R3 Reports

Implementing Derivatives Clearing on Distributed Ledger Technology Platforms

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Implementing Derivatives Clearing on Distributed Ledger Technology Platforms

Colin Platt, Peter Csoka, Massimo Morini

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Abstract

Clearing houses and central clearing counterparties (CCPs) play a pivotal role in managing collateral and counterparty risk, in increasing standardization and transparency of financial markets, and in the credit enhancement process for clearing banks. Further, CCPs in cleared and listed derivatives markets provide a well-functioning facility to reduce settlement risk, ensure that a default by one or more large counterparties can be managed, and enable market operations to continue with minimal disruptions. The importance of CCPs has increased with the raft of regulatory reforms following the 2008-2009 financial crisis.

Yet, recent regulatory opinions by IOSCO, Basel Committee, ISDA and the Financial Stability Forum have called for higher certainty, predictability, and more granular standards for CCP risk management. Distributed ledger technology (DLT) can be an opportunity for CCP's to improve their management standards. DLT can also be leveraged to provide a platform where CCPs, clearing members and qualified investors all interact with each other. Relative to traditional technologies, DLT allows for greater transparency and resilience, facilitates operational and capital cost improvements, and could lead to systemic risk reductions. To fully leverage these DLT networks, CCPs and their clients should use common DLT platforms in order to lower costs, simplify account management, and achieve more certainty with the movement of collateral and cash payments.

1 History and context

1.1 The history and reasons for central clearing

Central counterparties, or clearing houses, have existed in the financial markets since the late 19th century. Some of the first instances of clearing houses were the *caisses de liquidation* and *Liquidationskasses* at coffee and grain exchanges in Europe.[1] At exchanges across Paris, Amsterdam, London, Milan, Lisbon and elsewhere, buyers secured the price they paid for goods such as coffee. The goods would be delivered months later by sellers from plantations thousands of miles away.

On occasion, a trader expecting to receive coffee would turn up at the port on the pre-agreed date to find that the party that had sold the coffee no longer existed, or the ship had sunk during the voyage. At other times, the coffee would arrive, but the buyer was no longer financially able to pay for the goods or decided not to honour the original agreement. In both cases, the other party was left facing potentially crushing losses.

In response, clearing houses were established by the exchanges to mitigate the risk of default of either or both of these counterparties. These clearing houses asked both counterparties to post a partial payment to guarantee part of potential losses in the event they did not deliver. These clearing houses separated the trade into two parts, becoming the legal buyer of the coffee from the seller, and the legal seller of the coffee to the buyer in a process that we now refer to as 'novation.' As a result, the buyers and sellers only faced a risk from the clearing house.

[1] Platt, C (2016), Central Counterparties CCPs in Decentralised Blockchains. LinkedIn Blog. `https://www.linkedin.com/pulse/central-counterparties-ccps-decentralised-blockchains-colin-platt`.

Further advances came in a new system at the Chicago Board of Trade (CBOT) that decreased the risk that the clearing house held to any counterparty. The clearing houses created a list of members that had been approved to use their services and required that these members open their books for inspection if any other member suspected that the member had an above average risk of defaulting. Those who refused inspection were denied use of the clearing house. Clearing houses in Chicago also introduced a second form of guarantee: during the life of the contract (between the time that the trade is initially agreed until the expiry and/or delivery of the goods or payment), the clearing house could request that a counterparty make payments up to that date through variation margins. Variation margins proved valuable in reducing the default losses by keeping margins in line with the exposure to default risk that changes over time due to market volatility.

In the late 20th century, exchanges and regulators decided that the movement of non-derivative securities transactions would also benefit from the clearing house system. One party selling bonds or shares to another could also use a clearing house to ensure that the asset and payment were exchanged in a similar novation process. Unlike the earlier derivatives clearing, there was only a very short period in which the counterparties were exposed to each other's risk: the relatively short time needed to settle the securities and cash from one counterparty to the other after agreeing to the trade. This shorter period of risk, however, did not make the mitigation of that risk for these types of trades any less important. As volumes of traded securities increased, and execution latency decreased, the risk of failing to deliver against the promised trade could create a knock-on effect with the potential to destabilise the entire market.

1.2 The modern need for clearing

Despite massive advancements in technology and risk management techniques, modern clearing houses, or central clearing counterparties (CCPs), operate in a fundamentally similar way to the clearing houses of the last 200 years. Buyers and sellers meet in either a marketplace, such as a regulated trading venue (exchange), multilateral trading facility (MTF), other organized trading facility (OTF), or they meet through informal means, like with over-the-counter (OTC) transactions. After the price discovery, execution and matching processes, the CCP offers counterparties credit enhancement services through trade novation, allowing each counterparty to replace the credit risk of the other with that of the CCP. The CCP takes collateral to help absorb potential losses in case of any counterparty credit event.

The resiliency of central clearing through the 2008-2009 Financial Crisis was acknowledged by governments and regulators in major economies around the world, leading to new regulation that aims to ensure that all derivative contracts that can be centrally cleared are centrally cleared. At the Pittsburgh Summit in September 2009, the G20 Leaders Statement stated the following:

"Improving over-the-counter derivatives markets: All standardized OTC derivative contracts should be traded on exchanges or electronic trading platforms, where appropriate, and cleared through central counterparties by end-2012 at the latest. OTC derivative contracts should be reported to trade repositories. Non-centrally cleared contracts should be subject to higher capital requirements. We ask the FSB and its relevant members to assess regular implementation and whether it is sufficient to improve transparency in the derivatives markets, mitigate systemic risk, and protect against market abuse."

Though the Pittsburgh Summit marked a positive step towards an improved market structure, clearing does not have a perfect track record. The year 2017 marks the 30th anniversary of the last major - and perhaps most dramatic - example of the collapse of a CCP with the October 1987 bail-out of the Hong Kong Futures Exchange and Hong Kong Futures Guarantee Corporation. The 11.1% fall in the spot price of HSI on 19 October 1987 led to a four-day closure of the Hong Kong Stock Exchange and the Hong Kong Futures Exchange (HKFE). The Davison Report, which ultimately led to the creation of the Hong Kong Securities and Futures Commission (SFC), described the situation:

As the [Hong Kong Futures Exchange] HKFE could not resume trading without some reinstatement of the guarantee, the Secretary for Monetary Affairs held a meeting in the morning of 21

October with the Chairman of the [Hong Kong Futures Guarantee Corporation] FGC and representatives of the major futures brokers to consider the matter. At the meeting, the brokers stressed the gravity of the situation and pointed out that, of the approximately 40,000 outstanding HSI futures contracts, a very large number of the short positions were held by arbitrageurs and hedgers, who were mainly overseas institutional clients. The arbitrageurs' and hedgers' short positions were held against physical stock holdings, estimated to be in the region of between $5 billion to $6 billion. The brokers added that, if the futures markets collapsed or if any attempt was made to "ring out" contracts at an arbitrary price, these people would be forced to liquidate their physical holdings. This would create a massive downward pressure on the market and cause major economic disruptions and serious damage to Hong Kong's reputation as an international financial centre.

To resolve the problem, the brokers proposed a $2 billion capital injection into the FGC, comprising $1 billion from the Government, $0.5 billion from the shareholders of the FGC and $0.5 billion from the major futures brokers. This would cover a 1,000 points' fall in the HSI. The proposal was, however, rejected by the Government as it believed that the FGC should be recapitalised by its shareholders and that the holders of short positions should reach a voluntary agreement not to dump stocks.

While the failure of HKFE and FGC was disruptive to the normal functioning of the market, requiring a bailout equivalent to 0.25% of Hong Kong's GDP that year, the HKFE and FGC were extremely small compared with the size of today's exchanges and CCPs. The HKFE handled a turnover of $15.2 billion in September 1987 on HSI futures, the CME handled $312 billion on S&P 500 futures, and the LIFFE handled $4.8 billion on FTSE 100 futures.

November 2016 figures on those same contracts (including "e-minis" where applicable) measured approximately $400 billion, $4,200 billion and $160 billion respectively. In addition to the growth of the equity index derivatives market, new interest rate, credit, and commodity products have moved to CCPs, further increasing the total risk managed by CCPs globally into more than 500 trillion USD in outstanding notional.[2]

A collapse akin to that experienced in Hong Kong in 1987 in one of the larger CCPs would certainly have disastrous implications today for the global financial markets and the wider economy, which could require central bank intervention that could dwarf the actions taken during the 2008-2009 financial crisis.

Fortunately, the risk management of many of the larger CCPs was better than FGC in 1987 and has only further improved over time, involving continuous evaluation of their default management processes (DMPs) and pre-funded assets. The greater systemic importance of these institutions has attracted additional scrutiny from regulators including the implementation of stress tests in some jurisdictions.

1.3 Risk management waterfall

Before fully diving in, it is worth looking at the basic tools that a CCP keeps at its disposal: access to funds in the event that a counterparty fails to meet its obligations.

CCPs have each adopted a set of standards to help manage risks and absorb loss through a combination of pre-funded and unfunded assets provided by members in addition to their own capital. These provisions typically come in the form of high quality liquid collateral assets, and are tranched to absorb loss in the event of a member default as follows:

- **Variation Margin** - Realised mark-to-market (MtM) of positions charged or credited to a clearing member
- **Initial Margin** - Pre-funded collateral assets posted to the CCP, intended to cover any losses incurred by the CCP whilst unwinding the positions of a defaulting member under 'normal market conditions'
- **Default Fund Contribution (Funded)** - Pre-funded collateral assets posted to the CCP acting as a reserve insurance which can mutualise the loss of a defaulting member

[2] Bank for International Settlements (2016). Semi-annual OTC derivative survey. `http://www.bis.org/statistics/d5_1.pdf`.

- **Default Fund Contribution (Unfunded)** - Pledges provided by CCP clearing members to provide further funds if required
- **CCP Capital** - Equity buffer provided by shareholders of the CCP

2 Challenges in modern clearing

2.1 Collateral cost

While most market participants find increased clearing brings a number of benefits, they find that collateral requirements can at times cause liquidity problems. Before the 2008-2009 financial crisis with uncleared derivatives, the posting of collateral took the form that counterparties mutually agreed upon.

The advent of a higher proportion of outstanding collateral being cleared has meant that more collateral is calculated according to a rule established by CCPs, with a narrower definition of eligible collateral. Furthermore, eligible collateral is generally charged a larger haircut than would be required by a counterparty in a bilateral trade. The result is more capital put aside as collateral, and at a higher cost and lower remuneration.

Studies, such as Ghamini and Glasserman (2016), have found that, in spite of an increase of regulatory collateral requirements for uncleared contracts, meant to favour clearing, today's issues such as netting, margin period of risk and guarantee funds can still make uncleared derivatives more attractive.[3]

2.2 Reliance on accurate reporting

Though central clearing can create a number of operational efficiencies by giving a counterparty a single entity to work with, traditional reconciliation processes still create potentially serious operational risks. One such example occurred in November 2016 when a large clearing house reported inflated open interest numbers, as reported by a large derivatives clearing member, due to a computer glitch.[4] This error occurred during a period of heightened market volatility surrounding the 2016 US Presidential election and OPEC discussions.

After this discovery, the open interest was revised downwards by roughly $16 billion of notional value. While the initial overstatement in itself could have affected trading decisions for those using volume numbers, these inaccurate figures also led to faulty collateral and capital calculations required for a clearing member and their clients.

2.3 Multiple CCPs for clearing members

Many large clearing members transact globally across many clearing venues for a number of reasons: privacy (to ensure no CCP can see their entire portfolio), regulatory reasons (such as the location of their counterparty), CCP risk diversification, and arbitrage on CCP costs. While a CCP may have a complete view of a party for business conducted within their own venue, they do not have visibility of positions held at another CCP or for those that are not cleared at all. The counterparty is left at a suboptimal risk position.

Therefore, for a portfolio which clears their derivatives positions across a number of CCPs, the view that each CCP holds of that particular portfolio is a) incomplete, and b) inefficient. Take the example of a portfolio holding long US Index Futures in a US CCP, and long UK Index Futures in a UK CCP. From the point of view of an individual CCP, the siloed view of this portfolio takes no account of the positively correlated position held in the UK CCP.

As a result, if the counterparty becomes stressed because of a loss in the UK position, there is an invisible risk that will have a direct effect on the counterparty risk at the US CCPs. Should the loss in the UK be correlated with a loss in the US position, this increased risk of default of that

[3] Ghamami, Samim and Glasserman, Paul, Does OTC Derivatives Reform Incentivize Central Clearing? (July 26, 2016). OFR WP 16-07; Columbia Business School Research Paper No. 16-59. Available at: `https://www.financialresearch.gov/working-papers/files/OFRwp-2016-07_Does-OTC-Derivatives%20-Reform-Incentivize-Central-Clearing.pdf`.

[4] Canny W., Detrixhe J. SocGen Computer Glitch Said to Ripple Through Bond Derivatives. Bloomberg.(20 December 2016). `https://www.bloomberg.com/news/articles/2016-12-20/socgen-computer-glitch-said-to-ripple-through-bond-derivatives`.

counterparty will translate directly to a greater risk borne by the US CCP whilst limiting their ability to react by increasing the required pre-funded collateral posted by the counterparty at the US CCP.

A second, "market neutral" portfolio which holds a long position at the US CCP and a notionally equal and opposite position at the UK CCP has a potentially beneficial effect for the US CCP which remains invisible. Assuming that the correlation between the UK and US underlyings holds constant, the UK leg of the portfolio becomes profitable, decreasing the counterparty risk of the portfolio.

The loss then sustained on the US leg of the portfolio is easily met through the profits from the UK position. The US CCP, having no view of the UK position, bears less risk to this portfolio; however, it may increase the collateral required from that portfolio. Whilst the total position remains relatively stable from the point of view of the portfolio, the cost of funding the position increases due to the increased prefunding requirement from the US CCP.

For a real life example, we look at the results of this second portfolio from the CME CORE Margin Calculator™. We use a portfolio that holds two positions, 100 Long S&P 500™ Index E-Mini June 2017 Futures (ES), and 128 Short FTSE 100™ Index E-Mini June 2017 Futures (FT1). This portfolio represents $\tilde{}$\$11.38mn notional on both the long and the short position [calculated as: Notional=USD_Rate(Index Level * Tick Size)].

The requirement for the outright ES leg required the clearing member post \$475,000, whilst the short FT1 leg required an additional \$384,000. Looked at independently, a portfolio holding these positions requires \$859,000 to be posted as margin. Looked at together, this portfolio would require a margin of \$549,400 as calculated by CME CORE, a reduction of 36% when compared to the outright positions.

Using the existing model, without the ability to cross these positions, the portfolio would have to opt to trade both positions at the same venue. Unfortunately, this strategy creates a new risk for the portfolio, as liquidity for positions is generally concentrated at one venue (e.g., ICE Europe LIFFE for FTSE 100 Futures, and CME for S&P 500 Futures). This effect also exists to a greater or lesser extent for other asset classes outside of equity indices.

The research carried out by Prof. Darrel Duffie of Stanford University, consultant to the Fed and Basel Committee, has often pointed out the trade-off inherent in the CCP business model: the maximum risk reduction and collateral efficiency can be obtained only with one single Global CCP; otherwise examples can be shown where multiple CCPs can be used to fragment a portfolio in such a way that risk and collateral are even increased compared to a situation without a CCP.[5] On the other hand, one CCP would create a strong concentration of operational risk.

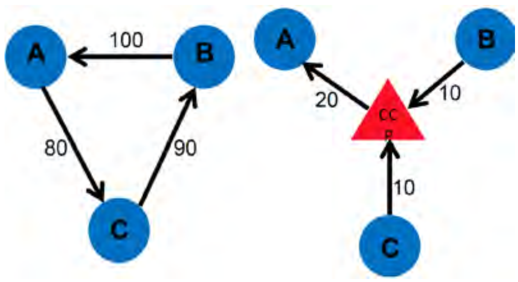

Figure 1: Duffie 2015, presentation to Basel Committee

2.4 Multiple clearing members for investor clients

Much like the position of clearing members with their CCPs, some large investors use the services of multiple clearing members for confidentiality, business relations, arbitrage and counterparty risk management. This practice means that investors do not give their various clearing members a full view of their collective risks, leaving those clearing members either over or under collateralised.

[5] http://www.darrellduffie.com/uploads/policy/DuffieTooImportantToFail2013.pdf, and http://www.darrellduffie.com/uploads/working/DuffieCCP-ResolutionDec2014.pdf.

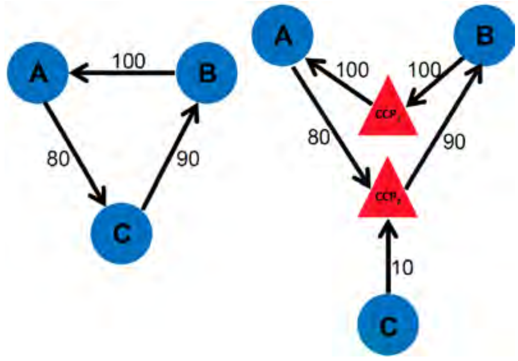

Figure 2: Duffie 2015, presentation to Basel Committee

Beyond the risk this poses to the clearing member by their investor clients, this practice also creates a frustration where limits are set by a clearing house on an investor's risk that is spread across multiple clearing members.

An individual clearing member may handle an amount of risk on behalf of a client, and be within their risk limit with a venue, while that client may work with another clearing member at that same venue. Should the joint portfolio of the investor exceed the allocated risk, one of the clearing members must decline the trade, which may create complications in their commercial relations.

3 Opportunity for clearing to benefit from distributed ledger technology

3.1 Defining distributed ledger technology (DLT)

The future DLT environment can be evaluated independently from a specific vendor or protocol, which could be R3's Corda platform, IBM's Fabric contribution to the Hyperledger Project, permissioned Ethereum platforms or a variety of other suitable technologies.

For the purposes of this paper, the solutions discussed are assumed to be built on a permissioned distributed ledger, on which a formal mechanism exists to 'onboard' accounts that can be fixed to an identifiable legal entity. In a permissionless public ledger, this effect could be pursued by the use of multisignature wallets, requiring the signature of an entity in charge of identity verification. Permissioned platforms may allow methods to obscure the identity of the account's owner, such as hierarchical deterministic account structures. Other confidentiality solutions such as only sending information to relevant parties, like the "need to know" point-to-point mechanism in Corda's distributed multi-channel ledger (DMCL) model could also be employed.[6]

Our model assumes that the DLT environment is able to execute code which creates, modifies and alters transactions. To facilitate the integrity of the contracts and mutual recognition of their workflows, these contracts should be available to users in their raw format (i.e., source code), and verifiable for consistency at the time of execution. The verification could take multiple forms, such as Ethereum's and IBM Fabric's related smart contracts (valid at time of writing under v0.6) where executable code can be held in the validation layer rendering it part of the ledger. For some financial products, updating the ledger requires the use of specialized mathematical computations. When the ledger programming environment does not provide appropriate libraries or sufficient computational efficiency, the computation can be delegated to external computation centers, potentially in the cloud, as long as methods of trusted computing and a secure communication with the smart contract is guaranteed.[7]

Executable codes could also exist at the application layer. Prior to executing contracts, parties can confirm validity by passing hashes of the executable code to each other. This method, used

[6]Platt, Colin (February 2017). Thoughts on the taxonomy of blockchains & distributed ledger technologies. `https://medium.com/@colin_/thoughts-on-the-taxonomy-of-blockchains-distributed-ledger-technologies-ecad1c819e28`.

[7]Morini, Massimo (April 2016). Journal of Financial Transformation, From Blockchain Hype to a Real Business Case for Financial Markets. `https://papers.ssrn.com/sol3/Papers.cfm?abstract_id=2760184`.

in Corda's model, requires that additional parties, while not currently a party to the contract, be included in the transaction on a "need to know" basis.

The executable code body implemented by the DLT environment forms the backbone for the economic agreements of the derivative contracts, the role of counterparties (client and FCM) and oracles (CCPs), as well as the workflow for margining and default management procedures. This executable code takes the form of a Ricardian Contract, whereby a legal contract is produced and linked to the DLT system for accounting and processing purposes.[8]

These contracts are made robust through use of identification by a cryptographic hash function, and rendered transparent through the use of human readable text for legal prose. Further, they are made efficient through markup language to extract essential information which can be processed either on-ledger or by external processes that in turn update the ledger.

In order to ensure that the transactions executed within the DLT environment have legal finality aligning with the timelines of the DLT environment, users are able to hold fixed or semi-fixed value instruments (e.g., cash or collateral) to post to meet liabilities arising from trading within the DLT environment. These assets should otherwise conform to eligible collateral status at CCPs.

The completion of a transfer of such instruments from one party to the next should fulfill the legal obligation of settlement finality as recognised by the relevant jurisdiction. This will normally, but not always, require registration or recognition by an appropriately registered payments system (PS) and/or securities settlement system (SSS). It should be noted that while these instruments need not be the sole representation of value, they should allow conversion by the bearer into the underlying instrument.

3.2 Better CCP risk management

One of the key benefits of an appropriately configured DLT environment is the ability for a sufficiently permissioned party to gain visibility into the economic agreements held between entities, both in the present and the future. Though this functionality is often used to describe the benefits to regulators in establishing "regulatory nodes" for the business model proposed in this document, the most relevant possibility here is the creation of networks where the CCPs haven nodes with access to trade information. By including the executable code within a "god-view", risk can be tracked and estimated across a portfolio including simulations of future cash flows. Specifically, CCPs could see positions that represent all "mechanics" and characteristics of final product, rather than simply "title" of ownership. This would increase dramatically the simulation capabilities of the CCP. If, additionally, an agreement includes its revaluation logic, in the form of computer code or of a secure reference to some external computer code, the CCP can easily run directly this smart code, increasing dramatically its real-time simulation capability.

For a CCP, this visibility of all dependencies, whether they are within their own books or at another CCP, would allow them the ability to form a more accurate base upon which to estimate the risk and the level of pre-funded assets required. Should a portfolio have offsetting positions held across the silos of separate entities, it may be able to reduce the amount of margin required to hold against the sum of those positions.

3.3 Better regulator data

Beyond the obvious benefits for a CCP, or clearing member who can be given greater visibility of house and client positions, easier access creates a trove of near real-time information for financial regulators and central banks. Such a data set, which includes not only positions, but like-for-like comparables of machine code controlling cash flows, can be used to create highly refined risk models and stress-tests for the entire cleared market. This could allow not only better estimations of future short falls, but potential areas where risk capital could be removed and reinvested creating a strong incentive to share this data with regulators. The capability to re-value cleared portfolios in real-time, while also applying to them stressed market representation, is crucial for risk management today.[9]

[8] Grigg, Ian (2004), "The Ricardian Contract", Systemics Inc., `http://iang.org/papers/ricardian_contract.html`.

[9] Morini, Massimo. Understanding and Managing Model Risk: A Practical Guide for Quants, Traders and Validators, `http://eu.wiley.com/WileyCDA/WileyTitle/productCd-0470977612.html`.

3.4 Provable sources of pre-funded assets

Peer-to-peer payments, which themselves are a core feature of many DLT systems, offer a more streamlined and efficient payment for variation margin, as well as other payments and even collateral movements between counterparties. This feature could be extended from the current clearing member to clearing member payment model to facilitate a direct clearing member/direct funding member clearing model, allowing an end client to pass payments to counterparties. A more complete DLT-based environment including a majority of an entity's assets and obligations on a ledger would likely allow a more complete breadth of assets which could be used as payments and collateral. Further, DLT would allow the ability to calculate sophisticated risk models around a counterparty if one was granted sufficient access to this data.

Beyond simply posting collateral on a DLT-based escrow, or moving collateral assets seamlessly and frictionlessly around the globe, complex arrangements could allow an increased opportunity to offer collateral conversion services. The ability to transfer assets digitally and seamlessly across borders and jurisdictions will almost certainly give rise to the demand for this service. As collateral becomes more available on a global basis, clients will have the need to ensure that collateral received meets the collateral acceptance criteria at multiple venues.

As clearing becomes more decentralised and works across different jurisdictions, counterparties will increasingly find themselves in a position of receiving profit in one currency and needing to pay for losses in another. This increased global connectivity will require new solutions that transform eligible collateral in one currency for eligible collateral in another through this system without the need to exit the DLT environment, which would incur additional costs and delays. This necessity could work in the favour of institutions which currently handle these, or similar functions, using traditional - non-DLT - technologies, but will require new investments and agile business models to avoid losing this advantage to new entrants, or smaller and more nimble competitors from today's world.

3.5 Information passing to authorised users

An important technology choice is whether to universally diffuse data to all DLT environment members (a permissioned blockchain such as IBM's Fabric v0.6 contribution to Hyperledger) or selectively share with relevant parties (Corda).

Each architectural choice has its merits and complications. Though it could be facilitated by the selective sharing model, by creating dynamic groups or secondary information sharing to other relevant parties, the universal diffusion method allows an interested party to analyse not only the current position of an entity's on-ledger assets and liabilities, but also if they are included in future obligations (e.g., loans) and contingent obligations (e.g., derivatives, and structured instruments).

However, broad data diffusion often does not account for privacy conventions and regulations for financial institutions, and is a legacy technical characteristic from public blockchains. Therefore, under this model, and given the sensitive nature of such information, it is likely that executable contract code pertaining to the future liabilities of an entity would be protected from other ledger participants and only shared on a permissioned basis. This encryption of data and contracts is a feature of some ledger protocols and is likely to gain further traction with permissioned and permissionless distributed ledgers.

Within the realm of derivatives clearing, we see the need for counterparties to see their own position and that of their counterparty (for shared trades only), as well as that of service providers to these contracts including a CCP. With this technology, including elaborate smart contracts like those developed using Corda, a trade could be cleared through a CCP without severing the link between the two original counterparties. A number of intermediate options between bilateral trading and full clearing can be much more easily implemented, both in terms of obligations of the parties and in terms of trade visibility. Should these trades act as a direct clearing trade, where a non-clearing member is the economic owner of the position and is "supported" by a clearing member, it is likely that the clearing member would have the same view as the counterparty on this trade.

3.6 Introduction of uncleared position tracking

Should a large proportion of clearing members' cleared derivatives positions move to a DLT environment, uncleared derivatives may also follow suit. This would allow them to benefit from services provided by DLT members and solutions providers without giving the CCP ultimate credit risk on a position. Such an approach could function similar to that of LCH's SwapsAgent.[10] As we mentioned, interesting intermediate services can be designed for uncleared trades, where some of the benefits of clearing can be matched with the special requirement of bilateral trades, such as the need of bespoke margin models. Different smart contracts can incorporate different logics for different bilateral portfolios, while all being maintained by the same CCP.[11]

In addition to benefiting from using DLT as a single venue, counterparties could also, for a fee, rely on calculation and settlement functions from the CCP. Should the CCP allow, these positions could also be netted against a cleared portfolio, following appropriate rules capturing the difference between cleared and uncleared positions.

3.7 A functioning central clearing counterparty without the central counterparty

Of the advantages that DLT provides, the ability to bilaterally transact with other counterparties within the network offers a useful opportunity, but one which requires a significant rethinking of existing processes and business models when approached from the lense of derivatives clearing.

Enshrined in most derivatives clearing rules and regulations around the world is the need to introduce legal protections which offer credit enhancement through novation to counterparties.[12] In addition to the credit enhancement that this offers to both counterparties, the novation process offers the CCP an important benefit in giving uniformity to receipt confirmations and variation margins payment distribution. Often the only visibility that a counterparty has made a variation margin payment to another counterparty is through reporting from both counterparties. This requires both counterparties to be aware of where the funds are to be sent and received.

Moving to a DLT-based transaction environment offers a significant benefit in this case whereby the counterparties are able to send and receive payments bilaterally. If constructed correctly, they may be able to avoid the need to identify themselves to their counterparty yet still confirm that the appropriate payment amount was made to a CCP. In the event that funds were not made as expected, the counterparty is able to take recourse on the contract, either making the payment themselves to the counterparty in credit or by requesting that another party fulfill the payment obligation of the debtor counterparty.

At scale this process can incorporate a portfolio of contracts which allows a single counterparty to manage a number of payments to multiple contracts as requested by a CCP to multiple counterparties. Payments due can furthermore be rerouted to compensate other contracts at the CCP, allowing for effective netting of payments.

The bilateral model allows non-clearing members the ability to affect their own variation margins payments, something that would be difficult to do in the existing system without a significant infrastructure investment at these firms. The DLT environment potentially alleviates the need for much of this investment by allowing parties to send, receive and custody funds on their own.

Even with this novel, and more direct transaction model, non-clearing members will likely not want to undergo the ongoing expense and burden of being a full fledged clearing model, and will in turn rely on existing clearing members to act as their 'sponsors'. These clearing members would act as the first line of defense in the event of a default, maintaining funds in the default fund, and other default management processes at the CCP. The model effectively then becomes something more in line with CME's direct funding party (DFP) model or Eurex's ISA Direct, where non-clearing members can rely on a global clearing member to provide assurance to the CCPs.

3.8 Implications for the market

Obviously the reworking of the clearing framework from one where counterparties log a portfolio of trades against their CCP and make payments on a net basis to one where each contract is

[10] `http://www.lch.com/lch-swapagent`.

[11] Morini, Massimo, Morini, Massimo (April 2017), From Blockchain Hype to a Real Business Case for Financial Markets, One year later. Forthcoming.

[12] Including CPSS-IOSCO PFMI, CFTC 17 CFR Part 39.27, EMIR Article 4.

independently accounted for and identifiable requires additional technology and process improvements. As each contract becomes an entity within the DLT in its own right, with counterparties and a governing CCP, initial margin processes can be logged at a very granular level against that contract. Two levels of smart contracts can be designed, one for the individual product obligations and another for the management of netting and margins at the appropriate portfolio level.

This would mean that to service these contracts, CCPs would assign a risk not only to the portfolio in its totality but to each individual contract. With this additional complication, there are still significant advantages to be had, as the CCP no longer functions as a pure counterparty, and they could more easily enter into agreements with other CCPs to treat portfolios holistically. This, in effect, opens the door to inter-CCP margining.

4 CCP risk management

4.1 CCP market exposure to derivatives contract

CCPs seek to operate a balanced book, meaning that for every buyer they have an equal and opposite position. This means that theoretically they cancel their market risk and are only exposed to the counterparty risks of each participant. Whilst this view of a balanced book removing all market risk from the CCP is true in theory, the practical operations of clearing positions is less clear-cut.

Take the example of a single futures position between a long and short counterparty, and cleared by a CCP. At the point of execution, the value of the contract is zero, as neither the short nor the long owes money to the other. Over the course of the day, the market may move resulting in a positive value (credit to the long) or negative value (credit to the short). A request is then sent by the CCP on a regular (usually daily) basis to the debtor counterparty to post variation margin to the CCP, which is in turn credited to the other counterparty. Once the successful payment is settled in the CCP's account they return to a flat position with (temporarily) no risk to the previously debtor counterparty.

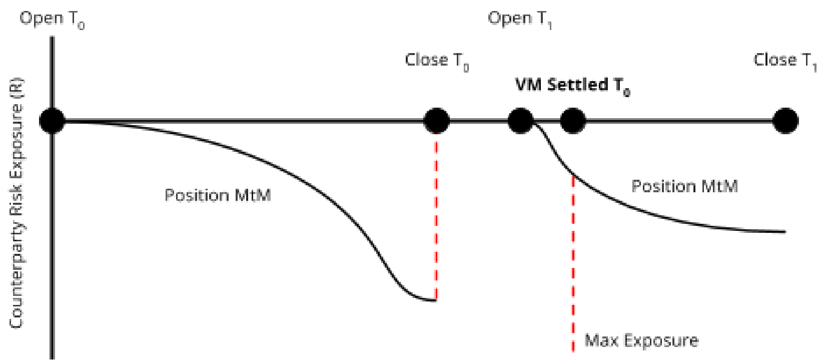

Figure 3: Counterparty Risk Exposure

At any point the current counterparty exposure taken by a CCP on a single position with a counterparty risk exposure (member view) can be represented as:

$$R = max(0; MtM_{T} - MtM_{T\text{-}1} + UVM).$$

MtM is the value of the position from the point of view of the counterparty (long or short) at time T (when assessed by the CCP), and time T-1 (the value taken for margin calculation purposes at the previous close), and UVM is unsettled margin calls, or monies due which have not yet been received in the counterparty's account.

CCPs seek to mitigate the counterparty risk exposure by holding initial margins (IM) from both counterparties. These are normally calculated using the maximum expected loss or Value-At-Risk over a given time frame at a given confidence interval (e.g., 99%).

The liquidation period required to close a position or portfolio is also called a margin period of risk (MPOR) and generally ranges from one to ten days depending on the asset class and jurisdiction. For a position with \$100, daily volatility of 1%, 10-day MPOR, and 99% confidence

to cover default losses, assuming a normal distribution of returns, (i.e. 2.33σ) a Value-At-Risk based Initial Margin could be defined as:

$$IM = \$100 * 2.33 * (1\% * SQRT(10)) = \$7.37.$$

The result for the risk of a single position from the point of view of a CCP at any given point in time is therefore E = IM - R.

Should a realised loss result in R becoming sufficiently large such that E is negative, the CCP is able to call upon its other resources, including the pre-funded default contributions of the defaulting member, CCP capital (shareholder equity), pre-funded default contributions of non-defaulting members, and unfunded commitments of non-defaulting members, in that order.

All of these processes obviously rely on a key assumption, the ability for a CCP or clearing member acting on their behalf to liquidate outstanding positions of a defaulting member, both neutralising the possibility of further losses and sourcing cash or collateral to make the other party whole. CCPs frequently employ forced auctions whereby clearing members have to bid on portfolios of positions of defaulting members.

By grouping multiple positions at different CCPs together in a portfolio rather than auctioning each position off independently the CCP can potentially minimise the sum loss of all of the positions in the portfolio. This single process allows CCPs to view portfolios more holistically, reducing initial margin contributions to reflect the counterparty risk of an entire portfolio rather than the sum of all positions.

4.2 Portfolio margin & cross-asset margin offsetting in conventional clearing

To calculate the risk of a given portfolio held by a clearing member at a CCP, asset classes are normally siloed into buckets and the risks of the positions within that silo are netted to produce a resulting risk assessment. This process can create situations where a member holding an offsetting position in another asset class with the same CCP is requested to hold a greater amount of capital than if the positions were taken holistically. Historically this was less of an issue given that fewer product types were centrally cleared, with many large CCPs focussed primarily on a single listed asset class traded on an exchange (e.g., US broad-based equity indices, or a single class of cleared OTC derivatives, such as Interest Rate Swaps or Credit Default Swaps).

In the current environment where capital is a costly asset for many clearing members, and CCPs handle a wider array of underlying assets, both listed and OTC, new measures have been introduced to allow a CCP to look at this risk from a higher-level, and assess a correlation of risk between portfolios of different types of assets (liquidation groups). One such method is Eurex Clearing's Prisma risk system.

4.3 Separation of DLT and conventional clearing portfolios

Given the assumption of cross-CCP margining which exists in the DLT environment, and which is not allowed in the current CCP existing approach to clearing, margin calculations for the different approaches should be isolated and evaluated independently.

As an example, a clearing holding a position in the non-DLT based CCP which is globally long a risk, could not offset that risk in the DLT based environment either with that CCP or another. Any attempt to net positions in both environments will leave the CCP with either too little or too much collateral (depending on the portfolio) to satisfy their internal margin models.

5 Processes best suited off-ledger

5.1 Execution/price discovery

In a world where the speed of latency is measured in milliseconds, we don't see that execution and price discovery of derivatives would opt to move to a distributed ledger, even in the highest throughput distributed ledger environments. Even in the relatively slow world of request for quote (RFQ) execution, distributed ledgers are unlikely to be more suitable than existing technology and methods. An exception, which is relevant in the context of this paper, is when prices depend on standardized models, like the case of interest rate swaps (IRS) cleared with a given CCP. In this

case smart contracts can include the valuation mechanism, with appropriate technological solutions potentially that trigger trusted external computation. Such a solution would make the ledger a natural place for discovering and executing deals.

5.2 Order management/matching

The CCP and exchange play important roles in maintaining anonymity between counterparties. Beyond the obvious importance that this confidentiality adds in terms of preventing trading positions and strategy from becoming known to the wider market, this function allows for the fungibility of contracts.

Given the nature of even the more private implementations of DLT environments, including Corda, this fungibility becomes extremely difficult to manage. As a result, we believe that it is important that matching processes, like price discovery and execution, remain off-ledger processes which happen within the confines of traditional technologies. Following the matching process however, the results may be ready to relay to the DLT environment, allowing counterparties to manage the post-trade processes through expiry.[13]

5.3 Risk calculations

While the entire process for calculating risk could be handled on a shared system, moving these processes onto such a shared system would require recreating the many calculations of all non-deterministic elements at each node of the DLT implementation. A better solution is a mixed model where the DLT has a secured connection with an external calculation agent, that can be an FMI or an automated service that passes only necessary proofs into the DLT environment.[14]

Risk calculations are a function that CCPs have performed effectively and consistently in the markets at scale. In a new environment we believe that these entities could be candidates to increase this function, acting as oracles for the DLT, provided that no new conflicts arise that might call their impartiality into question. Alternatively, a new class of entity may arise to perform these valuation and calculation functions which are able to demonstrate the validity of their processes and pass the end results into the shared ledger for shared processing.

5.4 Leverage and repurchase agreements (Repo)

As long as there are unfunded positions there will be counterparties in need of funding, and as long as these positions require the delivery of securities and collateral these markets will need repurchase agreements. Whilst DLT offers numerous potential opportunities to dramatically shift the structure of these markets, the arrangement and pricing of these functions, like that of the derivative product itself, will likely live off-ledger.

That said, moving the location of these assets to a new, flatter data structure with a potential direct line of sight onto those assets could allow for an entirely new and potentially more efficient structure. The structure would allow for something more akin to the model of hourly car rental, sourcing assets at the owner level for defined periods of time and shifting them as needed with ensured return at a fixed time and minimal risk of failure. This topic, however, is best covered in another analysis.

5.5 Pre-funded assets (excluding initial margin)

While the notion of a transparent and provable default fund held on-ledger, visible to all participants, is an interesting concept that could potentially improve the confidence of counterparties, we think that the likelihood of its happening is small in the foreseeable future.

In the event that pre-funded default funds are wholly visible to members and potentially non-members, there is a conflict if these assets are needed to make other parties whole in the event of a clearer default. Assuming that a larger member were to enter administration whilst suffering a loss on their positions, the rest of the market may mark down the value of their own holdings, creating further pressure and a cascade effect on the default fund.

[13] See page 28 of Corda technical whitepaper. https://docs.corda.net/_static/corda-technical-whitepaper.pdf.

[14] Morini, Massimo (April 2017), From Blockchain Hype to a Real Business Case for Financial Markets, One year later. Forthcoming.

By moving these assets outside of the ledger they remain within the discretion of the CCP to manage according to their rulebook. In the event that these funds are needed to compensate a counterparty following the default of a member, these funds can be released either through traditional channels or through a DLT environment.

5.6 Default management process

In order to ensure a smooth management of a member default, CCPs should be able to judge market conditions and handle the more delicate aspects of liquidating a portfolio outside of the DLT environment. This will also reduce the probability of other actors on the DLT network positioning ahead of a liquidation. These processes include the forced auction process and management of the defaulting member's default fund contribution in relation to the wind-down of the portfolio.

6 Processes best suited on-ledger

6.1 Contract settlement

After the matching process, which joins the buyer and seller of a contract, the processes related to settling the contract with each party becomes a natural fit for a DLT. The creation of a contract by the CCP allows each party to recognise and affirm its transaction.

This can be done either by the clearing member or potentially by an eligible non-clearing member with sufficient access to the DLT environment. Settling these contracts with DLT allows for easy access and analytics in near real time for the counterparty and any intermediaries, allowing more effective risk management whilst reducing errors.

6.2 Payments (variation margin)

The peer-to-peer nature of DLT allows for a much more efficient chain of transactions between counterparties when compared with the traditional method. Using the existing method, a long counterparty to a trade that needs to make a variation margin payment to compensate for losses must use collateral (usually cash) held by their custodian.

In the event that both their custodian is not their clearing member, and they are not a clearing member themselves, the variation margin must be paid to a clearing member. The clearing member then posts the payment to the CCP. In practice, the clearing member will make this payment to the CCP, in some jurisdictions through a protected payments system (PPS) within an hour, in turn debiting their client's account.

As these variation margin payments represent a real gain on the other side of the trade these two transactions will be mirrored on the short end of the trade with the CCP releasing margin to the clearing member, who in turn hands it off to the custodian of the short counterparty. Should the contract be held in such a way with DLT, the long counterparty can be instructed how much needs to be paid to meet the variation margin payment and where to send that payment.

Their successful initiation of the transaction can then be recognised by the clearing member on both sides of the transaction, the CCP and the short counterparty. This more direct process alleviates the need for the clearing members to process the payment unless a payment is not made, potentially relieving them of a significant source of their cost base.

6.3 Escrow (initial margin)

Accounts-based DLT (including Ethereum and Fabric) frequently allow for the creation of "on-chain" entities. These entities become accounts with permissions in their own right, controlled by codified rules according to their design. UTXO models (such as Corda) may include multi-signature accounts which can in practice mimic this entity functionality by a processes that happens adjacent to the chain, giving authorisation of an account to release funds when certain criteria are met (e.g. two of three keys are presented).

In both instances these accounts, which accept deposits but only allow funds to be removed under specified conditions, effectively act as escrow accounts that can be created quickly and cheaply. Collateral to secure derivatives positions therefore are a very natural fit for these constructs, allowing counterparties to hold their initial margin in accounts which can only be released if certain

criteria are met (e.g. a change in risk position resulting in lower need for initial margin, successful expiry of a trade, or a default resulting in initial margin being used to compensate another counterparty).

6.4 Default administration (winding down and transferring contracts)

As the contracts settle on the common ledger it therefore makes sense that, in the event that a counterparty is unable to meet their obligations, those contracts should be swept up in line with the rulebooks of the CCP. This is not to say that these processes should happen automatically without the discretionary elements provided by a CCP. Rather, it ensures that once these processes are triggered by the CCP, counterparties know how a process will execute. This is in line with ISDA observations on more clarity and determinism in the recovery and resolution process.

This includes the transfer of contracts to other counterparties or the CCP themselves, the removal of IM from escrow and the liquidation of contracts which in turn reduces the open interest.

Whilst this logic can also be held off-ledger in the "application layer", by including these processes third-party entities with sufficient authorisation to see the trades can be assured that these processes will execute as promised. This assurance allows them to more effectively enter into agreements which may allow a portfolio split across CCPs to reduce the amount of IM needed to secure that portfolio, without needing to resort to CCP interoperability of direct risk-taking between CCPs.

6.5 Decentralized clearing and multilateral netting

Payments could also be decreased if there is a possibility for bilateral netting. Consider a situation in which counterparty A needs to make a variation margin payment of \$300,000 to counterparty B due to a futures portfolio, whereas counterparty B needs to make a variation margin payment of \$200,000 to counterparty A due to an interest-rate swap agreement. Assume counterparty A currently has \$10,000 on its account and B has \$0 on its account.

DLT would enable this transfer of \$10,000 to B, who in turn would send it back. The process iterates until A has \$90,000 as a remaining margin requirement and B has no further margin requirement. Thus, only \$90,000 in extra payments are required by A compared to the situation without bilateral netting where A would pay \$290,000 and B would pay \$200,000. The same iterations process works for multilateral clearing as well. If, for instance, A has to pay \$100,000 to B, B has to pay \$100,000 to C and C has to pay \$100,000 to A and again only A has \$10,000 on its account, then at the end of a similar process no payments are required. Csóka and Herings (2017) call such a process a decentralized clearing process and show that, under some conditions, it terminates in finite steps in a situation which is essentially the same as solving the clearing problem centrally.[15] The important conditions are that there is a unit of account (like cents) and that if a counterparty has to pay to multiple parties, in each iteration the payment rules (being proportional or having some priority structure) should be kept.

To see the importance of the payment rules, consider a default situation in which A must pay \$300,000 both to B and C, and B has to pay \$300,000 to A. Assume that A only has \$100,000 on its account and defaults, and B has \$300,000. Using bilateral netting the liabilities between A and B are cancelled (technically both A and B pay \$300,000 to each other) and A pays \$100,000 to C. However, if there is no bilateral netting and B and C have the same seniority for A (that is, A should pay them proportionally), then we can solve the clearing problem centrally and get that B pays \$300,000 to A and from the total of \$400,000 A pays \$200,000 to both B and C. Thus using the proportional payment rules compared to bilateral netting, A pays \$100,000 more to C and \$100,000 less to B.

You can reach a centralized solution in a decentralized way by selecting A and B in any order and having them pay any in accordance with their payment rules. For instance, using proportional payments rules first select A to pay from its account of \$100,000 proportionally, that is \$50,000 to both B and C. Then, select B to pay only \$200,000 (say, the more liquid part of it current balance of \$350,000) to A. In the next round A has \$200,000, and again distributes it proportionally between B and C, paying \$100,000 extra to both. Then B pays the remaining \$100,000 liability to A, who in turn again pays proportionally between B and C, paying \$50,000 to both. Now that there are no payment possibilities, the procedure stops and declares A bankrupt (whereas B has paid all

[15] Csóka, P., Herings P.J.J. (2017), Decentralized clearing in financial networks. Management Science, forthcoming.

of its liabilities). Note that in each step, only information related to one trader is required: it is enough to know the current level of margin account, total liabilities and payments made so far.

6.6 Cross-jurisdictional default considerations

After reaching a centralized or decentralized clearing solution within a CCP, defaulted counterparties can be treated at higher levels by asking for additional funds. First, collaborating CCPs in the same jurisdiction should be considered (e.g., CCP1 in US vs CCP2 in US). The collaborating CCP could release margin to the other CCP instead of to the counterparty (who in turn has lower margin requirements in general). Moreover, CCPs from other jurisdictions could also collaborate (e.g., CCP1 in US vs CCP3 in Germany).

7 Business and strategic considerations

7.1 The CCP's role

We currently see the role for a CCP in two main areas, a) operating a DLT environment, and b) acting as a service provider to a DLT environment.

As in traditional non-DLT based environments, CCPs create technical infrastructure that allows for the standardization of terms, uniform payments and escrow. These functions need to be implemented in a DLT environment, where the CCP could initiate the service and distribute its maintenance amongst members.

Secondly, beyond creating the platform on which functions are performed, the CCP can create business solutions which migrate their existing functions, including standardised contracts, risk mitigation through margining and valuation, in addition to a more efficient and transparent technological framework. These functions may also include the holding of pre-funded assets outside the DLT environment (i.e. default funds held at a central bank or commercial bank). Though they rely on the underlying environment, these functions are distinct and are the domain of the regulated CCP which must be licensed by the relevant regulator.

The separation of the lower level functions and the value added business services is similar to the structure of many internet-based companies when compared to bricks-and-mortar business. The internet companies create an internet application but are not responsible for running the internet, unlike the bricks-and-mortar companies which must own or lease and operate their premises and perform core business functions.

7.2 Consortia & inter-CCP collaboration

Given the nature of DLT networks to operate between competing entities, and the advantages which could be made to clearing service users from a logically connected network, the major advantages for clients only become greater as the size of the network increases, not only in terms of additional clearing members but also with greater access to a multitude of clearing venues. The recognition of risks and the ability to offset these risks with positions managed by other CCPs therefore necessitates an approach that facilitates cross industry participation. This structure also offers a more robust underlying legal structure that further bolsters the attractiveness of the DLT offer in the event of a default by one entity, as existing portfolios and risk positions can be moved to other clearing entities. Currently, without the use of a DLT environment this would be a complicated and unpredictable endeavor.

7.3 Interoperability

Amongst the more contentious points in the clearing world is interoperability. In short, interoperability is the ability for one counterparty to hold a position for a trade in one CCP, and the other to hold the other leg of the trade in another CCP. In order to maintain a balanced book the two CCPs need to face each other. There are logistical complexities of this arrangement, including ensuring that the two CCPs are using the same form of contract, and that trade details are sent to both.

Interoperability requires that the two CCPs take on each other as a counterparty. In the event that their member defaults, the CCP must make a payment to the other CCP. This creates more

complex challenges whereby the two CCPs may require that pre-funded assets are held by the other CCP. They might also require greater insight into the creditworthiness of the other CCP's clearing member.

Outside of a few small niches where these details have been worked out, interoperability has not been viewed favourably by many participants, particularly within derivatives clearing. Within our model we have thus favoured orienting contracts between counterparties and creating a situation where only positive proceeds may be passed between counterparties. This eliminates the need for CCPs to directly face each other.

7.4 Need for mutually recognisable standards

As with proposed interoperability arrangements, contracts must be compatible between venues. This can happen at multiple levels, both in the economic terms of the contract and in the legal documentation that encapsulates those products. Our model thus considers that any cross-CCP margining takes place in a regime where the contracts have the same underlying terms and only vary in their specific trade details (e.g., underlying, expiration, counterparties, CCP venue, currency, eligible collateral). All other terms must be negotiated and agreed between all participating clearers.

7.5 Common auction processes & PnL transfer

Key to the ability of any clearing function is the ability to neutralise risk when a counterparty defaults, and to liquidate gains and losses into cash. Within our DLT-based environment this requires that all losses which fall into the normal (non-extreme) loss scenarios (only requiring VM and IM liquidation) can be liquidated simultaneously within a common and agreed time-frame. Further, the environment must be used to satisfy claims on behalf of the creditors of the defaulting party, first within each CCP, followed by claims held at other CCPs. This can first of all make the process more deterministic, fast and transparent at the level of a single CCP, and secondly introduce the same risk-netting logic across CCPs.

7.6 Alignment with open access

Under MIFID II & EMIR regulations, which are being phased in across Europe, CCPs and exchanges are required to offer non-discriminatory access to trading and clearing venues. This has been labelled "open access" and means, once fully applied, that a product traded in any relevant venue can be cleared at any venue. This changes from the previous model, under which many trading and clearing venues were linked, meaning that clearing would have to be done at the preferred clearinghouse of a trading venue.

While this opening up of siloes has drawn a lot of praise and criticism on all sides, much of the impact has yet to be felt. The implementation of a more seamless DLT-based environment could catalyse the usage of open access provisions with Europe, creating an environment where participants can more easily move positions from one clearing venue to the next, due in large part to the common network, and shared contract terms. This, in turn, may have transformative effects on the clearing business model, creating an environment where CCPs have to compete to offer value additive services to clearing members.

7.7 Adoption of DLT and DLT-based products

Given the numerous benefits outlined, we see a strong case to be made for the adoption of DLT-based clearing products. These benefits go beyond the directly identifiable and could bolster a wider adoption of DLT environments and products for other financial markets businesses which fall outside direct clearing applications.

This said, the development of the technology and its adoption will not happen overnight. Derivatives clearing, which leverages multiple Financial Markets Infrastrucures, could be among the earlier successes of DLTs and could further foster the wider adoption of DLT for a variety of other applications by improving their economic viability.

8 Conclusion

The use of distributed ledger technology could offer credible improvements to the functioning and operations of the cleared derivatives market. These improvements include operational enhancements, the streamlining of cash and collateral movements (between clearing members and their clients, between a CCP and its clearing members, and between independent CCPs), lower capital requirements for clearing members and investors, better regulatory oversight, and the improvement of financial markets infrastructure resiliency. Rather than acting as a disintermediating force, DLT highlights the need for good counterparty and market risk management practices as well as the imperative for robust resolution and recovery in the event of extreme loss or clearing member default. Furthermore, many processes and services offered by financial markets infrastructures and organised exchanges will require the involvement of a central party or functions that operate outside of a "pure DLT" process, like with legal settlement, maintenance of guarantee funds, and regulatory assurances. The introduction of DLT based platforms should focus on maximizing participation from financial markets infrastructure, clearing members and end investors to create a holistic structure which is best positioned to manage derivatives market and counterparty risk. When paired with cross jurisdictional default rules, these networks could create efficiencies that would otherwise be possible only through mutual interoperability agreements or clearing through a single monopoly CCP, but without creating counterparty risks between CCPs or requiring the complete centralisation of CCP services.

The design and topography of DLT network governance should also be a keen area of focus, as it creates a medium for services which are under direct regulatory purview of financial markets infrastructures. A network designed to function as an interbank platform may not meet regulatory scrutiny, and thus not allow participants to fully benefit from the potential of such an offer. It is the right moment for CCPs and regulators to integrate a technology that increases compatibility amongst venues, improves transparency and reduces uncertainty and risk, whereby avoiding that this technology is used to mirror some functions of regulated finance in a non-regulated environment.

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