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Transitioning into the future of securities post-trade

DLT and digital asset's path to smart custody

2nd Edition

Introduction

The positive feedback from clients and the wider industry following the publication of the 'Transitioning into the future of securities post-trade[1] whitepaper in May 2019 confirmed it as a helpful service to the securities services industry. With the industry trying to get closer to an "Amazonised" state, the paper provided a vision for the faster delivery of securities post-trade and suggested how the industry can get there by players adopting new roles and new technologies such as Distributed Ledger Technology (DLT).

In response to market feedback on this topical subject, the latest whitepaper from Deutsche Bank Securities Services Market Advocacy team delves into how these new technologies, specifically DLT and digital assets, can help to further automate processes and lead to a more sustainable post-trade future. Using a bond transaction on DLT as a case study, it explains how custody and settlement processes can be brought into the issuance phase, delivering those sought after efficiencies and bringing the industry closer to an "Amazonised" state.

Contents

Foreword

Persistent structural margin compression in the securities post-trade industry[2] reflects the asset management industry's declining fee levels[3] and the increasing regulatory and market requirements for asset protection and market stability. A divergence in the direct relationship between what is paid and the asset protection received prompts the question as to what can be done today for a more sustainable future in post-trade.

Deutsche Bank's Securities Services team has been looking into digitisation and the new ways it could create efficiencies and deliver value to clients and markets. For instance, it has launched real-time settlement digital information between the Hong Kong Stock Exchange and the Bank of New York-Mellon via an API "Debbie chatbot"[4], explored streamlined proxy voting processes from a SWIFT-led DLT project with Singapore Stock Exchange (SGX) and other bank participants,[5] and used an internal DLT issuance to custody prototype to investigate the new drivers in securities post-trade. The efforts to identify new operating models are complemented by investigations into laws and regulations, technology, cryptocurrency anti-money laundering, and digital evidences required in enforcement.

In a scenario that we assessed, ambitious DLT efforts by some financial market infrastructures (FMIs) to integrate the technology into their post-trade engines would create powerful network effects that can result in the production of other complementary services. Other post-trade participants can use DLT and related tools to transform their operating models by aggregating value creation activities to create new internal efficiencies. Additionally, issuers and asset managers can use DLT to issue digital securities, digitise cashflows and create new digitised assets on newly emergent asset tokenisation platforms that supports with horizontally integrated issuance-to-post trade services.

As a result, in the longer term, the current paper-based sequential paradigm industry structure can evolve into a modern, concurrent processing platform one to better serve an increasingly digital financial industry.

To contribute to the discussion on the future of securities post-trade in an environment where assets will be digital, this whitepaper assesses the feasibility of a DLT-facilitated platform-based industry, and the abilities of digitised assets to reorder post-trade value chain activities. In this whitepaper, Deutsche Bank also looks at aspects of settlement and custody in a digitised asset environment, highlighting where current laws and regulations may need to be reviewed and updated.

We hope you find this whitepaper useful.

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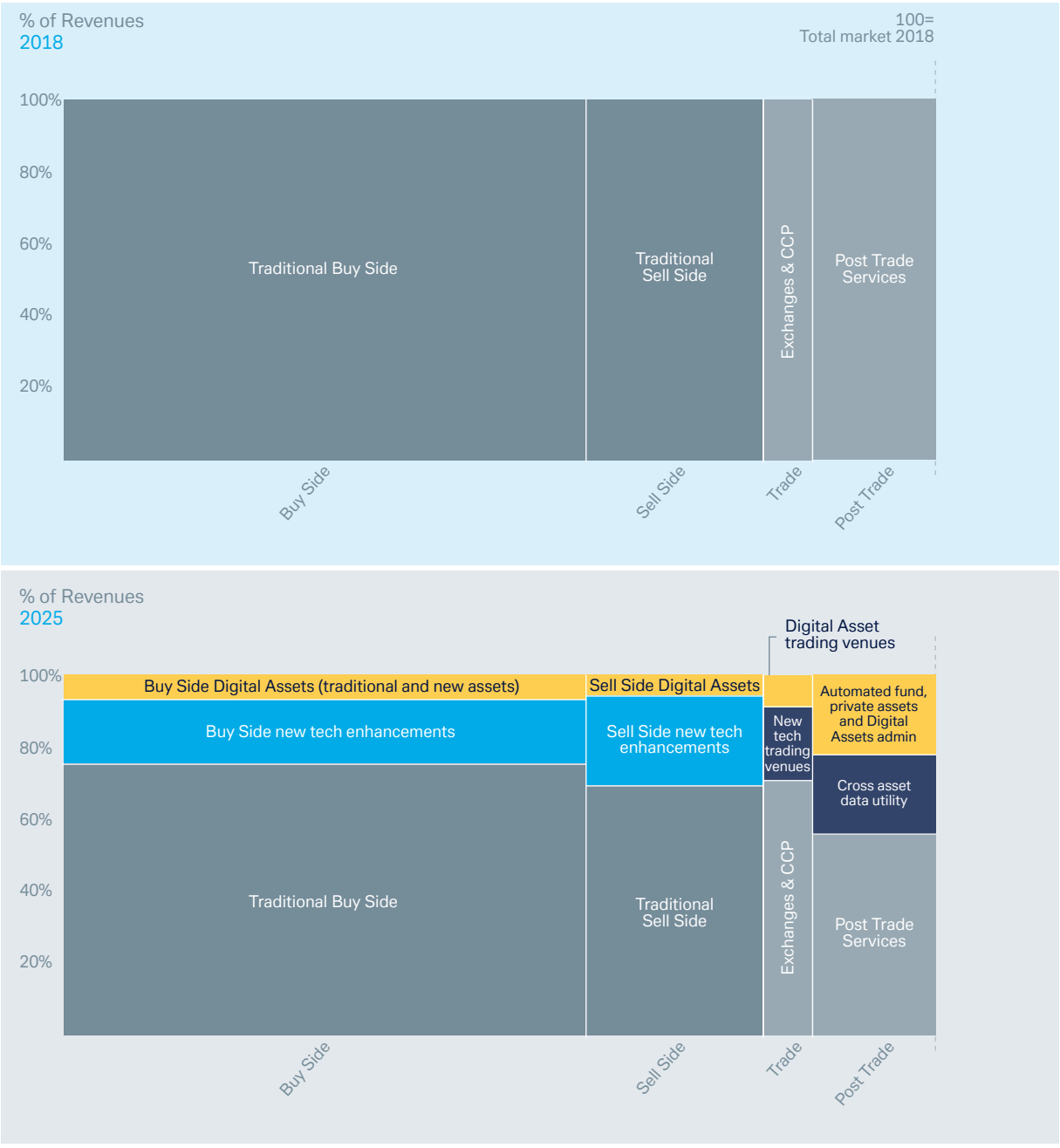
1

Margin compression is a structural challenge

Intense competition, as well as relatively static costs, in the asset management industry and post-trade space are driving declining profitability for post-trade participants. The outlook for a continued low interest rate environment will add to this challenge.[4] In fact, Bain & Co estimates that the global revenue pool for the traditional buy-side could decline by 20% by 2025, the sell side slightly more and the post-trade segment dropping by a staggering 35-40% (see figure 1).

Figure 1: New business growth should compensate for decline in traditional model revenue



Source: Bain & Co., 2019

This mega-trend could have a number of effects on the post-trade industry and custody service providers, some of which are already unfolding. These include the reduction of existing services, fewer clients, the introduction of new services to improve profitability, an increase in the level of outsourcing, participant consolidation and/or entry of new relatively unencumbered post-trade "fintech" players. However, in all these scenarios, investors will still need to have freedom of choice of custody providers who can deliver quality asset protection, investor safety and market stability. The focus on protection and stability implies continual investments into systems and people, which is unsustainable if every post-trade participant continues to experience falling margins.

Hence, an alternative future sees ecosystem participants reordering the industry structure and dynamics. Technology, and DLT in particular, can play an important role here by allowing custodians and post-trade participants to reposition their core capabilities, deliver further efficiencies and create visible new value for clients.

The digital infrastructure that can offer institutional-grade safety and soundness also brings potential for new "tokenised" assets[7] or digitised assets[8] which introduce new revenue sources and competitive dynamics.

Over time, the mass adoption of digitised methods should drive an evolution in the industry's current work flow, from a paper-based one to a more modern parallel one, where automation and digitisation would release it from today's unnecessary costs and introduce new growth areas.

The magnitude of the task to evolve, however, should not be underestimated.

2

DLT and digitised assets can address current structural challenges

Automating processes has been a focus for the post-trade industry since it first delved into computer assisted workflows during the 1960's "paperwork crisis" on Wall Street.[6]

Distributed ledger technology (DLT)[7] is a 21st century emergent trend. It is a departure from two-dimensional electronic entries to allow financial instruments to build-in self-executing codes, rules and even delivery mechanisms, which gives DLT a wide range of flexible and powerful applications. It is old and new at the same time: its integral components of cryptography, distributed computing and internet infrastructure are not new, and lend to integration with middleware systems to interoperate with different DLT systems. The methods to create more self-contained "smart" financial services and products, on the other hand, are new.

Applying to securities, computers first replaced physical paper scripts as evidence of securities with electronic records. However, the paradigm in the industry has remained largely that of sequential manual paper processes. DLT's distributed records can become the new evidence of securities rights embedded in codes, augmented by self-executing capabilities that update these rights, with concurrent processing flows.

Consequently, DLT can also be deployed to solve other related challenges, such as digital investor identification and the tension between omnibus and segregated account structures.

Figure 2: Evolution of asset protection and custody

	1960s	Present	Digitised Assets
Securities	Physical Scripts	Immobilised, dematerialised electronic entries	Embedded cryptography and codes
Rights are evidenced by	Physical Scripts	Electronic entries	Codes and cryptography private keys
Custodian protects investors from	Forgery Risks	Inaccurate electronic records over assets' lifecycle	Digitised forgery ("double spend"), codes that can override controls

Source: Deutsche Bank Securities Services

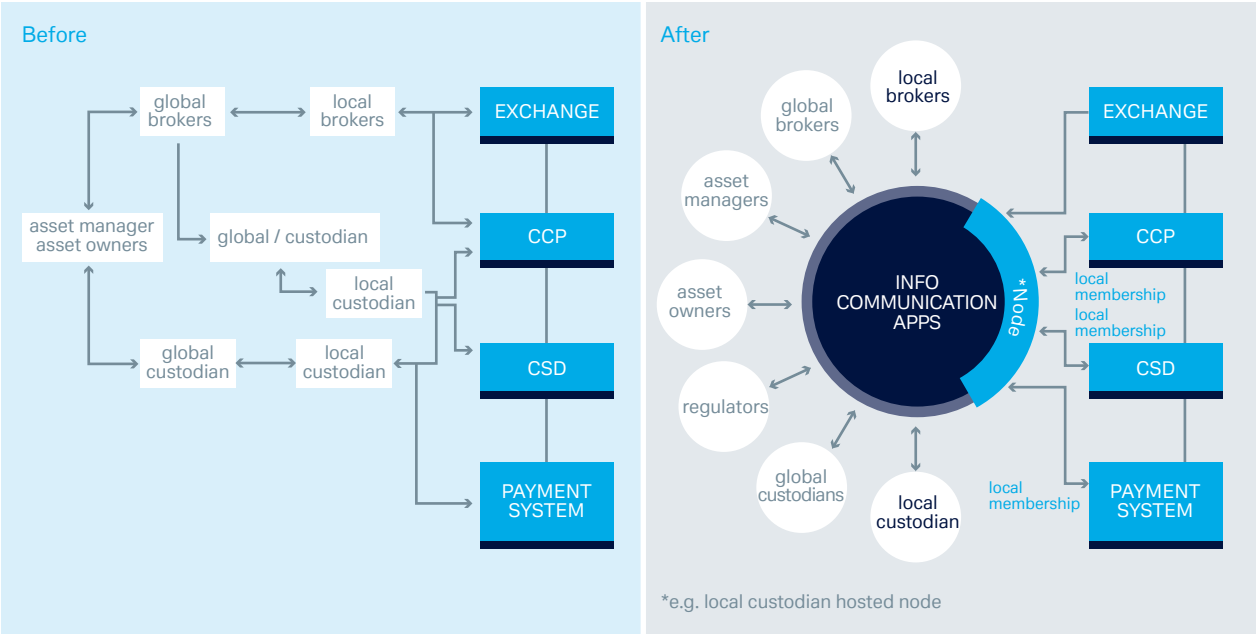
When it is combined with financial innovations like securitisations and technology's cost-effective precision, DLT opens up new product possibilities to represent non-traditional cashflows as "tokenised" asset classes, to use transparency of transactions for new risks management, and for seamless securities transactional capabilities.

By implication, DLT can help address current industry structure challenges in two ways – firstly, by allowing a cost-effective processing operating model, and secondly, by reordering process activities through the adoption of digitised assets and its environment. We will now review these two approaches.

2.1 New operating models, services and possibilities for further efficiencies

The post-trade cross-border industry has many participants, and data quality typically deteriorates when the different participants store data with different definitions, extracted and transmitted using different message formats, and the use of a mix of digitised, email and paper systems. This deterioration in data quality can be a fundamental process inefficiency driver, for example, manifested as missing or incomplete data fields in instructions in a time pressurised environment that requires clarifications.

Figure 3: Sequential versus concurrent paradigm



Source: Deutsche Bank Securities Services

The process to reflect information in cross-border investments requires participants in the post-trade supply chain to communicate sequentially from one participant set to another. Pre-settlement and settlement information flows between immediate participants, who initiate, authenticate, acknowledge and confirm the availability of funds and securities, and then reconcile (as well as process and manage exceptions). Such activities are then repeated by the next set of participants who may straddle different time zones.

Accordingly, participants build their own technological pipes and operational processes to handle their interactions. As communication needs to flow across borders within a shorter T+2 settlement cycle, reduced settlement risk has given way to increased operational risk concerns and controls. However, each investment made by individual participants adds to the industry's fixed costs that need to be recovered.

From a big picture perspective, DLT's simultaneous communication and recording basis improves the quality of data, enables speed and efficiency, and reduces unnecessary hand-offs between parties. Consequently, a mass adoption of DLT would move the industry from paper-based workflows to a concurrent platform model (see Figure 3), where the industry can better manage ever-faster and ever-more complex globalised portfolio investment.

2.1.1 Emerging concurrent-based post-trade industry initiatives

Powerful alternative models to address these challenges include the Australian Stock Exchange's (ASX)[11] use of DLT in its post-trade next generation technology. This solution creates an option for market participants to access "real-time, synchronised, permissioned, source of truth data" complemented by smart contracts and an open ecosystem data platform. Hong Kong Exchange (HKEX) is also exploring the application of DLT in its new post-trade cross-border "Connect" programme's account structure and operational flows.

Network efficiency benefits arise when it becomes possible for different but related groups of market participants to all connect into the same "node", containing digitised post-trade data flows, for updates, instructions and to initiate actions. A node can be hosted by the sub-custodians for their client ecosystem, with possible third party apps, to enhance the "final mile" interactions with the CSD and FMIs. Participants can simultaneously access their relevant data with reduced operational activities, fewer handshakes, and improved responses to time-zone latency and ad-hoc settlement issues.[12]

2.1.2 New ways of doing things and new services to be created

The potential to create further value does not just depend on the nodes operating as simple information hubs. Communication can be linked to account structures, channel corporate action information and activities, and deliver real-time aggregated reports and other services. Node-hosted "light weight" apps can be created to deliver customised services to participants; for example, real-time data analytics apps could be offered by the CSD[13] to allow participants to benchmark and fine-tune their operations.

By this time, paper-based communication should have been digitised and physical company stamps for legal recognition of authentication and other physical artefacts should also be no longer required. Key utility functions such as trade matching – that is, utility activities that will generate data – could be performed at the market level to mitigate the need for repetitive investments into similar systems by individual participants.

As a demonstration of DLT's deeper potential, it is currently possible for cross-border interconnected cryptocurrency exchanges and participants to trade, settle and custody almost instantly.[14] New scripting languages and DLT bridges that can interconnect different DLT technologies are becoming available, which offers a potential to link different DLT-powered exchanges for greater scalability in the future.

These are glimpses of possibilities from some FMIs' ongoing initiatives to embed DLT paradigms and technologies into their post-trade engines. The initiatives are important as FMIs stand in the centre of a huge network of direct participants and indirect dependents, and their changes would have significant "butterfly effects"[15] that can transmit and mutualise savings, benefits and other outcomes across the industry including onto cross-border dependents.

Hence, to anchor this progress and mitigate foreseeable risks, further rethinking is required in key topics. These topics include legal and regulatory clarity, relationship clarity, transaction confidentiality, re-engineered operational workflows, cost-effective systems, trust and security, and technological interoperability. Concerns about potential disintermediation of roles and shared accountability can arise, which would benefit from industry's open discussions.

For these and other reasons, bold visions, steadfast execution and cross-industry collaboration with FMIs at the centre of change will be necessary to modernise the industry structure over the longer term.

2.2 Second Approach: DLT, Digitised Assets and the reordering of post-trade value chain activities

At the level of the participant's process flow, DLT's ability to shift and aggregate value creation points using codes will allow a repositioning and aggregation of core capabilities (as outlined below in Figure 4):

Figure 4: Example of how codes can assume traditional issuance activities (extracted)

```
Function SESAPACToken () public {
symbol = "gtbSES";
decimals = 18;
_totalSupply = 100000000000000000;
balances[public address] = _totalSupply;
transfer(address(0), public address, _totalSupply);
}
```

_totalSupply: specifies the maximum number of token that can be issued.	→	Similar to entries in a Registrar.
transfer(): transfer the creation of the tokens to the public address.	→	Similar to the first credit to the CSD system before allocation.

Source: Deutsche Bank Securities Services

2.2.1 DLT related components that drive the reordering of value chain activities.

This reordering is a result of a synergistic combination of DLT's capabilities as a distributed simultaneous record keeping system, rules in the smart contract codes, Whitelists and Oracles. Briefly, they play the following roles, as outlined in Figure 5:

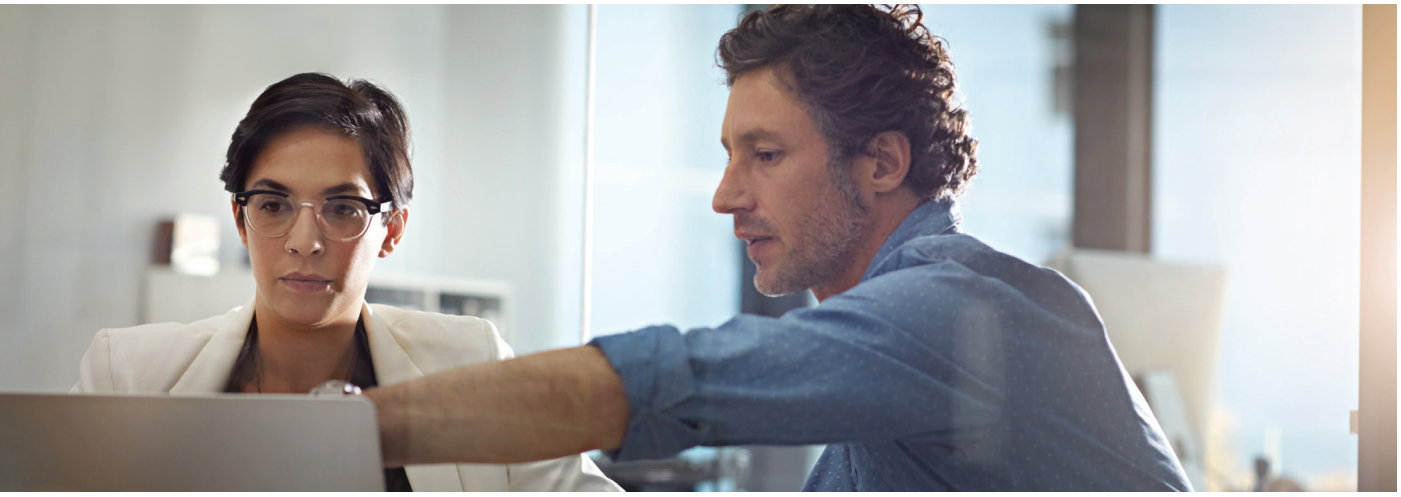


Figure 5: Synergising the different DLT components for benefits

Digital Asset's Components		Potential Benefits
Distributed Ledger Technology	Shifts from sequential to concurrent processes	Process efficiencies
Smart Contract Codes and Rules	Aggregate activities	Cost savings
Whitelists	Guide results of the self-executing codes	New services and revenue
Oracles	Leverage existing systems for data	Change competitive basis to mass customisation
		Can evolve current industry structure

Source: Deutsche Bank Securities Services

Rules in smart contract's codes execute, for example, certain registrar or transfer agency activities to transfer and allocate securities and cash, or to perform certain corporate action calculation and payment functions; in the form of investor-aware, compliance-aware and asset lifecycle-aware rules. From a control and governance perspective, a smart contract's "pause" command can be issued to quickly freeze a DLT-based security in investors' accounts if there was a financial stay event. Further, a DLT-based security can also be efficiently redeemed or redenominated via a "burn-and-mint" type of command. This programming also means that certain asset servicing activities are shifted (reordered) up front to the issuance set-up stage where coding happens (see Figure 6 overleaf).

Whitelists provide the filters, for example, to manage the different investor characteristics to drive asset servicing precision together with approval and governance policies. The cryptographic keys in the addresses that proxy investors' accounts can be safely maintained in highly secured hardware security modules, complemented by private keys regeneration capabilities[16] to enhance asset protection.

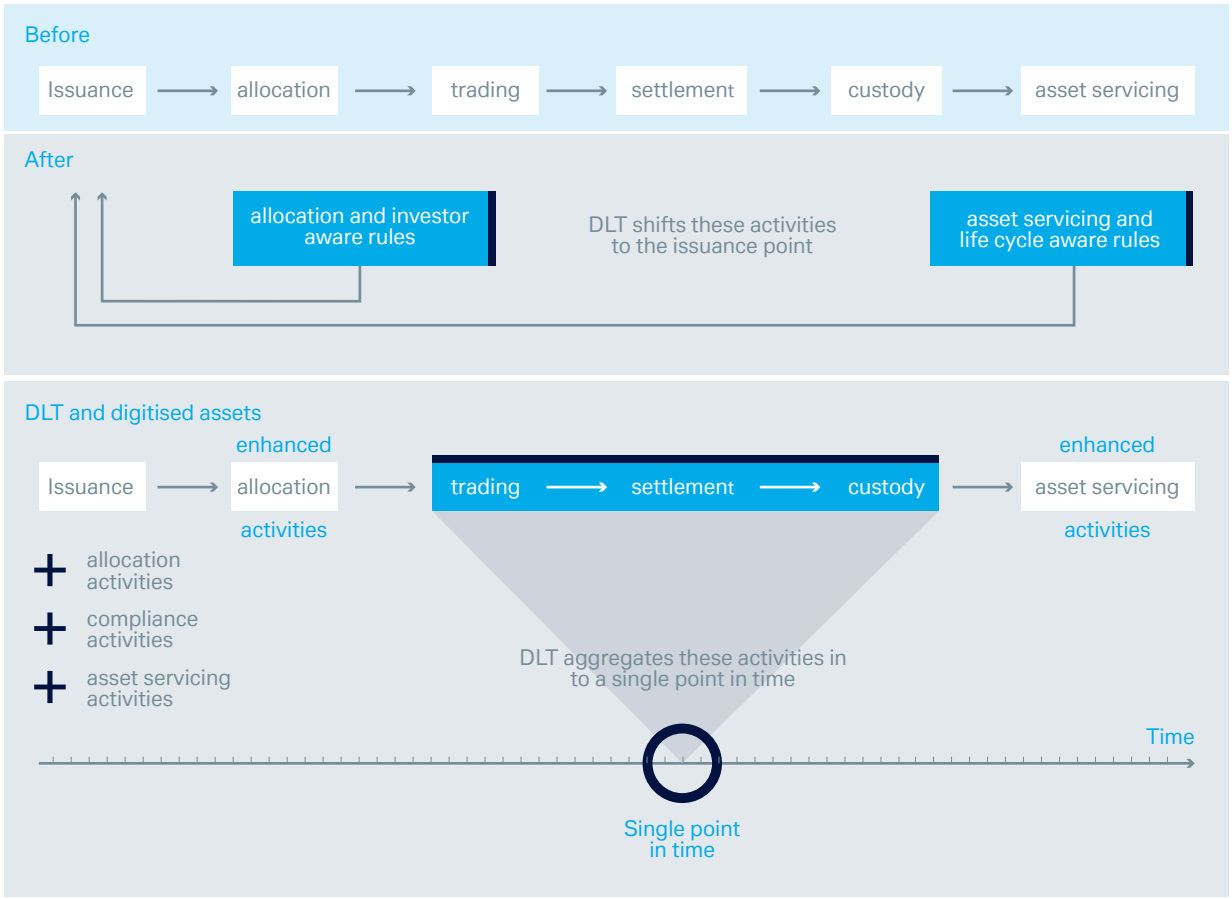
Oracles act as pipes between the smart contract's native environment with other systems to feed digital data into smart contracts for its execution. In this way, deploying DLT would not require a complete overhaul of legacy systems.

A stream of data to connect to certain smart contracts can be related to cash settlement. The cash settlement leg should ideally be on the same digital environment as the smart contracts. This leg can be represented as a digital depository receipt of deposited fiat money, a trusted "StableCoin"[17] or be linked to the formal cash channels like SWIFT to gain information of money flows. This category of smart contracts can facilitate settlement-cum-custody in near instantaneous time.

Acting in concert to dis-aggregate and re-aggregate existing post-trade activities, the four components of DLT, Smart Contracts, Whitelists and Oracles move value creation upfront to the "issuance" point. This new issuance point would then drive a higher level of efficiencies in follow-on processes like transfer agency-registrar allocation activities, investor restriction governance, income calculation and distribution, corporate action activities and other securities lifecycle actions.

Through this re-aggregation of activities with "smarter" automation and concerted processing, a service provider's internal processes can be improved, although other necessary criteria like re-engineered control points and common data definitions are needed to optimise the internal workflow benefits.

Figure 6: Value creation points



Source: Deutsche Bank Securities Services

2.2.2 New competitive strategic points are created

As a result, the control of this aggregated new issuance stage supports the service provider's competitive abilities to add new value – like new service creation and customisation – to clients' relationships. Conversely, if an incumbent surrenders or outsources this point to a third-party, it can introduce a strategic weakness that will allow a disintermediation of value creation and client relationships.

Another important difference brought about by DLT-based securities is the "T-Zero" effect that aggregates the separate activities in matching trade instructions, settlement and custody all into a near instant moment of each other. Like the "New Issuance Point", the "T-Zero" point is another control point in the digitised asset environment where new value is created and delivered.

Altogether, they also mean that the traditional post-trade process lines are blurred, and a more holistic organisational approach is required.

3

What can digital assets mean for issuers, asset managers and investors?

Currently, these altered and digitalised processes are represented by "tokenised asset platforms" that operate as a one-stop, horizontally integrated post-trade infrastructure platform across issuer services, post-trade securities services and payment functions. Digitised assets are the starting point to use these platforms, which offer programmable securities coding, hold investors' records and account structures, provide secondary trading market places and link to traditional third-party custodians if needed.

So far, the main protagonists of tokenised asset platforms include Deutsche Boerse-Sygnum, Swiss Digital Exchange, London Stock Exchange (LSE)-Niuvana, Singapore Exchange's stake in 1 Exchange and Singapore's HashSTACS, Hong Kong's HEX, New York Stock Exchange's BAKKT, USA's Polymath and Securitise. Additionally, the LSE-Niuvana tie-up has included the digitisation of securities legal documents that can provide their clients with a significant time advantage. Thailand and the Stock Exchange of Thailand also announced in September 2019 its intention to create DLT-based capital market processes and a regulated tokenised asset exchange. [19]

Figure 7: What DLT and digitised assets can mean

User Type	Objectives	Can be met by
Frequent issuers	Cost effective issuance Funding precision "Decentralised" book build Responsive investor managment	Tokenised Asset Platform Smart Contracts
Asset Managers	New product creation New risk-reward correlation Process efficiencies	Asset tokenisation e.g. Agricultural cash-flows
Investors	Thematic investments More transparent governance	Digitised money
Post-Trade Service Providers	Fund services of digitised and traditional assets New product development Process efficiencies	Tokenised Asset Platform Smart Contracts Node/platform services

Source: Deutsche Bank Securities Services

As outlined above in Figure 7, for asset owners, asset managers, investors and issuers, the platforms offer strategic leverages to investigate new product creation, new funding precision and new operational efficiencies. Some emergent use cases and possible future activities on these tokenised asset platforms include:

- Issuers: Frequent issuers can use the platform's real-time advantage to quickly and cost-effectively raise debt capital, deliver greater transparency to their investor base and ensure more precision in their funding and its investor management activities,[20]
- Asset managers can create, list and/or invest into digital tokenised assets that offer new return profiles like agriculture-based or commerce-based[21] cash flows that minimise correlations to traditional financial assets. Automating funds transfer agency and distribution functions has been another use case area,[22]

- Issuers, asset managers and investors can use the platform's associated digitised wallets as an "end-point" access. This access can allow them to manage the digitised securities via powerful lightweight integration applications[23] that allow transaction visibility, initiation, reports generation and other capabilities including crypto multi-signature and digital identity management,
- Digitised representation of money ("digital money") can provide a new level of transparency of digital money flows,[24] which can be attractive to environmental, social and governance (ESG) investors investors and facilitate cost effective reporting by an ESG bond issuer or asset manager.

While this innovative reordered operating model is not yet a competitive threat to traditional custodian banks, it is a valuable new business model reference to guide banks' assessment of a digitised method. Faced with this reality, bank providers have three choices:

1. Join the momentum but approach it with a different starting point such as the cryptocurrency space,
2. Analyse and understand, but join the momentum later through either a self-developed or a consortium platform, or
3. Wait, see and decide later

Regardless of the level of interest and readiness to decide, non-competitive legal and regulatory topics also need to be addressed. Figures 8 and 9 explore two such examples: settlement and custody in a digitised environment.

4

The emergence of DLT-related laws and regulations

To analyse the potential of DLT and its applications in financial services, legislators globally have started to develop specific laws. However, the approaches taken by policymakers and regulatory authorities vary from targeted adjustments to existing frameworks to the development of new concepts.

At the forefront of this analysis, the Principality of Leichtenstein's research into digitised rights through the launch in May 2019 of its "Act on Transaction Systems based on Trustworthy Technologies", or Blockchain Act has been recognised as one of the most progressive attempts. The act introduces the concept of a "Token Container Model" as a representation of rights[25] where the rights contained in the token would satisfy the relevant regulations. Switzerland's "blockchain/DLT law", which would also address a digitised asset's bankruptcy scenario, is expected to go live in 2020[26] and Thailand has worked on its "Tokenised Asset" law[27] to allow tokenised assets to be treated as securities. In the US, its Securities & Exchange Commission has invited industry consultation on non-delivery versus payment, or non-DVP, custodial practices and digital assets vis-a-vis the application of key laws such as the Investment Adviser Act of 1940.[28] Germany has also consulted on "electronic securities"[29] while the European Union's interest in blockchain and DLT continues unabated.[30]

4.1.1 The need for reinterpretation of laws and regulations

Current efforts to draft these digital assets-related laws should be seen as important starting points that set the stage for their interpretations and applications. These re-interpretations need to be focused on the intersection of technology, laws and regulations, business models and for the purpose of financial service activities. Figure 8 highlights some examples, with brief descriptions in the Appendix

Figure 8: Possible digitised asset's Delivery-Versus-Payment (DVP) methods

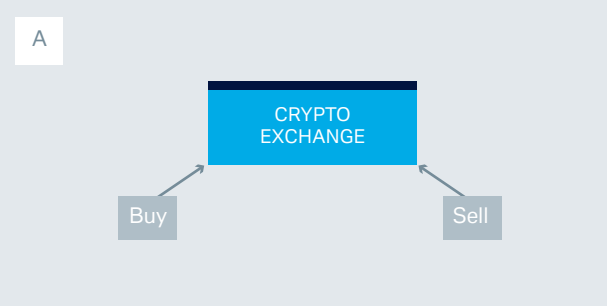


Figure A: A cryptocurrency exchange confirms settlement finality

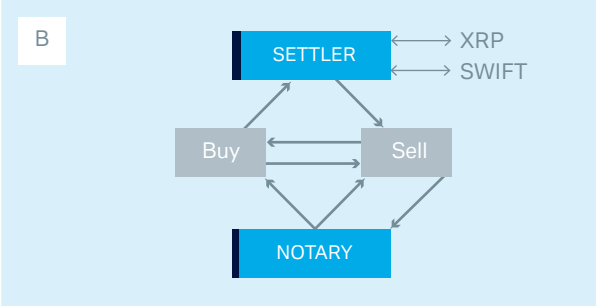


Figure B: A Corda settler intermediates settlement finality

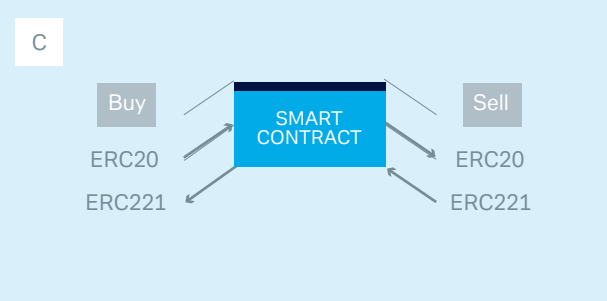


Figure C: A smart contract that exchanges two different tokens

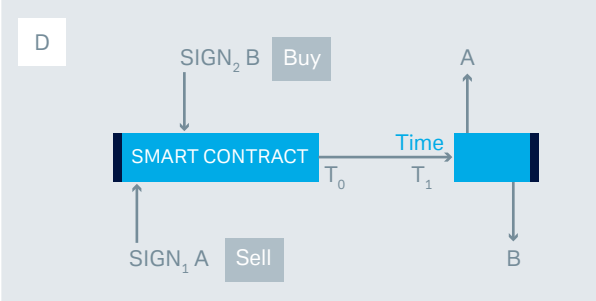


Figure D: A Hash-Time Locked Contract that releases two different tokens

Source: Deutsche Bank Securities Services

Figure 9: The three types of digitised assets and their custody considerations

	CONTROL	TRANSFERABILITY	POSSESSION
Cryptocurrencies Private key	●	●	?
Smart contract token Private key Smart contract	●	●	?
Private key only	◐	◐	?
Permissioned ledger message Private key Message record	●	●	?

Source: Deutsche Bank Securities Services

In a digitised asset environment, it is clear that settlement, settlement finality, as well as custody and other post-trade activities can and will occur differently from what they do today.

Reviewing current laws and regulations to help realise new growth and for equitable competitive potential is important. However, the focus and vigilance to ensure industry, safety and stability should not change, although the methods need to evolve too.

5

Conclusion

DLT serves as a driver of two change vectors that can stop the industry's structural long-term margin decline (Figure 1) and improve long-term competitiveness. In this process, there are near-term potentials to increase operational efficiencies, with prospects for new revenue sources from new services. New costs and risks will emerge too. As the securities post-trade value chain activities are re-ordered by DLT and a digitised asset environment, participants' roles, incumbent bank service providers' organisational lines will also be blurred.

Importantly, as more new DLT-related and digitsed assets laws and regulations are introduced, they will lend tailwinds to the reshaping of the new operating environment.

This is how today's post-trade can evolve into a DLT and digital asset-driven modern industry structure where hallmark features would include concurrent processing, reordered post-trade processes and redrawn boundaries, end-to-end digitised methods, and deep inter-disciplinary skills and knowledge.

There is much to be accomplished in this transition to a more modern post-trade industry and structure. For now, the road ahead for the post-trade industry can include:

1. In the short term, investigations to identify post-trade collaborative pilot areas where parallel communication and operational processing can practically reduce today's costs and inefficiencies. Valuable opportunities can arise as old IT systems become due to be overhauled.

2. A deeper exploration of DLT's applications to create new products with customised services like tokenised assets and digitised securities. Asset managers, securities issuers such as bond or equity issuers, investors and post-trade service providers such as custodian banks and FMIs can partner to explore and co-create digitised new products and services.

3. Starting now for the longer term, a review of existing laws and regulations pertaining to post-trade activities needs to be undetaken. This is another area that can greatly benefit from cross-expertise collaborations between DLT technologists, "traditional" custodians, CSDs, legal advisors and regulators.

The old adage, that the effects of technology tend to be overestimated in the short term, and underestimated in the long term, would hold true to DLT and to our visions in this paper. We look forward to our collaborations to discover the future of the post-trade industry and digitised assets within it.

Appendix

Examples where a review and reinterpretation of laws and regulations may be needed:

a) In a Corda DLT environment, a network's notary role maintains the list of spent outputs and signs its signature to confirm that it is not aware of a "double spend" of that specific asset. In this way, the notary could be seen as confirming settlement finality of a Corda-based asset, which is a core function of a traditional CSD (Figure 8(B)).

   How should this and other similar new ways of securities settlement i.e. off traditional CSD be recognised?

b) A Corda settler is a technical bridge that can ensure delivery of a Corda-based asset with an external (non-Corda) payment system. External systems could be traditional payment rails such as SWIFT gpi, or could be cryptocurrency such as Bitcoin. Can this be recognised as Delivery-Versus-Payment (DVP) mechanism?

c) A smart contract intermediates the atomic swap of two tokens (Figure 8(C)).

   In a smart contract environment such as an Ethereum ERC token one, "super" powers can also be embedded in the smart contract to allow a third party control on the tokens under custody . A key consideration here is how this should be interpreted in terms of custody's "control" over the assets.

   While there are easier ways to ensure that such "super" powers are excluded from the smart contracts, their capabilities play important compliance and asset servicing roles.

d) In a bitcoin-type of blockchain environment, a hash-time-locked-contract (HTLC) could allow for the time-controlled exchange of digitised securities and representation of money. Is this an escrow, a settlement DVP, or both depending, on the state of the HTLC (Figure 8(D))?

   Can a smart contract's intermediation of the near simultaneous exchange or "atomic swap" of two digitised assets be recognised as effective DVP of digitised assets?

e) From a segregation, asset protection and recovery and resolution perspective, can a legal lien be casted over a digitised money?

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All links were last accessed on 18 September 2019.

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[3]https://www.institutionalinvestor.com/article/b1d0twwmy45mc7/Asset-Managers-Shrinking-Margins-Are-Nearing-2009-Levels

[4]https://cib.db.com/insights-and-initiatives/flow/could-a-chatbot-help-resolve-the-speed-and-accuracy-need-in-trade-queries.htm

[5]https://www.swift.com/news-events/news/new-proof-of-concept-to-test-e-voting-on-dlt

[6]https://www.bis.org/review/r190827b.htm

[7]In this paper, we use term "tokenised" asset classes to refer to the embedding of rights in digital and cryptographic ways that can be traded and the rights transferred using DLT techniques.

[8]For the purposes of this paper, "digitised assets" adopt 'the Financial Action Task Force's (FATF) definition of Virtual Assets applied generally to securities but which exclude cryptocurrencies. For example, a digitised asset can be represented by a smart contract. FATF has defined Virtual Assets as "…digital representations of value that can be digitally traded or transferred and can be used for payment or investment purposes, including digital representations of value that function as a medium of exchange, a unit of account, and/or a store of value".

[9]https://qz.com/370553/what-the-cigar-chomping-schleppers-of-1960s-wall-street-mean-for-bitcoins-future/

[10]DLT is used in this paper in its broader interpretation that includes permissionless blockchains, permissioned distribute ledger technologies, concurrent processing, "smart contract" codes, and advance distributed database systems exemplified by Google's Spanner.

[11]https://www.asx.com.au/documents/asx-news/safaa-2019-ceo-address.pdf

[12]For example, Deutsche Bank's Debbie Chatbot with HKEX and Bank of New York-Mellon for real time settlement information.

[13]London Stock Exchange's reported revenue shows information services as a major revenue contributor https://www.lseg.com/investor-relations/investor-events https://www.lseg.com/resources/media-centre/press-releases/proposed-all-share-acquisition-refinitiv-create-financial-markets-infrastructure-leader-future. I would like to thank Thomas Olsen, Bain & Co, for sharing this example.

[14]For example, Blockstream's advance federated sidechains ("Liquid") that could include both regulated and unregulated exchanges in its inter connected network https://blockstream.com/liquid-faq/.

[15]The Butterfly Effect is where a small change in one state of a complex dynamic system can result in large differences in a later state as a result of sensitivities https://en.wikipedia.org/wiki/Butterfly_effect

[16]For example, Crypto Storage AG https://www.cryptofinance.ch/en/storage/

[17]In this paper, StableCoin refers to a digital representation that is pegged to a medium of value; for example, a USD Stablecoin.

[18]https://www.bangkokpost.com/business/1738619/sec-proposing-dlt-for-capital-market

[19]"…the bourse will develop a digital asset ecosystem or end to end platform for digital assets by structuring core infrastructure such as the issuance process, asset tokenisation, trading systems, settlement systems, e-wallet and custody providers." https://www.bangkokpost.com/business/1644256/set-to-kick-off-digital-operations-next-year

[20]https://www.worldbank.org/en/news/press-release/2019/08/16/world-bank-issues-second-tranche-of-blockchain-bond-via-bond-i

[21] An example of a tokenised livestock cashflow for financing. https://infocorp.io/Cow-Token-A-Local-Blockchain-UseCase.pdf

[22]http://www.funds-europe.com/fundtech-summer-2019/blockchain-blockchain-for-funds-projects-go-live

[23]For example, JAXX. https://jaxx.io/

[24]An example of how cryptocurrency's transparency can be used for public governance. https://nrc-cnrc.explorecatena.com/en https://nrc-cnrc.explorecatena.com/en/details/wkBxj3BzKwIw3YPA24VEURzOByNKyb

[25]http://www.ecri.eu/system/tdf/thomas_duenser_1.pdf?file=1&type=node&id=155&force=0

[26]https://www.efd.admin.ch/efd/en/home/dokumentation/nsb-news_list.msg-id-74420.html

[27]https://www.bangkokpost.com/business/1670664/

[28]https://www.sec.gov/investment/non-dvp-and-custody-digital-assets-031219-206

[29]https://www.bundesfinanzministerium.de/Content/DE/Standardartikel/Themen/Internationales_Finanzmarkt/2019-03-08-eckpunkte-elektronische-wertpapiere.html

[30]For example, https://www.ebf.eu/priorities/digitaltransformation/blockchain/, https://www.eublockchainforum.eu/

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