the Sterling Monetary Framework' published at the end of 2013 **[E5]**, addressed this problem by effectively amalgamating the functions of the ILTR and the ECTR. The 2014 innovation improved the ILTR design so that it provided '*consistent six-month committed liquidity, at cheaper (auction-determined) rates, and against the full range of eligible SMF collateral*' **[E4]**. In practical terms, this means that the range of collateral was expanded from two to three types from three different risk profiles, categorised as A (high quality liquid sovereign securities, min. bid +0 basis points), B (liquid collateral, including sovereign, supranational, mortgage and corporate bonds, +5bps), or C (less liquid securitisations, own-name securities and portfolios of loans, +15bps) **[E5]**. Additionally, by expanding the accessibility and practical use of ILTRs to encompass use in times of stress stigma attached to accessing emergency liquidity was significantly reduced.

The enhanced flexibility of the improved ILTR enabled it to automatically release extra funds at times of stress. An evaluation of the 2014 reforms, undertaken by the Independent Evaluation Office in 2018, observed that *'the ILTRs use a sophisticated auction mechanism that is designed to react automatically in size and price as stress increases'.* The usefulness of the improved mechanism to the Bank is reflected in its increased usage; rather than being run on a monthly basis, the ILTR auctions were held weekly from June-Sept 2016 (following the Brexit referendum) and from March 2019 (around the initially intended EU withdrawal date), to ensure banks did not suffer from liquidity constraints as they did during the financial crisis **[E6, p.15]**. Limits on the amount the mechanism can allocate were removed by the 2014 redesign; It has allocated up to GBP7,200,000,000 in a single auction, and between its introduction in 2014 and October 2020, approximately GBP150,000,000,000 has been allocated through this mechanism. The design of the ILTR was praised in the evaluation report, which noted that *'As we understand no other central bank has employed such a sophisticated approach'* **[E6, p.15]**.

The Independent Evaluation Office noted that ILTRs offer a *'degree of liquidity to the market at commercially attractive rates in order to limit stigma'* which had had the effect of changing business practice in financial institutions, encouraging *'routine take up among some, including smaller / challenger institutions, some of whom have integrated the facility into their business models'*. [**E6, p.15]**. Bigger financial institutions also increased their usage of this facility '*as banks sought to make use of the liquidity insurance provision on offer by pre-emptively securing term funding ahead of a period of potential uncertainty around key events, such as the UK general election',* whereas previously, according to the Executive Director of Markets at the Bank of England, *'the Bank's liquidity insurance facilities saw relatively modest usage'* **[E7, pp.2-3]**.

'The ILTR is now a core part of the Bank of England's provision of liquidity insurance to commercial banks in the UK, and [Klemperer's] *research and design work ensures the auction*

responds flexibly to market demand and the level and structure of participants' bids' Head of Sterling Money Markets Division, Bank of England **[E1]**.

Improving the BoE Quantitative Easing Toolkit: 2016 Bank of England Corporate Bond Purchase Scheme (CBPS)

Klemperer's research also had impact on another related area of Bank of England operations. In September 2016 the Bank of England launched the CBPS scheme, the purpose of which was to '*impart monetary stimulus by lowering the yields on sterling corporate bonds'* thereby lowering the cost of borrowing for companies and stimulating new issuance of sterling corporate bonds. A portfolio of GBP10,000,000,000 of sterling investment grade bonds representative of *'issuance by firms making a material contribution to the UK economy*' were initially purchased by the Bank in to '*impart broad economic stimulus'* **[E8]**. Klemperer's research **[R3-5]** and subsequent collaboration with the BoE fed into the CBPS design which included some features of the ILTR **[E1]**. The CBPS departed from past asset purchase programmes along a number of key dimensions, including the size of allocations and auction pricing **[E9]**. Unlike the approach used for gilt purchases, the size of each auction was designed to be flexible, adjusting automatically to reflect the quantity and quality of offers received, using the product-mix auction approach, and the auction pricing also followed product-mix pricing **[E9]**. The scheme thus improved the BoE's Quantitative Easing toolkit, reducing the spreads of eligible bonds compared to foreign bonds issued by the same set of firms by up to 14 basis points. **[E10]**.

The Bank used the same CBPS design, based on Klemperer's research, in March 2020, in the onset of difficult market conditions caused by the worldwide Covid-19 outbreak. GBP10,000,000,000 of investment-grade corporate debt was purchased, alongside GBP190,000,000,000 of gilts, *'Had the Bank not stepped in, things would have got very difficult,'* according to the chief executive of the Debt Management Office **[E11]**.

These changes led to efficiency gains in allocation that both the Bank of England and financial institutions benefited from, in allowing financial institutions to submit a broader range of collateral in bidding for UK treasury debt without significantly adding to the administrative or risk burden of the Bank of England.

International Impacts: Banco de Mexico

More recently, Klemperer's research has fed into the approach taken by other central banks. In February 2019 Klemperer met the Governor of the Banco de México and explained his mechanism. Since then, he has been advising Banco de México on its Subasta de Vasos Comunicantes, which also has some similar features to the ILTR. Through Spring 2019 Klemperer worked with the Bank on the revision of the algorithm used to determine price setting, and quantities to allocate, of zero-coupon bonds of different maturities. These revisions were implemented in Spring 2019, and the expectation is that this will reduce the government's debt-financing costs **[E12]**.

Summary

Klemperer's product-mix auction design, from its initial implementation in 2010 and redesign in 2014, has led to the efficient administration and function of the Bank of England's liquidity management of the UK economy and is key to the Bank's Sterling Monetary Framework. Described in 2010 as '*a world first in central banking'* by a then member of the Monetary Policy Committee **[E13]**, Klemperer's model continues to be successfully used to ensure that the UK central Bank can inject liquidity into the economy and so avoid financial crisis of the like witnessed in 2008. The direct beneficiaries are the Bank of England and the banks which use its facilities, but the wider impacts extend to the entire UK economy and beyond, as the purpose is ultimately to provide economic stability.

5. Sources to corroborate the impact (indicative maximum of 10 references)

E1. Email from Head of Sterling Markets Division, Bank of England

E2. Review of the Bank of England's Framework for providing liquidity to the banking system. Report by Bill Winters (October, 2012). https://www.bankofengland.co.uk/-/media/boe/files/news/2012/november/the-banks-framework-for-providing-liquidity-to-the-banking

E3. Frost, T, N. Govier, and T. Horn (2015) 'Innovations in the Bank's provision of liquidity insurance via Indexed Long-Term Repo (ILTR) Operations.' Bank of England Quarterly Bulletin Q2, 181-187 (esp. fn, p 181)

E4. Bank of England – ILTR Market Notice https://www.bankofengland.co.uk/markets/market-notices/2014/indexed-long-term-repo-operations-and-contingent-term-repo-facility-market-notice

E5. Bank of England – Liquidity Insurance at the Bank of England: developments in the Sterling Monetary Framework, October 2013. https://www.bankofengland.co.uk/-/media/boe/files/markets/sterling-monetary-framework/liquidity-insurance-at-the-boe.pdf

E6. Independent Evaluation Office : Evaluation of the Bank of England's approach to providing sterling liquidity (Jan 2018)

E7. Bank of England: Speech the Executive Director of Markets at the Bank of England on the SMF Annual Report at the Money Markets Liaison Committee meeting (July 2015)

E8. Bank of England Press Release re CBPS - https://www.bankofengland.co.uk/-/media/boe/files/news/2016/september/corporate-bond-purchase-scheme-eligibility-and-sectors.pdf?la=en&hash=7CBA04EEDBA2B91B5F2E833008CDB44B5479B1A8

E9. Bank of England Quarterly Bulletin, Q3 2017 (p170 and 172-73)

E10. Bank of England Working Paper no.719: The impact of the Bank of England's Corporate Bond Purchase Scheme on Yield Spreads

E11. The Times (30 April, 2020) – 'Bank of England Rode to government's rescue as gilt markets froze'

E12. Letter from the Director General of Central Banking Operations, Banco de Mexico

E13. Milnes, A (2010), "Creating confidence in cash", Oxford Blueprint, October 2010, p. 14.