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Research Paper

Central counterparty auction design

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ABSTRACT

We analyze the role of auctions in managing the default of a central counterparty's clearing member. We first consider two established sealed-bid auction formats in which clearing members simultaneously submit bids for a defaulting clearing member's portfolio: first price and first price with budget constraints. We argue that the use of some form of penalty could have significant implications for financial stability by inefficiently distributing losses deriving from the unallocated portfolio to surviving clearing members. In response to these potential adverse implications, we propose a third auction type, second price with loss-sharing, which increases the revenue by allowing bidders to consider potential losses within their bidding function without passively waiting for a possible form of penalty.

Keywords: auction; default management; central counterparty; loss distribution; financial stability.

1 INTRODUCTION

Central counterparties (CCPs) are a type of financial market infrastructure that improve the efficiency and stability of financial markets by placing themselves in

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the middle of trades between buyers and sellers as well as between any financial risks associated with the default of either counterparty. By using a CCP, clearing members replace their exposures to multiple counterparties with a single exposure to the CCP.[1] Because of the regulatory reforms following the 2007–8 global financial crisis, mandates have been introduced in major jurisdictions requiring financial institutions to clear new trades in many of the most popular over-the-counter (OTC) derivatives with CCPs. Authorities will continue to assess whether additional standardized OTC derivatives products should be subject to mandatory central clearing, and the Financial Stability Board expects the market share of CCPs to continue to increase in the future (Financial Stability Board 2017).

If one or several clearing members default, the variation margin payments no longer match each other. For this reason, the CCP must return to a matched portfolio as soon as possible. CCPs must ensure that any position taken on with one counterparty is always offset by an opposite position taken on with a second counterparty. Effective management of the default of a clearing member is therefore an important element of a CCP's risk management framework in order to reduce the potential for unmatched variation margin payments arising from the default of a clearing member. After the default, an auction would be necessary to allow the CCP to find one or more clearing members to take on the positions of the defaulted member and thereby restore a matched book. At the same time, the outcome of the auction determines whether any losses generated during the period in which the portfolio was unallocated are covered by the revenue of the auction, whether these losses are covered by the defaulted member's margin (and/or default fund contributions of remaining clearing members) and whether residual losses must be allocated to CCP capital.[2] For this reason, a CCP must devise a sequence of actions to prepare the portfolio for an auction and to get rid of it. This procedure is known as the closeout process and is enforceable by the CCPs. In general, the closeout process is composed of splitting,[3] hedging[4] and auctioning.

[1] "Clearing member" means a member of a CCP who clears and settles derivative trades.

[2] If the auction process is not successful in fully reestablishing a matched book, then alternative measures of forced position allocation may be used.

[3] Splitting is the process through which the original portfolio is segregated into smaller sets. The number of resulting portfolios can be calculated exogenously or endogenously from the closeout process, in accordance with the default management process.

[4] Hedging is the sequence of market operations to reduce risk exposure in an investment. Portfolio hedging typically entails the use of financial derivatives to curtail losses related to noncash portfolios. However, every hedge has a cost, so CCPs should weigh the costs of the hedge against its benefits.

For instance, when Lehman Brothers failed on September 15, 2008, it left behind a US$9 trillion notional portfolio of interest rate swaps and some 66 000 trades with SwapClear, LCH.Clearnet's interest swap clearing service. The priority for LCH.Clearnet was to hedge and auction off the portfolio of its defaulted clearing member in a timely manner by using a first-price auction with a juniorization mechanism,[5] and inviting the nineteen remaining members of SwapClear to participate in the auction. However, in many instances (see CME Group 2016; Eurex Group 2016; ICE Clear Europe 2014; LCH.Clearnet 2016), CCPs do not state clearly the rules of their auctions, leaving the bidders in an unclear setting until the auction materializes. In practice, though, first- or second-price auctions have always been preferred by CCPs (CPMI–IOSCO 2019).[6]

Given the importance of the auction process for default management, a number of CCPs also incentivize competitive bidding by penalizing nondefaulting members who either do not bid or do not bid competitively. The most basic forms of incentivization attempt to encourage submission of bids with the juniorization of default funds for nonbidders. When a juniorization mechanism is in place, if a member's bid falls outside a predefined band, a CCP can juniorize the member's default fund contribution in case the auction revenue is not sufficient to cover the defaulter's losses. This means that the default fund of the juniorized clearing member would be used to mop up any losses after a defaulting firm's resources have been consumed, but before imposing mutualized losses on any other auction participants.[7] More complicated versions also provide for a hierarchy of bids, whereby those unsuccessful bids far from the winning bid (ie, low bidders) are juniorized relative to those of winning bids (CPMI–IOSCO 2014). The level of granularity and sophistication varies between clearing houses and may include the establishment of categories of bidders (as in CME Clearing Europe Limited) whereby the default funds of clearing members in particular categories are used first on a pro-rata basis. Alternatively, the CCP may establish a reverse ladder (eg, ICE Clear Europe), where resources are used sequentially from worst bidder to best. Juniorization of the default fund only acts as an incentive if clearing members have a large default fund at risk of being used. To potentially overcome this shortcoming, Eurex also implements a fine (of up to €5 million) for nonbidders (when the auction disposes of the entire portfolio). When

[5] The juniorization mechanism determines the order in which members' default contributions are consumed in the event that the auction crystallizes losses beyond the defaulter's remaining resources and the CCP's skin in the game.

[6] The design of first- and second-price auctions implicitly assumes that bidders do not consider the losses deriving from a possible penalty deriving from a noncompetitive bidding process.

[7] If losses are large enough, even the highest bidder may incur some losses, since in some circumstances all the resources could be absorbed during the default management process.

part of the auction is unsuccessful, nonbidders assume a liability to dispose of the portfolio of up to €1 billion. These approaches are consistent with the CPMI–IOSCO (2014) guidance on incentivizing participants during auctions.

The aim of this paper is to investigate the revenue outcomes of alternative auction designs and discuss the mechanisms intended to incentivize more competitive bidding. Our study contributes to the literature by extending the analysis on auction theory to the framework of CCPs, examining approaches to limiting losses and introducing more realistic assumptions and circumstances faced by clearing members. The incentives for taking part in an auction are key to its success, and the incentives should be clearly incorporated into any bidding function.

2 MODEL AND RESULTS

It is standard practice in auction theory to evaluate auction formats according to one of two criteria: revenue maximization and efficiency. The former means maximizing the CCP's revenue or, in an alternative but equivalent framework, minimizing the loss generated while the portfolio was unallocated. Efficiency typically means putting the portfolios in the hands of those clearing members who value them the most. In the broader perspective of our regulatory framework, these two aims must be secondary compared with the stability of the financial system as a whole. In what follows, we consider revenue and efficiency more formally, while an intuitive discussion of system stability follows at the end of the section.

2.1 Some results on first-price auctions

Let us assume that every bidder is risk-neutral with an overall valuation (v) composed of a benchmark valuation V_0 and a private signal ε randomly drawn from a uniform distribution F. The auctioneer (ie, the CCP) is selling a single portfolio, which has no intrinsic value to the auctioneer.[8] The only objective for the auctioneer is to try to sell the portfolio at its market value and to cover the portfolio's losses, if possible. Under these assumptions, the most obvious types of first-price auctions are equivalent to the standard first-price auction in both expected revenue and efficiency. For example, if we consider a penalized first-price auction, where all nonwinners pay some proportion of their bid irrespective of winning, we are in a situation where

[8] This assumption is made without loss of generality. If the portfolio has a positive or negative intrinsic value to the auctioneer, and we set this equal to the benchmark valuation, the arguments we present in this paper follow as before. The same relative rankings still hold, but all the figures would shift accordingly.

revenue equivalence holds (Vickrey 1961). This auction rule is very similar to an all-pay auction, with the exception that now only nonwinners pay a portion of their bid. However, the bidder with the highest valuation still wins, and the lowest-value bidder expects zero surplus. Conditional on losing, all bidders in the penalized auction face a strictly negative payoff, and if this happens repeatedly, it may affect the bidder's ability to be a viable participant in future auctions.

A natural extension is to consider auctions where bidders are facing budget constraints. This is a plausible scenario, since bidders may face a shortage of liquidity due to wide market stress scenarios or due to limited access to capital markets. The leverage ratio also adds to the burden, by setting regulatory requirements without taking into consideration the risk related to the portfolio, so even a perfectly hedged book could have a significant cost. Che and Gale (1996) provide an analytical framework to calculate equilibria in these types of auctions, along with revenue and efficiency. Naturally, the revenue is capped by the revenue in the first-price auction without penalty since the surplus for a constrained bidder is slightly higher than in the unconstrained case. Thus, the CCP could receive a lower revenue when the members are budget constrained, and even a penalty or juniorization measure may not be enough to force a clearing member to bid for a portfolio it does not want to own: the risks might outweigh the costs.

2.2 Concerns about penalized auctions

Budget constraints, which are private information, do not preclude a CCP from using a juniorization mechanism to incentivize more competitive bidding to reduce its own losses (CME Group 2016; Eurex Group 2016; ICE Clear Europe 2014; LCH.Clearnet 2016). However, in an extreme scenario, a juniorization mechanism could also increase the probability that the penalized members will not be able to meet their own future obligations, such as future margin calls. The reason is that unexpected outgoing cashflows due to the triggering of a juniorization process are not included in the calculation of the liquidity requirements such as the liquidity coverage ratio.[9]

In the case of an auction managed by a CCP, bidders may face negative externalities deriving from their low level of competitiveness in the bidding process.[10] To the

[9] Under the liquidity coverage ratio requirements, banks must hold an amount of high-quality liquid assets that is enough to fund cash outflows for the next twenty-two working days.

[10] To incentivize more competitive bidding, some auctions also provide for a hierarchy of bids, whereby those unsuccessful bids far from a benchmark are ordered (CPMI–IOSCO 2014) and penalties are applied sequentially from worst bidder to best. Of course, there is no need to resort to this mechanism either when losses are completely absorbed by the defaulter's resources and the auction revenue or when the default fund could be used entirely.

best of our knowledge, the consequences of these externalities on bidding behavior and on revenue have not been previously studied for CCPs.

Under the assumption of a generalized market stress scenario, despite the well-known advantage of a loss-sharing mechanism to maintain the functionality of the financial infrastructure as a whole, we argue that a penalty mechanism can negatively impact surviving clearing members that are already under stress and thus unable to bid competitively because of budget constraints. For instance, Raykov (2016) showed that additional cash calls, such as additional default fund refurbishments, within a recovery plan may undermine the CCP's ability to collect funds after a stress event, potentially threatening both its recovery and its post-recovery viability. Raykov demonstrated how exposures to a CCP's loss allocation may affect participant welfare and incentives to trade in centrally cleared instruments.

A fundamental difference between an auction type with penalty and without penalty is the risk that a penalty may add an unexpected stress to the balance sheet of a surviving clearing member. In addition, a penalty can increase the risk that members may not be able to meet margin calls, default fund additional margin (DFAM)[11] and default fund replenishment.[12] Raykov (2016) quantified, and generally confirmed, the intuitive argument put forward by Singh (2015) that losses should be shared to the fullest extent possible. However, Raykov also identified an important special situation where institutions do not have the right incentives to share losses fully, creating a trade-off between loss-sharing and risk-taking activities such as trading.

It should also be considered that, since the default of a generic large financial institution will likely trigger the default management process in several CCPs at the same time, clearing members are likely to prioritize some clearing houses and some portfolios in order to reduce the impact of potential penalties (Sourbes 2015). However, an important question is whether members have the resources – and the risk-taking capacity – to participate in those multiple auctions.

In a period of generalized stress, the use of a penalty can potentially contribute to a number of serious consequences such as exposing participants to an unexpected liquidity stress, particularly when they do not consider this within their bidding function. Therefore, it is questionable whether the use of a penalty mechanism or

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[11] Currently, a DFAM may be called in the event that any member's uncovered loss values breach the default fund amount.

[12] To compare these variables, we assume that the supplementary contributions that members have to make in order to replenish their default fund contribution must be paid within a few business days. Alternatively, they would be required to add an even higher margin to compensate for the lack of prefunded resources.

an unclear set of rules defining the auction format actually facilitates the correct functioning of the market infrastructures.

2.3 The loss-sharing auction

In response to the potential adverse implications coming from a penalty or juniorization mechanism, we propose a novel modified version of the second-price auction that has a loss-sharing mechanism in which a CCP shares a portion of its losses with bidders and allocates the losses among the surviving members with the following payoffs:

$$u_i = \begin{cases} v_i - \max\limits_{j \neq i} b_j & \text{if } b_i > \max\limits_{j \neq i} b_j, \\ -\dfrac{(\psi - V_0)P}{N_\psi} & \text{if } b_i < \max\limits_{j \neq i} b_j,\ b_i < \psi, \\ 0 & \text{if } b_i < \max\limits_{j \neq i} b_j,\ b_i > \psi, \end{cases}$$

where the loss-sharing threshold is denoted by ψ, with N_ψ being the number of members whose bid is less than or equal to ψ.[13] In this situation, bidders have a more clear incentive to bid competitively in order to decrease the possibility of triggering a situation in which a loss-sharing mechanism must be used.[14] This setting has the advantage of including the potential losses within the bidding process, allowing a more realistic framework. This dynamic is a direct consequence of this paper's main finding, which is presented in the following theorem.

THEOREM 2.1 *Revenue from the loss-sharing auction is at least as high as in a standard second-price auction.*

PROOF In the loss-sharing auction, the revenue equivalence theorem no longer holds, since the lowest-value bidder expects a negative payoff. To establish the revenue ranking, we discuss the bidding incentives faced by bidders at different portions of the value distribution, for different realizations of individual values.

First, we look at the case where all bidders have values above ψ. This is equivalent to a standard second-price auction, where truth-telling is an equilibrium strategy. As

[13] It will require a portion P from $V_0 - \psi$ of the CCP's losses to all clearing members whose bid is below ψ, where $\psi < V_0$. Proportion P depends on the specific characteristics of the portfolio in the auction as well as the maximum loss that can be absorbed by the capital contribution of the CCP. Since the optimal bidding function is not obtained, finding the optimal level of P is beyond the scope of this paper.

[14] We also consider the case in which the CCP absorbs part of the loss using its capital contribution (ie, skin in the game). The skin in the game is in reality quite small compared with the size of the portfolio in the auction. Adding the capital contribution of a CCP to the bidders' bidding process would affect the bidders uniformly, and the results would be qualitatively similar.

a result, in the case when all bidders have values above ψ, the loss-sharing auction will be revenue-equivalent to a standard second-price auction.

Next, we consider whether a bidder with a value above ψ would ever bid under value, more generally. Since their value is above ψ, they will not pay a penalty if they bid their value, but they might if they reduce their bid below ψ. Conditional on not reducing the bid below ψ, the standard truth-telling argument for the second-price auction still holds. Thus, all bidders with values above ψ bid truthfully.

Finally, we consider a situation in which at least one bidder has a value below ψ. Would they ever bid below value? Since the value is already below ψ, if they bid even lower they still incur the penalty, but reduce their chance of winning. Is there an incentive to bid higher than value? For any continuous distribution that satisfies the assumptions specified in our paper, there will be a value close enough to ψ where it is worthwhile to bid ψ exactly and avoid the penalty. This gives a further incentive to bid (strictly) above our value. We can thus conclude that in any case it is never optimal for a bidder to bid below their value, and it may be optimal to bid strictly more if their value is below, but close to, ψ.

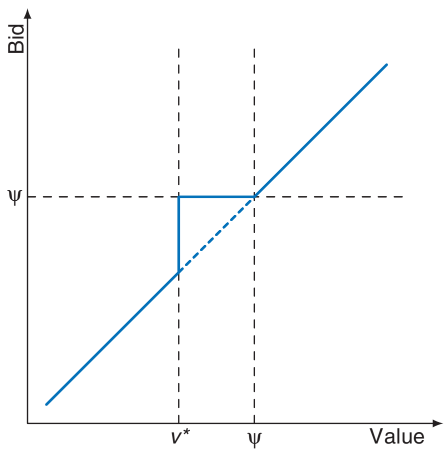
Thus, looking case by case, the loss-sharing auction induces bidding at least as competitive as the standard second-price auction, and for a value of ψ greater than zero it will induce strictly higher bids in at least some cases. Since the cases above are jointly exhaustive, we can conclude that the revenue from the loss-sharing auction will be higher than from the second-price auction (and also, by the revenue equivalence theorem, higher than in the first-price auction types). □

It may seem obvious that the loss-sharing auction is revenue-superior due to the imposition of punishments on low-value bidders, forcing them to participate in auctions where they can make ex post losses. Yet this alone is not what is driving the results. For example, in a standard all-pay auction, which is revenue-equivalent to a second-price auction, ex post, all bidders except the winner will make a negative profit. In a loss-sharing auction, it is only the bidders below the threshold who make a loss. Yet the loss-sharing auction is revenue-dominant over a second-price (and therefore also the all-pay) auction in our setting.

If bidders decide to participate in the auction before fully evaluating the portfolio to be auctioned off, it is the ex ante expected profit that matters, rather than just the payment after the auction. Indeed, in all standard auctions, in our setting, the ex ante expected profit is positive.

In practice, then, selecting parameters P and ψ in such a way as to increase revenue while still giving bidders ex ante positive profits is a task that the auctioneer must undertake. It is possible that the loss-sharing auction gives bidders ex ante profits that are lower than in a second-price auction but nonetheless above zero.

FIGURE 1 The shape of an optimal bidding function in the loss-sharing auction (not to scale).



The revenue result above does not depend on a particular functional form for the value distribution function; it is not restricted to the uniform distribution. Though we have no closed-form characterization of the optimal bidding function, qualitatively, it will look like that in Figure 1, with an upward step at some value $v^* < \psi$. At this point, the bidder is precisely indifferent between bidding above their value, potentially winning at a price ψ but not paying a penalty, and bidding their value and paying a penalty. We note that this equilibrium bidding function may not be unique. Where precisely the step will occur will be dependent on the bidders' value distribution, and we will attempt to locate this in future research.

THEOREM 2.2 *Assume that the bidders' valuations are independent and identically distributed with an overall value following the uniform distribution, and assume that the bidders are risk neutral. Then bidding one's valuation when it is greater than or equal to ψ is an equilibrium strategy if $F(\psi)^N \leqslant P$.*

PROOF If the clearing member has a valuation greater than ψ and bids its own valuation v, the situation is similar to the case of the standard second-price auction (Vickrey 1961). We now consider a clearing member with $v < \psi$. Its expected utility of bidding ψ is

$$P\frac{V_0 - \psi}{N} + \frac{F(\psi)^N}{N}(v - \psi) > 0, \tag{2.1}$$

while the expected utility of bidding below ψ is equal to zero. Then, the clearing member cannot do better by bidding more than ψ. □

As usual, the winner is the participant with the highest valuation, where the expectation of the highest value among N independent draws from a standard uniform distribution is $v_{(N)} = N/(N+1)$. Then, according to (2.1), the expected bid submitted by the winning bidder is

$$E[b(v_{(N)})] = N(1-F(\psi))F^{N-1}(\psi)\psi + E[Y^{(2)} \mid \psi \leqslant Y^{(2)}] + F^{(N)}(\psi)\psi, \quad (2.2)$$

where $Y^{(2)}$ is the random variable representing the second highest bid.

The revenue from the auction is then the sum of the payment made by the winning bidder and the fees collected from bidders who bid less than ψ. The estimated payment from one bidder is

$$\begin{aligned} E[b_i] &= \frac{F^N(\psi)}{N}\psi + (1-F(\psi))F^{N-1}(\psi)\psi \\ &\quad + \int_0^{\psi}\biggl(\int_x^{\bar{v}} f v \,\mathrm{d}v\biggr)(N-1)xf(x)F^{N-2}(x)\,\mathrm{d}x \\ &= \frac{F^N(\psi)}{N}\psi + (1-F(\psi))F^{N-1}(\psi)\psi \\ &\quad + \int_0^{\psi} x(1-F(x))f_1^{(2)}(x)\,\mathrm{d}x, \end{aligned}$$

where $f_1^{(2)}$ represents the probability distribution representing other bidders' highest bid.

Then, the revenue from the CCPs' point of view becomes

$$e_2 = F^N(\psi)\psi + N(1-F(\psi))F^{N-1}(\psi)\psi + \int_0^{\psi} Nx(1-F(x))f_1^{(2)}(x)\,\mathrm{d}x.$$

Though the revenue expressions may look straightforward, calculating them explicitly is complicated. Some of the integrals are taken with respect to order statistics of optimal bids (not just bidders' values), and these are no longer uniformly distributed.[15] We have included these expressions in case the reader is interested in using them as part of a broader model for simulation or numerical optimization of CCP auctions. Such an analysis is beyond the scope of this paper.

Improved revenue in the loss-sharing auction comes with two other consequences. First, the auction outcome may be ex post inefficient: if a few of the highest-value

[15] For example, if bidders' values are uniformly distributed, but optimal bidding functions feature a step, as described in Figure 1, the distribution of bids for a single bidder will no longer be uniform. Further, the distribution of "the highest bid out of N bids" will also not be uniform.

bidders pool to bid at ψ, there is no guarantee that the highest-value bidder wins. Second, the lowest-value bidder now earns negative expected profit; in the context of a single auction, this would break the lowest type's participation constraint if signal values (the value of the portfolio for that participant) were known prior to making the decision to join the auction (the value of the portfolio for that participant is known prior to deciding to join the auction).[16] In a repeated game setting, where participants' values are drawn independently across auctions, this may not be a major concern, but the explicit analysis of such a game is left for later.

However, the potential losses coming from the portfolio are now considered within the bidding function and bidders are not passively waiting for a possible penalty.

3 CONCLUSIONS

This study provides a theoretical framework for investigating the auction of a defaulted clearing member's portfolio. We argue that a good default management process should be able to preempt scenarios in which the penalty threatens the likelihood that surviving clearing members will be able to meet their obligations, exposing them to an unexpected liquidity stress. We thus propose a second-price with loss-sharing auction, which is explicitly motivated by the goal of getting a higher liquidation value without creating more financial stress for the surviving members while considering the losses generated by the unallocated portfolio.

Given the stylized nature of the model, further work is needed to explore how widely our findings can be generalized. Possible extensions for future work include enriching the representation of agents' budget constraints, studying how sensitive our results are to assumptions such as risk neutrality and calibrating model parameters to real-world observations to better establish the economic relevance of the results.

DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper. Any views expressed are solely those of the authors and cannot be taken to represent those of the Bank of England or any other institution with which the authors may be affiliated or associated. This paper should therefore not be reported as representing the views of the Bank of England or members of the Monetary Policy Committee, Financial Policy Committee or Prudential Regulation Committee.

[16] If participation decisions are made ex ante, that is, before each bidder learns their signal value, each bidder may, on average, still find it profitable to join the auction (with respect to the full distribution of possible values of the portfolio), even if in some cases they make losses after the auction.

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