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Towards effective post-trade clearing and settlement: The role of Distributed Ledger Technology

Research question: How can Distributed Ledger Technology effectivise post-trade clearing and settlement, and what regulatory challenges arise?

Supervisor: Christian Fieseler

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Abstract

The use of blockchain in finance has caught everyone's eye in the recent years. Blockchain is a form of distributed ledger technology (DLT), most famous for being the underlying technology of Bitcoin and Ethereum. Now that the dust has somewhat settled around these infamous cryptocurrencies, new use cases for DLT has started to emerge.

One of them being the use of DLT to increase efficiency in the complex world of post-trade clearing and settlement of securities. This paper aims to analyze how DLT can best address the inefficiencies in the industry, as well as determine challenges, both technological and regulatory, that appear along the way.

DLT is a highly secure digital database that distributes identical ledgers to all participants in a network. The technology is attractive to the post-trade industry because it can eliminate the costly and risky reconciliation of databases amongst intermediaries, enable a flexible settlement cycle, and provide transparency to ensure regulatory compliance. The use of a private, permissioned and hierarchical DLT system would allow central authorities to keep their governing role. However, decentralization of transaction validation could increase efficiency even in a private environment.

The current system for post-trade clearing and settlement is highly centralized. This is great from a financial stability perspective, but makes the system less efficient than it could be. Regulatory challenges tied to DLT are partly addressed in a new regulation form the EU, which grants exemptions from certain regulatory requirements. The new regulation also enables the creation of a new role in the industry, which merges the trading and post-trading processes.

Industry incumbents like central counterparties perform hugely beneficial tasks such as netting and risk management. If widespread adoption of DLT is to be achieved, the technology has to prove reliable enough to ensure financial stability, in addition to bringing efficiency.

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Introduction

Background

In recent years, the use of blockchain technology has taken the financial world by storm. At a conference in 2016, Matthew Bishop of The Economist presented the panelists with three possible scenarios for the future of this technology in finance (CoinDesk, 2016, September 30).

The first scenario is a revolution of financial markets towards a decentralized system that will radically change the economy. The second scenario is that incumbents in financial markets realize the looming danger of disintermediation. They will therefore decide to implement closed blockchain technology systems to reap the rewards of increased efficiency whilst still keeping the high level of centralization we have today. Bishop also mentions that this second scenario could potentially put a stop to the open-blockchain revolution altogether. The third scenario Bishop brings to light is that blockchain technology could turn out to be severely over hyped, and disappear into the history books after only a short while (CoinDesk, 2016, September 30).

When presented with these three scenarios, Brad Peterson of Nasdaq responded that the third one could be discarded immediately (CoinDesk, 2016, September 30). Chris Church of Digital Asset replied that even though there is indeed much more hype to this technology than what is justified, there are also significant benefits to blockchain (CoinDesk, 2016, September 30). Now, almost six years later, the future of blockchain (which is a form of distributed ledger technology) in finance is still uncertain, though we seem to have moved away from Bishop's third scenario.

Distributed ledger technology (DLT) can be used in many areas of finance. This paper will not examine the future roles of infamous cryptocurrencies like Bitcoin or Ethereum, but rather explore if and how DLT could effectivise the post-trade processes of financial trading. To understand why this particular use case of

DLT could be interesting, we must first look at how the post-trade processes of financial trades work today.

The trade life cycle

The life cycle of a trade can be divided into three phases: execution, clearing and settlement. The execution of a trade happens when a buyer and a seller enter into an agreement to trade with each other on a specific price and volume. However, in today's system, the buyer and seller themselves don't actually negotiate the terms with each other. In fact, they don't even have to find each other or even know who it is they're trading with. Generally speaking, they simply specify which financial instrument they would like to buy or sell, their desired volume and price, and post this request to their broker (Massachusetts Institute of Technology, 2020, January 23). The broker will then be in charge of finding the appropriate counterparty, and the trade is hereby executed (Massachusetts Institute of Technology, 2020, January 23).

After the trade is executed, the life cycle can move on to its next phase, clearing. At this stage, the broker will have matched the buyer with a seller and will then forward the instruction to a central counterparty (CCP) (Priem, 2020, p. 9). The CCP will make sure both counterparties in the transaction have the appropriate funds to complete the trade. If one side defaults on their commitment, the CCP will take on the role of the defaulting party and complete the trade (Priem, 2020, p. 9). This severely reduces counterparty default risk for the investors and therefore could remove a significant entrance barrier into trading for many participants. Depending on the specific financial security and market, the clearing of trades will normally take several business days to reach completion. The trade then moves on to settlement, the final stage of the trade life cycle.

Settlement of a financial trade occurs when the security legally changes ownership. After a CCP has cleared the trade, a central securities depository (CSD) is in charge of recording the change in ownership. A CSD is the final custodian of the securities and keeps track of current owners (Massachusetts Institute of Technology, 2020, January 23).

Pain points in the current system

The current system for securities clearing and settlement settles a vast number of trades each day, and is the result of many years of globalization, digitization and thorough regulation. However, there are still areas that could be made more efficient, as market participants are always looking for ways to minimize risk and costs.

One of the weaknesses of the current system for securities trading is that it requires many intermediaries (Priem, 2020, p. 10). For instance, an buyer needs to go through a broker who then needs to go through a CCP and a CSD who will in turn interact with the CCP and CSD for the broker representing the seller. Banks and market venues are also involved. This many "links in the chain" contributes to heightened costs and risk in a number of areas.

One of these areas is the often cumbersome task of reconciliation. All market participants involved in securities trading will have to reconcile their databases against each other to make sure they have recorded the same information. Fixing any mistakes requires manual intervention which exposes the system to a great deal of operational risk (Priem, 2020, p. 10). The high number of intermediaries also leads to a longer than necessary settlement cycle, and the siloed structure of the current system makes it vulnerable to cyber-attacks (DTCC, 2016; DTCC, 2021). The question arises of whether the current system may be due for an update.

The concept of distributed ledger technology

There is more to DLT than digital pictures of apes being sold for millions of dollars, or life savings being lost betting on the newest digital coin. Underneath all the hype lies a fascinating technology that may well represent the next big shift in financial markets.

Explained in simple terms, DLT allows for a digital ledger of immutable records to be distributed amongst all network participants. This is radically different from the situation today, where each intermediary keeps their own ledger which they constantly have to reconcile against others. Consensus models are utilized to ensure that the ledger only contains valid information, and a DLT system can be public, i.e., completely open for anyone to join, or private, i.e., only accessible to specific participants.

DLT presents exciting opportunities to mitigate operational risk as well as cutting costs in the post-trade landscape. The reconciliation processes could be eliminated, financial data could be stored more securely, and financial transactions could be processed more efficiently. Some even argue that DLT could reduce the need for CCPs and CSDs (Priem, 2020, p. 14).

However, even though DLT might be able to mitigate certain risks and costs related to securities clearing and settlement, new risks are emerging. It is important to look beyond the hype and realize that the technology is still in its infancy. Uncertainty exists both related to technological and regulatory aspects of DLT, and its implementation would constitute somewhat of a revolutionary change to today's financial markets. The question is, are we ready for it?

Research question

This brings me to my research question:
How can Distributed Ledger Technology effectivise post-trade securities clearing and settlement, and what regulatory challenges arise?

This technology certainly holds a lot of promise, but can the benefits outweigh the challenges? How would this technology be regulated, does it fit into existing legislation or would new regulations have to be created? What kind of DLT system would be best suited for this use case, and is the market ready for a change?

Knowledge gaps

It is difficult to answer these questions, as the technology is young and there are significant knowledge gaps related to both technological and regulatory aspects of DLT, as well as related to the future roles of industry incumbents.

The knowledge gaps relate to:

- Ensuring security in a DLT system while still enabling cancelation or correction of transactions recorded to the ledger
- The optimal settlement cycle to balance efficiency against liquidity management
- Balancing the transparency benefits of DLT against the level of privacy and confidentiality required in regulated markets
- Achieving a highly reliable and scalable DLT system
- The degree of centralization best suited for the future of securities clearing and settlement
- The regulation of DLT systems

In this paper, I have attempted to fill these knowledge gaps by researching relevant and timely literature from reliable sources and conducting interviews with key persons working in securities trading, clearing and settlement.

Literature Review

This section will contain an explanation of securities clearing and settlement, as well as the concept of DLT. Seeing as secondary data in the form of relevant literature has been my main source of data for this thesis, a more extensive literature review of this data will take place in the Findings and Discussion section below.

Clearing of Securities

As previously mentioned, clearing of securities is the middle step in the life cycle of a financial trade. Securities clearing dates back a long way and is a vital part of today's financial markets. The purpose of clearing is to make trading as secure and effective as possible, by having a central authority net transactions against each other and minimize settlement risk (counterparty default risk and other risks that endanger settlement will hereby be referred to as "settlement risk") (DTCC, 2016).

Netting of transactions

The CCP takes all daily trades in a specific instrument for a specific member (members of CCPs are typically brokers) and nets them down, so that each member is left with a single in or outflow for that specific instrument at end of day (DTCC, 2016). This means that the number of trades actually needing to go through the full settlement cycle is greatly reduced. This significantly lowers the liquidity requirements for the members, and is therefore highly economically beneficial (Priem, 2020, p. 9).

Risk management

The CCP mitigates settlement risk by representing the buyer to the seller, and the seller to the buyer, in all the trades of its members (on market venues with which the CCP operates) (DTCC, 2016). Thus, the CCP guarantees that if a counterparty defaults on their commitment, the CCP itself will be responsible for settling the transaction. This is especially important in exchange traded markets where the identity of the investor is hidden to all except the broker. This

means that investors cannot properly assess the counterparty default risk, and a CCP is therefore very handy (Bech et al., 2020, p. 68).

Because of the responsibility of the CCP to guarantee trade completion, it closely monitors the trades of its members until settlement is reached. Let us say that Broker X is a member of a CCP. All of Broker X's trades are forwarded to the CCP to be cleared. The CCP receives both the sell and the buy instructions of each trade to make sure they are matched, i.e., both parties agree on the same trade price and volume, and that both parties present the funds or securities needed to settle the trade by the intended settlement date (ISD). If a trade is not matched, the CCP will contact the parties prior to ISD and attempt to resolve the issue. E.g., the CCP could contact both parties and let them know there is a mismatch in trade volume, or the CCP could contact one of the parties and let them know that they are lacking sufficient funds or securities to settle the trade (Employee of Six x-clear, personal communication, May 2022).

Should one of the parties default on their commitment, the CCP will have to take on the role of the defaulting party and complete the trade themselves. The CCP clears a huge number of trades each day. For instance, on average in 2020, the National Securities Clearing Corporation (NSCC) in the U.S. cleared over 173 million equity trades daily (DTCC, 2021). Due to this high number of transactions, the CCP is only able to guarantee trade completion by having each member post cash or securities as collateral. E.g., if a member defaults on its obligation to deliver shares, the CCP can take the collateral that the member has posted in the form of cash, purchase the relevant shares in the market and deliver them to the counterparty of its member (Employee of Six x-clear, personal communication, May 2022).

Margin Requirements

The amount of collateral the CCP requires from its members are calculated through margin requirements. The CCP will calculate the appropriate margins for each of its members based on all of the members' currently unsettled trades. There can be several settlement cycles in a day, and the margin requirements are

therefore updated multiple times intraday (Employee of Six x-clear, personal communication, May 2022).

Different CCPs have different ways of calculating margin requirements, but generally speaking the requirements can be calculated based on the number of unsettled trades, the riskiness and volume of the securities being traded, and also the members' credit rating (Employee of Six x-clear, personal communication, May 2022). In the event that members choose to post collateral in the form of securities, there may be a limit on how concentrated their total collateral post can be in certain securities. This is due to the volatility of the securities in question. Margin requirements can be quite high, especially in times of market stress (DTCC, 2020a). The Depository Trust and Clearing Corporation (DTCC), a U.S. based CCP and CSD, states that they hold over $13.4 billion in margins every day on average (DTCC, 2021). They also state that margin requirements rose by more than 300% over the normal average during the COVID-19 pandemic (DTCC, 2020a).

Settlement of securities

The final stage in the trade life cycle is settlement, which DTCC (2021), describes as one of its "most powerful and critical processes". Settlement happens when ownership of securities is legally transferred, and this normally happens through a CSD. A CSD stores financial securities digitally, in book-entry form in securities accounts (Bech et al., 2020, p. 67). CSDs were originally created to immobilize the paper certificates representing securities in the past, and thereby removing the need to physically settle trades by transferring paper (Bech et al., 2020, p. 68). Today, securities aren't only immobilized, but also dematerialized, meaning that physical copies don't normally exist anymore (Bech et al., 2020, p. 68).

Some CSDs allow for a direct holding system, where investors themselves have accounts at the CSD. However, most common is the indirect holding system, where brokers and other custodians hold securities for their end clients (Bech et al., 2020, p. 68). This makes identity management easier for the CSD, but makes it harder for issuers to identify their investors (Bech et al., 2020, p. 68).

CSDs also perform a very important notary function. This means that when securities are issued, the CSD is responsible for ensuring that their creation is justified (i.e., not fraudulent), and that they are stored safely without being illicitly duplicated, changed or destroyed (Bech et al., 2020, p. 69; Benos et al., 2017).

Distributed Ledger Technology

Investopedia defines DLT as a "technological infrastructure and protocols that allows simultaneous access, validation, and record updating in an immutable manner across a network that's spread across multiple entities or locations" (Frankenfield, 2021). In other words, DLT is a form of digital database that, instead of being stored centrally, is shared and stored amongst all participants (also called "nodes") in the network.

There is a common misconception that Blockchain and DLT are the exact same thing. They share many similarities, but the two concepts are not always interchangeable. Blockchain is a form of DLT, but with certain specific properties that other DLTs may not contain. For instance, the cryptographically signed data on a blockchain are stored in blocks to provide immutable records, which is not a necessity for all DLTs (Priem, 2020, p. 1).

One of the best known qualities of DLT is its capability of being highly secure in a trust-less environment. By using specific consensus models (ways to ensure agreement), participants in the DLT system can validate transactions themselves, without the use of a central authority. Some consensus models mathematically ensure that data recorded to the ledger cannot ever be removed or altered, thus providing complete transparency and immutability to the transactions in a system (DTCC, 2016).

DLT systems can be completely open to all natural and legal persons, or only accessible to specific, trusted participants. There can also be differences regarding how consensus (i.e., transaction validation) is reached, and regarding view access for different participants.

Another key ability of DLT is the enabling of smart contracts. A smart contract is a self-executing digital contract where the conditions for all counterparties in a transaction are written in as code (Frankenfield, 2022). When the conditions are fulfilled (and only then), the contract will automatically execute, without the need for authorization by a central authority (Frankenfield, 2022). In the event

that smart contracts need information not available on the ledger to be able to execute, oracles can be utilized.

An oracle is software or hardware that provide smart contracts with external information (Blockchainhub Berlin, 2019). For instance, let's say that a smart contract has been agreed upon by a transporter of fish and a restaurant owner. The owner of the restaurant only wants the fish if it has been stored at correct temperatures during transportation. An oracle could obtain this information from a device measuring temperatures of the fish while its being transported, and pass on that information to the smart contract on the ledger.

Research methodology

Research design

I have chosen a qualitative research design to answer the research question for this paper. Qualitative research can be described as "an approach that allows you to examine people's experiences in detail by using a specific set of research methods" (Bailey et al., 2020, p. 10).

The key word here is "experiences". In other words, a qualitative method focuses on gaining an in-depth understanding of a topic through ideas and beliefs expressed in written words or conversations rather than in numbers (Scribbr, 2021, March 29). Rather than focusing on an objective, statistical analysis of numerical data, which is called quantitative research, qualitative research focuses on the researchers own understanding and interpretation of more subjective data (Scribbr, 2021, March 29). It is an inductive method, i.e., the researcher analyzes data to form a hypothesis at the conclusion, rather than a deductive method, which starts out with a hypothesis and then uses analysis of data to confirm or deny it (Scribbr, 2021, March 29).

A qualitative approach is best suited for this paper because I aim to analyze if the participants involved in post-trade processing are ready for a significant change to the way they go about their business. I will not focus on a statistical analysis of how DLT compares to legacy systems. This would prove difficult seeing as DLT still is in its infancy and there is not much quantitative data to measure yet.

Instead, I will gather information from various participants in the industry to find out how they feel about a possible switch to DLT, and what they perceive as the technology's most prominent strengths and weaknesses. I want to know if widespread adoption of DLT for securities clearing and settlement could be a reality. Given the current stage of the technology, I believe that question is best answered by examining peoples perception of it.

Population and sample

On the technological aspects of DLT, I have not limited my research to a specific population or sample. Technological innovations and research related to DLT is relevant for this paper regardless of where in the world it originated.

However, regulation of financial markets can be quite different depending on the geographical location. Therefore, I have chosen to focus my research on legislation towards the European Union and the EEA. I have made this choice to keep the paper concise, and also because the main regulatory focus throughout my degree has been aimed towards the EU and Norway.

Regarding different types of financial instruments, this paper is focused on exchange-traded securities.

Data collection

There are several ways of conducting data collection through a qualitative research method. For this paper, I have chosen to conduct a content analysis of relevant secondary data on the topic. I have also chosen to conduct interviews with key persons involved in securities trading, clearing, and settlement.

Data analysis strategy

I have chosen a thematic analysis strategy for the data I collect for this paper. My research on DLT for securities clearing and settlement can easily be split into two main themes: Technology and regulation. These two main themes will also be split into several sub-themes.

Analysis of secondary data

The main source of my research for this paper will be an analysis of secondary data in the form of relevant articles, white papers, and statements from various market participants. I have had three main criteria in mind when searching for relevant content.

Firstly, the content I have chosen has been produced relatively recent. As the world of FinTech is constantly evolving, literature is rapidly becoming outdated. Therefore, most of the literature I have analyzed has been produced within recent years.

Secondly, the content I have chosen has been produced by reliable sources. I have made sure that the literature has been produced by a person, persons or organization that carries a certain amount of academical weight.

Thirdly, the total content I have chosen for this paper is not biased towards a specific participant in the market for securities clearing and settlement. I believe that research on a concept that involves an entire industry should take the views of all participants into account. I have strived to find content that highlights the perspectives of all parties, including investors, brokers, CCPs, CSDs, market venues, and regulators, as well as independent third parties outside of the system (for an objective and unbiased perspective).

Analysis of interviews

I have also conducted interviews to gather knowledge for this paper. The interviews have been conducted as semi-structured conversations of around 30 minutes, and they have been anonymized for the publication of this paper. A semi-structured interview can be described as using a mix of pre-determined questions, and questions that emerge naturally during the conversation (Crabtree, B. F. & DiCicco-Bloom, B, 2006, p. 315). I have interviewed an employee of VPFF, the association for brokers in the Norwegian financial market, and an employee of the Norwegian branch of Six x-clear (a CCP operating in the Nordic financial market).

In the interviews I have sought to figure out how the subjects feel about a possible switch to DLT. I have asked them how they feel about the current system, what they perceive as its main strengths and also its main areas of inefficiency. I have also asked them how they stand with regards to DLT. What are the main strengths and weaknesses of this technology? Are they optimistic or hesitant to an implementation of it, or have they perhaps not even considered it? Is their place of work staying up to date on, or are they maybe even involved in, innovations relating to DLT?

Strengths and weaknesses of the research methods

As with any research project, this paper contains certain strengths and weaknesses that stems from the choice of research methods.

As for the secondary data analysis, the paper is trustworthy due to the fact that the literature chosen is current, produced by valid, reliable, and relevant sources, and represents a variety of perspectives. On the other hand, some of the literature comes from sources who are not necessarily objective. For instance, a paper from a CCP regarding its own future related to the implementation of DLT should be handled with caution. This is due to the fact that the CCP will be biased towards its own survival and cannot provide an objective view on whether or not CCPs are needed following an implementation of DLT.

As for the interviews, the strength of this choice of data collection is gaining information from relevant sources that is not otherwise available to the public. However, in this particular paper, there are a few prominent weaknesses that derives from the interviews.

Firstly, the interviews conducted are very few. This is due to a very low response rate amongst the possible interview subjects I contacted. The reason given for the many rejections was not that the concept of DLT for securities clearing and settlement is not an interesting topic, but rather that not many people considered themselves qualified to speak on it.

Secondly, the subjects I have interviewed for this paper are representing organizations based in the Nordic market. I am not limiting my research for this paper to Norway, so the fact that all the subjects have a Norwegian perspective should be taken into account when reading.

Thirdly, as with most qualitative research, the interviews are based on the subjective and potentially biased beliefs of the subjects, as well as my own subjective interpretation of their answers.

Findings and Discussion

Both the current system for securities clearing and settlement and DLT have some main advantages and challenges that I will explore further in this section. They can briefly be summarized as such:

Advantages of the current system

- Netting of transactions
- Risk management

Challenges of the current system

- Inefficient siloed structure that requires constant reconciliation and leaves the system vulnerable to cyber-attacks
- Inefficient length of settlement cycles
- Inefficiencies related to intermediation

Advantages of DLT

- Distributed single source of truth to eliminate the need for reconciliation
- High level of cyber security
- High level of transparency
- Possibilities for decentralization

Challenges of DLT

- The technology is still nascent
- Regulatory uncertainty
- Issues related to privacy and confidentiality

Eliminating reconciliation

The siloed structure of the current system for securities clearing and settlement creates the need for reconciliation of databases between different intermediaries. There is a lot of information needing to be reconciled. For instance, a CCP needs to reconcile their record of transactions and ownership (as well as their record of active financial instruments) with the relevant market venues and CSDs. They also need to reconcile their record of current bank balances with their affiliated banks (Employee of Six x-clear, personal communication, May 2022). These processes need to execute daily, and there are often mismatches in the databases that need to be corrected (Employee of Six x-clear, personal communication, May 2022). DLT presents an opportunity to eliminate these rather cumbersome reconciliation processes.

Reconciliation processes are expensive and inefficient due to the significant manual intervention they require, which add latency to post-trade processing (CoinDesk, 2015, November 20; SWIFT, 2016). The reconciliation processes themselves are automated, but manual intervention is still needed to fix errors, delays and other inconsistencies that will inevitably occur when dealing with such a vast number of transactions per day (CoinDesk, 2015, November 20).

DLT is by design a distributed system in which all records are always in sync, which makes it very attractive for securities clearing and settlement (Göb, 2022). This is highly efficient because all parties in the system would have access to a single source of truth and be up to date with the current, relevant information (SWIFT, 2016). Dr. Wolfgang Göb (2022) of Software Daten Service, a company providing software solutions to the financial industry, mentions that the inefficiencies related to reconciliation could also be solved through storing data in one central location. However, he adds that there are often technical, organizational, and legal constraints that keep this solution from seeing the light of day (Göb, 2022).

There is little doubt that the reconciliation processes currently needed constitute one of the system's biggest pain points. As of today, there does not seem to be

any other solution that could solve the issue of reconciliation as elegantly as DLT.

The idea of a centralized data storage between all participants in the post-trade industry would probably be very hard, if not even impossible. This is for a few reasons. Firstly, the database would be extremely vulnerable to cyber-attacks as all data would be stored in a single location. This would be very dangerous from a financial stability perspective. Back-ups could be created, but then those systems would need to be reconciled against the original, and we are back to square one. DLT avoids this issue by distributing the exact same ledger to all nodes in the system.

Secondly, the centralized data storage would probably have to hold data from virtually all securities trades in the entire world. This is because virtually all securities markets are interconnected in some way. For example, CCP A needs to reconcile its database with Market Venue B, CSD C and Bank D, and so this data needs to be included in the centralized data storage. However, Market Venue B also needs to reconcile against CCP E and CSD F, and so this data needs to be included as well. Then we see that CCP E also needs to reconcile against Market Venue G and H, and this data would also need to be included. We could carry on with this example until we include most, if not all, participants in the post-trade industry. Instead, let us conclude that the amount of data would simply be too large to handle for a single system. Interestingly, the issue of data storage could also be a challenge with DLT, especially since all transactions recorded with DLT are stored forever (SWIFT, 2016).

Thirdly, data from many different participants in the same place would probably cause issues related to confidentiality, as trade information should not be available to parties who aren't involved in that particular trade. To avoid this issue with DLT, you might need to keep separate ledgers, e.g., one per market venue. However, they would not need to be reconciled.

As the current system struggles with inefficiencies, costs, and risk related to reconciliation, and alternative solutions don't seem feasible, the distributed

nature of DLT could prove very valuable to the post-trade industry. However, pre-ledger processing of data might still need to occur even if DLT is implemented, and this data could need to be reconciled. Even so, a lessening of the load of data needing to be reconciled would still make a big difference.

Shortening the settlement cycle

Since 2014 the settlement cycle for equities in the European markets has been at T+2, which means that an equity trade should settle two business days after it has been initiated (European Capital Markets Institute, 2021). In the U.S., the settlement cycle moved to T+2 from T+3 in 2017, and according to DTCC, this was a lengthy process that demanded significant effort from market participants as well as regulators (DTCC, 2020a).

The discussion today revolves around whether the settlement cycle should move further ahead to T+1, or even to T+0 (European Capital Markets Institute, 2021; DTCC, 2021). With T+0, there is an important distinction between end of day/intraday settlement and instantaneous real-time settlement. DTCC actually has the capacity for a shorter settlement cycle, and already settles some of their transactions at T+1 and T+0, which they believe should be the goal for the industry (DTCC, 2021).

Thus, the current technology is not what is keeping the settlement cycle at T+2. Instead, back-office processes and management of liquidity seems to be the reason (Bech et al., 2020, p. 75). T+2 is beneficial for liquidity management because it removes the need for pre-funding of trades. This is important because it allows trading to take place even though one does not yet possess the sufficient cash or securities to settle, which eases the liquidity requirements in the industry and also enables securities lending (Massachusetts Institute of Technology, 2020, January 23.).

A shortening of the settlement cycle could still prove highly beneficial to the industry. The settlement risk related to a trade increases the longer it takes for the trade to settle (Bech et al., 2020; DTCC, 2020a). This means that shortening the cycle would decrease risk, thereby decreasing the margin requirements imposed on brokers by CCPs (DTCC, 2021). DTCC (2020a) states that in 2017, the move to T+2 for settlement of U.S. equities saved the industry $1.36 billion by reducing margin requirements by approximately 25%. They also state that the component for volatility in the calculation of margin requirements (which

accounted for around 60% of total margins) could decrease by as much as 41% by moving to T+1 (DTCC, 2021). In addition to this, a shorter settlement cycle could also lead to lower costs for the investors and improve the resiliency of the entire market (DTCC, 2021).

Despite these benefits, DTCC (2021) reckons that the operational and technical processes involved will make a move to T+1 or T+0 require a lot of effort form the entire industry. They state that the change would impact all participants in the market, and that "one can only move as fast as the slowest adopter" (DTCC, 2020a).

With all the benefits associated with a shorter settlement cycle, it is rather interesting that the industry seems to be holding out on the change. It could appear that having two business days to gather the needed liquidity is of such benefit to the industry that they prefer to keep the cycle at T+2. However, margin requirements could be seen as form of pre-funding, and these requirements could be significantly reduced by shortening the cycle. It seems likely that the industry will eventually have to implement a shorter settlement cycle, both to mitigate its own risks and costs, but also to increase efficiency for investors. The question is what role DLT could play in this.

DLT is very flexible and can handle any settlement cycle (Benos et al., 2017; DTCC, 2021). There has even been talk of a possible "T+ Whatever you want"-structure so that participants can adjust the cycle depending on their own liquidity needs (Benos et al., 2017). This shows promise, but the fact that the technology in use today is already capable of supporting T+0 settlement could mean bad news for the implementation of DLT. If the benefits of shortening the settlement cycle in the current system are great enough, industry participants may choose this instead of implementing DLT. After all, DLT has many benefits, but it also comes with uncertainty and the emergence of new risks.

It is understandable that industry incumbents may push to go on with the current system, as a move to DLT could render them obsolete in the future. If the benefits from shortening the settlement cycle using the current system proves

significant enough, it may be well justified to keep the current system in place, at least for the time being. However, if DLT proves to be the more efficient solution, the incumbents may have to "face the music" and innovate at some point in the future. Also, as DTCC (2021) argues, the move to a shorter settlement cycle will require quite a significant change to the current processes. If the industry is looking at making big changes regardless, a switch to DLT might be the better solution, as this technology brings many other benefits besides a shortened/flexible settlement cycle. In addition, DLT could also help effectivise the settlement cycle for financial instruments other than equities. For instance, syndicated loans often settle as late as T+21, due to unpredictable and inefficient post-trade processing of these instruments (Benos et al., 2017).

DLT can also enable instantaneous, real-time settlement. As mentioned earlier, there is a difference between an intraday/end of day settlement that is still somewhat delayed to enable the netting of transactions, and real-time settlement. According to DTCC (2016), netting settles over 97% of their total daily equity trades. This is clearly a huge benefit both with regards to settlement risk and transaction costs. Real-time settlement is therefore generally not desired by the industry (Massachusetts Institute of Technology, 2020, January 23). From an investor point of view, real-time settlement could bring significant efficiency, but this has to be measured against the added risk and costs for the industry.

What type of DLT is best suited for securities clearing and settlement

Before an eventual implementation, one has to decide what kind of DLT is best suited for the specific use case. Establishing who has access to use, update and view the ledger, as well as what method is used to validate transactions, are ways of separating different types of DLT.

Public vs Private

Access to use the ledger could either be public or private. Public ledgers, such as the blockchains used in Bitcoin and Ethereum, are open to use for anyone. Private ledgers on the other hand, only allow use access to selected, trusted parties (Bech et al., 2020, p. 72; Benos et al., 2017). DTCC (2020b) explored the use of a public ledger in Project Whitney, a project aimed at testing the trading of tokenized securities using DLT. A security token is a digital representation of a security, that is not stored in a securities account (Bech et al., 2020, p. 67).

The project found some challenging aspects with regards to public ledgers for financial trading. Firstly, they found that uncertainty with regards to regulation and governance makes regulated financial institutions turn away from public ledgers (DTCC, 2020b). They also found that public ledgers struggle with transaction throughput, i.e., the number of transactions that can be processed within a given time frame, and that during periods of high network activity, transaction costs could rise (DTCC, 2020b). Even though this project focused on the trading of securities, the findings are still relevant for post-trading activities.

There seems to be a general consensus in the market that a private DLT system would be best suited for securities clearing and settlement. This is mostly due to the regulatory demands for confidentiality (Benos et al., 2017).

Non-hierarchical vs Hierarchical

In addition to deciding who would have access to use the ledger, one should also decide who would have access to view it. A non-hierarchical system would

allow all participants to view all information stored on the ledger, whereas a hierarchical system would only grant this right to specific parties (Bech et al., 2020, p. 72). A hierarchical system seems most suited for securities clearing and settlement because it would make it easier to comply with regulatory demands for confidentiality (Bech et al., 2020, p. 74). Also, this restriction in view rights is very important to keep brokers from seeing the trading strategies of other brokers, and using that as an unfair advantage in their own trading (Bech et al., 2020, p. 74).

Permissionless vs Permissioned

A third important decision is deciding who would have access to update the ledger. A permissionless ledger enables all participants in the system to validate transactions, whereas a permissioned ledger only allows certain trusted parties this right (Bech et al., 2020, p. 72; Benos et al., 2017). A permissioned system would generally need the presence of a central authority to distribute the validation rights (Göb, 2022). Currently, most projects with DLT in the settlement industry focus on permissioned ledgers (Benos et al., 2017).

An interesting point is brought up by Benos et al. (2017), which is that validation could be decentralized (i.e., permissionless) while still keeping governance centralized in a private and hierarchical DLT system. However, it could be challenging for participants to validate transactions in a hierarchical environment, given that view access could be restricted. Zero Knowledge Proofs (ZKP) could possibly help with this. A ZKP is a mathematical method used to confirm the validity of information without actually revealing the information itself (SWIFT, 2016). This could help validators get around the issue of restricted view access in a hierarchical ledger, if the participants with view access (also called “provers”) can prove that the information is valid using ZKP.

However, if CCPs need to remain present in a DLT environment (for purposes of governance, netting, etc.) they might continue to validate transactions, as they do today.

With this, it seems highly plausible that if DLT will be implemented for securities clearing and settlement, it will first be through a private, permissioned and hierarchical system. Decentralizing transaction validation in a private, hierarchical environment is however a very interesting concept, and could be a step in the direction of disintermediation in financial markets.

Interestingly, there is a way to make this happen even in a permissioned system. As we know, a permissioned system restricts access to validate transactions and update the ledger. However, it is not thereby given that this access is only granted to a central authority. A permissioned system could also be a "peer-to-peer" system. This means that participants can validate transactions without the need of a central authority. A peer-to-peer system in which only specific participants is allowed to validate specific transactions would be characterized as permissioned. This kind of system would merge the trading and post-trading processes, and it is therefore unclear if the benefits of netting and risk management will outweigh the benefits of a peer-to-peer system for securities clearing and settlement.

DLT systems in use today

Businesses around the world have opened their eyes to the possibilities of DLT outside of cryptocurrencies and their public, permissionless blockchains. Three examples of private and permissioned DLT systems currently in use are Corda, Hyperledger and Quorum.

Corda is a DLT system made by the enterprise software company R3, and describes itself as "The leading permissioned DLT platform for developing multi-party applications in regulated industries" (R3, 2021). It is private and permissioned, but still peer-to-peer. Corda offers privacy in that it only shares transaction information between the counterparties in a given trade (Corda, n.a.). It also claims to be highly secure, scalable and regulatory compliant, as well as able to guarantee a deterministic settlement finality (Corda, n.a.).

Hyperledger Fabric is one of the DLT systems made by The Hyperledger Foundation, which was created by Linux. Hyperledger Fabric was created

through contribution from IBM and describes itself as an “open, proven, enterprise-grade DLT” (Hyperledger Foundation, 2020). This DLT system is also private, permissioned and with a peer-to-peer structure. It is designed to accommodate a wide range of use cases, and it is used by a multitude of acclaimed participants, such as IBM and Google (Hyperledger Foundation, 2020). One of the main benefits of Hyperledger Fabric is that it enables a “network of networks” (Hyperledger Foundation, 2020). This means that businesses that interact with many different clients, but need to keep information related to each specific client private from the other clients, can do so through the “channels” available in the Hyperledger Fabric blockchain (Hyperledger Foundation, 2020). This is highly beneficial for players in the post-trade industry, and would remove the need to keep different ledgers, as mentioned earlier in the paper.

Quorum is another private, permissioned, and peer-to-peer blockchain, that is supported by Microsoft and J.P. Morgan, among others (Quorum, n.a.). Quorum is derived from the Ethereum code, and promises high levels of privacy, security and high performance, as well as scalability and settlement finality (Quorum, n.a.)

The Australian Securities Exchange (ASX) is going to replace its current post-trade clearing and settlement system CHESS with a DLT system. This is a very exciting project that could provide the industry with meaningful insights. However, the project has been delayed several times, and it is now clear that the intended go-live date of April 2023 will likely be pushed even further ahead (Chanthadavong, 2022).

Transparency vs Privacy

DLT is inherently a highly transparent system. DLT stores all transactions forever, and each recording is therefore completely traceable (DTCC, 2016). This would be great news from a regulatory and audit perspective. For instance, the demands for regulatory compliance in several areas (AML, KYC, etc.) are quite strict in the industry today, and the pressure only seem to be increasing (SWIFT, 2016). The complete traceability of transactions using DLT could therefore be very helpful.

However, we also have to consider the regulatory requirements for privacy and confidentiality. As much as complete transparency helps with detecting and avoiding fraudulent transactions, it creates conflict with the need to keep financial transaction information away from unauthorized parties.

Many blockchain solutions utilized for cryptocurrencies are completely transparent, but they anonymize the identities of the trading parties (DTCC, 2016). Applied to the post-trade industry, this would make it very difficult for intermediaries to comply with regulatory and audit requirements, especially with regards to money laundering (Göb, 2022). Once again, this highlights the reason for why public, non-hierarchical DLT systems are unfit for the regulated industry that is post-trade clearing and settlement.

The question arises of how one could achieve the necessary balance between privacy and transparency using DLT. A solution could be to use a private, permissioned and hierarchical DLT system. As discussed above, this would only grant read/write access to certain trusted parties, and sensitive information could therefore be kept private, while still being able to be presented to regulatory authorities.

However, within the European Union, a problem arises related to compliance with the General Data Protection Regulation (GDPR). Compliance with this regulation is not necessarily confined to participants located within the EU, but could also include all participants whose business involves the data of subjects

who reside there (Compert et al., 2018). Therefore, it is a relevant regulation for participants in the post-trade industry, as the trading of financial instruments often happens across borders.

GDPR articles 17 and 19 constitutes that data subjects have "The right to erasure", which means they have the right to have their personal data removed under certain conditions (Data Protection Commission, n.a.). The transparency and immutability (which I will discuss further below) of DLT is a problem here. Since compliance with GDPR is crucial, IBM argues that personal data could be stored off the distributed ledger, and that only the cryptographic evidence of this data should be visible and stored forever (Compert et al., 2018). This would ensure compliance with GDPR, but it would probably make the personal data itself vulnerable to cyber-attacks, and in need of centralized protection.

In other areas of compliance, DLT seems to be presenting opportunities instead of challenges. DLT could simplify processes by keeping personal information used for the same purpose from being recorded in many different databases e.g., the tracking of consent (Compert et al., 2018). Smart Contracts could also help with automating KYC and other compliance processes (Compert et al., 2018).

Delivery versus payment

An important thing to avoid in financial transactions is the possibility of one counterparty irrevocably fulfilling their end of a commitment, and thereby losing its full value if the other party defaults (Bech et al., 2020, p. 71). This is known as principal risk, and a way to avoid it is by ensuring that neither the security nor the cash transfer occurs if the other doesn't (Bech et al., 2020, p. 71). This is called delivery versus payment (DvP), and according to Benos et al. (2017), there are two ways of ensuring DvP using DLT.

The first option is that the cash leg of a securities transaction could be processed internally on the distributed ledger. The second option is that the DLT system could interact externally with a digital cash ledger, or even just the regular cash accounts (Benos et al., 2017). The first option would normally require the presence of digital central bank money in the DLT system (Benos et al., 2017) Currently, several central banks are experimenting with Central Bank Digital Currencies (CBDC), and this option could therefore be a possibility. However, the EU has released a new regulation on market infrastructures based on DLT (which will be discussed below). This regulation allows for an exemption from the requirement to settle in central bank money (Deloitte, 2022).

Bech et al. (2020, p. 76) states that if cash and securities reside on different ledgers, a hash timelock smart contract can be used to ensure DvP. In simple terms, these contracts allow for participants to submit securities or cash and present them to the other ledger in a "locked" state, for however long the participants desire (hereby enabling a flexible settlement cycle). The counterparty will lock in their securities or cash, and if the trade instructions match, the trade is completed and DvP is ensured (Bech et al., 2020, p. 76).

Cyber Security

One of the main attraction points of DLT is the high level of cyber security. There are two main design features of DLT that makes the technology highly secure, namely the immutability of records and the technology's distributed nature (Göb, 2022).

Immutability of records

The immutability of records is ensured by the "append only" structure of DLT. Meaning that when a transaction is recorded on the ledger, it is basically mathematically impossible to remove it (Göb, 2022). This is because the blocks in the chain are all linked together, ensuring that if one tries to alter data in a previous block, all blocks further ahead will become invalid. Wolfgang Göb of SDS (2022) compares the current system to Iron Man, a vulnerable human in a protective suit of armor, and DLT to The Hulk, an invulnerable creature without the need for protective armor.

The immutability of records is great from a security perspective, but is challenging from other perspectives, e.g., the previously discussed right to erasure in GDPR, because immutability makes it impossible to cancel or correct transactions recorded to the ledger. This is also challenging because the cancellations and corrections of transactions is something that happens all the time in securities clearing and settlement today (Employee of Six x-clear, personal communication, May 2022). A few reasons why this happens so often is the need to correct for a manual mistake or a software error, or the need to reverse a transaction for legal reasons (Göb, 2022). According to SWIFT (2016), the cost of the immutability of records in DLT would outweigh all the security benefits for the financial industry. Therefore, as will be discussed further below, the choice of consensus model is very important for the use case of securities clearing and settlement.

The use of Smart contracts could possibly be helpful, as they only execute transactions when pre-determined conditions are fulfilled (Frankenfield, 2022). Smart contracts would therefore ensure that both parties agree completely on the

recorded transaction. However, the need to reverse transactions for legal purposes would still be a challenge. One must also be very cautious of the possibility for malware to enter into Smart contracts (Göb, 2022).

The distributed nature of DLT

The other feature of DLT that makes it highly secure is the distributed nature of the technology. This is beneficial both from a security perspective as well as from being able to eliminate reconciliation, as was discussed earlier in this paper. The distributed nature of DLT prevents there from existing a "single point of failure", which is vulnerable to cyber-attacks (Benos et al., 2017). As all nodes in the network has an automatically updated copy of the ledger, the system can recover much faster if some of the nodes are attacked (Benos et al., 2017). This would be extremely beneficial from a financial stability point of view.

However, SWIFT (2016) argues that the distributed nature of DLT can cause severe risk of data leakage. They state that removing the single point of failure might create several points of entrance into the system (SWIFT, 2016). Fortunately, this seems to be easily fixable through a hierarchical DLT system. Through a hierarchical system, one could ensure that view access is restricted to the relevant parties. Thus, the risk of data leakage would not increase beyond the levels of the current system.

Data exchange through encryption

Confidentiality in the exchange of data on a distributed ledger can be enabled through public and private key encryption, which increases the ledgers security (Benos et al., 2017). Confidentiality is important both with exchanges of personal data, and also with competitively sensitive data, which are both often present in financial transactions (SWIFT, 2016). Public and private keys are numerical strings that are connected mathematically to each other through "one-way" mathematical functions (Bech et al., 2020, p. 73). The public key is distributed to all participants in the network, similar to an email address. The private key is in this sense like a password, only one person should have access to their private key. Where the public and private key differ from an email

address and a password, is that they can be linked together, without revealing what the password (this would be the private key) actually is.

Let's use the signing of a document as an example of how this works. A sender could send an encrypted document to a receiver using the receiver's public key. The only way this document can be decrypted, is by using the private key linked to the receiver's public key. The receiver decrypts the document and signs it using her private key. The sender can then be sure that the signature on the document is verified, not because he can see the receiver's private key, but because he can see that the document is signed with the private key that is linked the receiver's public key. In other words, the linkage between the two keys is what is visible to the sender, and what makes the signature verifiable.

Another way of thinking of it is through the example of locking and opening doors. Imagine that everyone has a private key that can open a door, but only if the door has been locked with a key that is linked to your private key. If you then lock the door using a public key that is linked to my private key, and you later come to find the door to be open, you can be absolutely sure that it has been opened by me, and no one else. This is of course unless someone has stolen my private key, which is a very real possibility, even in a DLT system.

SWIFT (2016) mentions another challenge with key encryption. The management of keys could quickly become cumbersome if data needs to be decrypted by multiple parties at once. This is because new public/private key combinations are required for each combination of parties, which could become impractical (SWIFT, 2016). A centralized authority could probably help ease the need for data encryption, but if the goal is to have a peer-to-peer network, other solutions may have to come in to play. An option is to have a trusted central authority manage and issue the keys in an otherwise decentralized peer-to-peer network (Benos et al., 2017).

Consensus Models

A distributed ledger is updated through a consensus model. This model ensures that the information recorded on the ledger is valid, and is therefore an important part of DLT. In the world of financial trading, not all parties trust each other. Therefore, in the current system for securities clearing and settlement, validation is performed solely by trusted central authorities to mitigate settlement risk. However, an interesting concept of DLT is that it enables a network of trust-less participants to reach consensus without a central authority.

Two main steps are included in the validation of a financial transaction using DLT. Firstly, the transaction needs to be valid, i.e., both parties have the necessary funds, their signatures are in order, the transaction adheres to any rules or constraints applicable to it, etc. (Benos et al., 2017). Secondly, the transaction needs to be unique, i.e., the funds are not simultaneously being spent in another pending transaction (Benos et al., 2017). This is known as the double-spending problem.

Proof of Work (PoW), which is used in Bitcoin, is probably the best known consensus model out there. This model is often used in a public, permissionless blockchain, because with this model, none of the participants need to trust each other to reach consensus. Consensus is achieved by PoW by a participant solving a very computationally expensive mathematical problem, and thereby "winning" the right to add the next block of transactions to the chain (Simply Explained, 2018, March 21). The complexity involved in the mathematical problem itself is out of scope for this paper. The important part to grasp is that PoW makes the DLT system highly secure (and immutable) because an attacker would have to control over 50% of the computing power on the network to alter the ledger, which makes an attack economically unviable (Benos et al., 2017; SWIFT, 2016). To incentivize participants to validate transactions, Bitcoin provides coins to the validators of each block (Simply Explained, 2018, March 21).

However, despite the clear benefits that is cyber security and consensus without trust, PoW is unattractive for securities clearing and settlement for numerous

reasons. Firstly, as already discussed in this paper, immutability of records is not necessarily desired for this use case due to compliance with the right to erasure and the need to cancel and correct transactions. Secondly, this consensus model struggles massively with latency in transaction throughput and scalability, which is unacceptable in post-trade processing (Priem, 2020, p. 13; SWIFT, 2016). Many systems in the financial industry handle as much as thousands of transactions per second, and consensus models like PoW do not come close to matching this (SWIFT, 2016).

Thirdly, for legal reasons, establishing a clear time of settlement finality is hugely important for risk management in securities clearing and settlement (Benos et al., 2017). PoW can't guarantee an exact time of settlement due to a concept known as "forking" (Benos et al., 2017). Forking means that a block of transactions is added to a block which isn't considered to be the last one in the chain, thus creating a chain with deviating paths. This is solved by a shared agreement in the network that the longest chain will be considered the one that is valid (Benos et al., 2017).

Lastly, the amount of computing power needed for PoW makes this consensus model require incessant amounts of energy, which would make it inefficient and could also be deemed incompatible with the increased focus on sustainability in the financial industry.

The use of a private, permissioned ledger makes the choice of consensus model much easier, because only trusted parties are allowed in the system. This means that the need to incentivize parties not to validate fraudulent transactions through a specific consensus model falls away, and transactions can be validated faster and cheaper (Benos et al., 2017). In fact, if we keep using central authorities such as CCPs and CSDs for trade validation in securities clearing and settlement, we don't have to bother with the issue of consensus at all, as the central authorities will ensure the validity of transactions.

However, as previously mentioned, there are private, permissioned DLT systems today with a peer-to-peer structure, meaning they function without a

central authority validating transactions. For instance, in Hyperledger Fabric, the peers (also known as nodes or participants) validate the transactions themselves. For reasons tied to efficiency and scalability, as well as privacy and confidentiality, it wouldn't make sense to have a system where all peers are required to validate every single transaction (Hyperledger Foundation, 2017, April 28). Instead, peers in the Hyperledger Fabric system are split into three different roles: endorsers, committers, and consenters (Hyperledger Foundation, 2017, April 28). Again, the complexities of the consensus model is out of scope for this paper. The main takeaway is innovations are happening to enable efficient and scalable consensus in peer-to-peer systems.

In conclusion, a private, permissioned and hierarchical DLT system removes the need for a slow performing, economically incentivized consensus model. However, a peer-to-peer network still needs a secure and scalable way of updating the ledger. The question remains of whether or not a central authority should still be the main validator of transactions in post-trade clearing and settlement, or if a peer-to-peer structure is more efficient.

Centralization, reliability and financial stability

Determining the optimal level of centralization in a DLT system for securities clearing and settlement is difficult, yet highly important. Decentralization could be key in gaining all of the efficiency DLT can provide. However, a high degree of centralization appears to be the main ingredient in ensuring reliability and financial stability in the financial markets today.

As discussed earlier in this paper, DLT will most likely be utilized in a private, permissioned and hierarchical network. This would exclude the possibility for total decentralization as a central authority would have to grant entrance to the network, decide restrictions in view access, etc.

At a conference back in 2015, Blythe Masters (then working at Digital Asset) stated that a world of complete decentralized financial markets is very far from how the situation is today (CoinDesk, 2015). She also stated that the intermediaries play a very important role in facilitating trust in the system. This appears to still be the case today. The risk mitigation of CCPs is undeniably hugely beneficial for the industry. According to DTCC (2021), when a counterparty has defaulted in a trade when using NSCC as a CCP, the other party has always been fully compensated. The notary function of CSDs is also a very important part of facilitating trust in the industry (Benos et al., 2017).

In other words, financial intermediaries such as CCPs and CSDs clearly perform absolutely crucial roles in ensuring the financial stability and investor protection in the industry. In their new regulation for market infrastructures based on DLT, which will be discussed below, European legislators constantly bring up their commitment to ensuring financial stability, market integrity and investor protection (Regulation 2022/858, 2022).

DLT can certainly bring increased efficiency to financial markets, but it seems that efficiency meets a tough opponent in financial stability. Until DLT systems can prove reliable enough to earn the same level of trust that inhabits industry incumbents today, it would appear difficult to implement this technology on a

broad level. In our interview, the employee of VPFF (personal communication, April 2022) stated that brokers in the Norwegian markets seem happy with the system as it is today, and that DLT has not yet proven to be better.

Regulation of DLT

Regulatory uncertainty

Securities clearing and settlement is a highly regulated industry. This imposes restrictions on digital innovations, as they have to be compliant with regulations in the area they operate within.

Even though financial regulation in the EU is considered to be technologically neutral, the current regulation was not created with DLT in mind (Priem, 2020, p. 16). As DLT is a completely different technology compared to the system in use today, it has been argued that a new regulatory approach will be needed (Priem, 2020, p. 16). However, ESMA stated in 2017 that if CCPs and CSDs utilize DLT merely as a technological improvement, there probably won't be need for much regulatory change (Priem, 2020, p. 16).

Regulatory uncertainty has been brought up by many as one of the main challenges of implementing DLT. Professor Randy Priem (2020, p. 17) highlights two challenges a permissioned DLT system in securities clearing and settlement could face. Either the current legislation could block the implementation of DLT altogether, or the new risks emerging after an implementation of DLT would not be sufficiently addressed by the current legislation (Priem, 2020, p. 17).

A potential block in the current legislation could be the requirement in the EMIR regulation (a regulation on OTC derivatives, central counterparties and trade repositories) for standardized OTC derivatives to be cleared through a CCP (Priem, 2020, p. 17). Should a DLT system be implemented without the use of a CCP for clearing (for instance a peer-to-peer system), standardized OTC derivatives could not be included in the system. Also, the CSDR regulation requires that a CSD has to be used to record transferable securities in book-entry form when they are issued (Priem, 2020, p. 17). Thus, an issuer CSD has to be present in the DLT system for it to be implemented. There also exists confusion regarding interpretation of the word "account" used in EMIR, CSDR and SFD (The Settlement Finality Directive). Securities accounts in CSDs may not be

replicable in DLT systems, and there is no clear definition in the legislation today that could tell us whether or not the use of DLT would require new legislation (Priem, 2020, p. 17). Therefore, some countries may interpret the legislation in a way that allows for the use of DLT for securities clearing and settlement, whereas others may not. This could lead to a bifurcated market in Europe (Priem, 2020, p. 17). This would be in conflict with the idea of a single European financial market, which the EU seems to be highly invested in working towards.

As technologically secure as DLT might be, risks that are currently kept at bay by central intermediaries (e.g., settlement risk) might be spread amongst the participants in a peer-to-peer system (Priem, 2020, p. 19). These risks might require new legislation, or at least an update of it, to be properly addressed (Priem, 2020, p. 19). Assigning the proper roles of governance will also be important, seeing as DLT could drastically change the roles of participants in securities clearing and settlement. In addition, the legal status of smart contracts needs to be decided to figure out whether they can be implemented by themselves or if they can only execute actions agreed upon in traditional legal contracts (Priem, 2020, p. 20; SWIFT, 2016).

The DLT Pilot Regulation

For a while, regulators stayed silent about the legal concerns regarding DLT, stating that it was still too early to regulate the technology (Priem, 2020, p. 21). However, legislators of the EU are now entering the playing field through their new regulation on a pilot regime for market infrastructures based on distributed ledger technology, hereby referred to as the DLT Pilot Regulation.

This regulation follows an assessment by The European Banking Authority (EBA) and The European Securities and Markets Authority (ESMA) in 2018. The assessment stated that "provisions in existing EU legislation may inhibit the use of DLT" and that "most crypto-assets fall outside the scope of EU financial services legislation and therefore are not subject to provisions on consumer and investor protection and market integrity, among others, although they give rise to these risks" (European Commission, 2020). In other words, EBA and ESMA

found that, even though European legislation is supposed to be technology neutral, it does not integrate well with DLT.

The DLT Pilot Regulation was agreed upon by The European Parliament and The Council of the European Union on May 22nd 2022, and will apply from March 23rd 2023 (Regulation 2022/858, 2022). The main objective of the regulation appears to be a temporary softening of current legislation to allow for innovation of DLT in post-trade processes.

DLT market infrastructures

According to article 1 of the DLT Pilot Regulation, the regulation applies to "DLT market infrastructures". A DLT market infrastructure could either be a DLT multilateral trading facility (DLT MTF), a DLT settlement system (DLT SS) or a DLT trading and settlement system (DLT TSS) (Regulation 2022/858, 2022).

A multilateral trading facility (MTF) is a European trading venue with fewer restrictions and lower costs than a traditional stock exchange (Smith, 2021). A DLT MTF may only admit DLT financial instruments to trading, meaning instruments that are issued, recorded, transferred and stored using DLT (Regulation 2022/858, 2022). This probably shouldn't be interpreted as that a regular MTF can't innovate and start a DLT MTF, but rather that only the trading of DLT financial instruments will fall under the scope of this regulation.

A DLT SS is "a settlement system that settles transactions in DLT financial instruments against payment or delivery (…) and that allows the initial recording of DLT financial instruments or allows the provision of safekeeping services in relation to DLT financial instruments" (Regulation 2022/858, 2022). This is equivalent to the role of a CSD in today's system.

Interestingly, the regulation presents the possibility for a brand new participant in the world of financial trading. The DLT TSS is a single participant performing the activities of both a DLT MTF and a DLT SS (Regulation 2022/858, 2022). This is quite the radical change from the current set up of intermediaries in

financial trading (Göb, 2022). Through this DLT pilot regime, a single intermediary could successfully facilitate the whole life cycle of a trade. This would be a step towards the quite revolutionary merging of the trading and post-trading world. However, a DLT TSS would have to satisfy regulatory requirements applicable to both MTFs and CSDs, which could be a tough ask (Göb, 2022).

The regulation states that the possibility to create a DLT market infrastructure should not be exclusive to industry incumbents, but also available for new entrants (Regulation 2022/858, 2022). This is an exciting opportunity for new players to establish themselves using DLT. However, new entrants would still have to satisfy the current regulatory requirements applicable to an MTF and/or a CSD (Regulation 2022/858, 2022).

Exemptions from current legislation

The regulation states that a DLT MTF or TSS has to comply with The Markets in Financial Instruments Regulation (MiFIR) and The Markets in Financial Instruments Directive (MiFID 2), just like a regular MTF (Regulation 2022/858, 2022). Similarly, a DLT SS or TSS has to comply with CSDR and SFD (Regulation 2022/858, 2022).

However, the DLT market infrastructures can be granted exemptions from current regulatory requirements. For instance, a DLT SS or TSS can be exempted from the previously mentioned CSDR requirements to represent securities in book-entry form and to store them in a securities account (Regulation 2022/858, 2022). To be granted the exemptions, the DLT SS or TSS must show that these requirements are incompatible with the DLT used (Regulation 2022/858, 2022).

A DLT SS or TSS can be granted exemptions from several other CSDR and SFD requirements, and a DLT MTF or TSS can be granted exemptions from several requirements in MiFIR and MiFID 2. However, a common theme in all articles regarding exemptions is that they should not be granted without thorough

justification from the operator of the DLT market infrastructure (Regulation 2022/858, 2022).

Since operating a DLT market infrastructure could involve handling personal data, the GDPR is still very much relevant. There are no possibilities for exemptions from GDPR, which means that the right to erasure still has to be complied with (Regulation 2022/858, 2022). Thus, the issues with data immutability still persists.

DLT financial instruments

The regulation poses limitations on which instruments can be traded and stored on a DLT market infrastructure, as well as on their value (Regulation 2022/858, 2022). For instance, shares who's issuer has a market capitalization of more than €500 million and bonds with an issue size of more than €1 million are not applicable to be admitted to trading on a DLT market infrastructure (Regulation 2022/858, 2022). These limitations remove the most liquid securities from consideration, and this is important to mitigate financial stability risk, as the usage of DLT for securities trading and settlement is still in its beginning stages (Göb, 2022).

Impact of the regulation

As probably made clear by the word "pilot", the DLT Pilot Regulation is not a permanent one. Permissions to run a DLT market infrastructure are only valid for up to six years from when it is granted (Regulation 2022/858, 2022). Also, in 2026, The Commission and ESMA will assess whether or not the pilot regime was successful, and how the EU should move forward with it (Deloitte, 2022). It is important to finish the pilot phase at some point, to avoid a bifurcated market between DLT and the traditional system (Göb, 2022). European legislators also agree that having different sets of rules for DLT systems and traditional systems is not desirable in the long run (Deloitte, 2022).

Interestingly, the regulation focuses on innovation with DLT for MTFs and CSDs, but not for CCPs. This could be seen as a signal that CCPs are viewed as redundant in a future where DLT dominates the world of financial trading.

However, the regulation states that becoming a DLT market infrastructure is optional, and that CCPs (as well as market venues and CSDs) should feel free to experiment with DLT outside of the DLT Pilot Regulation (Regulation 2022/858, 2022). Of course, one would not be granted regulatory exemptions in that case. Still, it could very well be the view of the European legislators that the current legislation poses no limitations for the implementation of DLT by CCPs. Thus, there would be no need for CCPs to be included in the DLT Pilot Regulation.

It will be very interesting to see on what scale MTFs and CSDs will create DLT market infrastructures, and especially if DLT TSSs are crested. The requirements for DLT market infrastructures (of reporting, transparency, etc.) could be seen as quite strict, although reasonable to ensure financial stability and investor protection during the pilot regime (Göb, 2022) It could perhaps be the case that the work needed to satisfy the requirements in the regulation will outweigh the benefits of regulatory exemptions. In this case, it could be more attractive for MTFs and CSDs to innovate outside of the regulation.

Standardization, interoperability, collaboration and broad adoption

Standardization and interoperability between systems could play an important part in the possible implementation of DLT for securities clearing and settlement. A few years back, SWIFT (2016) raised concerns about the total lack of standardization in the DLT landscape. They raised the question of whether standardization should be required across all DLTs used, or if different, but interoperable, standards are acceptable (SWIFT, 2016).

They also raise concerns around the possibility of bifurcated markets, where some participants operate using DLT while others don't (SWIFT, 2016). They state that this could create a distorting of prices, due to varying settlement cycles (SWIFT, 2016). As discussed above, these bifurcated markets are not desirable from a legal perspective either. The European legislators' solution to this is the limited timeframe of the DLT Pilot regulation, so that a single legal framework can be created rather quickly if the regulation turns out to be successful (Deloitte, 2022).

Another concern raised by SWIFT (2016), is how messaging standards like ISO 20022 could be used with DLT. ISO 20022 is a payments messaging system that is well on its way to become the global standard between financial institutions (Murphy, 2022; SWIFT, 2016). Integration of this standard on DLT is also well underway through the "ISO 20022 protocol", which is important for DLT systems to ensure communication with banks worldwide (Lincoln, 2022). Several cryptocurrencies already use this protocol, and are therefore ISO 20022 compliant (Lincoln, 2022). This could be an important step on the road towards broad adoption of DLT.

Benos et al. (2017) raises an important point concerning collaboration in innovation. They state that single entities that innovate in something that later becomes a public good (like technological innovations often do), often bear the full costs of innovation without reaping the full rewards (Benos et al., 2017). Thus, they won't be incentivized to innovate on their own. Benos et al. (2017) concludes that innovations in DLT for securities clearing and settlement is best

achieved through collaboration from all participants in the industry. This is because such innovations are both radical (i.e., with potential for fundamental change) and systemic (i.e., affecting all participants in the system) (Benos et al., 2017).

Radical innovations for securities clearing and settlement has been slow moving due to a structural inertia in the industry (Benos et al., 2017). It has even been reported that banks will only invest in new technology if they gain back the cost of their investment within three years (Benos et al., 2017). The idea of an industry wide structural inertia is echoed by the employee of VPFF. In our interview, the employee (personal communication, April 2022) stated that participants in the Nordic trading markets are hesitant to innovate because the system today works well enough, and that a switch of technology is risky. In other words, there appears to be an "if it ain't broke, don't fix it" kind of attitude residing in the industry.

Nevertheless, innovations are occurring. An important part of the previously mentioned DLT systems Corda, Hyperledger Fabric and Quorum is that they are all open source blockchains. Open source software means that the code is available to be both used and modified by the public (Saltis, 2022). This means that corporations and developers all over the world can contribute to a continuous improvement of the system. The Hyperledger Foundation (2020) states that allowing for innovation through collaboration in an open source blockchain is the key behind the rapid evolution of Hyperledger Fabric. DTCC (2016) also encourage collaboration on DLT. They state there has been a "disorganized and almost chaotic market-driven rush to productize different ledger opportunities", and that while short-term financial gain may be motivating, a collective effort could prove much more beneficial (DTCC, 2016).

Open-source blockchains may provide an accelerated route to innovation, but the possibility for anyone to alter the code could be challenging from a security perspective. Due to the inertia in the industry, one could imagine a scenario where incumbents let others drive the innovation through open source blockchains, while they themselves stay away from the risk until the technology

is reliable enough for broad adoption. Such a scenario could present a free-rider problem, and also slow down innovation.

In our interview, the employee of Six x-clear (personal communication, May 2022) stated that the complexities of the current processes would make an implementation of DLT for securities clearing and settlement very difficult in practice. They also stated that collaboration between market participants, as well as an active role of legislators, would be crucial to achieve broad adoption.

Conclusion

Answer to Research Question

The aim of the research was to figure out how DLT can effectivise post-trade clearing and settlement, and what regulatory challenges arise. In conclusion, after a thorough review of relevant literature and interviews with persons in the industry, it is clear that DLT can bring a great amount of efficiency to the post-trade industry. It can remove costs and risk tied to reconciliation and the length of the settlement cycle, in addition to increasing security and transparency.

The concerns of privacy and confidentiality can, at least in part, be solved by adopting a private, permissioned and hierarchical DLT system, as opposed to the public systems used in Bitcoin and Ethereum.

The challenges that remain mainly relate to ensuring the required level of reliability to achieve financial stability and investor protection. This is challenging as the reliability of the current system is quite high, and participants are therefore reluctant to risking the implementation of DLT. Collaboration from all sorts of participants in the industry could speed up innovation, but inertia amongst participants still persist.

The level of centralization desired in the industry going forward is still uncertain. Centralized authorities play a big part in the industry today, but peer-to-peer systems that enable efficiency, privacy and scalability make the idea of decentralization seem less distant.

As for the regulatory challenges, the DLT Pilot Regulation from the EU allows for exemptions from certain regulatory requirements, in order to allow for innovation. The regulation enables the creation of a DLT Trading and Settlement System (DLT TSS), which is a very interesting concept. A DLT TSS performs both the trading and post-trade processes, which is a new role in the industry. However, strict requirements may prevent participants from creating DLT market infrastructures using the regulation. Another regulatory challenge, that

still remains, is the legal status of smart contracts. This status is still unclear and needs to be established.

Reflections

After concluding my research, I am left with a heightened understanding of a central conflict in the financial industry. The conflict being the one between efficiency on the one side, and financial stability and investor protection on the other. I feel that I possess a deeper understanding of both sides after writing this paper. On one hand, technology like DLT is so exciting, and the concept of using mathematically (almost) airtight solutions to achieve consensus without trust on a large scale is really quite astonishing.

On the other hand, a financial crisis (like the one in 2008) can cause severe damage to both businesses and people. Therefore, centralization and thorough regulation to ensure stability and protection is very important, even though the regulatory requirements may seem excessive at times. Nonetheless, I look forward to follow the evolution of the industry to see if technological solutions like DLT could prove reliable enough to enable decentralization.

Recommendations for Further Research

I hope my research has succeeded in providing readers with an understanding of the use of DLT for securities clearing and settlement, and its current position on the road to broad adoption. To further investigate on this, I recommend researching the following:

- The effects of the DLT Pilot Regulation. Did market participants actually create DLT market infrastructures, or did they innovate on their own? How does the new role of DLT TSS work in the market? Should the regulation be made permanent, modified or terminated?
- The replacement of CHESS by ASX. Is it successful? Will other participants follow their example?
- The optimal legal status of smart contracts

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