RISE
FINANCIAL

DVP on DLT

LINKING CASH AND SECURITIES FOR DELIVERY VS PAYMENT SETTLEMENT IN DISTRIBUTED LEDGER ARRANGEMENTS

Kathleen Tyson

Peter Jacaruso

Ruud Sleenhoff

Alexei Fedotov

RISE ThinkTank

March 2017

RISE FINANCIAL TECHNOLOGIES LTD
200 Aldersgate Street,
EC1A 4HD, London, UK

thinktank@rise-technologies.com
www.rise-technologies.com

Foreword

Dear Reader,

Distributed databases have been proven in production for many years. These are resistant to local operational failures, demonstrate impressive performance, and secure data via firewalls and centralised-key encryption. Distributed ledgers inspired by Bitcoin's blockchain are at a point now where performance levels can accommodate financial industry volumes, data is protected cryptographically, and the ledger has no single point of failure. Most importantly distributed ledgers can operate with improved trust and are more resistant to cyber attacks.

The word "distributed" also implies shared control of data and transaction access. This has profound implications for the post-trade securities industry. However, the transition to a distributed or decentralised solution to modernise centralised financial infrastructures must respect existing legal enforceability, regulatory obligations, common industry standards, and many other factors.

RISE develops distributed technology solutions for financial market infrastructures and regulated financial institutions such as central banks, exchanges, central securities depositories, custodians, and banks. Those firms must operate technology to the principles and regulations appropriate to their services. To successfully shift the industry into the distributed era, at RISE we provide a comprehensive solution that uses cutting-edge technology interoperating with client operations, governance, legal and regulatory status. Technology is core to our proposal, but is not sufficient by itself to ensure the success of our clients.

This paper is intended for non-technologists. It does not dive into the details of distributed ledger technology but assumes that we are well on the way to delivering a mature enough technology for usable solutions. It explores how cash and securities can be brought into a distributed ledger, how ownership can change via delivery versus payment settlement, and gives a steer toward planning for modernisations using distributed ledger technology.

We are grateful for the contributions of Kathleen Tyson from Granularity, Peter Jacaruso, and Ruud Sleenhoff from RISE's Advisory Board and RISE's post-trade team. Without claim to covering all aspects and scenarios, hope you find this useful and inspiring. We welcome all your questions and constructive feedback to further improve the views represented in this paper for the benefit of the wider post-trade industry.

Thorsten Peisl

Chief Executive, RISE Financial Technologies Ltd.

Contents

1 Introduction

Distributed Ledger Technology (DLT), also known as "blockchain", is redefining the interaction models between diverse market stakeholders. It has great potential to enhance the performance and security of today's highly centralised market infrastructure. The core proposition of DLT for securities custody and settlement is that investor ownership of assets and control of transactions across the settlement cycle can be securely and immutably recorded using a de-centralised ledger so that investors have better control and visibility of asset uses, rights, revenues, and transfers. This can reduce investor and intermediary risk of fraud, loss or abuse of trust.

In addition to changing the way securities can be owned and transferred, it is increasingly recognised that DLT can bring significant benefits to global capital markets operations by improving efficiency, security, transparency and resiliency. While the efficiency and risk management of centralised market operations have been greatly improved by collaboration as documented in the CPMI-IOSCO Principles for Financial Markets Infrastructures (PFMIs) [1], better fail and dispute management as well as risk management are still achievable through technology for secure de-centralised DLT custody and settlement. The BIS Committee on Payments and Market Infrastructures has recognised the potential of DLT to deliver better market infrastructures and has provided an analytical framework for supervisors evaluating DLT arrangements [2].

In this paper we aim to explain some of the benefits of DLT migration and the challenges that need to be overcome during the transition. We then show how existing securities and cash can be moved into DLT arrangements for delivery versus payment (DVP) transaction settlement. DVP is a fundamental requirement as it eliminates the principal risk that either counterparty to a trade or financing transaction could lose the full value of cash or securities while either leg of the trade or transaction remains unsettled. PFMI 12: Exchange-of-value settlement systems states that a Securities Settlement System "should eliminate principal risk by ensuring that final settlement of one obligation occurs if and only if the final settlement of the linked obligation also occurs, regardless of whether the system settles on a gross or net basis and when finality occurs". We provide models for meeting this obligation by interfacing legacy centralised securities settlement infrastructure with DLT platforms. The paper concludes with a set of recommendations for financial market infrastructures aimed at guiding a successful migration strategy.

2 Benefits and Challenges

2.1 Benefits

DLT potentially offers securities markets improvements equivalent to or greater than the innovations of book-entry settlement in the 1970s or multilateral netting in the 1980s. Despite huge improvements in recent decades, today's centralised and intermediated market operations still retain many shortcomings that investors and market participants aspire to overcome.

The principal weaknesses in centralised systems are reliance on "single point of failure" central processing infrastructure and the tiers of intermediaries for custody, settlements and payments (custodians and sub-custodians present complex risks to custody clients, see [3, 4]). When operational problems cause outages at payment systems or CSDs then all the markets and all investors with pending transactions are put at risk during the outage. Network dependencies mean outages in one system can communicate instability or liquidity problems to other systems. Systems complexity and evolving cyber threats make central infrastructure increasingly vulnerable. Likewise, tiered bank and custodian intermediaries create operations risk, custody risk and systemic risk for investors and counterparties.

The following points summarise some benefits we believe can be realised with DLT:

- **Optimised Settlement:** DVP settlement on de-centralised DLT platforms can be faster, with unconditional finality whenever counterparty exchanges of securities and cash are validated and recorded to distributed ledgers. Current centralised T+x Securities Settlement Systems can be integrated to DLT, but de-centralised settlements allow a wider range of dynamic settlement and transactional models to emerge.
- **Lower Custody Risk:** Securities custodians are generally banks. Cross-border holdings are typically tracked through chains of tiered sub-custodians. While client assets are generally segregated, clients are still exposed to leveraged institutions dependent on short-term finance and exposed to market risks. DLT can provide direct holding by investors, but even where assets continue to be held by intermediaries, DLT can make segregation more robust and verifiable to investors, auditors and supervisors.
- **Capital and Balance Sheet Efficiency:** Regulated investors and intermediaries are required to hold capital in respect of unsettled trade exposures, credit, repo and securities lending. Faster settlement, whether principal-to-principal or intermediated, will reduce the amount of regulatory capital required in the industry. Mark Carney, governor of the Bank of England and chair of the Financial Stability Board, has estimated the capital savings in the "tens of billions of dollars" [5]. In addition, innovative DLT transaction models may also yield balance sheet benefits for incumbent intermediaries.
- **Cost Efficiency:** A 2014 study by SWIFT and Oliver Wyman [6] estimated the global cost of clearing and settlement between $65 and $85 billion per year. DLT can transform and integrate trade documentation, transmission, confirmation and settlement to streamline back office processes and reduce reconciliation, fails

and exceptions management, compliance and reporting costs. Bank Santander has estimated industry-wide costs could be reduced by $15 to $20 billion by 2022 [7]. These cost advantages can potentially be achieved over time by initially improving interaction models between market players around settlement, reconciliation, or failure resolution, and eventually by rationalising market structure or promoting new business models.

- **Settlement Finality:** *Settlement Finality* is Principle 8 of the PFMIs and must be legally defined as a point in a process when a transaction settlement becomes unconditional and irrevocable. A blockchain can evidence "clear and certain final settlement" as an immutable cryptographically secured record of asset ownership with an auditable record of transfer, which can be legally recognised as "final settlement". The consensus algorithm for DVP on DLT must provide a credible method for ensuring a valid transaction will settle both legs irreversibly, a legally defined moment when the settlement becomes final, and a transparent record of the settlement [8]. Arguably for tiered custodian and sub-custodian chains, the finality of DLT settlement as a shared record may reduce financial and operational risks relative to current practices of periodically updating diverse data records.
- **Transparency and Confidentiality:** Distributed ledgers designed for post-trade operations must and can protect confidential data of individual investors and individual transactions while at the same time offering more flexible ways to aggregate and publish data in a controlled way to market participants, issuers, markets, supervisors and other stakeholders.
- **Reconciliation and Audit Trail:** DLT can immutably record all transactions, actions and state changes, and therefore can improve trust and efficiency for financial institution interactions. Documentation, compliance, reconciliation, fails management, and data distribution to diverse parties over multiple systems impose huge costs and complexity on markets. Controlled sharing of DLT records can rationalise industry processes and bring better accuracy and traceability, for example, promoting more efficient fails management.
- **Default Resolution:** DLT can record investor ownership or entitlement immutably and transparently. Assets in client accounts can be more easily verified by insolvency practitioners. It may become simpler and faster to resolve an insolvent intermediary with lower client losses and less systemic contagion to counterparties[1]. These benefits can be realised when client asset segregation and beneficial ownership are recorded inside the DLT.
- **Security and Systemic Resiliency:** No single record can be altered on a DLT network without detection, a feature which will prevent fraud, misappropriation and abuse. The risk of a central point of failure is reduced; DLT networks can continue to operate despite some entities being affected by outages. DLT networks are expected to be more resistant to fraud and cyber attacks.

[1]Clients in many jurisdictions have no right to portability or return of margin and custody assets in an intermediary insolvency, retaining only a financial claim on the bankruptcy estate. Even where margin and custody assets are recognised as beneficially owned by clients it may be months or years before they are restored to client control as insolvency practitioners will need to determine proprietary and client claims, reconcile balances with CSDs, custodians and banks, and apportion any shortfalls equitably among like claimants.

2.2 Challenges

Industry experts have identified the following challenges for the implementation of DLT in financial markets:

- **Legal Certainty:** *Legal Certainty* is Principle 1 of the PFMIs. Modernisation of securities laws and regulations in the 1990s looked to the law of the single jurisdiction governing a depository or intermediary. Because records are replicated to multiple nodes on a DLT network, legal and regulatory regimes in some jurisdictions may require modernisation to recognise tokenised cash and securities on DLT platforms as equivalent to cash and securities in book-entry depository or custody accounts. The model of elective situs and jurisdiction long respected in English common law and provided in the 2006 Hague Convention on Securities[2] may offer a useful framework for legal certainty of DLT networks. There may be conflicts of law internationally while the nature and situs of DLT assets and regulation and jurisdiction remain contested, but global cooperation toward common principles and best practice will ease legal risks over time. Similarly, finality of settlement, always a legally defined determination, will need to be reviewed for DLT operations for each network. To avoid uncertainly, DLT solutions can be architected in a closed permissioned way to respect local legal finality and enforceability requirements (e.g., Canadian law clearly governs the Bank of Canada auxiliary DLT as all nodes are in Canada).
- **Compliance:** Securities issuance, intermediation, investment management, clearing, payments and settlement are all heavily regulated. Any new DLT securities settlement or custody platform must meet existing standards for Payment Systems, Securities Settlement Systems and CSDs, and demonstrate substantial compliance with relevant PFMIs. While peer-to-peer networks are technically possible using DLT solutions, the ECB has asserted a financial stability interest in ensuring the integrity of securities issuance and settlement that makes a peer-to-peer network for securities origination and settlement unlikely, and ESMA has indicated it has supervisory interests in the use of DLT [9, 10]. Know-your-customer (KYC), data residency and protection, and anti-money-laundering/counter-terrorism-finance (AML-CTF) regulations must also be respected by any payments or securities settlement arrangement. As a result, DLT must be architected so that it can be compliant with today's regulatory and supervision frameworks.
- **Standardisation:** DLT arrangements will need to interface to Payment Systems, Securities Settlement Systems and CSDs to ensure issued or immobilised cash and securities are exactly mirrored in the DLT arrangement as tokens, especially during a transition period when assets are not originated on the DLT. In a similar way, assets transferred or earmarked on the DLT platform for specific use outside the DLT platform (e.g. collateral, margin, etc.) will need to be reconciled with external claims and operations. DLT implementations need to fully support standardised transition interfaces. Over time interoperability concepts between DLT and legacy environments can also inspire the interoperability between industry focused DLT providers.

[2] See *Convention on the Law Applicable to Certain Rights in Respect of Securities Held with an Intermediary*, Hague Conference on Private International Law (5 July, 2006), https://assets.hcch.net/docs/3afb8418-7eb7-4a0c-af85-c4f35995bb8a.pdf.

- **Interoperability:** DLT assets can either be originated native to the DLT (e.g., Bitcoin) or be tokenised as digital mirrors of immobilised book-entry cash or securities existing external to the DLT system (e.g., Canadian dollar tokens on the Bank of Canada auxiliary DLT network). Immobilisation of assets for DLT tokenisation would parallel the immobilisation of securities certificates to create book-entry securities during the transition to dematerialisation. Rules for segregation and enforceable legal claims to immobilised external assets must be mapped to DLT processes and tokens. Originated assets also need to be recognisable on legacy systems infrastructure.
- **Dispute Resolution:** Once validated and recorded, DLT transactions are immutable. An industry appropriate DLT protocol should not allow a settled transaction to be modified, cancelled or revoked. From a governance perspective, however, securities market participants and supervisors recognise a need for recourse, rules and dispute resolution to address obvious errors, misconduct or unforeseen events. If an external procedure determines a claim is justified, then a new transaction can be instructed to correct the ledger. As such, dispute resolution can be improved by immutable records and asset-linked audit trails in DLT.
- **Governance:** DLTs can deliver benefits over legacy environments by defining and enforcing access among multiple permissioned legal entities. As a result a strong governance model is required, e.g. to manage permissions and the technical evolution of the DLT system. This governance can initially be offered by DLT providers and eventually by existing or new governance bodies, or by mandated central entities such as CSDs.
- **Scalability, Confidentiality, and Reliability:** While reliability and high resistance to central cyber attacks are inherent systemic features of DLT, scalability over time and data confidentiality need to be addressed at the foundational system design to be delivered in high-performance operations. These technical aspects are not discussed in detail in this paper but are addressed in solutions under development.

3 Migrating to DVP on DLT platforms

Despite the challenges, we believe the technology for DLT has matured to the point where PFMI-compliant DVP settlement can be achieved. More than that, we believe the benefits justify the early integration of DLT with existing market infrastructures. This section reviews models for DVP on DLT that can be considered during a transition and in a new target state.

3.1 Assumptions

We start by making some assumptions about DLT architecture for securities settlement and custody that are compatible with industry best practice and regulation. A common framework based on agreed principles can promote wider and more rapid acceptance:

- **Mature Technology:** DLT has been developed and matured specifically with financial industry requirements in mind that meet supervisor and market expectations of performance, security, integrity, compliance, and resiliency and reliably meet stakeholder needs.
- **Permissioned Operators:** Consistent with regulation and best practice, operation of DLT platforms for securities settlement and custody will be limited to regulated financial institutions which reuse their existing licenses, governance models, and legal frameworks and are capable of reliably performing required operations, risk management, KYC and AML-CTF checks before transactions are instructed for settlement.
- **Governance Framework:** DLT is being operated under a well-defined governance framework that is being managed by a defined institutional structure. The framework addresses permissioning, DLT standard evolution, DLT parameterisation.
- **Technology Integration:** DLT will be interfaced with legacy book-entry payment and settlement systems during a transition period in order to bring non-native assets into DLT. Incumbent FMIs who operate DLT arrangements will also need to integrate DLT records into their upstream systems such as accounting, record keeping, risk management, and investment compliance systems.
- **Participant Confidentiality:** Investors and issuers will be qualified and permissioned by financial market infrastructures and visible to supervisors. Individual transaction records can be kept confidential to preserve market sensitive insights, client trading strategies and portfolio holdings[3].

3.2 Creating and Redeeming DLT Securities and Cash

Securities and cash exist today as primarily book-entry assets on bank and custodian ledgers. Investors have credit claims to deposited cash in banks and beneficial ownership of custody securities. Specie currency and certificated securities are no longer used in modern Securities Settlement Systems, having gradually given way to

[3]Bitcoin and some DLTs are open to public participation by anonymised participants and protect integrity with consensus algorithms and validation protocols, but such networks would be unacceptable in regulated financial markets.

book-entry accounts as depositors and investors gained confidence in banks and dematerialisation. The shift to DLT assets can be gradual too, as investors and intermediaries adapt, with interfaces operating between DLT and book-entry legacy systems during a transition period.

Settlement today requires interaction between book-entry accounts for payment and a CSD for securities transfer through the institutional arrangements of a Securities Settlement System. Payment funds can be either central bank money (CeBM) or commercial bank/ICSD money (CoBM). *Principle 9: Money settlements* of the PFMIs states that settlements by a Securities Settlement System should be in CeBM "where practical and available" and otherwise "should strictly control the credit and liquidity risk of using commercial bank money". Where CoBM is used Securities Settlement Systems can mitigate risks by having special-purpose banking licenses, strict controls on credit risk, netting to reduce liquidity risk, multiple CoBM settlement banks, and pre-funding of cash settlement balances[4]. DLT settlement platforms can be interfaced and adapted to accommodate either CeBM or CoBM payments, whichever is used for securities settlement. Integration and migration of securities custody and settlement requires an interface between the book-entry CSD and DLT arrangements, paralleling the co-existence of certificates and book-entry securities during dematerialisation a generation ago, the early architecture of T2S, or the Euroclear-Clearstream "bridge" framework[5]. Tokens represent units of assets in the DLT arrangement. Converting external book-entry cash (CoBM or CeBM) and securities into DLT tokens will require the steps of immobilisation and tokenisation. Operators of Payment Systems and CSDs will immobilise assets by crediting them to a DLT Immobilisation Account. The DLT Immobilisation Account is an omnibus account that holds no record of underlying ownership or interests. Assets in the DLT Immobilisation Account are then tokenised and transferred to DLT Investor Accounts. Ownership and other interests will be recorded on the DLT ledger accordingly. Non-native tokenised assets must always reconcile to immobilised assets to promote confidence in DLT settlements, just as assets recorded in book-entry securities accounts needed to reconcile with immobilised physical certificates in vaults during dematerialisation.

Participants who wish to hold or transfer securities and cash in the DLT arrangement will send book-entry cash and securities to the DLT Immobilisation Account identifying the DLT account to be credited with equivalent tokens. An interface will instruct the creation of tokens for equivalent units of cash or securities in the DLT arrangement and transfer these tokens to the DLT participant account as instructed. The creation of tokens and the transfer to the depositing participant will be final when recorded to the DLT ledger. Participants can then hold and transfer the tokens indefinitely in the

[4]Both Euroclear and Clearstream, the two International Central Securities Depositories (ICSD), are special-purpose banks with restricted business scope to reduce the commercial bank risk they pose for custody and settlement participants. Where practical the ICSDs themselves settle transactions in central bank money. All lending to fund settlement liquidity is fully collateralised by securities held in ICSD custody so that the ICSD is not exposed to credit risk. Additionally both Belgian and Luxembourg law provide a right of revindication to custody clients of the ICSDs so that custody assets are insolvency remote and can be reclaimed by custody account holders in the unlikely event of ICSD failure.

[5]During dematerialisation non-fungible certificated securities were delivered to and physically immobilised in vaults in depositories and then equivalent fungible book-entry securities were credited to CSD securities accounts. The first T2S system interfaced remote central banks which immobilised securities that T2S tokenised and used for settlement to internal accounts. The Euroclear-Clearstream "bridge" framework has each ICSD immobilise securities in an omnibus account for the other ICSD which can then transfer entitlement to securities internally to account holders.

DLT arrangement without any centralised processing or operations[6]. In addition, once the DLT ledger is updated with the record of credit to Investor Accounts, receiving participants can use or transfer the tokens freely thereafter.

When a participant wants to redeem tokenised units of cash or securities from a DLT account, the process is reversed. Participants send the tokens for de-tokenisation with instructions for external credit or delivery of cash or securities. When received, the interface simultaneously cancels the tokens in the DLT arrangement and instructs a transfer of equivalent cash or securities from the DLT Immobilisation Account to an external account in the legacy book-entry payment or custody system.

3.2.1 Book-entry Securities in DLT

Figure 1 shows tokenisation of legacy book-entry securities. A depositor instructs his broker or bank custodian to move 100 bonds to the DLT Immobilisation Account so that he can evidence ownership and use the bonds as tokens in the DLT arrangement. Within the CSD or ICSD's platform the bonds move from the bank or broker's account to the DLT Immobilisation Account. An interface then instructs creation of DLT tokens for the bonds in the Issuance Account for onward credit to the Investor Account. The holder of the Investor Account can then engage in market operations to exchange or move the asset to other Investor Accounts.

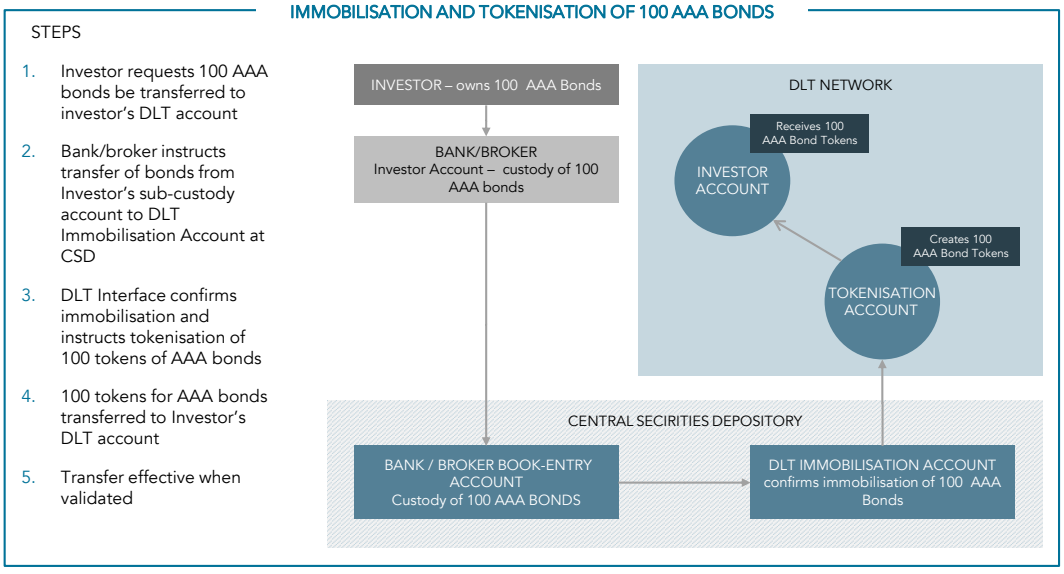

Figure 1

Interfaces to the DLT platform can be configured for multiple market infrastructures. It is a matter for each Securities Settlement System, its central banks and its supervisors how the DLT interfaces to legacy payment and custody systems are configured, but project planning should evaluate how lower risk and operational efficiency can be realised with DLT solutions.

[6] A similar design is being conceptually evaluated by Deutsche Boerse Group. A DLT platform will be interfaced to a segregated account holding collateral. The value of the collateral will be credited to DLT accounts of participants as tokenised coloured coins. Participants can transfer the coins among themselves. When a coin is transferred to another participant in the DLT ledger it will transfer entitlement to equivalent collateral in the segregated account. The structure reduces the risks of using Commercial Bank Money in DLT as the collateral diminishes credit risk. See *Deutsche Boerse presents blockchain concept for risk free cash transfer*, Deutsche Boerse Group (23 January, 2017), http://deutsche-boerse.com/dbg-en/media-relations/press-releases/Deutsche-Boerse-presents-blockchain-concept-for-risk-free-cash-transfer/2883236

3.2.2 CeBM in DLT

Figure 2 shows tokenisation of CeBM. A depositor requests his bank to move funds from a deposit account to his DLT Investor Account so that he can use the funds as cash tokens in the DLT arrangement. The bank makes funds availability, KYC and AML-CTF checks, and then sends a payment instruction to the central bank RTGS system for transfer to the DLT Immobilisation Account for the benefit of the customer's DLT Investor Account. Within the central bank's RTGS platform the funds move from the bank's reserve account to the DLT Immobilisation Account. An interface then instructs creation of cash tokens in the Issuance Account for credit to the depositor's account. For various reasons other models may also be configured to meet individual operations requirements. In any case, once the DLT ledger is updated, the customer holding the Investor Account can use or transfer the cash tokens in the DLT arrangement.

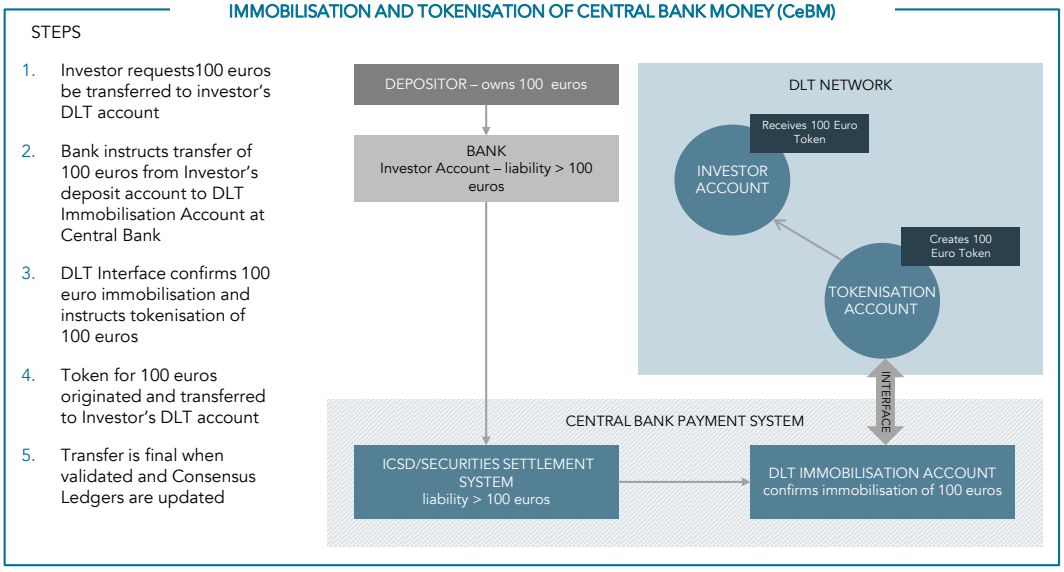

Figure 2

A similar system for interfacing DLT and RTGS is already being tested at the Bank of Canada to provide auxiliary overnight DLT payment operations[7]. When the RTGS closes at each end-of-day, cash balances in Canadian dollar reserve accounts are immobilised and credited as cash tokens to clearing bank participant accounts on a closed DLT network. Banks can then transfer their Canadian dollar tokens freely during the night (no credit or overdrafts) with transfers recorded in near real-time on the DLT ledger. Because initial DLT balances exactly mirror immobilised RTGS reserve balances, the money transferred thereafter in the DLT arrangement is as good as central bank funds. Before the book-entry RTGS reopens for business all tokens in the DLT network are redeemed to update reserve account balances in the RTGS. UBS and partner banks have proposed a more ambitious solution; a multi-currency "Utility Settlement Coin", which would immobilise and tokenise reserve balances at several major currency central banks[8].

[7] See *Bank of Canada Demos Blockchain-Based Digital Dollar*, Coindesk (16 June, 2016), http://www.coindesk.com/bank-canada-demos-blockchain-based-digital-dollar/.

[8] J. Kelly, UBS leads team of banks working on blockchain settlement system, Reuters (24 August, 2016), http://uk.reuters.com/article/us-banks-blockchain-ubs-idUKKCN10Z147

3.2.3 CoBM in DLT

CoBM is often used for securities settlements as it has lower operational and liquidity management demands, but CoBM is a contractual claim or bank liability with credit risk on the commercial bank. CoBM credit risk may be mitigated by legal segregation of cash or collateral or insolvency remoteness in law for the immobilised cash assets and/or collateral in DLT arrangements, but that is out of scope of this paper.

As Fig. 3 shows, technically there is no difference between CoBM or CeBM. Therefore, market participants can consider starting operations with a CoBM model and later introduce CeBM, without changing the underlying technology platform.

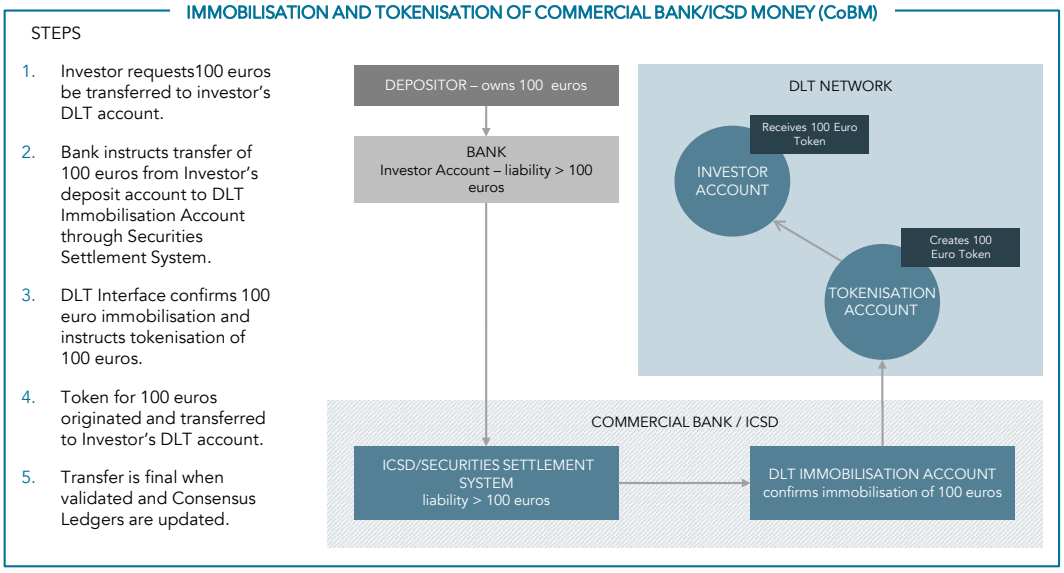

Figure 3

Each Securities Settlement System will have to model its DLT interfaces to its existing CSDs and Payment Systems. The important principle to bear in mind is that this technical challenge is nothing new, is presented by any systems modernisation, and that the interfaces should operate to promote flexible access in either direction for efficient systemic liquidity and risk management.

When cash and securities are exchanged with finality it has positive regulatory capital and risk management impact for regulated institutional investors and intermediaries. Regulated institutions have a strong interest in improving processes for faster and more transparent finality. Flexible tokenisation and de-tokenisation will promote a flow of settlement transactions towards more efficient operations and settlement behaviour. Giving a choice of DLT or legacy settlement will empower market participants to exercise better control over risks and cost and promote more efficient liquidity, balance sheet and capital models.

3.3 Modelling DVP on DLT and Settlement Interfaces

There are three basic models for DVP settlement identified and described in the 1992 paper from the BIS on "Delivery versus payment in securities settlement systems" (see [11], page 16):

- **Simultaneous Gross-Gross Settlement (Model 1):** Transactions settle on an unconditional gross-gross basis such that delivery of securities is instantaneous with payment of the paired cash obligation for each transaction throughout the business day as securities and cash become available within the system; unsettled transactions recycle on a queue until close of business. All transactions are unconditionally final when settled. Settlement is usually T+1 but can be T+0 for repos and other liquidity facilitating transactions.
- **Periodic Gross-Net Settlement (Model 2):** A clearing process evaluates all transactions in a batch (usually daily) and determines the gross securities for delivery and the net cash for payment on T+x. All participants must position the gross deliverable securities and short participants must post net cash in accounts by the cut-off time on T+x. After the cut-off time, a settlement cycle processes all available securities and cash against pending transactions and satisfies as many pending transactions as possible. Any shortage of delivered securities or cash will cause fails traceable to individual transactions. Finality is determined by the Securities Settlement System at the end of the settlement processing cycle when it confirms gross securities debits and credits and net payment debits and credits to participant accounts.
- **Periodic Net-Net Settlement (Model 3):** A clearing process evaluates all transactions in a batch (usually daily) and determines the net securities for delivery and the net cash for payment on T+x for each participant account. Short participants must position the net securities and net cash by the cut-off time on T+x. After the cut-off time, a settlement cycle processes all available securities and cash against pending transactions and satisfies as many pending transactions as possible. Fails are not traceable to individual transactions in the central system but require reconciliation to resolve. Finality is determined by the Securities Settlement System at the end of the settlement processing cycle when it confirms net securities debits and credits and net payment debits and credits to participant accounts.

These DVP models were created under a conception of centralised processing by infrastructure with a limited set of direct participants and all others participating through chains of tiered intermediation. Another conception of DVP may be appropriate for a technology where investors and market intermediaries can all either participate directly or where ledgers can be shared instantaneously to all stakeholders in a transaction settlement. New models of investor and intermediary engagement can evolve as DLT technology matures and improves.

It is fundamental principle that distributed or decentralised and processing of bilateral DVP on DLT can happen, and can only happen, when both cash and securities are available for simultaneous exchange between buyer and seller accounts. DLT account holders can make a DVP settlement happen in near real-time, or at any other agreed interval, potentially without intermediation and without centralised infrastructure.

DLT account holders need to agree on the proposed exchange, a step that equals matching in today's legacy environment, and then pre-position assets for exchange before final settlement can occur. During the settlement process a number of validation checks need to be performed while protecting confidentially of counterparties and potentially of their representative intermediaries. Transaction level checks that need to be performed include enforcing systemic integrity and KYC and AML-CTF compliance. Local markets may impose additional compliance checks on transactions, such as sanctions controls. When transactions are validated by consensus the DLT is updated with immutable shared records documenting simultaneous exchange of cash tokens and securities tokens between investor accounts.

Therefore, DVP settlement between bilateral counterparties can be conducted without intermediation if so desired or at faster or more frequent intervals than T+x, and can reduce operational dependency on centralised infrastructure while interfacing with Immobilisation Accounts operated by CSDs or settlement banks. Multiple CSDs and multiple settlement banks, both for CoBM and CeBM, can all be linked to a common DLT platform to provide flexible immobilisation, tokenisation and de-tokenisation to DLT account holders. DLT settlement can operate in parallel to today's centralised infrastructure, offering scope for smart(er) liquidity and securities finance solutions to evolve. Cross-border settlement, cross-asset liquidity and securities finance today is complicated by diverse time zones, local cut-off times and local processing. If assets are held on a connected multi-asset, multi-currency DLT permissioned networks, then asset transfers can be rationalised to improve global settlement certainty and market liquidity.

Intermediaries, CCPs and Securities Settlement Systems could also initiate settlements in a DLT arrangement with appropriate permissioning to allow legacy Model 2 or Model 3 systems to operate in parallel with the gross-gross DLT arrangement. While all transfers recorded in the DLT must be gross-gross transfers, an external CCP or SSS could initiate settlements with the permission of investors or intermediaries to clear transactions and net settlement funding or securities provision as required for external settlements. An interface between the Securities Settlement System and the DLT platform would promote efficient movement of cash and securities in and out of DLT accounts.

Different market infrastructures with different ambitions for their participants will specify different requirements from DLT as they do in specifying legacy technology. What is important to establish now is that DLT can expand the functionality and reduce the risks of securities settlements either as an adjunct to existing legacy platforms or as an alternative gross-gross settlement environment.

4 Recommendations

This paper has shown models describing how cash and securities can be brought into DLT arrangement so that PFMI-compliant settlement is possible today using DLT platforms, which interoperate with existing Payment Systems and Securities Settlement Systems. The transition will be eased if these infrastructures begin their planning now and collaborate on some basic principles. Changes in financial markets infrastructure are rarely rapid or uncontroversial, so starting now with a collaborative approach will reduce project risks and lead to more realised long-term benefits.

To guide this process we offer the following recommendations:

- Collaborate with issuers, investors, banks, custodians and intermediaries to identify assets and transactions that are suitable for early adoption of a smaller scale DLT implementation. This will keep the project manageable and faster results can then be demonstrated.
- While DLT securities origination and settlement may represent the ultimate target model, initially consider the design of easy tokenisation and de-tokenisation interfaces between legacy and DLT arrangements to promote overall systemic liquidity and operational efficiency during a transition phase.
- Develop a roadmap on how the initial DLT implementation should evolve over time to gradually increase the value proposition. This includes the potential evolution from an asset immobilisation to an origination model, extension to other asset/investor base, or the development of new services.
- Agree the initial system governance model, rules with and permissions with all stakeholders; the governance model can evolve over time based on reallocating permissions enabling a recalibration of the industry value chain and without replacing the underlying DLT platform.
- Finally, at any time, respect existing common industry technical standards and business rules to promote harmonisation, standardisation and interoperability of DLT solutions.

The most successful projects will probably start with a small core group of pioneers and target a limited scope, perhaps simple, less regulated securities with low trade volumes, poor liquidity, and higher settlement or issuance costs. Once initial benefits are realised, business models can evolve, and the scope can incrementally expand to embrace more participants and asset classes.

RISE is proud to be a part of an exciting and promising transition to DLT networks. RISE provides the crucial business and technology expertise as a solution provider to ease the progress of market infrastructures as they progress along their individual roadmaps at their own pace. This holistic offering is fundamental for successful deployment of initial DLT infrastructures and successful transition to decentralised infrastructures.

Feel free to contact us with questions, projects or ideas as well as suggestion to improve the view in this paper for the benefit of the wider post-trade sector.

Glossary

Batch settlement	The settlement of groups of payments, transfer instructions, or other obligations together at one or more discrete, often pre-specified, times during the processing day.
Beneficial owner	A person or entity that is entitled to receive some or all of the rights deriving from ownership of a security or financial instrument (for example, income, voting rights and power to transfer) as a result of a contractual claim when legal ownership is vested in an intermediary.
Book-entry	The transfer of securities and other financial assets which does not involve the physical movement of paper documents or certificates (for example, electronic transfer of securities between CSD or Payment System accounts).
Business continuity	A state of uninterrupted business operations. The term also refers to all organisational, technical and staffing measures used to ensure the continuation of operations following a disruption to a service, including in the event of a wide-scale or major disruption.
Central bank money (CeBM)	A liability of a central bank in the form of deposits held at the central bank which can be used for settlement purposes. Central bank money is preferred for systemically important settlement systems.
Central securities depository (CSD)	An entity that provides securities accounts, central safekeeping services, and asset services, which may include the administration of corporate actions and redemptions, and plays an important role in helping to ensure the integrity of securities issues (that is, ensure that securities are not accidentally or fraudulently created or destroyed or their details changed).
Collateral	An asset or third-party commitment that is used by a collateral provider to secure an obligation vis-à-vis a collateral taker.
Commercial bank money (CoBM)	A liability of a commercial bank or special purpose bank (e.g. International Central Securities Depository) in the form of deposits which can be used for settlement purposes. The risks of Commercial Bank Money depend on the nature, constitution and business model of the bank holding deposits, and on relevant governing law and supervision.
Consensus algorithm	The fixed and collectively governed rules agreed by a DLT network of stakeholders for processing, validating and recording DLT asset ownership, transfers and interests on a distributed ledger. The consensus algorithm ensures DLT assets cannot be altered or misrepresented to dilute investor claims.

Custody risk	The risk of loss on assets held in custody in the event of a custodian's or sub-custodian's insolvency, negligence, fraud, poor administration, or inadequate recordkeeping.
Delivery versus payment (DVP)	A securities settlement methodology that links a securities transfer and a funds transfer in such a way as to ensure that delivery occurs if and only if the corresponding payment occurs.
Dematerialisation	The elimination of physical certificates or documents of title that represent ownership of securities so that securities exist only as book- entry accounting records.
De-tokenisation	The process of redeeming tokenised assets for equivalent immobilised securities or cash in a DLT Immobilisation Account in accordance with the instructions of a participant holding the tokenised asset. The tokenised asset is then debited/cancelled in the DLT arrangement simultaneous with the transfer of the immobilised assets by means of an interface.
Distributed ledger technology (DLT)	A network, methodology and consensus protocol that enables the creation and transfer of tokenised assets using a blockchain-inspired database technology.
DLT arrangement	Any DLT-based implementation, embracing both technical design and institutional structure, whether a standalone system, platform interoperating with legacy infrastructure, or a layer providing interconnectivity between systems.
DLT Immobilisation Account	A special-purpose account with a book-entry Payment System (central bank money) or bank (commercial bank money) or CSD for the purpose of interfacing with a DLT arrangement to tokenise and redeem cash and securities.
Final settlement or finality	Irrevocable and unconditional transfer of securities against cash, or the discharge of an obligation by a securities settlement system or its participants, in accordance with the terms of a trade or underlying transaction. Final settlement is a legally defined moment in Securities Settlement Systems.
Immobilisation	The act of concentrating the location of securities in a depository or sub-depository so that ownership can be transferred thereafter by book-entry records.
Immutability	A property of distributed ledgers such that there can be no alteration, modification or unwind as provided in the consensus algorithm. Like finality for book-entry settlement and non-repudiation for electronic messaging, immutability can enhance investor confidence in DLT records of transactions.
Issuance account	A special purpose interface account in a DLT arrangement for creating tokenised assets received in a book-entry Immobilisation Account for onward credit to Investor Accounts.
ICSD	A multi-currency, multi-asset International Central Securities Depository for cross-border securities settlements at the centre of a diverse tiered custody and payments network (e.g., Euroclear and Clearstream).

Legal risk	The risk of an unexpected assertion of legal or regulatory jurisdiction, application of law or regulation, usually resulting in a financial loss or reputational damage.
Liquidity risk	The risk that a counterparty, whether a participant or other entity, will have insufficient assets to meet its obligations as and when expected, although it may be able to do so in future.
Netting	The offsetting of obligations between or among participants in the netting arrangement, thereby reducing the number and value of payments or deliveries needed to settle a set of transactions.
Operational risk	The risk that deficiencies in information systems or internal processes, human errors, management failures, or disruptions from external events will result in the reduction, deterioration, or breakdown of services provided by financial market infrastructures.
Payment system	A set of instruments, procedures, and rules for the transfer of funds between or among participants; the system includes the participants and the entity operating the arrangement.
Permissioning	A methodology and rules for defining which roles or functions participants on a DLT network can perform so that the consensus algorithm or protocol is enforced. Permissioning restricts who can have access and propose transaction updates on the ledger, and read encrypted information stored in the ledger.
Portability	The operational aspects of the transfer of custody or client positions, funds or securities from one party to another party, usually in the context of the insolvency of the first party, in order to prevent contagious loss and illiquidity.
Principal risk	The risk that a counterparty will lose the full value involved in a transaction, for example, the risk that a seller of a financial asset will irrevocably deliver the asset, but not receive payment.
Real-time gross settlement	The real-time settlement of payments, transfer instructions, or other obligations individually on a transaction-by-transaction basis.
Reconciliation	A procedure to verify that two or more sets of records issued by different entities match.
Securities settlement system	An entity that enables securities to be transferred and settled by book- entry according to a set of predetermined multilateral rules. Such systems allow transfers either free of payment or against payment.
Segregation	A method of protecting customer collateral and contractual assets or positions by holding or accounting for them separately from assets or positions of a direct participant.
Settlement	The completion of a transaction such that the seller transfers securities to the buyer and the buyer transfers funds to the seller.

Settlement bank	A financial institution holding cash accounts for a Securities Settlement System or CCP. There may be multiple settlement banks.
Settlement risk	The general term used to designate the risk that settlement in a funds or securities transfer system will not take place as expected or contracted. This risk may comprise counterparty risk (risk the counterparty operationally or financially unable to settle when due), credit risk (risk of loss of permanent loss of value) and liquidity risk (risk of illiquidity contagion as undelivered funds or assets communicate a shortfall to the expecting participant).
Situs	The location attributed to an asset or property interest for determining legal ownership, rights, interests and judicial enforcement.
Smart Contract	Technology or code-based protocols that facilitate, enhance or enforce the execution of a contract or trade to automate transaction agreement, confirmation, execution and fulfilment by the relevant parties.
Systemic risk	The risk that the inability of one or more participants to perform as expected will cause other participants to be unable to meet their obligations when due.
Token	An asset originated in a DLT and transferred to a participant account which represents a cash or securities claim. The account holder is entitled to use the token, transfer the token, and receive any income from the cash or securities it represents until it is transferred to another DLT network participant, matures or is de-tokenised by redemption against immobilised assets. Each token has a unique address; an account holder gives access to a public key that has the address.
Tokenisation	The creation of a token representing a claim to or proprietary interest in an immobilised asset (whether securities or cash) which originated or issued outside a DLT platform. Tokens may be de-tokenised by cancellation in the DLT arrangement and redemption of equivalent assets from the DLT Immobilisation Account.
Validation	The process by which participants on a network check that a proposed update to the ledger complies with the consensus algorithm. At RISE, validation can be used to ensure regulatory compliance by confirming counterparties are Qualified Investors (e.g., regulated entities and not on KYC or AML-CTF blacklists), are within acceptable geographic jurisdictions (e.g., jurisdictions providing acceptable legal certainty and sanctions enforcement clearance) before a transaction update is immutably recorded to the ledger.

About the Authors

KATHLEEN TYSON, CEO Granularity Ltd and Advisory Board, RISE Financial Technologies Ltd

A widely experienced market infrastructure consultant and serial innovator who started her career in the Federal Reserve Bank of New York and supervised UK dematerialisation and international securities infrastructure at the UK Securities and Investments Board. She innovated tri-party repo, global cross-border margining, and off-shore clearing of US Treasuries at Clearstream before founding her consultancy. She was domain expert on the legal and operational solutions for CLS Bank and has contributed to many other projects for design, modernisation and improvement of financial market infrastructures.

PETER JACARUSO, Advisory Board, RISE Financial Technologies Ltd

An experienced product creator in the financial services arena who is passionate about bringing new capabilities to the financial market. He has more than twenty-five years of experience in the financial services industry, using his background in finance, technology, and accounting to design, develop and launch new products. Those new products were tightly tied to four major themes; identifying new sources of value, handling increased business complexity, strengthening risk management and leveraging new technology to innovate. Peter is the former Head of Product Development at State Street (Global Services) and Deutsche Bank (Transaction Banking).

RUUD SLEENHOFF, Advisory Board, RISE Financial Technologies Ltd

Ruud has a broad and in-depth knowledge and experience in the financial markets and transaction banking industry. His focus is now on the application of Distributed Ledger Technology in the securities Post-Trade area. In his last, full-time professional position he was Head of the Industry Engagement Team of the Royal Bank of Scotland, responsible for leveraging the position of the bank in the Payments and Financial Markets industry, ensuring awareness of upcoming developments for the bank. Before that, Ruud worked for ABN AMRO Bank as the Head of Market Infrastructures and as Head of Business Management Domestic Custody & Securities Clearing. Ruud represented the bank on selected number of industry influencing bodies and working groups at SWIFT, the European Payments Council (EPC) and the European banking Federation (EBF). On behalf of the EBF he participated in the TARGET2 Advisory Group.

ALEXEI FEDOTOV, Head of Business Development for RUK, RISE Financial Technologies Ltd

Alexei joined RISE in August 2016 and brought with him 25 years of experience in the international Banking/Investment industry. His areas of expertise include Custodial Services, Agency and Trust, Depository Receipts. Alexei worked 11 years for Citibank in the role of Securities and Funds Services Head of RUK region. Prior to Citibank Alexei managed ABN AMRO's custody business in Russia for more than 9 years. In early 90s Alexei worked for a number of USAID Capital Markets projects in Russia and Ukraine which have established the basis for market infrastructure in two countries. Alexei has graduated from Moscow Technical University of Radio-technics, Electronics and Automation, Cybernetics department.

About Granularity

Granularity Ltd is a specialist consultancy that advises financial market infrastructures, IT companies, central banks and supervisors on the design, modernisation, procurement and supervision of complex cross-border and multi-currency payment and settlement systems. Granularity combines deep understanding of technology, law, regulation, operations and risk management to ensure payment and settlement systems are efficient, PFMI compliant and resilient.

For any enquiries, please email kathleen.tyson@granularityltd.com.

About RISE

RISE is a London based solution provider of distributed ledgers for the post-trade industry. It allows its clients to efficiently issue, settle, and record-keep financial assets.

The team behind RISE includes a group of post-trade industry veterans who started investing in the idea in 2014. When an initial search revealed that no off-the-shelf solution fit the purpose, the group acquired a pioneering blockchain technology firm to build a solution that would meet all the requirements for the post- trade industry. Development efforts started in 2015.

Today, RISE is an independent firm that is a market leader in the provision of distributed ledger solutions for post-trading. RISE frequently speaks at industry conferences and engages with numerous regulators.

Ultimately RISE aims to help regulated financial institutions move into a new world of shared and distributed ledgers - with confidence in scalability, confidentiality, and compliance of the solution to which they are entrusting assets.

For any enquiries, please email info@rise-technologies.com.

References

[1] Bank for International Settlements. *Principles for financial markets infrastructures, committee on payments and market infrastructures and international organisation of securities commissions.* 2012

http://www.bis.org/publ/cpss101a.pdf

[2] Bank for International Settlements. *Distributed ledger technology in payment, clearing and settlement: an analytical framework, committee on payments and market infrastructures.* February 2017

https://www.bis.org/cpmi/publ/d157.pdf

[3] Charles Gubert. *On and off: global custodians and their balance sheets.* June 2012

http://www.globalcustodian.com/Magazine/2012/Summer-/On-and-off--global-custodians-and-their-balance-sheets/

[4] Thomas Droll, Natalia Podlich, and Michael Wedow. *Out of sight, out of mind? on the risk of sub-custodian structures.* Journal of Banking & Finance, *volume* 68:47–56. 2016

[5] Mark Carney. *The promise of fintech – something new under the sun.* In *G-20 Conference on Finance and Digitalisation, Wiesbaden, Germany.* January 2017

http://www.bankofengland.co.uk/publications/Documents/speeches/2017/speech956.pdf

[6] Oliver Wyman and SWIFT. *The capital markets industry: The times they are a-changin'.* 2014

http://www.oliverwyman.com/content/dam/oliver-wyman/global/en/files/insights/financial-services/2015/March/The_Capital_Markets_Industry.pdf

[7] Santander InnoVenture, Oliver Wyman, and Athemis Group. *The fintech 2.0 paper: Rebooting financial services.* 2015

http://santanderinnoventures.com/wp-content/uploads/2015/06/The-Fintech-2-0-Paper.pdf

[8] David C Mills, Kathy Wang, Brendan Malone, Anjana Ravi, Jeffrey C Marquardt, Anton I Badev, Timothy Brezinski, Linda Fahy, Kimberley Liao, Vanessa Kargenian, et al. *Distributed ledger technology in payments, clearing, and settlement.* doi:https://doi.org/10.17016/FEDS.2016.095. 2016

http://santanderinnoventures.com/wp-content/uploads/2015/06/The-Fintech-2-0-Paper.pdf

[9] A. Pinna and W. Ruttenburg. *Distributed ledger technologies in securities post-trading: revolution or evolution?* April 2016

https://www.ecb.europa.eu/pub/pdf/scpops/ecbop172.en.pdf

[10] European Securities and Markets Authority. *The distributed ledger technology applied to securities markets.* June 2016

https://www.esma.europa.eu/sites/default/files/library/dlt_report_-_esma50-1121423017-285.pdf

[11] Bank for International Settlements. *Delivery versus payment in securities settlement systems.* 1992

http://www.bis.org/cpmi/publ/d06.pdf