# Evolution or revolution?
## Distributed ledger technologies in financial services

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(There are two versions of this paper: a short summary report of 16 pages plus references; the full research report of 121 pages plus references.)

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# 1 Introduction to the full report

Over the past five years there has been a lot of discussion of cryptocurrencies and their supporting 'blockchain' or 'distributed ledger' technologies.[1] While the opportunities of 'crypto' as an asset class have attracted most media attention, for many practitioners and policy makers it is the technologies that are of greatest interest. Over one hundred announced projects have invested hundreds of millions of dollars applying distributed ledger/ blockchain in mainstream financial services.[2] A handful of projects are reaching commercial scale.

This report examines the adoption of distributed ledgers in financial services, both what has taken place to date and prospects for the future.[3] Are distributed ledgers, as some suggest, a radically disruptive technology that will transform banking, insurance, capital markets and asset management?[4] Or are they supporting tools, to be gradually deployed in a range of applications but without fundamentally changing the industry?

Our investigation is both conceptual and empirical. We discuss the distinguishing features of distributed ledgers. This has required grappling with considerable terminological confusion. Practitioners and technologists use the terms distributed ledger, distributed ledger technologies (or DLT) and blockchain in different ways, sometimes with no precise meaning at all and on other occasions consciously departing from the ways in which these terms are used and understood by others. We provide definitions of these key terms correspond to their most common usages, but also note where usage varies.

Do these definitions matter? Proponents of the application of distributed ledgers in financial services may argue that accurate definition matter less than practical application. This though masks an important practical issue, one that helps explain why there is so much confusion about distributed ledgers. There is no single distributed ledger technology, rather distributed ledgers are a 'pick and mix' solution using modern cryptographic security tools to address an old challenge of sharing business and operational data. Each distributed ledger is a combination of technologies tailored to the requirements for sharing data in a particular business situation. One distributed ledger solution can be very different from another. There is often little commonality between them.

To make sense of this complexity, our analysis is founded on a detailed review of what is going on in practice, looking at: the many 'blockchain' start-ups; the work of the various distributed ledger consortia (R3, Distributed Assets, the Ethereum Enterprise Alliance and the participants in Hyperledger). We look at the application of distributed ledgers in fourteen different areas of financial services; and in a little more detail at seven case studies of more developed implementations of distributed ledgers.

Our emphasis throughout is on the business and operational applications of distributed ledgers, not technical implementation. We think our analysis is long enough, without paying unnecessary attention to technical details, for example to the supporting cryptography, to the

[1] Google Trends reveals a thirty-fold increase in searches for the terms "blockchain" and "distributed ledger" from January 2015 to Dec 2017, falling back a little since as the cryptocurrency prices fell from their end-2017 peaks.
[2] Documented in Appendix 1. This count excludes cryptocurrency and crypto asset projects.
[3] There is so much activity of this kind that we have not been able to cover all current developments, for example Facebook's Libra project, announced in June of 2019, is not covered in this report.
[4] Our focus is on financial services. There are also many applications in both non-financial industries and public administration, e.g. health records, supply chain transparency, see (Government Office for Science 2016).

establishment of 'consensus' across the multiple distributed copies of a distributed ledger or the fashionable references to 'tokenisation' of financial transactions (a shorthand for automation of operational processes through digital record keeping). For decision makers this is the appropriate focus: balancing the benefits of using a distributed ledger for data sharing and on the associated costs, both the one-off costs of system change and the ongoing costs of ledger governance, without getting diverted into excessive detail of the supporting technology.

We do examine in detail the adoption decision: when is a distributed ledger solution business relevant? what must be taken into consideration when making the decision to adopt? We find that adoption of distributed ledger technologies is appropriate when existing arrangements for sharing of data are insufficient and the additional costs of governance and replacing legacy arrangement to support a shared arrangement are justified.

We also argue that adoption of distributed ledgers is not something to be left solely to the initiative of market participants. Adoption requires co-ordination and overcoming vested interests which in turn can justify promoting adoption through regulatory initiative or other public policy intervention. Distributed ledgers may support radical improvement in the organization and structure of financial services, but in our view more radical change is only going to take place through public policy leadership.

Our paper is organised as follows. Section 2 discusses the key features of distributed ledgers and what distinguishes them from other forms of databases. We offer definitions distinguishing distributed ledgers from distributed ledger technologies. Distributed ledgers are permanent, tamper-proof, sequences of data records with (i) multiple operators storing copies of the ledger and independently adding data records; and (ii) multiple users reading and proposing new data records. Their key distinguishing feature is having multiple operators – but there can also be multiple users of conventional databases each with a single operator and these are often also referred to as distributed ledgers. This section also: discusses the range of component technologies and how they are combined in ledger operation (the 'data base stack').

Section 3 is our examination of how distributed ledger technologies are actually being employed in financial services. We first offer a general overview, looking at applications in fourteen broad areas, summarised under four main headings (see Table 2): A. Asset ownership and management; B. Trading and Derivatives; C. Corporate Financial Services; and D. Regulatory oversight. We then summarise seven major ongoing initiatives in the application of distributed ledger in financial services, those we have identified as coming near to commercial scale: these are the Digital Asset/ ASX project on upgrading of the Australian post-trade securities clearing and settlement; DTCC's TIW for trade information; Utility Settlement Coin or as it is now named Fnality in the cash payment leg of securities settlement; SETL's IZNES platform for pan-European investment funds record keeping; J.P. Morgan's Interbank Information Network (IIN) to support international payments and Ripple's RippleNet suite of solutions for international payments. We choose these because they are the most prominent projects that are moving beyond proof of concept to commercial scale implementation (though even for these early first movers, implementation may still take some years). We also discuss why implementation is protracted and as yet limited to only a few areas of application.

Section 4 examines the adoption decision for potential applications of distributed ledgers – or other advanced technology data solutions in financial services. Where does sharing of data offer the largest potential private and social gains? We argue that this is where data is currently most fragmented and difficult to deal with. We also examine the issue of limited versus radical change. Yes, distributed ledgers can deliver substantial operational efficiencies and promote greater competition; but reshaping and improving the institutional architecture of financial services is a much bigger task, requiring far more than just the employment of a new form of database. Finally this section examines the governance of distributed ledger and the associated challenges of data management.

Section 5 briefly discusses the public policy issues associated with distributed ledgers in financial services, the legal and regulatory treatment of crypto assets, the use of distributed ledgers in financial regulation and central banking and the role of public policy in promoting adoption. Section 6 is a concluding summary. Our analysis is supported by two Appendices. Appendix 1 is a review of announced distributed ledger/ blockchain initiatives in financial services. Appendix 2 is a summary of legal and regulatory perspectives on 'crypto-assets'.

# 2 Distributed ledgers: basic concepts and supporting technologies.

This section outlines the key technological elements employed in distributed ledgers (with a conscious effort to avoid being side-tracked by unnecessary technical details). A main finding is that users seeking to achieve the benefits of distributed ledger do not have to buy into the overall concept: a data base with no central operator; they can select the technological elements relevant to their particular use case and, if they prefer, apply them using a more conventional database maintained by a trusted party.

## 2.1 Definitions

We begin with definitions of three key terms. [5]

First a definition of a distributed ledger:[6]

> ***DEFINITION 1: (not universally accepted) A distributed ledger (DL) is a database of cryptographically-secured time-ordered immutable data records, with multiple operators storing and independently updating their own copies of the database and multiple users reading and proposing the addition of new data records.***

This definition emphasizes that distributed ledgers are databases and focuses attention on rights for reading and updating of records and on data integrity and security. It also identifies a critical distinguishing feature: multiple operators i.e. distributed ledger provides a complete record of past data without a single controlling institution. Note that permissioned versions of DL required for application in mainstream financial services (see later discussion) still require some institutional control over participation. This definition captures the key features associated with DL, but it is *not* universally accepted. As we discuss many data solutions described as DL or DLT fall outside of this definition.

It is helpful to distinguish distributed ledgers from both distributed ledger technologies and from blockchains:

> ***DEFINITION 2: Distributed ledger technologies (DLT) are the range of component technologies employed in distributed ledgers, delivered through a common software environment.***

A range of software environments for distributed ledger technologies have been developed over the past five years. The best known are Hyperledger, Ethereum (e.g. in its permissioned Quorum implementation), R3's Corda and Distributed Asset's DAML. As we document below,

[5] The terminology itself is not so important – in the words of Shakespeare's Juliet 'What's in a name? A rose by any other name would smell as sweet." Disagreement on terminology can though result in confusion. In our judgement, the current efforts at developing distributed ledger solutions in financial services have become something of a 'Tower of Babel', with much discussion undermined by failure to agree on what exactly is meant. We therefore propose the following definitions, while acknowledging that others may sometimes use the same terms differently from us.

[6] The danger of such distraction is especially great over synchronization – i.e. element (iv) – which is where the energy intensive process of Bitcoin mining or other forms of proof of work have been employed.

all four are becoming widely used in financial services but more often for shared ledgers with central institutional control rather than for distributed ledgers proper. They can all support secure data sharing solutions that would be relatively difficult to implement using conventional database software. The reason, though, for calling them all distributed ledger technologies seems to be more about persuading company boards to agree to substantial expenditures on new technology. They are less about providing a precise description of what is being done.

Blockchains are the class of distributed ledger technology supporting cryptocurrencies:[7]

> ***DEFINITION 3: A blockchain is an implementation of a DL with an append-only chain of cryptographically-linked secure 'blocks' of data, open for any participant to read and propose changes to data records, without reference to their real world identities and with consensus established entirely through the supporting software without any additional institutional responsibilities.***

These are the definitions of the three terms "Distributed Ledger", "Distributed Ledger Technologies" and "Blockchain" employed in the rest of this paper. These most appropriate definitions for our analysis – but consensus on these key terms has not yet been established.

Here are some other perspectives inconsistent with our proposed definitions:

- It is quite common to see references to 'the blockchain' (as in "the asset holdings will be recorded on the blockchain"). This is typically just a mistake. There are many different distributed ledgers and blockchains so what is probably really meant is just 'a blockchain'. [8]

- Our definition of blockchain is limited to 'unpermissioned' implementations of distributed ledgers' – those where anyone can join. [9]

- Some proponents of the use of distributed ledgers, especially those who see substantial business and customer benefits from the application of smart contracts, prefer an even broader interpretation of distributed ledger than we do – including also databases with a single operator with data shared amongst multiple users. A long-established example of such shared databases are the global distribution systems (e.g. Amadeus, Sabre, Galileo) used for sharing details of flight reservations amongst airlines, booking agents

[7] This is consistent with the more technical definition of (Rauchs et al. 2018): "*An append-only chain of cryptographically-linked 'blocks' of data, maintained and updated by a decentralised network, with network nodes encouraged by economic incentives to engage non-strategically to maintain and secure the system so that the data - organised in a specific structure often referred to as 'global ledger' - is robust to adversarial interference, double-spend, censure, counterfeit, collusion, tampering, or other types of malicious actions.*"

[8] Where it is not simply a mistake, "the blockchain" could be a reference to the original blockchain used to support Bitcoin ownership and transactions OR to a futuristic (and in our view unlikely) world in which one single distributed ledger dominates global sharing of data, much as today "the internet" dominates global communication.

[9] There are many though who refer to 'permissioned blockchains', on the grounds that permissioning is required for application in regulated financial services. While we agree that permissioning is necessary for application in regulated financial services, we believe that confusion is minimised by avoiding associations with unpermissioned cryptocurrencies and hence we restrict the use of the word blockchain to unpermissioned ledgers.

and air travellers. These have a single operator updating the central master copy of the database, rather than multiple operators updating multiple copies of the data base – so we prefer to call these shared databases not distributed ledgers. But others, for example some vendors we assume for marketing reasons, describe similarly controlled single operator database solutions supporting smart contracts as distributed ledgers not as shared databases.

## 2.2 The component technologies used in distributed ledgers

Distributed ledgers combine a range of cryptographic and other tools.[10] We distinguish nine component technological elements (Table 1).

**Table 1: the nine elements sometimes used in distributed ledgers**

| |
|---|
| ***Core functionality (required under Definition 1)*** |
| 1. Multiple, identical, copies of a computer-readable database |
| 2. Multiple operators responsible for updating the ledger, no central operator |
| 3. Complete time-ordered immutable records containing the entire data history |
| 4. Individually specified rights for reading and for instructing changes to the ledger allocated amongst multiple users (essential) |
| ***Supporting technology*** |
| 5. Synchronization (or a 'consensus mechanism') avoiding inconsistent versions of the ledger. |
| 6. Identification of users and operators through public cryptographic keys, linked as required in the design of the ledger to real-world identities (essential) |
| ***Additional technological elements*** |
| 7. The possibility (not a requirement) of a ledger specific asset 'owned' by users |
| 8. Incorporation of extra-ledger information in ledger entries or user keys |
| 9. Potential for algorithmic updating of the ledger based on its current state (what are often referred to as 'smart contracts'). |

The first four of these elements – (i) multiple, identical, copies of the ledger; (ii) multiple operators instead of a central operator (iii) time-ordered records containing the entire history of the data; and (iv) allocation of rights for reading and for instructing changes to the ledger amongst multiple users – are core functions. The benefits possible from these core functions are the reason for the huge interest in distributed ledgers. There is also though the possibility of providing many of these functions using a single central operator – although this would not be a distributed ledger in some contexts this is as good or an even better solution for users.

[10] Some insight can be obtained from comparing distributed ledger technologies with the technologies of the internet and the world wide web (see for example Ito, Narula, and Ali 2017). The internet is also supported by a combination of technologies (a communication layer that carries messages e.g. by Ethernet; IP the internet addressing protocol used for directing packets of data to their recipient on the network; TCP the 'transport communication protocol' that ensures that the data in the packets of data reach their destination complete and in the correct order; and application layers such as HTML for webpages and IMAP or POP for email; together often described as 'the internet stack'). The difference is that the core elements of distributed ledger can also be implemented separately – e.g. there is no need to have multiple copies of the ledger in order to allocate individual user rights or record a complete time-ordered history of the data.

The next two – (v) operational updating and synchronizing; and (vi) identification – are necessary supporting elements. The remaining three are additional functions important for particular distributed ledger applications.

Note that the four core functions of Table 1 are all embodied in our definition of distributed ledger (Definition 1). Not all core functions however are novel. For example, arrangements for allowing multiple users to access and process records of security holdings have been employed since the mid-1970s in major financial markets.[11]

A widely discussed distinction is between unpermissioned and permissioned ledgers:

- an unpermissioned ledger is one in which anyone can join the network of users without having to provide a real-world identity (for example the Bitcoin blockchain).
- a permissioned ledger is one in which operators and users must provide real world identities for permission to join the network

There has been extensive discussion by technical experts of *consensus in unpermissioned ledgers*, addressing the slow speed, high costs, environmental damage and lack of scalability of Bitcoin blockchain 'mining' (a proof of work scheme) and possible alternatives (based on proof of stake). [12] Ongoing technological innovation has led to recent development of several, more efficient alternatives to blockchain, supporting lower cost, faster and more scalable consensus, such as DAG (Directed Acyclical Graphs) or Hashgraphs as well as the locally based consensus mechanisms of Ripple and Stellar.[13]

In business and public administration application, which require known real world identities, these debates over consensus and proof of work are of little relevance. Conventional tools of law, regulation and administrative command can ensure acceptable behaviour and prevent malicious network participants threatening the integrity of the ledger. The costs of such control can be further reduced by partial centralization, for example giving a small number of privileged network members the role of validating write instructions.[14]

## *2.3* How the technologies are combined: the database 'stack'

To discuss the different ways in which the supporting composite technologies can be combined together in distributed ledger operations, we distinguish five different layers of the distributed ledger 'stack' (Figure 1).

The key points we will make using this figure are: (i) this 'stack' applies also to conventional databases; and (ii) the degree to which a particular layer is centralized and whether the

[11] These decentralised (but not distributed) arrangements for recording security ownership since the mid-1970s bring to our minds the words of Monsieur Jourdan in Moliere's 1670 play Le Bourgeois Gentilhomme "*Well, what do you know about that! These forty years now I've been speaking in prose without knowing it!*"

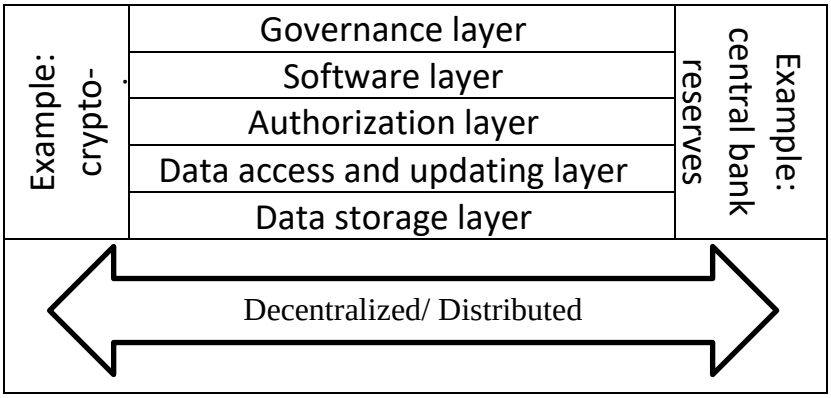
[12] Consensus in an unpermissioned network requires addressing the possibility that a malign network participant or group of malign participants could replace the true version of the ledger with a previously hidden false version, for example through a so called 'sybil attack' creating and controlling large numbers of new network nodes. Proof of work – or mining i.e. a costly expenditure to achieve a randomly allocated right to extend the network to the next 'block' – together with a rule that the longest of two competing versions of the ledger is treated as authentic, ensures that such replacing the established version of the network with an alternative requires control over 50% of the resources devoted to proof of work. See (Narayanan et al. 2016) for more detailed description.

[13] See (Anwar 2018) for a succinct summary and discussion.

[14] An example is the validation of the Ripple network transactions.

database is a distributed ledger or a conventional database is less important than the services it provides and the security it offers

**Figure 1: the 5 layers of distributed ledgers and conventional databases.**




Note: This figure extends the distinction of (Rauchs et al. 2018, esp Section 4.1.4) between the data, network and protocol layers of distributed ledgers. Their data layer are the records held on the ledger i.e. our data storage layer. Their network layer is the interaction amongst the different network participants who access the distributed ledger. We divide this network layer into two: the authorization layer (determining the status and participation rights of different participants in the network, both users and operators) and the data access and updating layer (access to data and issue of instructions for adding new records from network participants and actions taken by network operators to update data records). We also divide their protocol layer into two, distinguishing the software controlling the participation and data processing layers and a governance layer operating outside the software. A governance layer is needed since not every ledger action can be fully software controlled (e.g. agreement on participation or software changes).

<u>The similarities of distributed ledgers and conventional databases</u>

Figure 1 applies both to distributed ledgers and to conventional and more widely used relational databases, where records are maintained in multiple tables (e.g. one for customer records, another for orders, yet another for invoicing and payments etc. and keys used to cross refer between tables and allow users to extract different views or summary information from the databases according to their particular needs). This difference in structure suggests that distributed ledgers are a major departure from conventional database design.[15]

The distinction between distributed ledgers and conventional databases is not though so clear cut. Nowadays commercial and administrative data is frequently stored in multiple copies, for example cloud storage alongside local versions, and accessed by multiple users (though only one operator makes changes). As capacity and costs of storage have fallen it is now much more feasible than in the past to maintain a complete record of past information. Modern cryptography makes it possible to provide many users with access to a database, while limiting their access to specific read or write permissions. There is no insuperable technological barrier to offering multiple user access to a relational database or maintaining a complete time-ordered version of a relational database recording all past versions. In short, the technical features of distributed ledgers, (i), (ii) and (iii) of Table 1 are *not* unique to distributed ledgers. They can all also be provided by conventional databases. Only when it is essential having a single operator is a distributed ledger required.

<u>Different degrees of centralisation</u>

[15] (Rauchs et al. 2018) Figure 1 is an example; (Mainelli and Milne 2016) Table 1 is another.

Figure 1 focuses attention on different possible degrees of centralization:

- Unlike a conventional database with a single operator and a centralized data storage layer, there can be many operators and no central master copy of a distributed ledger. The data storage layer is decentralized or 'distributed' amongst the operators who all add ledger records. But the extent of this decentralization can vary. The original unpermissioned cryptocurrency blockchains have a fully decentralized data storage layer – all users are also operators. Commercial applications using permissioned ledgers have relatively few operators, so the data storage layer is only partially decentralized.[16]
- Partial decentralization is possible within other layers: e.g. responsibility for updating records in the data storage layer or the allocations of permissions in the authorization layer limited to a subset of participants; the software and governance layers might be centralized or partially centralized (a single institution or subset of participants deciding the design of the ledger) even when other layers are decentralized;

There are further important differences between distributed ledgers and conventional databases are at the higher software and governance layers. All use of a distributed ledger is within a single software environment. This helps supports greater transparency and security.[17] This also requires clearly articulated shared governance mechanisms for agreeing changes in authorization and software layer.

Conventional databases are either controlled by single institution or have an institutionalized corporate governance framework with members or owners voting on governance decisions. Changes in authorization or software can be slow and expensive.[18]

Cryptocurrency blockchains are the extreme opposite case with near complete decentralized governance. They are permissionless. Any network participant can recode the open-source software and propose this replaces the existing software; but this proposal is only adopted if there is majority agreement to the change across the network.[19]

Any business or public administration application of distributed ledgers requires interfaces for data import or export. This in turn requires identifying real world identities of users:

- When data is imported real world identities are required for data validation.
- When data is exported real world identities are needed for further data processing.

i.e. they have to be permissioned, with access to the data subject to establishing the real world identity of users and access limited as necessary to a restricted set of eligible participants. Institutionalized corporate governance is then also required to control this access.

[16] Allowing them to avoid the slow and costly 'proof of work' consensus mechanisms used in unpermissioned ledgers, for example Bitcoin mining. See Section 3 below for further discussion.
[17] It would have for example been very much more difficult for Bernie Madoff to have continued as long as he did with his investment fraud had investments in New York markets been recorded on a distributed ledger.
[18] SWIFT is an example of such co-operative governance, with an institutional process to make key databases and communication protocols that support international payments.
[19] The software itself defines the determination of the majority, in the case of Bitcoin it is 75% of recent mining power must agree to the adoption.

# 3 Applications of distributed ledgers in financial services

## 3.1 Fourteen areas of application

We now examine some of the opportunities for potential distributed ledger application in financial services, as listed in Table 2.[20]

**Table 2: potential financial services applications of distributed ledgers**

| Application area | Summary Assessment |
|---|---|
| ***A Asset ownership and management*** | |
| 1. Equity ownership and transactions | Some limited DL opportunities |
| 2. Bond ownership and transfers | Some limited DL opportunities |
| 3. Illiquid assets: syndicated loans and asset backed securities | More substantial opportunity for DL in both ownership and transactions |
| 4. Funds allocation by asset managers | Complex operations: DL may help. |
| ***B Trading and derivatives*** | |
| 5. Derivative exposures and clearing | Helping overcome complexity through data sharing, DL useful but multiple operators not required. |
| 6. Collateral and default management | Promising initiatives, potential application of DL, but multiple operators not required. |
| 7. Money and forex markets | Limited application of DL to foreign exchange post trade processing. |
| 8. Metals and commodity markets and trading | Similar picture as in many other areas: limited niche application. |
| ***C Corporate financial services*** | |
| 9. Trade finance | Many initiatives, strong case for data sharing using DL, but unclear any will achieve critical mass. |
| 10. Corporate supply chains | Opportunities for digitisation, sharing of data using DL can be important but multiple operators not required. |
| 11. Insurance and reinsurance | Many opportunities for digitisation, few require data sharing using DL. |
| 12. International payments | Shared ledgers including DL are facilitating information flow, unclear if multiple operators are required. |
| ***D Regulatory oversight*** | |
| 13. Client on-boarding & KYC/AML | A critical area but main issue is agreed standardized identity solutions, could then be supported using DL. |
| 14. Regulatory reporting | Main concern is standardisation to support automated reporting and to allow supervisors direct view of underlying data; some limited potential for DL. |

[20] We have chosen not to cover personal financial services, e.g. payday lending. While a number of start-ups propose using distributed ledger for personal financial services, none seem to us to have yet developed credible applications.

This table serves as both a table of contents and summary assessment for the analysis presented in the rest of this section. To make this a more manageable exercise, we divide these opportunities into four broad areas of applications. For each of these four areas of application we remark about the more specific opportunities. Our discussion here focuses on specific adoption in particular areas not radical change in financial architecture – but we will mention radical change where relevant.[21]

Each of these areas of possible application of distributed ledgers are specialisms to which skilled professionals have devoted entire working careers. As independent researchers, we make no claim to match the levels of knowledge and understanding of those working day-to-day in these business activities. What we offer are initial assessments that taken together a can be a guide to the most promising DL opportunities in financial services.

*A*: *Asset ownership and management*[22]

Application of distributed ledgers in conventional financial services usually means *replacing* existing arrangements not starting from scratch. Could adoption of distributed ledgers yield sufficient benefits to justify the costs of migration to a new system? Even if this is justified for the industry as a whole, will individual firms have incentives to make this move when they are unsure about adoption by others? To address these questions, we discuss first distributed ledgers for recording equity holdings and transactions. We then move on to examine their potential use for recording holdings and transactions in bonds, syndicated loans and asset-backed securities, and in fund management.

1. *Equity holdings and transactions*

We are aware of no commercial scale initiatives to facilitate equity transactions through holding of security investment accounts directly on a distributed ledger rather than as at present maintaining accounts with custodian banks who in turn hold securities in omnibus accounts with a central securities depository.

This possibility received a lot of attention three years ago, when interest first arose in the application of distributed ledger technologies to securities settlement.[23] Yet only one initiative – the ASX replacement of its Chess settlement system, one of the seven case studies that we explore further in Section 3 – is re-engineering core systems for recording securities ownership. As we describe more fully in this case study, this is an application of distributed ledger *technologies* but not (in our definition) a distributed ledger. The core replacement for CHESS is still a centrally operated database. It will change how cash equities are transferred and serviced by market participants (brokers, custodian banks), replacing inflexible COBOL based system with one with fully integrated cryptographic security and full compliance with ISO20022 standards that support interoperability of transaction systems.

[21] The possibilities of radical change are more fully addressed in Section 6 on public policy.

[22] There is an overlap of issues in between this subsection "A. asset ownership and management" and the following subsection "B. trading and derivatives". Our emphasis in this sub-section is the potential impact of adopting distributed ledgers on the long-term holders and issuers of securities and other financial assets. Our emphasis in the next subsection is on market participants taking relatively short-term positions – in brokerage, dealing in OTC markets, cash management, proprietary trading or hedging financial risks.

[23] See (Mainelli and Milne 2016) (Mainelli and Milne 2016) discuss the use of the R3 Corda platform for sharing trade and pre-settlement data on a bilateral basis, to reduce operational cost and risk between brokers acting on the two sides of the trade. This limited application of distributed ledger technologies was not really distributed ledger since it was bilateral not multiple users and did not involve maintaining permanent records.

The Chess replacement is will support an important element of distributed ledger technologies, allowing the use of smart contracts to automate the business processes of market participants. If they wish they can use the shared ledger services offered by ASX to ensure that clients and counterparties have access to the same data as they do eliminating the need for manual reconciliations. But it is not introducing a ledger updated by multiple operators or supplanting the role of custodians in maintaining records of security holdings on behalf of clients.

There has been some exploration of the use of distributed ledgers in corporate governance through employing distributed ledgers to support the exercise of proxy votes at corporate annual meetings (something that is presently requires a complicated process of communication through the various layers of intermediation). A leading example is the use distributed ledger technologies supporting proxy voting solutions for mutual funds and ETFs offered by Broadridge.[24] This is not though a distributed ledger according to our Definition 1: it is (as with many other practical applications labelled as blockchain or distributed ledger) a conventional database with a single operator, but one adopting elements of distributed ledger technology, in this case immutable cryptographically secured record keeping to ensure that there can be no dispute about the outcome of votes, along with other digital technologies to inform fund participants about corporate decisions. There have been other pilots using forms of distributed ledger technologies to support proxy voting, for example conducted by SWIFT working with the Singapore Stock Exchange and several Singapore banks.[25]

This lack of adoption of distributed ledger in securities settlement may seem surprising, given that one of the most widely circulated reasons for anticipating a 'distributed ledger revolution' in financial services has been the prospect of reducing the current two-day delay in securities settlement to near-real time. This expectation was though always greatly exaggerated: the reason for delay in securities settlement is far from being just the inefficiency of legacy systems. It is largely a reflection of a preference for market participants for delayed settlement.[26]

The barriers to real time settlement of securities trades are not technological. Current settlement systems, such as those operated by DTCC , Euroclear and the T2-Seurities operated by the European Central Bank, can execute DVP settlement (the delivery of the security against payment finalising the transfer of ownership) in near real time without using any form of distributed ledger technology. Delay arises because of the need to check that the two sides of trade are ready to settle before DVP: that the seller or their agent has control of the security in a custodian account and is ready to deliver; and that the buyer or their agent has cash in a transactions account ready to pay. The reason that current systems do not support real time settlement that that many participants in securities markets do not have and do not want to have the security or the cash ready to settle the transaction at the time the trade is executed.

For buy side cash investors – whether investment funds operated by asset managers, or direct investment by institutional investors or retail investors – investment securities are purchased as investments and are held for weeks, months or years. The two-day delay from *T* to *T+2* in

[24] See (Collins, Kozakis, and Wisdom 2018; Broadridge 2019)
[25] See (Ledger Insights 2019d), who also note similar projects in Japan, Estonia, Canada, Russia and Poland.
[26] See (Mainelli and Milne 2016) for more detailed discussion. One reason for this exaggerated expectations may have been a mistaken analogy between securities market settlement and execution of retail payments. There are obvious customer benefits in terms of better cash flow management and certainty of payment from real time crediting of retail payments to beneficiary accounts, achievable through co-ordinated technological development and investment (for example 'Faster Payments' in the UK). As discussed on our text, there are no such obvious equivalent benefits to securities markets participants from real time securities settlement.

acquiring the securities is immaterial to efficient portfolio management. Provided the eventual settlement is 'DVP' and through established credit worthy investment institutions the financial risks of the settlement not taking place is negligible. The probability of such an event is already extremely small and, even if there is a default on a contract to buy or sell a security, the only exposure is that of replacing the transaction a couple of days later, an exposure that is any case typically protected through a guarantee from a central counterparty spreading the risk of loss across many market participants.

Short term leveraged investors such as macro-orientated hedge funds have even more reason to prefer settlement at *T+2* : this provides time to manage their liquidity, to borrow securities for settlement of a sale when maintaining a short position overnight; or to borrowing money for settlement of a purchase when maintaining a long position overnight.[27] As long as they can obtain liquidity in money markets (see below for our discussion of money markets and collateral management) then they have little need for an accelerated timescale for receiving the proceeds of trade from securities transactions. Forcing the pre-positioning of cash and securities prior to trading in order to support immediate post trade settlement, would require much greater pre-commitment of capital and liquidity, sufficient to finance the maximum anticipated long and short positions taken during the trading day.[28]

It can still be argued that market participants would benefit from greater flexibility in settlement times, being able to choose a settlement time, short or long, that is suited to the counterparties to particular transaction. Settlement timing is currently determined by time zone and the need for both sides of a trade to position themselves for delivery against payment, according to the overnight (T+1 to T+2) local batch processing cycles. As a result, both cash and securities can be locked up in securities settlement for longer than many involved in securities transactions would like. A combination of a shared ledger – to record global trades dues for settlement – and automated matching identifying potential for early settlement before T+2 could conceivably do more than current netting arrangements to reduce settlement times.

But this is an immensely complicated co-ordination problem, made more even more complex by the standard practice of netting of securities trades and then novation of resulting net positions (involving hundreds of counterparties) to a single position against a central counterparty. While a global system determining individual settlement times to better meets the needs of these hundreds of counterparties. In our judgement the benefits are far too little to justify the substantial costs of developing and adopting such a system on a market wide basis.

This does not mean that distributed ledger has no role in securities settlement. It just means that the use case is not settlement speed. An example of a use case is Utility Settlement Coin developing a commercial implementation of distributed ledger, allowing investors in security markets to hold cash funds for securities transactions directly on a distributed ledger rather than indirectly with a commercial bank. This is another of our seven case studies.

[27] Confusingly the terms short and long are of course not investment horizon, both short and long positions taken with an investment horizon of at most a few days in order to make profit from perceived market mispricing

[28] For a persuasive statement of this argument see (Monahan 2019), who argues (from review of clearing and settlement in securities markets and bank payments going back to 1584 and examination of contemporary data) that current arrangements are highly efficient: only $8,2bn of committed reserve collateral, through netting and CCP clearing, supports some $326bn of daily gross trades in US security markets. If this were replaced by real time pre-funded DLT settlement, ruling out both multilateral netting and CCP guarantees, would require substantially increased upfront commitment of cash and collateral to preposition for trades that may or may not take place)

This project should offer substantial benefits to asset managers and other investors – they no longer have to rely on their commercial bank for the settlement of large value payment transfers and getting 'sucked into' additional potential delays because the commercial bank needs to delay a payment for their own reserve management purposes (awaiting an incoming payment or intraday liquidity from the central bank). Utility settlement coin effectively pre-positions them with the holding of central bank money required for final settlement and guarantees the cash leg of the trade. This together with accompanying simplifications of the operational steps involved in settlement reduces the costs and risk of settlement delay.

2. *Bond holdings and bond transactions*

Our discussion of the use of distributed ledgers for recording bond holdings and transactions can be relatively brief, since the issues involved are very similar to those for equity investment. Current arrangements holding and transacting in bonds parallel those for equities, holding bonds in security accounts held with custodian banks, and work reasonably well. The cash leg for settling a bond transaction can employ a distributed ledger solution such as utility settlement coin just as easily an equity transaction.

There are operational differences between bond and equity markets. For government bonds settlement is typically *T+1* not *T+2*. In the past bonds, in contrast to the exchange trading of equities, were traded in dealer markets offering telephone (voice) quotes. As with equities, much bond trading is now electronic, but through a wide variety of single dealer and multiple dealer platforms.[29] These platforms in turn link trade execution to post-trade settlement. Had distributed ledger technologies first emerged in the early 1990s, when the shift from voice to electronic execution of bond trades began, then it is quite possible that these new platforms would have been leading adopters of distributed ledgers. They then though established custody and settlement processes very similar to those used in equity markets. Application of distributed ledgers in bond holding and bond transactions requires (just as in equities) the replacement of existing systems that already work reasonably well.

We should mention one promising exploratory transaction, the Aug 2018 issue by the World Bank, working with the Commonwealth Bank of Australia CBA, of a two year bond on an Ethereum based distributed ledger.[30] This was a live deal, not just a proof of concept, with the investors (a range of Australian institutions) using the platform to participate directly without the support of an issuing syndicate.

While successful, it is unclear if there is appetite for replication of this transaction, moving the investment as it does outside of the usual framework of operational support provided by custodian banks. The experiment was limited: cash payments for purchase, coupons and redemption were not handled on the distributed ledger, all the ledger does is issue automated instructions for cash payment to the lead arranger CBA. It does though reveal some potential for employing distributed ledger in primary issuance. The principal benefit seems to have been automation of the book building process for CBA with real time changes in investor submissions and greater transparency for investors of their own commitments to the deal.

[29] A review of these changes is provided by (BIS 2016).
[30] Described in (Lee 2018).

### 3. *Illiquid assets: syndicated loans and asset backed securities*

With the limited private benefits and substantial barriers to adoption of distributed ledgers for holding and transacting in equities and bonds, it is unsurprising that the interest in employing distributed ledgers for recording ownership of and transactions in financial assets has shifted. Now most attention is paid to using DL for those financial assets where the institutional arrangements for ownership and trade are relatively undeveloped or fragmented, for example the possibility of using distributed ledgers to record participation in syndicated loans or ownership of structured products.

A prominent example is the development of 'Fusion LenderComm', a collaboration between Finastra, who operate the leading loan servicing platform Fusion LoanIQ, and the R3 consortium using their open source Corda implementation of distributed ledger technology to allow syndicated loan investors to access information on loan.[31] As described by Finastra, the key advantage of Fusion LenderComm is allowing the loan agent (the arranger or lead lender i.e. the bank that co-ordinates the loan syndication and often also oversees subsequent loan servicing) to fully control who has access to information on the borrower and the loan; and also ensure that all this information is held in a standardized and easily accessible form. Subsequently it is intended that the same platform will be developed to support the execution and subsequent settlement of loan transactions.

Fusion LendingComm does not however seem to rely in any essential way on using a distributed ledger (under our definition, a database with multiple users and multiple operators). Such data sharing could as easily be supported by a traditional centralized database. This is illustrated by a competing initiative to address fragmentation and inefficient communication of information on syndicated loans by IHS Markit, describes itself only as an "information portal" and makes no reference at all to blockchain or distributed ledgers.[32] IHS Markit are investigating the use of distributed ledgers for transactions in syndicated loan, but their initiative – rather like the Utility Settlement Coin project – seems to be focused on co-ordinating the cash leg of loan syndication.[33]

Another potential application of distributed ledgers is to record the component assets and payment obligations in asset backed securitizations – including mortgage backed securities (MBS), other securities backed with household loans (ABS), collateralized loan obligations used to securitize syndicate loans (CLOs) and collateralized bond obligations (CBOs). A major concern during the global financial crisis was the lack of transparency about payment obligations, especially modelling the 'waterfalls' created by tranched structures and hence the implications of loan default on payments to different tranches of a securitization. There are clear benefits

[31] See (R3 Finastra 2018)

[32] This initiative, announced in October 2018, is described by (IHS Markit 2018) as follows: "Specifically, the portal provides:– Position reconciliation data: 10 agent banks submit data on 9,000 loan facilities to the service each day and 200 different institutions, representing nearly 8,000 funds, use IHS Markit to electronically reconcile loan positions; – Asset servicing data: IHS Markit is the leading aggregator of agent notices in the syndicated loan market. In 2017, the firm transmitted more than 13 million notices from a broad range of agent bank systems to nearly 8,000 lender funds; – Loan reference data: IHS Markit actively maintains 150 reference data fields on more than 8,000 loan facilities, covering terms and conditions, covenants, amortization schedules, multiple types of identifiers and other data loan managers use for market surveillance, valuation, credit analysis and performance attribution. Corporate actions, amendments and restructures are tracked and processed intraday to provide customers with the most accurate data possible."

[33] Described by (Allison 2018) who quotes John Olesky head of product management at IHS Markit "…the smart contracts decide when a trade is ready to close and perform the cash settlement".

to investors to having a shared database where they can track the allocation of past cash flows and use for prediction of future cash flows to tranche holders.[34] There has yet been only limited effort to develop distributed ledgers that provide such transparency, one effort of this kind is by the start-up Global Data Registry.[35]

There does not yet though seem to be large scale take up by the industry. There are several reasons for this. One of the benefits of greater transparency only arise in a financial crisis and so the private commercial return to such investment I such a platform is not so attractive. Another is simply the difficulty of co-ordinating change involving a wide range of market participants with no central authority to coordinate or market infrastructure to ensure all are working to a common plan.

4. *Investment and funds management.*

Some of the most complex operational processes in global capital markets take place in funds management. It is usual – in order to reduce transaction costs and take advantage of netting of offsetting trades – to aggregate trade orders from several individual funds for execution, in turn requiring re-allocation of the cash or securities obtained from the trade amongst individual funds after settlement. At the same time funds and the brokers who execute their orders operate complex execution systems (supporting algorithmic i.e. computer managed trade execution supporting a range of different forms of order) and are subject to detailed and complex regulatory compliance, in order to demonstrate best execution and fair allocation of proceeds amongst different funds. New regulation, for example the EU Markets and Financial Instruments Directive MIFID II are requiring increasing transparency of costs for final investors.

The complexity and operational costs of these processes and the increasing pressure from regulatory requirements make them ripe for simplification and standardization of operational processes. There is though relatively little discussion of the application of distributed ledger in asset management, compared to its use in capital markets, commercial banking or insurance. The most detailed discussion we have found is that of (Hunt and Mills 2018) who have conducted extensive industry interviews focusing on the role that distributed ledgers might play in reducing costs and providing investors with much better value for money. While as they note, to date development of distributed ledgers is a relatively low expenditure priority in stretched asset manager IT budgets, there are major opportunities including:[36]

- Delivery of paid for services, such as research reports or peer to peer service inputs such as 'crowd validation'.
- Simplification of the duplication of asset registers held across Asset Managers, Registrars, Custodians, Depositaries and Administrators, based on timely delivery of position data were delivered in a distributed fashion from a shared transaction ledger. Also reduced time and money spent on data reconciliations between asset registers.
- Automation of manual and paper-based processes, especially the use of smart contracts to support the automation of manually-intensive processing of complex assets such as exotic derivatives and structured investment products.

[34] (Sindle et al. 2017).

[35] See https://gdr.co/ , their product is described in (Groenfeldt 2018)

[36] They also identify other potential benefits that apply across financial services such as a distributed identity service to reduce costs of client on boarding; application to liquidity and collateral management; and direct reporting access for regulators and clients using underlying granular data, all discussed elsewhere in our report

- A transition to real-time immediate settlement with reduced reliance on central infrastructures and direct access to central bank money; something that could be especially valuable in repo/ securities financing.

Some asset managers also perceive opportunities for the adoption of distributed ledgers supporting more fundamental change, for example "peer to peer" distribution where retail investors hold assets directly and with current retail platforms and distributors and asset managers playing only an advisory and operational role; also in supporting the automation of corporate actions such as proxy voting and class actions. These are certainly possibilities.

Perhaps most importantly, (Hunt and Mills 2018) locate the adoption of distributed ledger within the context of a bigger picture of digitisation and change in systems architecture:

> *The Asset Management business is positioning for a move towards a service-based approach, within which market data, reference data, entity data, transaction data and position data will be maintained and delivered by central services. Applications will consume, rather than maintain that data, and will cease to be islands of self-contained data: they will be leaner and fitter as a result…. The architectural objective is becoming clear, but it is not at all clear yet how we get there: establishing the critical mass required for genuine wide-scale services and utilities has always been challenging….Distributed Ledger Technology is seen by Asset Managers as potentially very beneficial in this context, not because it is the only solution / technology in the space, but because it can facilitate and accelerate the establishment of the key services, and help us to navigate our way towards service-based architectures.* (Hunt and Mills 2018 pg 20)

One of our case studies, that of the IZNES distributed ledger, illustrates some of the opportunities that arise from applying DL in this area. This can be especially useful in providing final investors with reliable and consistent information about underlying costs of custody and investment transactions. We believe though that DL alone is part of the answer to these challenges, there is still a long way to go with standardization of many aspects of operational process across the funds management industry.

*B Trading and derivatives*

We now turn to our second broad area of application of distributed ledgers in financial services.

5. *Derivative exposures and clearing*

A major challenge for derivative traders and brokers is the complexity of the instruments, especially for OTC products are tailored for the requirements of each individual client, unlike the standardized derivatives contracts traded on exchange.

A further case study we examine later in this section is the work of Digital Asset with ISDA the International Swaps and Derivatives Association to develop standard cross-industry processes for the execution of derivative contracts. Here we discuss this initiative in the broader context of the ongoing work of ISDA, supporting the standardization and the efficient trading and settlement of OTC derivative contracts. This has been a central ISDA responsibility since the emergence of OTC derivative markets in the 1970s. ISDA master agreements and protocols provide a well understood legal contracting environment. ISDA has also been centrally involved in the automation of OTC derivatives market since 1999, in its role as manager of the XML

business information exchange language FpML used for electronic communication in derivatives trading.

ISDA's work on automation seems consistent to us with the view that distributed ledgers are not themselves revolutionary; what is revolutionary is digitisation including support through sharing of and independent processing of data using appropriate distributed ledger technologies. With several parties involved in processing of a derivatives contract, both clients and dealers, the coordination of operational processes requires an appropriately structured environment for shared processing with standardized machine executable concepts fully describing each possible processing event.

Over the past three years ISDA have focused on a major technology project the 'Common Domain Model' or CDM, supported by Digital Asset, which in March 2019 was released in an open source version for commercial application to interest rate and credit derivatives: "*CDM for the first time creates a common blueprint for events that occur throughout the derivatives lifecycle, paving the way for greater automation and efficiency at scale.*"[37] This overcomes limitations in existing communication standards (FIX-XML, FpML as well as some older SWIFT messaging standards) which still accommodate considerable variation of implementation across institutions. Fully automated shared processing requires a deeper level of standardization.

The CDM has been inspired by the opportunities presented by distributed ledger technologies. As discussed in their 2017 design definition document, the core concept is that modern transaction and post-trade processing must involve multiple parties (dealers, clients, banks, central counterparties, interdealer brokers) and that as a result the automation of derivatives processing benefits from two key elements of distributed ledger technologies: Multiple, identical, copies of a computer-readable database; and complete time-ordered immutable records containing the entire data history.[38] This can then support the application of smart contracts. ISDA has collaborated with Digital Asset employing their smart contract language DAML to bring offer automated open source business processing solutions as part of the CDM initiative.

One focus in developing CDM has been in ensuring that automatically executed operations ('smart contracts') are both legally and operationally valid and implantable using their CDM. ISDA has released two white papers on this.[39] As described in our case study, ISDA has been cooperating with Digital Asset on using Digital Asset's smart contract coding language DAML to provide an open source reference code library to facilitate application using the ISDA CDM.[40] The leading systems solution provider in collateral management Baton Systems has also announced that it's its platform now natively supports ISDA's Common Domain Model (CDM) for derivatives.[41]

CDM though not specific to any distributed ledger solution or even to the adoption of a distributed ledger for data sharing. As the documentation in the Rosetta Technology release of CDM 2.0 explains:

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[37] From (ISDA 2019a)
[38] See (ISDA 2017) – we will not discuss the formal technical definitions they provide of 'lineage' and 'consistency'; we simply note that these closely correspond to these two of our core functionalities.
[39] These are (ISDA/ Linklaters 2017; ISDA/ KWM 2018)
[40] Announced in (Digital Asset/ ISDA 2019; Ledger Insights 2019a)
[41] See (Ledger Insights 2018a)

"*The ISDA Common Domain Model is an initiative that ISDA has spearheaded to produce a common, robust, digital blueprint for how derivatives are traded and managed across their lifecycle…. ISDA anticipates that establishing such digital data and processing standards will lead to the following benefits:*

- *Reduce the current need for continual reconciliations to address mismatches caused by variations in how each firm records trade lifecycle events;*
- *Enable consistency in regulatory compliance and reporting;*
- *Accelerate greater automation and efficiency in the derivatives market;*
- *Provide a common foundation for new technologies like distributed ledger, cloud and smart contracts to facilitate data consistency;*
- *Facilitate interoperability across firms and platforms.*" (Rosetta Technology 2019)

6. *Money and foreign exchange markets*

There are two reasons for anticipating strong interest in the opportunities for employing distributed ledgers in improving the efficiency of transactions in money and foreign exchange markets.

- Market participants often need to be able to complete transactions immediately (in contrast to securities markets, where as we have seen T+2 settlement is more of a desired feature than a bug).

- The money and foreign exchange markets were at the centre of the conduct problems that emerged since the global financial crisis – the manipulation of both the LIBOR index and the 4pm Foreign Exchange fix and also broader concerns about front-running and other examples of exploitation of clients.[42] If distributed ledger can serve as a means of improving transparency and trust, then nowhere is this more relevant than in the money and foreign exchange markets.

Given this, surprising that little attention seems has been paid to the development of distributed ledger applications in money and foreign exchange markets. This is perhaps because same day settlement is already available for money market transactions, for example DTCC's Money Market Instrument Transaction Process service that supports end-of-day settlement for fourteen US money market instruments.[43] Also the benefits of greater transparency through digitisation in controlling conduct risk are primarily social and not private, so limiting incentives for market participants to adopt distributed ledger in support of transparency of trade execution.

We have identified few initiatives for applying distributed ledger in money and foreign exchange markets.[44] Most work has been on employing distributed ledger for the settlement of foreign exchange. A leading initiative is that of CLS-net, a service built by CLS with IBM using

[42] See (BoE / FCA/ HMT 2015; Myles 2015; Carney 2017)
[43] This is described in (DTCC 2013)
[44] We do not cover efforts at developing decentralized exchanges where cryptocurrencies or crypto assets can be traded without revaluation of identity, some discussion is provided by (Lin 2019). In Section 5 on public policy we discuss the use of distributed ledger to address conduct risks.

the Hyperledger Fabric.[45] CLS is the settlement service for the $5 trillion a day global foreign exchange market. It provides settlement at *T+2* for the 18 principal internationally traded currencies from its core service 'CLS-Settlement'.[46] CLS-net went live in late 2018. It provides a complementary service, supporting settlement in 120 currencies i.e. those not covered by CLS-Settlement. It is a multi-user ledger in which the two parties to a foreign exchange transaction both submit their trade in order to coordinate settlement, but to our understanding CLS-net has only a single operator CLS. It is yet another example of a financial services application of distributed ledger technologies that is not a distributed ledger.

A complementary project that appears to be gaining some traction is Cobalt, a start-up that focuses on post-trade technology in the institutional foreign exchange market. Their core product is Cobalt Blue Sky, a shared (not distributed) ledger to which foreign exchange market participants can post trades, providing an agreed 'golden copy' for automation of post-trade services, including settlement via CLS and credit and credit risk management (just as in securities markets foreign exchange traders prefer T+2 settlement in order to have time to arrange the necessary funding to settle their trades).[47]

The only other money and foreign exchange projects we have found are for conducting repo transactions on a distributed ledger. As this is related to collateral management, we discuss this in the following subsection.

### *7. Liquidity and collateral management*

Collateral and default management is perhaps the most complex of capital market business processes. The issue here is providing systems for prediction and management of short-term requirements for acquiring cash and securities. We cover three things in this subsection. First, we provide an overview of collateral management. Next, we consider the relationship of collateral management to default management and systemic risk. Finally, we examine some of the proposals that have been made about applying distributed ledger to obtain efficiency gains in collateral and default management. We identify some solutions applying distributed ledger technologies to support cash liquidity and collateral management, but once again these turn out to be relatively conventional solutions that employ some elements of distributed ledger technologies, not a revolutionary shift to a new approach to record keeping and transfer of ownership with multiple operators updating a distributed ledger.

<u>The collateral management functions: speedy response to margin calls; optimizing collateral</u>
A major current challenge for all institutions taking trading positions in security and derivative markets is collateral management.[48] Collateral is required for capital market trading in two circumstances –

[45] For description see (Morris 2018b, 2018c; CLS 2018)
[46] As described in (Lindley 2008) CLS-settlements effectively eliminates settlement risk, through its key features: daily netting of settlement, so all payment due are on a net basis against the CLS bank; 'PVP' (payment versus payment) so that payments are received only when paid; and with a liquidity facility (not a guarantee) so that if there is settlement failure the counterparty still receives and pays funds as anticipated until the situation is resolved (this is not a central counterparty guarantee but sufficient to protect from the impact of all but the most extreme possible default risks).CLS is owned by an industry consortium and was originally established in 2002 as the Continuous Linked Settlement Bank.
[47] See (Cobalt 2019; Ledger Insights 2019c). They also provide an integrated information management tool Cobalt Blue Sky and a credit management tool Cobalt Credit.
[48] Much of the following is based on the insightful summary provided by (Murphy 2014).

- financing of a securities trade. A long securities position requires posting the securities as collateral to obtain leveraged financing. Similarly, a short position also requires financing, in this case the borrowing of securities through repo or securities lending matched by the posting of cash collateral.
- limiting the counterparty risk of derivative contracts, almost all of which now require margining either to a central counterparty or on a bilateral basis.

In either case the initial posting of collateral can be followed by calls for further collateral either calls for 'variation margin' as the market price of contracts changes; or calls for additional 'initial margin' in times of market stress with heightened market price volatility and falling collateral values.

The collateral management function therefore has two main responsibilities:

1. Ensuring that collateral is always posted promptly as required, both as part of the conduct of securities and derivative trades and in response to margin calls.
2. 'Optimizing' the use of collateral, making sure that the institution holds sufficient uncommitted or unencumbered collateral (cash or good quality securities) so that collateral needs are always met but not more than necessary since these are relatively low return assets.

<u>Counterparty default and systemic risk</u>

A related concern is assessing the firm's ability to manage the default of a major counterparty – the situation where collateral provides protection – or negotiating a period of extreme market stress, when demands for posting collateral rise substantially. The collateral management system should provide risk management with the information needed to assess and prepare for risks of counterparty default and coping with systemic crisis.

We mention a number legal and contractual details that go beyond the management of collateral. In Section 5 below we discuss related issues of public policy and how distributed ledger technologies might be used by the regulatory authorities to reduce the risks of systemic financial crisis.

First there are two distinct legal mechanisms used for 'posting' collateral: the first is title transfer, the asset is sold and then sold back (an example is the transfer of security ownership in a sales and repurchase transaction or repo); the second is the transfer of a security interest, in which title can be claimed in the event that the counterparty fails to perform their contractual obligations, an example is a mortgage. A major difference between these two cases is that with transfer of ownership the asset is 'unencumbered' it can be freely sold or used again as collateral (so called 'rehypothecation').

Sometimes the collateral is held by a third party (e.g. the 'tri-party' repo used in the New York markets) which prevents re-use but this can instead cause problems around matching the timing of return of borrowed funds/ securities and their matching collateral. In the event of default, it may not be possible to close out a long securities position where title has transferred because the collateral is trapped.

A short securities or bilaterally margined derivatives position is less of a problem because these can still be closed out and the worst possible outcome is a smaller cash claim on the defaulted

counterparty. A centrally cleared position is least likely to be a problem since it is guaranteed by the central counterparty with risks of loss shared amongst market participants (but it is conceivable that the central counterparty could itself default and calls by the central party for increased initial margin during periods of market stress can be a concern).

Employing distributed ledger technologies in collateral management

This seems to be an area with much discussion but relatively few applications that are adequately addressing the business issues. There are many claims that 'smart contracts' will help collateral management, but not all seem to have a proper appreciation of the business requirements for putting this into practice.[49]

Three prominent initiatives are exploiting the potential for distributed ledger technologies for the automation of collateral management and the borrowing of cash and securities. DTCC working with Digital Asset successfully completed the proof of concept applying digital ledger technologies to improve the netting efficiency of the start-leg of repurchase agreements.[50] This project aimed to promote greater use of their central clearing services for repo contracts (Fixed Income Clearing Corporation FICC) which already nets and settles the repayment or 'close leg' in the $1.7tillion a day of repo contracts for US money markets.[51] The purpose of the project was to introduce similar netting into the initial start leg of the repo contracting, thus further reducing collateral requirements in these money market transactions.

While the initial POC was favourable, further exploration of this project led DTCC to decide that the project was not worth bringing forward to commercial scale. One reason, we understand, is that the required data was already available on internal conventional DTCC databases. Thus increased start leg netting did not require the integration of DTCC systems with the systems of external users that would have justified pursuing a distributed ledger implementation:

"*DTCC believes the value of DLT is derived from the synchronization of business processes, which eliminates redundant and siloed activities and results in a lower total cost. After consultation with banks and other financial institutions, DTCC found that the desired scope and business objectives of the start-leg repo project could be achieved using traditional technologies. The repo project produced valuable insights and led us to explore additional use cases for DLT*."[52]

A second practically relevant digital technology solution in collateral management is the Asset Baton data management system provided by Baton Systems to Citigroup, a real time information and payments executions system used to monitor collateral positions and simplify the initiation of required cash payments in multiple currencies.[53] Baton are specialists in providing middleware software that integrates legacy payment systems. This again appears

[49] We have found a number discussions of distributed ledger based solutions for collateral management e.g. (Halbertsa 2017; DreamzTech Solutions 2018; Bloemer and Sekar 2018; Storm 2018), but regrettably almost none explain how distributed ledger technologies might support collateral management with any clarity and some exhibit substantial misunderstanding of how collateral management is conducted. A common claim is that smart contracts can automate collateral management but this is clearly an oversimplification: for example an automated immediate response to margin calls would require firms to hold increased levels of unused collateral rather than optimum levels with occasional delays in margin payment while sourcing additional cash or securities.

[50] This POC is described in (DTCC 2017a)

[51] http://www.dtcc.com/clearing-services/ficc-gov/repo

[52] Reported in (Cullinan 2018)

[53] Adopted by Citigroup working with CME clearing, see (McDowell 2017; Baton Systems 2019).

not to be a distributed ledger, according to our Definition 1, because it has only one user/ operator (although Baton describe it as a distributed ledger). This is simply a database internal to Citigroup that employs distributed ledger technologies to bring together collateral positions and margin requests from a variety of Citigroup legacy systems, supporting rapid and largely automated response.

A third collateral management solution based on distributed ledger is that for bilateral repo offered by Broadridge, in partnership with Digital Asset and utilising their open source DAML smart contract language. [54] Broadridge focus on "building permissioned network solutions using Enterprise DLT Platforms" (and are also well known for their proxy voting solutions for mutual funds, described above). Broadridge value DAML in this context because it has been *"… specifically designed to model and execute multi-party workflows".* Their solution is designed to provide end to end functionality throughout the life of the repo-contract, in which delivery of collateral and collateral management is one aspect, after contract agreement and confirmation. The benefit of a shared cryptographically secured database is providing a single version of data on which different repo transaction participants can draw – hence eliminating the need for manual reconciliation and contract disputes Once again, while described as a distributed ledger, it appears to have a single operator so not distributed ledger on our Definition 1.

Overall, what these examples show is the growing importance role of the application of various distributed ledger technologies as part of the ongoing digitisation of collateral management processes. The various component of distributed ledger technologies, immutable shared records, smart contracts are valuable both in accessing consistent data from a variety of external and internal systems on risk exposure and collateral requirements, for anticipating potential calls to provide collateral, and for prompt execution of the transfer of both cash and securities collateral when required. Distributed ledgers themselves though are less obviously relevant, it seems to be much more cost effective to build these tools on existing conventional systems and databases than start from scratch with a revolutionary new approach.

We will return to collateral and default management in our discussion of public policy provided in Section 6, discussing the possibility of using distributed ledger to deal with the potential trapping of collateral in a counterparty default and in management of central counterparty and other collateral requirements in a systemic financial crisis. These are further potentially valuable applications, but not commercially justifiable since they are a response to potential systemic risk not enhancing the efficiency of collateral management processes inside firms.

### *8. Metals and commodity markets and trading*

We can be brief here. The overall picture is similar to that for other applications of distributed ledger in financial services documented elsewhere in this section.

Practitioners have explored several potential applications of distributed ledger in metals and commodity markets, these exploratory projects falling into three main groups;

(i) settlement of trades in established metal and commodity markets

[54] This discussion largely based on (Mayadas 2019; Sheshagiri 2019).

(ii) trading of metals on crypto platforms through creating a token that represents the underlying, applied mostly to precious metals;[55]

(iii) applications in the supply chain for commodity production and distribution.[56]

The overall picture is very close to that documented for other financial services elsewhere in this section. Initial exploration between Euroclear and Paxos for using distributed ledger to settle gold trades in the London Bullion market ground to a halt in 2017 and has not been since followed up.[57] There is no obvious gain over existing settlement arrangements. The shift in interest from volatility cryptocurrencies to stablecoins has stimulated projects to 'tokenise' precious metals for trading on crypto exchanges (but does not contradict our view that 'crypto' will merge with mainstream assets). There are some substantial efforts at applying distributed ledger to provide transparency in the metals and commodities supply chain, but these are challenging systems developments not easy wins.[58]

## *C Corporate finance*

### *9. Trade finance*[59]

Trade finance is the provision of credit and insurance in international trade. It is another complex area, with many instruments involved. Investopedia lists some of the main instruments used (i) lines of credit from banks to both importers and exporters (depending on whether payment is made in advance or on delivery); (ii) Letters of credit in which the buyer's bank guarantees payment to the seller for the goods shipped, once the terms in the LC are met by the seller; (iii) factoring of account receivables, when companies are paid invoices upfront before the buyer makes payment, on a discounted basis (iv) government supplied export credit or working capital; (v) insurance of shipping and goods which can also (as an alternative to the letter of credit) protect the exporter from non-payment by the buyer. Trade finance is also a common target for fraud and in the front line of AML/KYC compliance, so the financial institutions involved have to know exactly who they are dealing with.

Much of the complexity arises because financial arrangements are contingent, on satisfactory delivery as well as regulatory compliance. Trade finance therefore involves multiple documents and multiple parties. The operational process, still used for the overwhelming majority of global trade, continues to be fragmented and with both paper-based operations and a requirement for frequent manual interventions, for example response to emails.[60] It should

[55] An example is the trading of a token representing a precious metal on Tradewind, the main difference from conventional precious metals ETF funds is that the token is ownership of the underlying metal and can be exchange for physical delivery not just for monetary repayment at the current market price (Barley 2018).

[56] See discussion of Komgo under trade finance initiatives below. Another promising example is the cross industry collaboration Forefield on traceability of metals backed by the London Metal Exchange (Ledger Insights 2019b)

[57] See (Zhao 2017)

[58] A similar assessment, with more detailed discussion and examples, is offered by (Belt and Kok 2018)

[59] A recent independently written report (Ganne and Patel, 2019), providing more detailed analysis of the application of DL in trade and trade finance, reaches very similar conclusions to us.

[60] This is well described by (Ramachandran et al. 2018) "However, this facilitation mechanism remains complex, with a large number of players (banks, corporates, shippers and other facilitators) exchanging numerous data points across multiple locations and links in the value chain. A single transaction can involve approximately 5,000 data field interactions. Processes are still largely paper-based. An end-to-end process can include 10-20 documents with a total of more than 100 pages, but containing as few as 60-80 unique data fields. These are then re-used and duplicated across documents at various stages in the process, leading to errors, discrepancies and

therefore offer considerable possibilities for digitisation through the sharing of data amongst many users on a distributed ledger.

The prospect of addressing these trade finance inefficiencies using distributed ledger has prompted the launch of several initiatives:[61]

- R3 is supporting two major initiatives for using distributed ledger in trade finance, employing its Corda platform. The first is HSBC's VoltraOne platform, now being developed to a commercial scale by CryptoBLK.(R3 CryptoBlk 2018) This focuses on the digitisation of letters of credit. On 1 May, 2018 R3 and HSBC undertook the world's first blockchain-based trade finance deal. In the deal, HSBC issued a letter of credit for U.S. food and agriculture firm Cargill using blockchain.

- The second Corda bases solution is the TIX platform of TradeIX and Marco Polo, launched and providing a range of trade finance related solutions.(TradeIX 2019; Marco Polo 2019) This is designed to improve transparency in the bank accounting systems that track customer trade finance and through this help customers obtain receivables finance.

- IBM has been supporting two initiatives. The first is we.trade based on the Hyperledger Fabric. This is a collaboration of several European banks with an emphasis on providing trade finance to SMEs who are unable to access traditional trade finance instruments such as letters of credit.[62] The solution is very complete, providing a variety of internal financing instruments and with automated links to initiative SWIFT payments

- Another IBM initiative involving five banks was Batavia, focusing on monitoring trade flows and associated corporate financial obligations. Batavia has since merged into we.trade with an apparent ambition to extend that initiative beyond the SME space.

- A fifth trade finance collaboration is HKTFP, the Hong Kong Trade Finance Platform, established as a co-operation between seven Hong Kong banks in 2017 in an effort to digitize all aspects of trade finance.[63] This is apparently working towards commercial lunch in 2019.

- Another, specialized on commodity trade finance, is the Komgo platform, distinguished by being a collaboration between banks and corporates, and incorporating secure encrypted document exchange that supports KYC compliance. Komgo engage in proof of concept in late 2017 early 2018 and a commercial launch is anticipated relatively soon.

These initiatives are promising but should be assessed alongside the many efforts that have been underway for some years to digitise trade finance. A leading example is the Finastra Fusion Trade Innovation software, which is already used by around 200 banks to integrate their customer channels and payments systems in supporting trade finance solutions.[64]

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large amounts of wasted manual effort. As a result, a trade transaction can take up to 2-4 weeks, creating costly bottlenecks in physical flows of goods. Fraud is another concern, with paper forgery and duplicate invoicing common in many locations."

[61] A valuable review is provided by (*CB Insights* 2018)

[62] A useful description is (H. Morris 2018)

[63] See (KPMG 2018)

[64] https://www.finastra.com/solutions/transaction-banking/trade-supply-chain-finance/fusion-trade-innovation

Last year the Boston Consulting Group, working with SWIFT, released a review of the ongoing digitisation of trade finance, highlighting several technological opportunities, including: the use of optical character recognition to read paper instruments; the development of mobile and internet channels for customers; and fuller dematerialization and automation of operations using data from 'the Internet of Things' (for example shipping data) and artificial intelligence/ robotic process automation to replace manual processing.(Ramachandran et al. 2018) They further note that while some banks are now investing in digital ledger solutions for trade finance, these are still a long way short of achieving the widespread adoption that will be needed if they are to widely used by importers and exporters; and they also point out to the fundamental legal obstacles to adoption of distributed ledgers solutions – a digital instrument has to be legally valid in the both he importer and exporter's jurisdictions.

There have also been to develop distributed ledger solutions for digitizing of global supply chains, monitoring the physical movement of goods and the required accompanying processes of checking compliance with trade agreements, safety and other product regulations, and the assessment of tariffs. These global supply chains also have relied largely on paper-based processing. The leading initiative of this kind is the IBM-Maersk TradeLens project.[65] Maersk is the global leader in international container shipping, so has a natural interest in this digitisation. There are though reports that competing shipping services companies other than Maersk have been reluctant to join TradeLens, because Maersk is seen as being too dominant in the governance of the project, and a competing initiative Global Shipping Business Network (GSBN) has been established by a group of Asian ports and shipping companies.[66]

Overall, it seems that while there are a very large number of initiatives, there is also still a long way to go. Addressing the gap in the provision of trade finance to SMEs seems to be more about KYC regulation and credit information than data sharing.[67] Ultimately, to fully exploit the opportunities for digitisation, there should be interoperability between the platforms for trade supply chains and for trade finance. A 'super platform' that integrates all aspects of trade is unlikely, and individual platforms may struggle to attain critical mass. It is not clear that any of the many initiatives to share trade finance data – whether the platforms involved are digital ledgers or centrally operated – will achieve critical mass on their own.

*10. Corporate supply chain finance.*

We offer a brief discussion of domestic corporate supply chain finance. The issues are similar to those in trade finance. Most transactions are though within a single jurisdiction so simplifying some legal and regulatory compliance and payment transactions.[68]

There are many initiatives seeking to develop distributed ledgers for supply chain finance, even more than for international trade finance. Examples include AntFinancial's launch of Ant Double

[65] See (White 2018; Scott 2018; Tradelens 2019).

[66] See (Tinianow 2018; Safety For Sea 2018). Reports that TradeLens has only attracted one shipping service company other than Maersk also prompted some remarkably ill-informed chatter claiming that this demonstrates that 'permissioned ledgers' do not work and only a truly open and truly decentralized unpermissioned ledger can truly deliver trust e.g. (Broersma 2018). For the reasons we discuss above in Section 3, we think such views are completely off target, the problem if there is one is in the governance layer and removing permissions will only make that problem worse not better.

[67] A recent BNY/ICC survey ranks better KYC as far more important than distributed ledger for bridging the trade finance gap for smaller companies, though greater transparency could help (Ledger Insights 2019e)

[68] Supply chain applications generate even more than the usual amount of blockchain absurdities. One can only laugh at this one from Greensill: "You will no longer finance the delivery of an asset—be it physical or a service. Technology will predict that you are going to receive an order for that asset, work out when you will deliver it and when your customer will pay, and let you have the money upfront so you can finance the work." (Greensill 2018)

Chain linking Alipay with supply chain to finance SMEs with large corporate customers; and by TenCent again for SME finance working with the We.pay payments solution (no connection with we.trade); Dianrong and FnComm aiming to serve 40 million SMEs in China, after a successful proof of concept test of their distributed ledger product 'Chained Finance'; an ambitious proposal by Citrusexchange that is intended to bring access to finance to the world's SMEs; a project led by Mizuhuo Finance in Japan; The Digital Trade Chain Consortium involving eight leading European banks including Deutsche and HSBC; IBM's projects with Mahindra Finance in India and with Union Bank in the Philippines; the XMBC project aiming to solve SME financing problems in Russia.

The number of supply chain distributed ledgers at 'proof of concept' stage is even larger when broadened to include all aspects of the supply chain. The website www.ledgerinsights.com lists more than one hundred news items about distributed ledger initiatives for supply chains over the past year alone, including in arms procurement, food chains and agribusiness, metal and commodities, pharmaceuticals, the automotive industry, public procurement, and construction.

The principal goals of these developments are:

- Improving supply chain visibility and traceability
- Driving operational efficiency, removing manual processing in both contracting and in invoicing and payments

Tools are being built using distributed ledger software such as Corda, DAML and Hyperledger and provided by major consultancies and vendors.[69] It is though far from clear that distributed ledger with multiple operators is necessary to achieving either of these goals, compared to the alternative of a ledger with a single operator or APIs and other software solutions to facilitate communication between different systems.[70]

*11. Insurance and reinsurance*

Across the insurance industry there are substantial problems with fragmentation of data, continued reliance on paper-based rather than fully digitized operational processes and the common challenge of sharing incompatible data between multiple parties in the insurance value chain (IBM, n.d.). The insurance industry has been seen as particularly appropriate for distributed ledger adoption, because of the networks of participants involved in distribution (a policy application can pass through the hands of several brokers), in claims processing (often outsourced to a network of providers) and in reinsurance (requiring the sharing of underlying contracts and claims data to support reinsurance treaties.)

The US insurance industry has shown particular interest in the use distributed ledger and other technologies such as AI in insurance. One major initiative is RiskBlock – a consortium of more

[69] Two examples: IBM offers a range of supply chain solutions built on Hyperledger Fabric (IBM 2019); Ernst and Young has a commercial scale product EY OpsChain built on Ethereum (Brody 2017; EY 2019).
[70] Some of the barriers to application of distributed ledger in the supply chain are identified by (Alicke et al. 2017), who suggest that other simpler technologies can achieve most of the transparency and efficiency gains in supply chains and by (Pisa 2018) who highlights complexity of decentralized solutions and the underlying challenge of 'serialization', obtaining a unique identifier for each asset in the supply chain in order for it to be digitally traced.

than thirty US insurance companies – and their Canopy 2 platform based on R3 Corda.[71] Canopy 2 is a modular suite of solutions covering both policy writing and claims management. The first applications are for proof of insurance and initiation of claims. The driver though seems to be obtaining efficiency by using common shared solutions, so multiple operators may not be required.

Another initiative is the Blockchain Insurance Industry Initiative, B3i, founded by 15 re-insurers in December 2016 and joined by another 23 companies including brokers in October 2017. Its initial purpose was to explore the potential of blockchain to increase the efficiency of insurance transactions. On March 23, 2018, B3i was incorporated in Zurich with a vision to create a re/insurance ecosystem enabling members to develop innovative products and services, and increase the relevance, accessibility and affordability of insurance for consumers. This ecosystem is intended catalyse the generation of new business models offering growth, efficiency and quality, and ultimately closing the protection gap. https://b3i.tech/home.html

Globally IBM is taking a leading role in applications of distributed ledger in insurance, involved in most widely publicized applications. An example from their work of how distributed ledger may help cope with these data challenges is the 'open-IDL' project, a co-operation between IBM and the American Association of Insurance Services (AAIS) (Portier 2018; AAIS 2018). This is largely a regulatory reporting initiative. It is a response to the particular US challenge that insurance regulation is divided amongst the 50 states, not a federal level responsibility, and gives national insurance commissioners wide ranging powers to control premiums on property and casualty (P&C) insurance under the P&C Model Rating Law. OpenIDL (Insurance Data Ledger) is written in the HyperLedger Fabric for open-source distributed ledgers. It allows insurers to report both policy and claims data to insurance commissioners across the US in formats required by P&C Model Rating Law under the guidelines of the National Association of Insurance Commissioners. It also serves to automate the process of updating regulatory reporting data, with real-time rather than batch data transfer and minimising manual intervention, with the permissioning to review data that is provided state insurance commissioners reducing the need for time-consuming data calls.

Open-IDL is a promising initiative, and is using the security and permissioning tools provided by the HyperLedger Fabric, but is it a distributed ledger? Not really, because at least at present it is not being used for sharing of data between insurance companies (which could be a breach of anti-trust laws): "*data remains private and protected from external parties and other openIDL participants*" or for supporting reinsurance transactions. Governance is not shared but remains the responsibility of AAIS. It could have been set up as a conventional database. Nonetheless, even if not distributed ledger, it could provide a foundation for future cross-sharing of data in US P&C insurance.

Another IBM example is a co-operation between IBM, AIG and standard-chartered on the proof of concept for employing distributed ledger to support multinational insurance contracts, where the insured party requires a single insurance policy that covers their activities in multiple jurisdictions (IBM 2018a). Again it is the need tailor to jurisdictional differences in regulation and market practice that that is critical, in this case combining data from a master contract written in the UK with three local policies in the US, Singapore and Kenya into a single real-time database, tracking premiums and payments events and offering read permissions to other parties such as

[71] Described by (Morris 2018)

brokers and auditors. Again though it is unclear that this had to be a distributed ledger rather than a conventional database supported by cryptographic security.

A further IBM example is their work with ISN, "… *the global leader in contractor and supplier management. We support more than 590 Hiring Clients in capital-intensive industries to help manage more than 70,000 contractors and suppliers with operations in over 80 countries.*"[72] The business problem faced by ISN is ensuring that the contractors and suppliers they provide have valid indemnity insurance. IBM have worked with ISN and Marsh the global insurance broker to provide a distributed ledger build on Hyperledger Fabric that provides digitally signed insurer proof of contractor and supplier insurance cover at the time policies are agreed for all hiring clients and also brokers and insurance underwriters on the ISN network (Derebail 2018). Once again it is unclear that this is or needed to be a distributed ledger. There is no consensus mechanism – simply a reliance on insurer's validation of the policy. But the use of cryptography with a properly permissioned data base avoids the possibility of contractor fraud and real time automated updating is a major improvement over conventional manual processing.

Distributed ledger is often mentioned in the context of specialized insurance products with multiple beneficiaries. An example is marine insurance, providing protection in to marine cargos in international supply chains (Mavrias and Lin 2018). Automated payouts, triggered by data from the 'IoT' (for example excessive temperature in a refrigerated cargo), can not only speed up payout but also automate what is otherwise a difficult claims process. Multiple parties are involved requiring extensive documentation in both claims handling (bills of lading, charterparties and reports) and risk underwriting (data on identities, risk and exposures). This challenge is similar to the situation in the closely related business of trade finance, supporting digitisation and efficient automated processing through the sharing of reliable data in standardized form. Component distributed ledger technologies are of great potential value, for permissioning and security and for maintaining a permanent record of data, but it is still an open question whether this should be through a distributed ledger or using these technologies with to a conventional database.

We briefly discuss some other potential insurance applications. (FCA 2017) highlights some of the benefits of using distributed ledgers in the reinsurance market. As multiple reinsurers are required to underwrite each reinsurance treaty, data-sharing through ledgers would be beneficial. (FCA 2017) though highlight that for this to work the development of standards for risk data is critical, mentioning one recent initiative for insurance B3i which was launched in October 2016 with members such as Zurich Insurance Group, Allianz, Generali.

In addition (FCA 2017) discuss the possibility of using smart contracts on ledgers for automated claims settlement would be advantageous to industry loss warranty products. There are though fundamental difficulties, as pointed out by (Edmonds 2019). Any form of indemnity insurance requires assessment of the resulting loss and so only initial provisional insurance payout could be automated. Smart contracts may work better for parametric products where the payout can be precisely determined when an insured event takes place.

Others envisage distributed ledger supporting not only data sharing and automated claims management but also supporting disintermediated P2P insurance underwriting both amongst individuals and corporates. Such an approach is far from new – for example one important

[72] https://www.isnetworld.com/hiring-clients

example of protection from private insurance pools are the P&I clubs protect for 90% of the world's sailing tonnage; similar schemes for sharing risk could it is claimed be based on distributed ledgers and fill gaps in insurance provision (von Gunten and Mainelli 2014; Sarasola 2018).

*12. International payments*

Alongside application to securities settlement, much of the early attention paid to distributed ledgers in financial services has been about application in international payments.

This is unsurprising. There have and continue to be substantial inefficiencies in international business to business payments. Two points are broadly accepted:[73]

- International business to business payments are much more costly, risky and opaque than domestic consumer payments, taking up to five days to move from the sender to the receiver's bank account, lacking accompanying information and requiring cumbersome manual instruction with relatively high charges and all too frequent errors leading to payments delay or even outright rejection.
- Digitisation is creating an opportunity to end this situation: appropriately deployed digital technologies should make it possible for international payments to be as rapid, transparent and reliable as domestic consumer payments and only a little more expensive.

Little of this requires further discussion here. We focus on a specific issue: what role if any can distributed ledger technologies play in supporting greater efficiency in international payments?

Here we note a parallel with distributed ledger to securities settlement: misunderstanding of the underlying business operations, in this case misunderstanding of the role of correspondent banks in international payments that has led to much nonsense being widely stated and accepted.

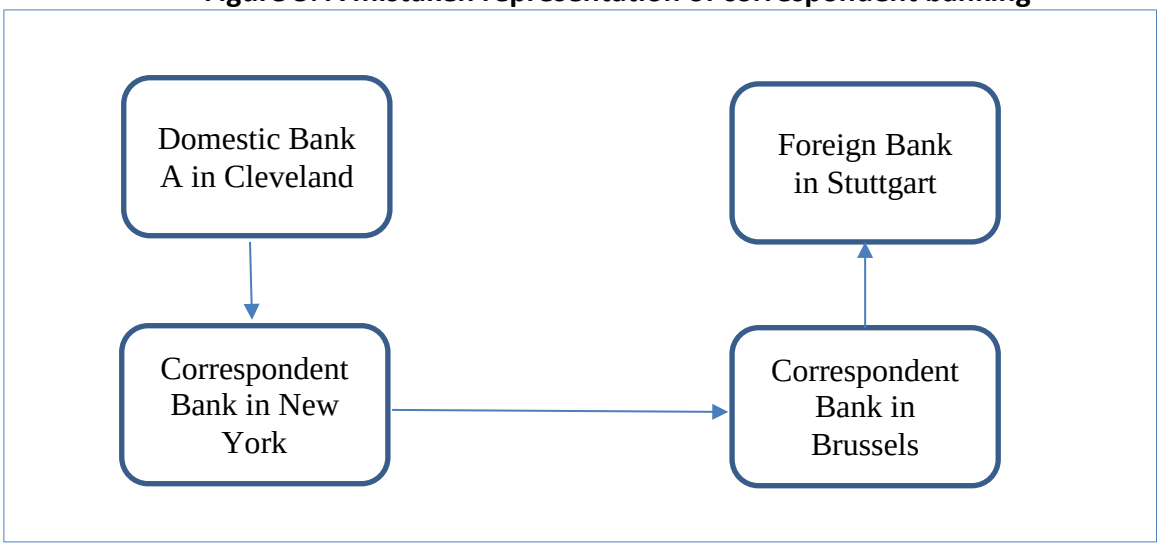
To illustrate this misunderstanding, consider Figures 5 and 6 adapted from an otherwise well written paper from InfoSys.[74]

- In Figure 5 the customer's bank holds the virtual representation of value (call this 'virtual gold'), transfers it a correspondent bank who sends it internationally to another correspondent bank who in turn transfers this 'virtual gold' to the recipient's bank.

[73] Detailed discussion of these points can be found in various consultancy reports and practitioner media, e.g. (Accenture 2016; McKinsey 2018; Boston Consulting Group 2018; Horowtiz and Stabicki 2018; Treasury Today 2018). Payments inefficiencies are also found in consumer payments and in domestic business to business payments but are most pronounced in international business to business payments.

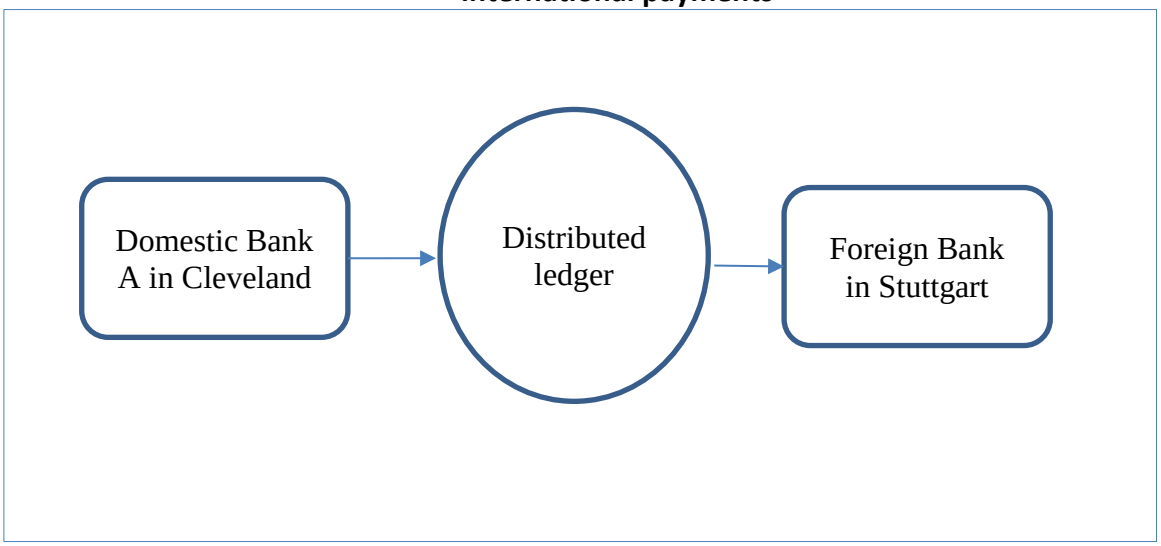
[74] Figures 1, 2 from (Achanta 2018). We pick this report to illustrate the prevalent muddled thinking about use of distributed ledger in international payments because of the clarity with which the argument is presented, similar discussion is found in many other reports and blogs promoting 'blockchain based international payments'.

**Figure 5: A mistaken representation of correspondent banking**




- Figure 6 illustrates how this 'inefficient' system can supposedly be improved using a distributed ledger as the rails for communication. Put tokens for 'virtual gold' on the ledger, so it can be moved directly from the domestic bank to the foreign bank and the inefficiencies of correspondent banking are removed.

**Figure 6: Leading to mistaken representation of the role of distributed ledger in international payments**




The mistake in these figures is representing a monetary transfer as the transfer of a virtual object, akin to the movement of gold or some other physical asset.[75] This omits two crucial aspects of international payments.

1. Most domestic money is held in fractionally reserved bank accounts so there must be matching settlement transfers of reserves held at the accounts of the domestic and foreign central banks (no domestic bank can accept a payment for credit to a customer

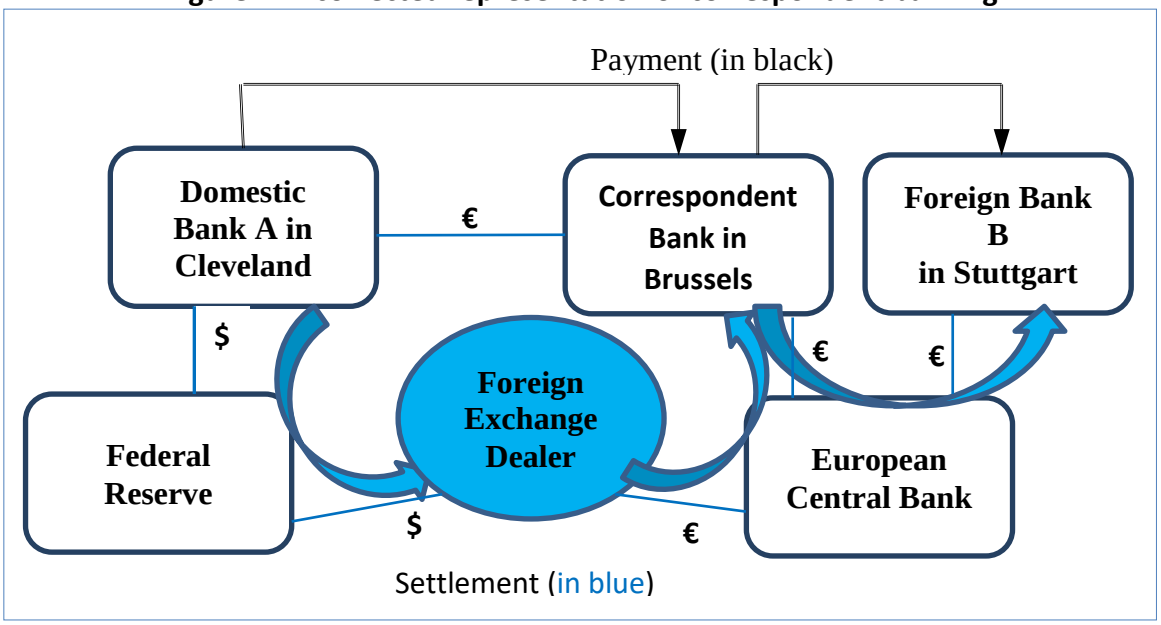
[75] (Milne 2018a) provides a detailed critique of the notion that cryptocurrencies are 'virtual objects' or 'tokens'.

account without a matching credit of central bank money). The reason a correspondent bank is required is *not* for routing of the payment instruction but because under current architecture and regulation banks cannot maintain accounts directly with central banks in other countries; they need to use a correspondent bank (or a local subsidiary) to provide them with this access.

2. The execution and settlement of any necessary accompanying foreign exchange transaction. Only a few dealer banks have direct access to the global foreign exchange markets. The adoption of a distributed ledger does not avoid the need to sometimes execute the transfer with a foreign exchange transaction (where not avoided by 'netting' of offsetting transactions). Where a foreign exchange is required, this requires a further layer of intermediation, passing domestic funds to the foreign exchange dealer or other counterparty in exchange for foreign currency, with a subsequent settlement of these two legs of the foreign exchange transaction.

Figures 7, 8 and 9 are corrected versions of these diagrams, allowing for domestic settlement and the need to conduct a foreign currency exchange transaction and settlement.

**Figure 7: A corrected representation of correspondent banking**




Note: Figure 7 corrects Figure 5 by including the necessary accompanying settlement processes for an international payment. Settlement of an international payment is complex because three different stages are required: (i) settlement of the $ payment to foreign exchange dealer; (ii) settlement of the € payment to overseas correspondent bank; and finally (iii) a further € settlement to reach the bank of the recipient.

In Figure 7 the domestic bank A in Cleveland does not have a reserve account at the European Central Bank. It instead holds a 'nostro' account with a correspondent bank in Brussels, enabling indirect access to reserves at the European Central Bank required for settling an international payment.

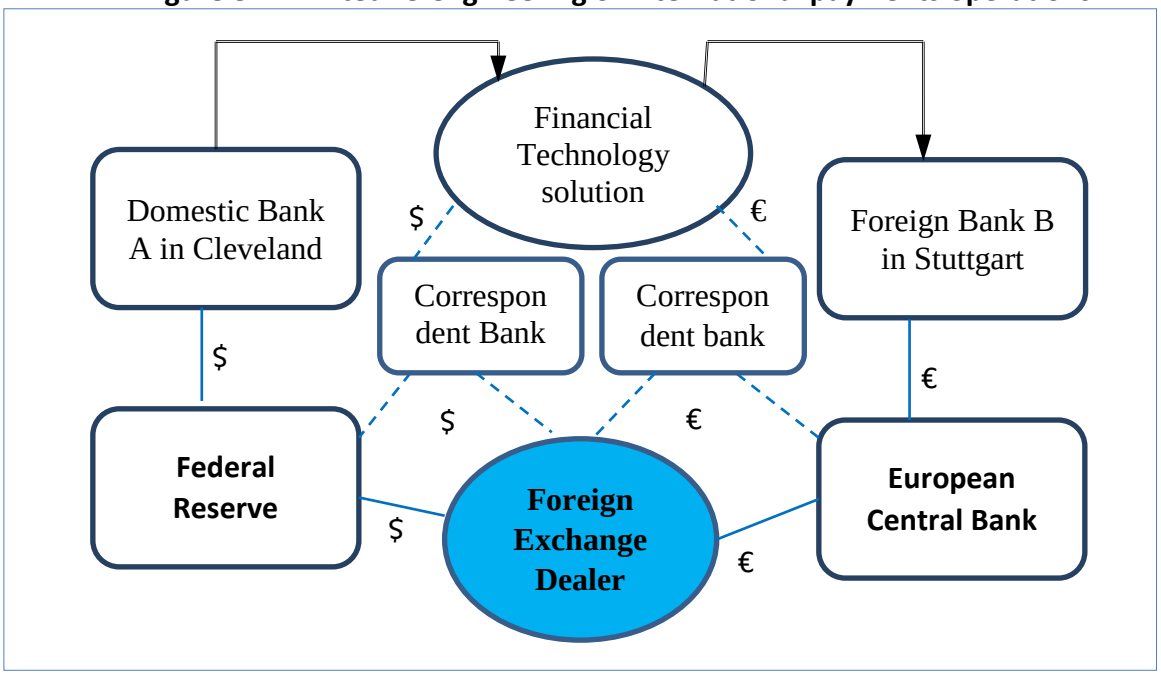
International payment requires three steps for settlement: (i) the bank in Cleveland exchanging dollars from their reserve account at the Federal Reserve for Euros held with the foreign exchange dealer (domestic leg); (ii) the bank in Cleveland then moves these Euros to their correspondent bank, settling through transfer of reserves from the foreign exchange dealer to

the correspondent bank (foreign currency leg);[76] and finally (iii) a standard domestic settlement in Euros to complete the payment to the recipient bank in Stuttgart.

Using distributed ledger technology to address the inefficiencies of international payments, could involve (just as in the case of securities) either radical or limited change in payments operations. Figure 8 (limited) and Figure 9 (radical) illustrate these possibilities.

Limited change along the lines of the following Figure 8 is the more obvious outcome. While they can use distributed ledger technologies (for example the J.P. Morgan IINET project, one of our case studies), this is not necessary (for example the recent SWIFT Global Payments Infrastructure or gpi building on existing operational arrangements).[77]

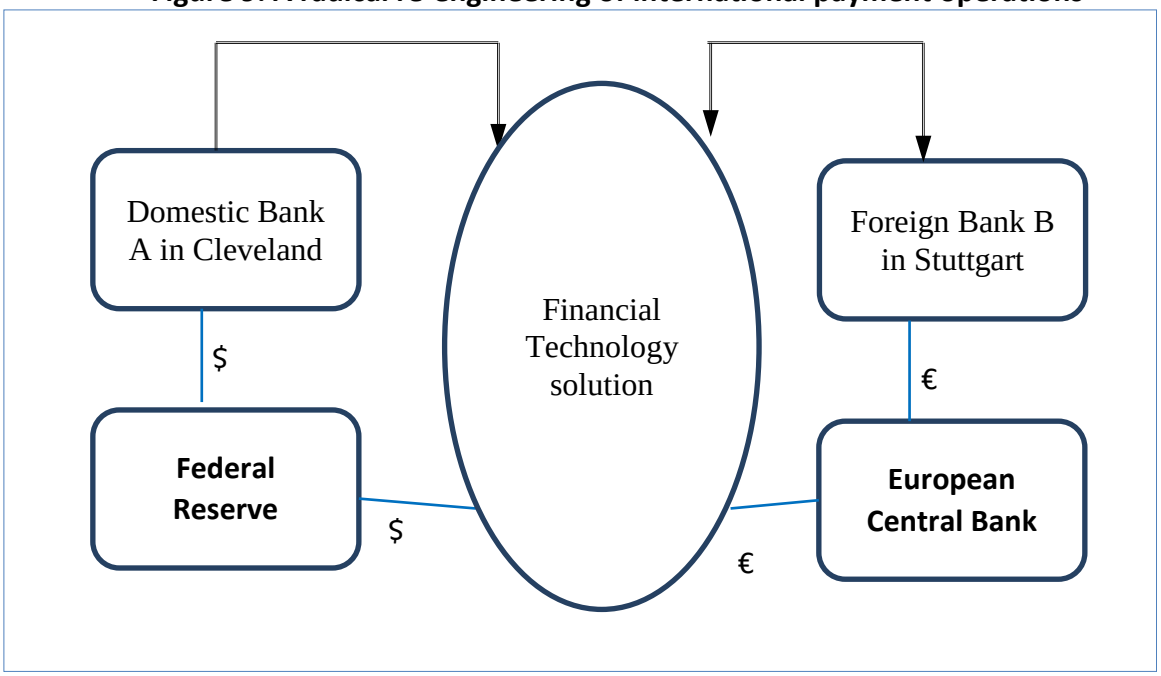
**Figure 8: A limited re-engineering of international payments operations**




Note: based on Figure 7 but dropping the blue arrows representing the accompanying settlement, so showing just the payment (the black arrows) and institutions involved in supporting payment and settlement. The banks in the US and Eurozone play the role of correspondents for the financial technology provider.

[76] How can the foreign exchange dealer have reserve accounts at both central banks since they are not licensed and regulated in both jurisdictions? The answer is that, for a major foreign exchange dealer such as JP Morgan, wholly owned subsidiaries licensed and regulated in both jurisdictions. This detail is omitted from Figure 7.
[77] gpi, as a relatively small shift from existing arrangements, is relatively easy for participating banks to implement and is achieving rapid adoption. Since it makes no claim to use distributed ledger technologies, is not one of our case studies. It is described in (SWIFT 2018).

**Figure 9: A radical re-engineering of international payment operations**




Note: Amendment of Figure 8, combining the roles of financial technology, correspondent banks and foreign exchange dealer into one "super platform".

Many distributed ledger solutions for international payments seem to have in mind a much more radical approach, such as that illustrated in Figure 9. In order to achieve all the benefits that are claimed this (as we understand it) will requires two broad changes in international payments architecture:[78]

- Central banks must be willing to allow all direct participants in the new technology based international payments platform, whether domestic and foreign, to hold reserves for settling foreign exchange either directly or through accounts fully backed by central bank money. This will in turn allowing them to offer execution services for international payments passing through the payments platform.
- A replacement of the main dealer structure of global foreign exchange markets with something closer to the market microstructure employed in equity transactions. All direct participants in the new platform would be able to place both limit and market orders from their central bank reserve holdings on limit-order books for foreign exchange.

Together these two changes could offer a 'single ledger' solution to simplify foreign exchange operations, offering all clients complete visibility of their international payments transaction. They would be able to trace when their payment was placed as a market order and hence confirm a fair market price. Competing international payment service providers would provide low cost execution with complete payments tracking and full accompanying information. An international payment would be as transparent as ordering a ride through Uber and observing the processing of the service.

[78] As will be obvious, this analysis implies that 'XRP' the Ripple cryptocurrency has no future role as a payments solution, introducing it into the payment chain only creates a further layer of intermediation from say $ to XRP and XRP to €.

As we discuss below, two of our case studies – Ripple and Fnality settlement coin – have potential for going beyond the limited technological solution of Figure 8 and providing something closer to the radical solution of Figure 9.

We complete our discussion of international payments by commenting on proposals to use distributed ledger to support international remittances and reduce transactions costs (currently around $25bn per year.)[79] There has been a lot of discussion about application of distributed ledger to reduce the cost and lengthy time involved in international remittance payments, with a number of start-ups seeking to address these limitations.[80] There are reports highlighting the potential;[81] but these lack any discussion of operational detail into how it might actually work. Those reports that do examine the detail are more sceptical.[82] There are some claims that Bitcoin is achieving traction as a remittance mechanism, but no clear evidence that this is happening on any scale (outside of remittances to economies such as Zimbabwe, Venezuela and Argentina where capital flight seeking to evade state controls on foreign currency transactions provides a natural outgoing counterparty for an inward remittance transaction, which can therefore get a much more favourable exchange rate than through official channels). What evidence is available suggests a major role for behavioural and other biases in user adoption: the important market position of established providers such as Western Union seems safe for now, even though their market share and margins are being squeezed by competition from online alternative foreign exchange providers such as Transferwise. These new competitors, moreover, while using internet technologies and offering transparent real-time quotations for exchange do not employ distributed ledgers. It seems clear that while it is being digitized and costs are slowly falling, distributed ledger or cryptocurrency (blockchain) solutions are having little impact on global remittance markets.[83]

## *D Regulatory oversight*

### *13. Client on-boarding*

One frequently proposed application of distributed ledger technology is customer on-boarding, including support for reliable third-party information that will allow lower cost compliance with KYC regulations without unnecessary multiple repetition of compliance process. This is a clear example of potential benefits from multiple users creating and using data and therefore a natural use case for distributed ledger technologies: as (Weinberg 2019) argues "*Blockchain in KYC is one of the most promising applications of the decentralized technology, serving a real need by decreasing KYC administrative costs and lost time while at the same time increasing security and transparency. KYC using blockchain represents a true paradigm shift, away from individual institutions doing repetitive and redundant work.*"

[79] The World Bank report a weighted average cost of 5.20% of the value remitted for 2019Q1 (World Bank 2019) on total remittances to low and middle income countries of over $500bn per year.
[80] A dozen remittance focused blockchain start-ups are listed by (Flore 2018)
[81] For example (Parulava 2017; Flore 2018)
[82] For example (Wu 2018) identifies four barriers: inefficient correspondent banking relationships; lack of competition in remittance 'corridors'; KYC/ AML and other regulation; and undeveloped agency networks for converting from digital to cash. He suggests that distributed ledgers only deal with the first two of these barriers. As we have argued, even this would require radical change in 'payment rails'.
[83] A valuable, regularly updated webpage, providing a lot of evidence that supports a sceptical view of the application of distributed ledgers to remittances is (Save-on-Send 2019).

Amongst analyses suggesting this use (Patel 2017), a report released by R3, argues that a combination of a global distributed ledger based utility plus robust country level KYC protocols could substantially reduce costs of on-boarding and help overcome the withdrawal of correspondent banking services resulting from 'de-risking', reluctance to engage in international payments services because of the risk of substantial fines for breach of AML regulations. Other similar argument include (Lootsma 2017; Curry 2018; Middleton 2019).

Despite this enthusiasm, other examinations of the application of distributed ledger technology to identity, KYC and ALM compliance that look more closely at practical implementation are more cautious e.g. (Refinitiv 2017; GMSA 2018; Group 2018). Our search for commercial scale applications of distributed ledger in financial services, we found none relating to KYC. This should not be so surprising. The concept of a shared utility for implementing KYC is something that has been around for a long time, predating the interest in distributed ledger technologies. The reasons this has not already been developed do not seem primarily to be technological. Distributed ledger technologies can obviously help, but as we have argued already, they do not themselves generate trust, there has to be additional mechanisms to ensure that the identifications placed on a shared ledger are accurate and in compliance with regulation. A regulated firm's legal liability for KYC compliance cannot be automatically delegated to a third-party, so governance needs to be in place to ensure there is effective compliance service. While there could still be substantial gains, it is not so surprising that the challenge of co-ordinating such a solution has not yet been overcome.

*14. Regulatory reporting and systemic risk*

Since the global financial crisis, regulators are expecting to be able to access and analyse large volumes of data in order to monitor and respond to systemic financial risks. To enable this multiple providers need to share their transactions and other data in consistent formats. This though can be 'many to one', many providers of information but one user, in which case it not clear that this needs a decentralized solution. Where it is multiple user, e.g. sharing of regulatory data between agencies or across jurisdictions, a decentralized solution may be more appropriate but there may be legal limits to the ability to this data sharing. Such 'granular reporting' has been an ongoing topic of discussion amongst global regulators and can clearly be supported by the control over data access provided through distributed ledger technologies (Bank of England 2015; Kavassalis et al. 2017; Coeure 2017).

We have come across examples where components distributed ledger technologies are being applied in this way. ISDA is working the FCA and BoE surrounding regulatory reporting and the CDM (ISDA 2019d) . Other proof of concept of the Project Maison where the FCA worked with R3 and other industry partners on distributed ledger based regulatory reporting for mortgage exposures; and the BARAC project with researchers at University College London on automated regulatory reporting and compliance are discussed in (FCA 2017).

Central banks and regulators are justifiably concerned about the role of collateral management in any future financial crisis. Since the global financial crisis requirements for widespread posting of collateral, either against central counterparties or bilateral positions, were introduced to provide an additional defence against counterparty credit risk. The idea was to ensure that the equity capital of firms remains adequately protected when other firms fail. This though has resulted in risks of loss of equity capital being replaced by heightened liquidity risk, especially since collateral requirements are inevitably 'procyclical' rising at times of heightened systemic

risk and potentially limiting the ability of firms to trade (and the equity capital requirements have themselves been reduced as the increased use of collateralization has lowered calculated counterparty risk, so arguably overall systemic risk has been increased not reduced).

A related concern about there being *"sufficient good quality collateral"* in the system to ensure problems of trading liquidity do not exacerbate a financial crisis, the view of the authorities being that there is no overall problem, but some individual firms might face difficulty in accessing cash or securities to maintain their access to markets (in contrast to the situation of commercial banks, there is no lender of last resort so capital markets firms without banking licenses may have to rely on market access to cash and highly quality securities). Regulators will therefore be especially concerned to ensure that the automation of collateralization and liquidity management using distributed ledgers does create unintended consequences, especially during periods of heightened systemic risk when access to liquidity is problematic.

## 3.2 Seven case studies

Table 3 summarizes our seven case studies and the information we have obtained from them:

**Table 3: Summary of our seven case studies**

| *Initiative* | *Launch* | *Expected Full deployment* | *Supporting Technology* | *Digital ledger on our Definition 1?* |
|---|---|---|---|---|
| Digital Asset and ASX collaboration on CHESS replacement | 2015 | March – April 2021 | DAML | No |
| ISDA's common domain model CDM implemented using Digital Asset DAML | 2016 | 2019 | DAML | No |
| DTCC's Trade Information Warehouse DLT re-platforming | 2016 | Q4 2019 | Hyperledger Fabric | No |
| Utility Settlement Coin (USC) now renamed as Fnality. | 2015 | Live 'as soon as possible' (2020?) | Clearmatics platform (permissioned Ethereum) | Yes, permissioned |
| SETL IZNES platform for Investment funds transactions | 2017 | Live 2018 full uptake 2020+ | SETL ledger platform | Yes, permissioned |
| J.P. Morgan Interbank Information Network IIN | 2017 | Network expanding, live in 2019 | Quora (permissioned Ethereum) | No |
| Ripplenet suite of products (xCurrent, xRapid, xVia) | 2013 | Ongoing | Own platform | Yes, hybrid |

Note: these cases illustrate the range of possibilities when using the component DL technologies listed in Table 1. Several (e.g. ASX, ISDA, and J.P. Morgan) have a single operator rather than multiple operators. Only ASX and ISDA make important use of smart contracts. The DTCC and J.P. Morgan networks are focused on information sharing not transfer of ownership.

We discuss each of these case studies and then provide a concluding summary.

**Case study 1: ASX's collaboration with Digital Asset to modernise** Cash Equities Clearing and Settlement in Australia.

**Profile**

ASX is the Australian Securities Exchange. ASX have prided themselves on the technical capacity of their exchange, and in particular the efficiency of their 'CHESS' clearing and settlement system established in the early 1990s which has maintained close to 100% reliability for more than a quarter of a century. ASX members were increasingly interested in the replacement of CHESS with a system more aligned with the modern digital technology solutions they were using for their own internal portfolio, trading and risk management systems.

Digital Asset is a software company founded in 2014 to provide the tools and services that allow innovators to harness smart contracts and the power and security of blockchains. Digital Asset is the creator of DAML™ — the smart contract language for modelling multi-party business workflows on traditional databases or enterprise-scale distributed ledger technology (DLT). DAML enables enterprises from start-ups to large, highly-regulated organizations to achieve more efficient business processes, reduce risk, and develop new products and services that can transform an industry.

**Products and/or applications**

The history of the ASX project is thoroughly documented on the ASX webpages (ASX 2019) . ASX first began exploring the possibility of replacing CHESS in 2015 selecting Digital Asset as a partner in January 2016 (Digital Asset, 2016). The project fully replaces CHESS (Clearing House Electronic Subregister System), ASX's twenty five year old system for post-trade clearing and settlement, , with a modern ISO 20022 compliant system.[84] Digital Asset first developed a prototype system using their distributed ledger technologies which was then reviewed in Dec 2017, testing its ability to replace CHESS functionality, to provide appropriate security and to scale to support expanded services in future y ears.

Alongside this exploratory work ASX launched detailed consultations with ASX members about the CHESS replacement beginning with a September 2016 consultation paper (ASX 2016) followed by the establishment of working groups focusing on clarifying the business requirements for six aspects of the new system (account structures and participant models, corporate actions, transfers and conversions, settlement enhancements, data storage and reporting, other 'non-functional' requirements). This input then led to a second detailed consultation paper "New Scope and Implementation Plan" with the consultation and ASX's response continuing until September 2018 (ASX 2018).[85] A further development was the establishment of a technical committee to ensure that the project was fully compliant with ISO 20022 standards for messaging in payments, clearing and settlement.

ASX is now moving onto establishing further working groups on transition topics such as connectivity, integration, implementation and transaction; alongside demonstrations of the

[84] (Computerworld 2018a)

[85] One decision in Sept 2018 was that go-live should take place over a single weekend, but to allow an additional six months from original planned start date in 2020 so that users to undertake the necessary developments of their own systems. This was widely interpreted in the trade press as "delay" e.g. (Crozier 2018) but is more favourably and we would say appropriately interpreted as a flexible response to stakeholder feedback.

Digital Asset prototype to ensure all stakeholders are fully familiar and comfortable with the replacement system. Their forward planning includes a customer development environment (now available), an industry wide test environment from July 2020, a pre-live production environment from mid-October 2020 and a target go-live window of March- April 2021.

We highlight the following points about the ASX project:

- The clearing and settlement at ASX, rather like that for Deutsche Börse in Germany but unlike arrangements in the US or the UK, is provided by an exchange owned utility providing both clearing through ASX Clear (the central counterparty that guarantees trades and supports anonymity of trading) and subsequent DVP (delivery versus payment T+2 settlement).

- The six year implementation period from initial discussion in 2015 is nothing out of the ordinary for an investment in post-trade infrastructure. The full views of users have to be considered and built into the project.

- Digital ledger technologies are a valuable contributing component of this project. The CHESS replacement has been billed as "the first blockchain based securities settlement system", but this is something of an overstatement. It will be permissioned with rigorous control of access; the ledger is under the overall control of a single operator - ASX (so not a distributed ledger under our Definition 1). From the perspective of many users they will not be able to tell how and to what extent the underlying system is using new distributed ledger technologies (permanent record keeping, cryptographically controlled control over reading and writing privileges), though it will offer opportunities for additional functionality based for example on automated 'smart contracts'.

- T+2 will remain as the standard settlement cycle, with cash and securities "locked for settlement" at 11.30 am on T+2 to avoid a settlement failure. There will, however, be an option for agreed accelerated bilateral settlement, which it is anticipated will be used for occasional large trades (presumably 'upstairs' trades undertaken for strategic rather than trading reasons, negotiated privately and then reported to the exchange) i.e. flexibility in the timing of settlement but only likely to be used in very specific circumstances.

- A key feature of the project will be to allow supporting automated processing through algorithmic or smart contracts written in Digital Assets DAML language. This may for example be applied to automation of corporate actions, allocation of proceeds of trade by fund managers, the provision of data services and other aspects of the digital automation of securities holdings and transactions.[86] An advantage of DAML over other smart contract platforms is that written agreements through DAML can remain private and do not have to be shared across multiple nodes in a network.[87]

[86] On data services application to ASX see (Financial Review 2018). Another example of application of DAML was October 2018 announcement that Hong Kong Exchanges and Clearing (HKEX) has partnered with Digital Asset using DAML to improve efficiency of connection to the mainland Chinese market (Ledger Insights 2018b).

[87] (Computerworld 2018b). In private communication Digital Asset DAML has been described to us as "a powerful smart contract language for modelling multi-party business workflows on traditional databases or enterprise-scale distributed ledger technology (DLT). DAML enables enterprises from start-ups to large, highly-regulated organizations to achieve more efficient business processes, reduce risk, and develop new products and services that can transform an industry."

**Case study 2: ISDA collaboration with Digital Asset on their Common Domain Model (CDM)**

**Profile**

International Swaps and Derivatives Association (ISDA) is the trade organisation supporting the global over the counter (OTC) derivatives market. It now has around 820 members in nearly 60 countries. ISDA's Common Domain Model CDM (which is more fully described above) has been in development since 2016 in order to provide a precise common language for describing all the events and processes involved in processing of derivative contracts (it is thus no accident that the name chosen for the organisation providing technical support for the releases of the various versions of the CDM is Rosetta Technology. CDM is now in open source release as version 2.0.

Digital Asset: see profile above under their collaboration with ASX.

**Products and/or applications**

The ISDA CDM first industry solution to try to standardize the representation of derivatives trade events and processes. (ISDA 2019b). ISDA proposed the Common Domain Model in May 2018 and within a year has already obtained supported from R3, Axoni, Goldman Sachs and Barclays. (Coindesk 2019b). (Braine 2019), CTO of Barclays speaking at Digital Asset's conference Synchronize Europe, 2019 was very positive about industry level standards and hence ISDA.

(Clive Ansell 2019), Head of Market Infrastructure and Technology, ISDA in the same conference argued that the key issues are all about *"standards",* not technology. ISDA is looking at use cases and supporting cooperation, critical as ISDA has proposed standards before but the effectiveness of any new standard depends upon successful adoption.[88]

ISDA Common Domain Model is a *"blueprint for how derivatives are traded and managed across the trade lifecycle"* (ISDA 2019c). The aim is to standardise derivatives trade and processes coding and to obtain consensus among the industry on standards. (Ledger Insights 2019a).Consequently, it hope to achieve agreement on the "*representations for events and processes"*. (ISDA 2019c) argues that the benefits include i) "*golden source of trade data*", 2) environment for innovation, 3) improved regulatory oversight. This could save substantial amount of money as much as $2.5 billion.

In February, 2019, ISDA released version 2.0 its Common Domain Model (CDM) and in March 2019 it published the full version opening access to all market participants (ISDA 2019b). In April 2019 ISDA and DA announced they are working together to develop an open-source reference code library to support the adoption of the CDM. DA's DAML will be used as a common language with the code library enabling ISDA CDM to fully integrate with DAML (Digital Asset/ ISDA 2019).

This project is still at an early stage, but given the central importance of ISDA to global OTC derivative markets, we anticipate that DAML supported smart contracts will be widely applied to derivatives processing in the not too distant future.

[88] For a broader discussion of the challenges of setting standards in wholesale financial markets see (Houstoun, Milne, and Parboteeah 2015)

Once again, we conclude that according to our Definition 1, this is an initiative does *not* employ a distributed ledger solution. The sharing of data is supported through the standardisation of the common domain model not the sharing of data on a ledger with multiple operators. The standardisation and sharing of data then in turn supports the use of smart contracts, illustrating that these do not require agreement on data but not a distributed ledger per se.

**Case Study 3: DTCC's Trade Information Warehouse ("TIW") DLT**

**Profile**

DTCC is the clearing and settlement institution for US securities transactions. It also provides a number of other post-trade services in money and derivative markets.

DTCC has been responsible for supporting the Trade Information Warehouse for credit derivatives since 2006. This currently automates the record keeping, lifecycle events, regulatory reporting and payment management for $10 trillion of cleared and bilateral credit derivatives. DTCC entered the test phase of relaunching TIW on DLT and cloud in November, 2018, as detailed on its webpages (DTCC 2019). The firm is looking to go live on the service in Q4 2019.

**Products and/or applications**

DTCC is working with IBM, Axoni and R3 to re-platform DTCC's Trade Information Warehouse ("TIW").[89] Consequently, a derivatives distributed ledger solution for post-trade processing based on existing TIW capabilities and interfaces with technology providers and market participants. The solution has been developed with input and guidance from Barclays, Citi, Credit Suisse, Deutsche Bank, J.P. Morgan, UBS, Wells Fargo, IHS Markit and Intercontinental Exchange. IBM leads the initiative, Axoni provides the distributed ledger infrastructure and smart contract applications, with R3 as a solution advisor. The PoC was successfully completed in 2016. The re-platforming will support TIW's separation from MarkitSERV's credit derivative confirmation system. It will be replaced with a combination of DLT and cloud technology. TIW's current mainframe system will be replaced with cloud technology.

The existing TIW system "*… is a centralized, electronic database holding the most current details on the official, or "gold," record for virtually all cleared and bilateral credit default swap (CDS) contracts outstanding in the global marketplace. The Warehouse contains more than 50,000 accounts representing derivatives counterparties across 95 countries. DTCC also offers CDS Kinetics, weekly stock and volume reports that deliver detail on global CDS contract activity; historical data older than six months is available as a separate report.*" (DTCC 2019)

A key feature of this project is that the Axoni solution is to be built using the open source tools provided by the Hyperledger Fabric, where both DTCC and IBM are closely involved.[90] An important feature arguably of this project is its collaborative nature, involving close consultation with a range of stakeholders and using open source technologies to ensure that transparency for the underlying technological architecture and to allow all users to fully operationally integrate with the solutions as it develops. The solution uses Distributed Ledger Technologies, but the

[89](DTCC 2017b)
[90] See (Bear 2017)

upgraded functionality does not require a distributed ledger, there is as we understand the project essentially one ledger, which will now be cloud based and where multiple users can update their own records. So once again this is not a distributed ledger according to our Definition 1.

DTCC suggested that it expected to launch the re-platformed TIW for credit derivatives using DLT by the end of 2019 (DTCC 2019). An article on 20 September, 2018, suggested that DTCC passed TIW milestone, with the chief technology architect suggesting they finished coding TIW. The chief technology architect noting that functional coding for TIW completed in September 2018, and as of yet testing is continuing.

**Case Study 4: Fnality (formerly known as Utility Settlement Coin (USC))**

**Profile**

Fnality is the commercial implementation of Utility Settlement Coin or USC project (Coindesk 2019a). It is an asset-backed digital cash instrument implemented using distributed ledger technologies, with a version for each of five major currencies (US dollars USD, Euros EUR, British pounds GBP, Japanese Yen JPY and Canadian dollars CAD).

USC was started in 2016 as a co-operation between UBS and distributed ledger technology company Clearmatics.[91] Involvement increased to 17 banks including BNY Mellon, CIBC, Credit Suisse, Deutsche Bank, HSBC, MUFG, NEX, State Street and Santander. (Coindesk 2018b) R3 tried unsuccessfully to persuade USC's bank members to build the project on Corda instead of using Clearmatics but this approach was rejected. [92] It developed a proof of concept during the research and development stage of the project.

To take this project forward to commercial scale 14 of the world's largest banks have invested in Fnality. As described on their website (Fnality 2019a) "*Fnality International has been founded to create a network of decentralised Financial Market Infrastructures (dFMIs) to deliver the means of payment-on-chain in tomorrow's wholesale banking markets. Fnality, backed by a consortium of Financial Institutions, including many of the Globally Systemically Important Banks (GSIBs), who sponsored the "USC Project" believe that there will be widespread adoption of tokenisation, both for new and for existing assets, creating new Value Chains. A means of payment is an essential need for those Value Chains. The founding shareholders of Fnality comprise: Banco Santander, Bank of New York Mellon, Barclays, CIBC, Commerzbank, Credit Suisse, ING, KBC Group, Lloyds Banking Group, MUFG Group, NASDAQ, Sumitomo Mitsui Banking Corporation, State Street Bank & Trust, and UBS. Clearmatics continues in its role as the technology partner to Fnality*." These banks have invested £50mn in Fnality in the Series A equity round (Ledgerinsights 2019a).

**Products**

Fnality is building a 'tokenized' versions of five major fiat currencies (Coindesk 2019a). What does this mean? The holdings of USC will fully backed 1:1 with central bank money, eliminating credit

[91](UBS 2016)
[92] (Coindesk 2019a)

risk. But because they are held on a distributed ledger, transfers amongst holders on the ledger will support instantaneous 'peer to peer' transfer of this central bank money. According to Chief Executive Rhomaios Ram, as quoted in (Coindesk 2019a), this will complement other projects for supporting financial transactions on distributed ledger by allowing the cash leg of any Delivery against Payment DVP exchange to take place instantaneously in tokenized funds i.e. money fully controlled by the market transactor rather than relying on banking services from a commercial bank. In this way non-banks would effectively gain access to central bank balance sheets. In the same article Robert Sams of Clearmatics the technical partner supporting Fnality states that "*Legal settlement finality is happening inside the system's blockchain rather than across the books of a legacy settlement institution. This might appear to be a subtle distinction, but it's what turns a cryptographic key pair into cash itself. It's a foundational distinction.*" We agree that this is a key distinction: when relying instead on a commercial bank the cash leg of a financial transaction is dependent on a further settlement, with the commercial bank making the required transfer of funds through the large value RTGS system on behalf of the market participant, only when this has happened is the trade fully settled and final.

Fnality's distributed ledger architecture developed by Clearmatics is a private permissioned version of Ethereum called Autonity (Coindesk 2019a). Sams is quoted describing this as "*A distributed state transition system, where all participants on the chain keep a continually updated record of the blockchain's full state, is essential to ensure the system's resiliency.*" There will be a wide range of potential applications of Utility Settlement Coin USC (as the tokenised currencies will still be called) across all the securities, derivative and money market and foreign exchange applications we have discussed earlier in this section.

A recent white paper from Fnality, especially chapters 5, 7 and 10, explores the range of use cases in which USC may be applied.[93] This focuses on the use of nostro accounts with correspondent banks for settlement of foreign exchange transactions. Fnality offers the opportunity of replacing such nostro accounts with what is, effectively direct access to central bank money. The key is what they refer to as 'atomic settlement'. This is simple a fancy way of saying that provided both the sender of money and the recipient hold accounts on the single USC ledger, then a movement of value between them requires no further process of settlement. This is quite different from a payment where the sender and recipient hold accounts with two different commercial banks, including nostro accounts with correspondent banks. These must be settled using central bank money; and, as explained in our Figure 7, the reason for using the nostro account is to give foreign banks without direct access to central bank money the ability to make and settle domestic payments.

One of the most obvious application is in simplifying the 'PVP' settlement of foreign exchange transactions between any of the five Fnality currencies. As long as payer and payee in both the buying and selling legs of the transactions hold sufficient funds in USC then it straightforward to make a genuinely simultaneous payment v. payment of the two legs of the foreign exchange contract(or of a set of netted contracts). This is problematic when funds are held in a nostro account. This reduces counterparty risk and the need to hold collateral. It can potentially radically simplify the management multi-currency liquidity risk for international banks, because of the greater transparency of and control over the settlement of foreign exchange transactions. It can also in turn allow greater competition in foreign exchange markets, because smaller banks

[93] (Fnality 2019b)

need not rely as much as before on the main foreign exchange dealers for supporting execution and settlement.

It will still take some time for full commercial applications of Fnality's USC. The challenge they have set themselves is described on their webpages as follows (Fnality 2019c)"*the focus for Fnality is now to create and deploy a solution incorporating Legal, Regulatory, Operational and Technical aspects, to create a regulated network of distributed Financial Market Infrastructures (dFMIs) to support global exchange of value transactions.*" There are however always two sides to every trade, so while this sorts out the cash leg, it may take quite substantial further work to ensure that USC is integrated into for example established securities settlement processes. Our judgement is that the first applications of USC will be in those areas of application, e.g. cash collateral management, OTC derivatives processing, where existing processes are most fragmented and the ability to transact directly in the equivalent of central bank money is most useful. Integration with smart contract languages such as that of DAML would seem to be a very real possibility.

We also envisage an opportunity for using USC for settlement of foreign exchange outside of the network of global foreign exchange dealers and the established CLS system for net settlement (a kind of 'alternative venue' for foreign exchange that could lead to a narrowing of margins in foreign exchange dealing). Once established USC transactions may then gain further traction, leading closer to radical transformation of international payments envisaged in our Figure 9 above, but full adoption is likely to be a matter of some years.

**Case Study 5: SETL IZNES platform for mutual funds management**

**Profile**

SETL is a London based institutional payment and settlement infrastructure provider. Citi and Credit Agricole Investment Bank, Computershare, S2iEM and Deloitte are shareholders in the company. SETL was launched in July 2015 to deploy a multi-asset, multi-currency institutional payment and settlements infrastructure based on blockchain technology[94]. SETL offers the ability for users to move cash and assets directly between each other, facilitating the immediate and final settlement of market transactions. It has been actively working on a number of global platform implementations across the post-trade market. FN's Trading and Technology Awards included SETL (along with Cobalt, DTCC Trade Information Warehouse, R3, Utility Settlement Coin) in the shortlist for their blockchain initiative of the year (Fnlondon, 2018a) in March, 2018.

We focus on what seems to be their most successful product, the IZNES platform for funds allocation.

**Product**

IZNES is a pan-European record keeping platform for EU mutual funds utilizing SETL's a proprietary permissioned distributed ledger solution.[95] OFI AM, Arkéa IS, Groupama AM, La

[94] (SeTL 2018)
[95](Siliconangle 2017)

Banque Postale AM, La Financière de l'Échiquier and Lyxor AM are the six founding shareholders of IZNES. A capital reorganisation of SETL saw the end of its own shareholding in this project in May 2019, but it continues to be the technology provider. IZNES continues to enlarge the group of French and Luxembourg asset managers using its service.

IZNES went live in March, 2019 and now has over €1bn of assets registered on its platform. . The platform is described on their webpages (IZNES 2019) "*The Blockchain based pan-European platform for investment in UCITS units and recordkeeping compatible with all distribution channels*". It offers companies the ability to develop new investor relationships, handle subscription instructions, manage KYC processes, execute corporate actions and settle transactions and record positions. IZNES now has over 20 active fund managers using its services in Europe (Fnlondon, 2018a). France's securities regulator has provided SETL a license to operate a central securities depository system using its distributed ledger technologies (Coindesk 2018a).

As discussed above, funds management have some of the most fragmented business processes in financial services. IZNES offer simplification for example avoiding the need to have a transfer agent taking responsibility for subscriptions and redemptions (the current manually orientation of the transfer agent services and the potential for efficiency gains in these services driven by technological change, including IZNES is discussed in (Pratt 2018)).

An open question is whether a distributed ledger solution – according to our Definition 1 – is essential to the IZNES : why not allow each fund to be the responsible operating institution for its own ledger? Our interpretation is that the distribute ledger supports a standardised solution that can be offered to many fund managers, allowing them to focus on their own value added, risk management, portfolio selection and marketing, while effectively outsourcing key elements of technological support. So as we understand IZNES the distributed ledger approach her is not so much about creating a distributed financial ecosystem that will replace traditional intermediation, but rather allowing financial intermediaries to share and hence outsource common supporting technologies. In turn over time this may support a variety of other functions, for example closer involvement of mutual fund investors in corporate governance.

**Case Study 6: J.P. Morgan's Interbank Information Network (IIN)**

**Profile**

J.P.Morgan is the world's largest global transaction bank, and has prioritized tehcnological innnovation as a strategic priority across its business lines.

J.P.Morgan's blockchain-based cross-border payment product, the Interbank Information Network (IIN), began development in 2017 with the involvement of the Royal Bank of Canada and the Australian and New Zealand ANZ Banking Group, and by late 2018 signed up more than 75 banks to help with testing.[96] As of 22 April 2019 IIN had grown to over 220 banks, tackling cross-border payments in Africa, Asia, Europe, Middle East and Latin America.[97]

As well as IIN, J.P.Morgan has launched its own wholesale token coin project, J.P.Morgan Coin, with some similarities to Fnality's USC. We do not discuss their coin further in this report.

**Product**

IIN was initially announced in October 2017 during a trial involving a small number of partners.[98] IIN uses Quorum, a permissioned-variant of the Ethereum distributed ledger software to reduce friction in global payments.[99] It was initially to address compliance issues, but as described by John Hunter, J.P. Morgan's head of clearing in the Financial Times, it has been extended to address the wide range of issues that can require manual interventions in payments (e.g. errors in account number, routing code or other aspects of the transaction) enabling real-time verification that a transaction is being sent to a valid account).[100] Hunter suggests that IIN reduces the high rate of exceptions requiring manual intervention that can be as much 5-20% of international payments. According to the Financial Times article the platform was expected to go live in Q3 2019 (though we have found no official annoucment of this yet). The J.P. Morgan webpage for IIN listed 365 participating banks as of 14 November 2019.[101]

IIN is essentially a communication and information system, like SWIFT's gpi and Ripple's xCurrent, a solution corresponding to our 'limited re-engineering' illustrated in Figure 8. Value is not transferred on IIN. While full details have not been disclosed in the public domain, it appears that the crucial technological component is the cryptogrpaphicaly secured permissionning, so that every institution involved in a payment can see and exchange information on a particular

[96] Announced in (JP Morgan 2017, 2018).
[97] See (Financial Times 2019)
[98] In (JP Morgan 2017). Other institutions involved include, India's ICICI Bank, Bank of Sharjah, National Australia Bank Limited, and others. (Coinspeaker 2019) The network continues to expand. For example June, 2019, JP Morgan's IIN has been selected by Chong Hing Bank to exchange payments related information. Note this Chong Hing Bank is the first Hong Kong to join the network.(Asset Servicing TImes 2019).
[99] A related initiative illustrating the wider potential use of Quorum is 'Project Khokha' Settlement System in South Africa, for which the proof-of-Concept (PoC) established the possibility of conducting interbank transfers using J.P. Morgan's Quorum. The aim is "to build a proof-of-concept wholesale payment system for inter-bank settlement using a tokenized South African rand on distributed ledger technology."(Newsbtc 2018)
[100] Quoted in (Financial Times 2019)
[101] Authors calculation from the list of participating banks on J.P. Morgan webpage for IIN (J.P.Morgan 2019). Of these 51 are in the Americas, 46 in the EEA, 136 in Asia-Pacific, 105 in rest of Europe, middle east , central Asia and Africa together with a further 27 banks that have not disclosed their participation.

payment from the tine of intiial execution, and hence also provide immedaite validation of payment instructions.

**Case Study: 7 Ripple**[102]

**Profile**

Ripple is one of the most prominent initiatives using distributed ledger technologies in financial services. Its goal is to use these new technologies to provide alternative mechanisms of international payments that reduce the substantial costs and inefficiencies of current conventional systems. It is though difficult to understand: as we shall discuss it is not always clear exactly how Ripple products will address these costs and inefficiencies, especially the costs and inefficiencies associated with correspondent banking.

We will first provide a short history of Ripple and then summarise and critically assess their solutions. We discuss this case at greater length than the other six, primarily because Ripple, unlike the other case studies, promises fundamental disruption to existing financial processes along the lines of our Figure 9.

The following quotation provides a succinct summary of the establishment of Ripple: "*In 2004, a developer named Ryan Fugger developed a payment protocol and decentralised platform, Ripplepay, to create a financial network that could work without banks, amongst others by peer-to-peer lending. In early 2011, Arthur Britto, Jed McCaleb, and David Schwartz formed a team, working on what we know today as the XRP ledger, focusing on creating an alternative system to optimise where they found weaknesses in Bitcoin, e.g. to eliminate the risk of 51% attacks …. In August 2012, Chris Larsen joined the team, and after this, they approached Ryan Fugger to use their digital currency with his credit network. Fugger agreed to support the new effort, and the team founded a new company known as OpenCoin with full control of what was previously known as Ripplepay. Over the next years roughly $9 million USD funding was secured, and in 2013 they reverted the brand to its "Ripple" origin, Ripple Labs, Inc* [and now referred to just as Ripple] *while also making the source code public to make the project maintainable by the community. To ensure the sustainability of the company, the founders decided to donate XRP to the company (OpenCoin): Company (OpenCoin)* [in 2013 as follows]*: 80 billion XRP, Jed McCaleb:9 billion, Chris Larsen: 7 billion, Other Founders: 4 billion."* (Silkjär 2019).[103]

Ripple has raised substantial external funding. Most of this has been secured between 2016 and 2019, because Ripple has (according to Ripple market reports summarised on Wikipedia) raised some $1.14bn by sale of XRP on crypto exchanges, reducing its holdings of XRP from 80% to 60% of the total. According to (Silkjär 2019), of this 60% , 55% is held in a cryptographically secured and software controlled 'Escrow' and cannot be used for business purposes, while Ripple retains

[102] We sent a draft of this case study with Ripple's public relations team in early-Sept, 2019. They responded saying that our summary contains inaccuracies. We offered them the opportunity to correct any inaccuracies by end-Sept. They did not come back to us.

[103] This is evidence of the strong technical knowhow at Ripple. For example JedMcCalebwho has since left Ripple to found Stellar, a cryptocurrency that claims to avoid the high resource costs of proof of work used by Bitcoin. From their webpages (Stellar 2019) "*Fundamentally, Stellar is a system for tracking ownership. It uses an accounting ledger, shared across a network of independent computers, to store two important things for every account holder: what they own (their account balances) and what they want to do with what they own (operations on those balances, like buy or sell offers.) …. Stellar has been running for four years and has handled over 450 million operations by over 3 million individual accounts. Transactions cost roughly 1/millionth of a dollar.*"

5%. Ripple can be regarded as the first 'ICO' (even though the issue of XRP preceded these sales to outsiders and initial coin offerings were really only established after this initial 2016 sale of XRP). The amount of funding raised through sales of XRP substantially exceed the $96mn raised in conventional Angel, Seed and Series A and Series B funding.[104]

At the time of writing (Aug 18th, 2019) the market price of XRP was $0.288 giving it a total market value of $12.35bn. This means that the 5% retained by Ripple is worth $618mn, even though there has been a major fall of around 90% since its peak valuation in January 2018. The value of XRP has fallen much further than that of Bitcoin's XRP (which fell by 75% from its Dec 2017 peak but has since recovered to around 60% of its December 2018 valuation i.e. the valuation of XRP in terms of XRP has fallen by more than 80% in 18 months). This has led to lawsuits against Ripple arguing that they have failed to support the price of XRP, but Ripple argues that XRP is a commodity and its pricing (in part because of its decision to Escrow 55% of XRP) is entirely outside of its control.[105]

Ripple supported its efforts to improve international payments by announcing in 2016 the establishment of a Global Payments Steering Group.[106] Their announcement at that time stated that "*Ripple, the global provider of financial settlement solutions, today announced that a number of global banks are joining forces to establish the first interbank group for global payments based on distributed financial technology. Bank of America Merrill Lynch, Santander, UniCredit, Standard Chartered, Westpac Banking Corporation, and Royal Bank of Canada are the founding members of the organization, known as the Global Payments Steering Group (GPSG). The GPSG will oversee the creation and maintenance of Ripple payment transaction rules, formalized standards for activity using Ripple, and other actions to support the implementation of Ripple payment capabilities. CIBC will also join the GPSG as a new member.*" GPSG was then joined in March 2017 by The Bank of Tokyo-Mitsubishi UFJ. Since then however the GPSG appears to have been inactive - we can find no trace of it through Google search over the past two years.

Ripple remains very wealthy from its sales of XRP and uses these funds, in part, for a variety of charitable purposes including university funding to support research on distributed ledger technologies.[107] It also supports a variety of developments through xPring, its 'ecosystem initiative to build the internet of value'.[108] Ripple has supported a variety of xPring technology initiatives investing (through transfer of XRP some $500 million) in 20 firms over the last year to augment use cases for its blockchain based token XRP (ledgerinsights 2019). In addition some $100 million has been invested in gaming related technology (Ledgerinsights 2019b).

As described below, Ripple offers a suite of solutions ("RippleNet") for executing international payments, employing distributed ledger technologies and APIs (application programming interfaces). Ripple's product offerings have attracted considerable interest from commercial banks and other institutions worldwide. The number of countries through which xCurrent

[104] These fundraising are detailed in Wikipedia https://en.wikipedia.org/wiki/Ripple_Labs
[105] Documented in (Crossman 2019)
[106] In a Ripple press release (Ripple 2016a; Treacher 2016)
[107] $50mn has been announced as support for leading universities. One recent example resources to University of Sao Paulo, and Fundação Getulio Vargas business school to support research in engineering, business and law. The firm suggests academia will push Blockchain forward (Coindesk 2019d).
[108] As it is described on the xPring webpages (Ripple 2019).

transfers may be made is increasing.[109] As of early 2019 Ripple was reported to have more than 200 institutions using its xCurrent service. Application of Ripple by Santander has received particular prominent press coverage.[110] Many of these participating institutions though are not commercial banks, instead they are themselves FinTech start-ups seeking to provide low cost remittance services and taking advantage of the greater visibility provided by xCurrent.[111] The number of commercial bank users appears to fall some way short of the number experimenting with J.P.Morgan's IIN or using SWIFT's gpi.

**Products**

Ripple provides a suite of products, previously described as follows.

- xCurrent – for members of the Ripple network supporting their international payments using distributed ledger technologies
- xVia – am API solution giving access to the Ripple network for other users enabling them to send payments internationally
- xRapid – an advanced solution for members of the Ripple network, designed to provide access to payment liquidity

Recent rebranding on their website has removed these labels.[112] They now refer to the first two, collectively as 'RippleNet'. The third has been rebranded as 'On-Demand Liquidity'.

Ripple provides only limited documentation on the operation of these products. A five-minute video was their official statement. We have transcribed the text, as amended to reflect the rebranding of their products. This runs as follows.

> "*At Ripple we have talked a lot about the internet of value, our North Star of enabling money to move like information does today. But how does the internet of value translate into banking? It starts with your customers. Your customer's payment demands are changing and the internet of value plays a large part on delivering on those demands. Across, retail, SMEs and corporate customers, as well as the emerging wave of platform-based businesses, they are demanding global transactions that are seamless, real-time, certain and cost-effective. Yet today's global transactions fall far short of those*

[109] An undated webpage (Ripple n.d.) describes xCurrent as providing international payment across 27 countries (it is unclear how many of these are Eurozone countries and therefore essentially one from a payments perspective). Numbers are though growing. In June, 2019, Ripple launched in Brazil, the first stage of expansion into South America (Coindesk 2019e)

[110] Santander launched One Pay FX in 2018, a Ripple-enabled mobile app for cross-border payments by their customers using Ripple's xCurrent., described in (Ripple 2018b). There are many other media reports of uptake of Ripple services. MoneyTap app, a money transfer app has been launched in Japan. The app offer ability to make bank-to-bank money transfers in real time also using Ripple's xCurrent payment product. This service is able to remit between accounts held at the three participating Japanese banks-SBI Sumishin Net Bank, Suruga Bank and Resona Bank. Wihtin the last few months, the CEO of Ripple suggests that xCurrent system is now used by over one hundred financial institutions.(Coindesk 2018c). Recently on November, 2018 MUFG bank subsidiary of Banco MUFG Brasil signed a memorandum of understanding with Banco Bradesco to work on cross-border payment service. They will be using Ripple's technology for payments between Japan and Brazil.(Bankingtech 2018).

[111] According to (Ripple 2018c) remittance service providers using xCurrent services now provide remittance payments to over 40 countries across all six continents. Service providers include InstaReM and RationalFX to Asia, Remitr and FlutterWave to Nigeria and BeeTecha and InstaRem servicing Brazil from Europe. Another example is the CurrencyBird Reported in (Cointelegraph 2019a).

[112] (Mitra 2019).

*expectations. That's because the current payments infrastructure is a patchwork of centralised networks, legacy technology and different payment rails. It's disparate. The technology, systems of record, messaging and rules are different from one network to the next. Its slow, it takes an average of three to five days to settle across the various intermediaries, its error prone failure rates are high and data flow between intermediaries is poor, and its costly, processing costs are high an average of between $20 and $25 for each payment. The downstream impact of these problems provides a sub-par customer experience that is driving customers from your bank to fintech providers that can provide a better customer experience.*

*"We are solving this with RippleNet which is the cornerstone of enabling the internet of value. RippleNet is a global decentralised network that brings together a diverse ecosystem of payments players for the first time in history. Let's look at what could be the fully realised future state of RippleNet, starting with the ecosystem of players who are categorised into two functional groups. First are network users: these are corporates, SMEs, small banks and payment providers who only send payments. Second are the network members. These are banks and payments providers that serve as the foundation of the network as they process payments and source liquidity. Network members process payments through provides real-time settlement with bi-directional messaging. With RippleNet banks and payment providers can process payments more efficiently, through the pre-validation of every transaction to eliminate failures and through rich data attachments for every payment. It also provides certainty through the pre-disclosure of information prior to settlement to eliminate failures and through atomic settlement that provides pass-fail processing across all intermediaries to avoid settlement-like risk. Network members can also source liquidity through a pool of on-demand liquidity through digital assets. xRapid provides the ability to lower liquidity costs by being able to source liquidity on demand and reduce the amount of nostros required to make global payments. For network users, again these are corporates, SMEs, small banks and other payment providers, RippleNet provides a standardised API based interface to originate payments through their banking partner. They can access across networks globally, they can send payments on demand in real time, they can attach rich data like invoices to any payment and they can gain complete visibility into payments status and delivery timing. RippleNet is solving the inefficiencies of today's payments networks. It's standardised, the technology, APIs and governance and consistent across the network. It fast. The technology provides real-time settlement and bi-directional messaging. It's certain: atomic pass-fail processing eliminates payment failures; and its high low-cost. High STP rates and flexible liquidity provisioning lowers processing costs. RippleNet sf the first step towards bring the internet of value to life through one frictionless experience to send money globally. "* Author's transcription of (Ripple 2018a) made on Nov 20th, 2019.

This quotation from Ripple does a good job of explaining the problems with current international payments. The description of their services is a little less clear. Particularly problematic is their statement that RippleNet provides "real-time settlement". As a general statement this must be

wrong – providing real-time settlement requires access to central bank money – either directly holding accounts with central banks from both the sending and receiving country, or indirectly through a correspondent bank (see our Figure 7) – but this is something which RippleNet does provide.[113]

Also unclear is their discussion of 'the internet of value' and 'liquidity provision' and what added value is obtained from their On-demand Liquidity service. We find it difficult to understand what this means in practical terms. Discussion of liquidity needs to distinguish three quite separate things (but not clearly distinguished in Ripple's discussions of 'On-demand liquidity'):

1. The liquidity needs of bank customers.

This is provided either through lines of credit from the bank or through customers holding reserves of liquid assets, e.g. bank deposits, money market investments or short term securities. Such lines of credit are needed to support international payments, and Ripples xCurrent service can make more visible the need for short term credit to meet liquidity needs. But xRapid does not enhance these liquidity services.

2. The liquidity needs of banks, providing payment services to customers

This is a matter of balance sheet management that has to be addressed at the level of the institution as a whole. In the domestic context the liquidity challenge, now greatly constrained by Basel 3 requirements, is to maintain sufficient high-quality liquid assets and access to sufficient lines of credit from money markets to be confident of meeting any foreseeable outflow of settled funds. For international payments the corresponding liquidity challenge is to balance foreign exchange assets and liabilities and ensure they do not involve excessive maturity mismatch. Ripple's services, aimed as they are at the level of customer payment service, and not providing an overview of a bank's entire balance sheet, do not seem to address these bank balance sheet liquidity issues

3. Liquidity in foreign exchange markets, where a foreign exchange settlement is required to support an international payment

This is where Ripple's On-Demand liquidity service seems to be most relevant. Banks must pay a margin to exchange through foreign exchange dealers (as illustrated in our Figure 7. and 8.) and large transactions can be even more costly because of adverse movement in the exchange rate. The most widely used mechanism for avoiding such charges and market impact is netting of offsetting flows.[114]

[113] None of Ripple's own descriptions of their service accurately explain what it means to settle a payment (i.e. as illustrated in our Figure 7, settlement meaning the corresponding transfers of bank reserves matching the transfer of value from the customer sending money to the customer receiving money). An early example is (Ripple 2016b) which claims demonstration of international payment settlement using the Ripple network in 8 seconds at a payments conference in Calgary, whereas what they actually mean is that the payment was debited from one account and credited to another within 8 seconds, without any reference to the corresponding settlement which may take place subsequently after necessary foreign exchange transactions and movement within domestic payment systems. We are aware of no subsequent fuller explanation of what they mean by settlement from Ripple.

[114] For some international payment 'corridors' i.e. direct flows in both directions between particular currencies, foreign exchange flows in opposite directions largely cancel each other out. An example is international sterling-euro payments, an important factor in the early success of Transferwise was that their initial core market sterling-Euro exchange the customer orders in each direction were in approximate balance, they could net them off and only occasionally needed to conduct a foreign exchange transaction. Source: private communication with Transferwise management.

All of this is a little separate from settlement, the final exchange of value on the books of central banks. Ripple clearly states that it seeks to supplant centralised networks through its 'internet of value', but exactly how RippleNet's provision of "On Demand liquidity" can replace the need to access central bank money remains unclear.

Given this lack of clarity, we offer the following interpretation of Ripple's services. We believe they can be understood in terms of our Figures 8 and 9 above. We think the basic RippleNet service is simply a limited re-engineering of the operations of international payments as in our Figure 8 above.

The provision of full 'On Demand liquidity' goes much further, requiring a radical reengineering corresponding to our Figure 9 above. The possibility of using their cryptocurrency XRP for foreign exchange, on its own, would seem on the face of it to absorb rather than provide liquidity to customers. This is because if involves moving from bilateral exchange in two currencies (e.g. $ to Rupiah) to trilateral exchange in three currencies ($ to XRP to Rupiah). We can see thought that this may work in the context of a radical reengineering of international payments, as illustrated in our Figure 9. What they seem to have in mind is that RippleNet supplants the entire global foreign exchange market, replacing the role of dealers in providing liquidity and price discovery by direct 'atomic' or payer to payee transactions on the Ripple network; and also by operating on a single global system maximising opportunities for offset netting on a multilateral rather than bilateral basis, so minimising the need for settlement provided through direct access to central bank balance sheets.

We think it unlikely that adoption of Ripple will be great enough to achieve this level of radical transformation. This is though not at all to diminish the achievement of RippleNet as an early initiative highlighting the opportunities for using technology, including distributed ledger technologies, to automate international payments at lower cost and with greater reliability. How widely used it will be though remains, to us, an open question.

**Case studies: concluding summary**

Referring back to Table 3, we highlight the main points we draw from these seven case studies

- These case studies provide fairly strong support for our view that it is the component technologies of distributed ledger, not distributed ledgers per se, which is the principal and most important development. Of the seven case studies only three are using a distributed ledger and only one – Ripple – is even attempting to develop a distributed financial ecosystem in which the role of current intermediaries is displaced by more direct 'peer to peer' transactions.

- Many of these describe themselves as 'distributed ledgers', but distributed ledger means different things in these different business contexts. For the two applications of Distributed Assets DAML language, both supporting services for the ASX replacement and for the ISDA common domain model CDM, this is a reference to automated processing in which agreement on shared data and definitions of processing events is key. These automations do not need a distributed data ledger without a single operator.

- The full impact of these developments requires both co-operation and time: the

perception that distributed ledger is a disruptive innovation that will sweep aside existing practice receives virtually no support from our case studies. WE have discussed one possibility, that of RippleNet replacing the conventional architecture of foreign exchange, but this while it is a fascinating prospect is in our judgement not realistic. We also see the possibility of the widespread adoption of Fnality's USC leading to dramatic transformation of international payments, but this will be a process of change taking some years, not overnight revolution.

- Overall the impact of ongoing digitisation of financial services will be profound, but this is a gradual evolution over years, not a sudden revolution. Moreover a focus on 'distributed ledger' or blockchain is, if anything, a distraction from the key issues.

# 4 Distributed ledgers: the adoption decision

This section discusses the decisions involved in adoption of distributed. This discussion supports two main findings:

(i) Adoption of a distributed ledger is most appropriate in situations requiring shared multiparty governance of data and data access.

(ii) In digitizing operational processes and systems, using a distributed ledger or another approach, it is necessary to address familiar and difficult challenges of data quality, data governance and data management. Potentially substantial costs of changing operational processes cannot be avoided.

This section reviews a range of opportunities for sharing the storage and processing of data records amongst multiple users in financial services. We ask: where amongst these potential opportunities for applying distributed ledger technologies are the trade-offs between costs and benefits of adoption appear most favourable and hence where, across the full range of financial services, are distributed ledgers more likely to be first and most fully adopted?

This discussion draws on several sources. First our own understanding of the operational and business processes involved in these many different financial services. Second, our analysis of announced financial distributed ledger projects in Appendix A to our paper.[115] Third a wide-ranging desk review of commentary on distributed ledger technologies.

## 4.1 The benefits of distributed ledger technologies

Bold claims are routinely and widely made for the benefits that can flow from employing distributed ledgers in both business and public administration, prompted in part by the investment frenzy over cryptocurrencies.[116] Discussion of these benefits is hampered by a huge amount of low quality online material, mostly copied uncritically from other online sources.[117]

[115] This list of 124 distributed ledger (or 'blockchain') projects contains all the initiatives in mainstream financial services that we could find, announced in the course of three and a half years between September 2015 and April 2018. Most of these are exploratory 'proofs of concept', with little detail in the public domain about what was actually done, and only a few have been taken forward beyond the proof of concept stage. Still together, they give an indication of the wide range of interest in developing distributed ledger solutions for financial services.

[116] Some examples amongst many "Distributed ledger technologies (DLTs) have disruptive potential beyond innovation in products, services, revenue streams and operating systems within existing industry frameworks. They have the potential to disrupt the whole economy, and society." (Government Office for Science 2016 pg 53) "Quite simply, we believe that blockchain will do for business what the internet did for communication." (IBM 2018 pg 5). "Blockchain technology has the theoretical capacity to apply to and disrupt any form of value or data transfer recorded in a ledger." (Casey et al. 2018 pg 13).

[117] There are exceptions, e.g. 'The Great Wall of Numbers" the blog of Tim Swanson (Swanson, n.d.) provides reliable, carefully considered independent analysis of distributed ledgers and related technologies..

There is a vast amount of nonsense.[118] Claims demonstrated to be false continue to circulate, until they become accepted by dint of repetition.[119]

Despite all this noise, distributed ledger technologies can deliver many substantial benefits.[120] These benefits are usefully separated into two broad groups: (i) data management benefits, when holding and sharing data of any form (ii) transaction efficiency benefits, when using ledgers to hold records of ownership and financial obligations.

*Data management benefits*

(i) Shared secure permanent records of data amongst a network of users

These is a fundamental benefit of distributed ledger technologies. The sharing of the ledger, with several operators confirming the eligibility of user requests and then updating the records, is essentially more secure than a system relying on a single shared database. A hacker who managed to break into the systems of one operator could attempt to make unauthorized changes in the ledger. But unless they penetrated the systems of many operators, these changes cannot be accepted. The structure of the ledger, with no data records ever overwritten, ensures permanency.

(ii) Data transparency: with full control over access to data records

The original Bitcoin blockchain is completely open – anyone can download the complete record of past transactions. Several websites use this feature to provide a wealth of derived data on transactions and Bitcoin 'mining' that go right back to when Bitcoin was first traded in 2009.[121]

Such complete openness is not appropriate for the permissioned distributed ledgers applied in business and public administration. But the fact that these ledgers are permissioned and operated using a single shared software allows precisely tailored control over what data records can be read and by which users. Moreover, these permissions are themselves transparent. All users can see who is able to read the data they have provided to the ledger.

(iii) Data provenance: a complete audit trail of changes to the ledger and support for dispute resolution

[118] One example: (Gupta 2018) appears reputable because it is published by IBM and Wiley. It is not reliable. Errors include: (i) "One solution that's been developed to address the complexities, vulnerabilities, inefficiencies, and costs of current transaction systems is Bitcoin" (false, Bitcoin is far more expensive and inefficient); (ii) "For example, blockchain enables securities to be settled in minutes instead of days." (false, conventional technology can also support immediate 'real time' settlement, as it does already for large value cash payments; delay in settlement is a design feature in security markets allowing traders time to locate the cash and securities for settlement of trades (Mainelli and Milne 2016)); (iii) "Blockchain enhances trust across a business network. It's not that you can't trust those whom you conduct business with; it's that you don't need to when operating on a blockchain network." (overstated, only applies for data not introduced from outside the ledger, conventional institutional arrangements of internal corporate control and of external law and regulation are still needed to ensure accuracy of external data imported into the ledger, see further discussion below);

[119] For example, the 2015 claim that Honduras, one of the poorest countries in Latin America, had adopted distributed ledger for land registration and that similar adoption of distributed ledger for land registration could help lift low income countries out of poverty. This myth was disposed of in 2016 (see Cadasta Foundation 2016 for detail: uncertainty of title in Honduras and other low income countries is due to failure to survey land and agree title not inadequate record keeping technology) but yet still regularly re-appears (e.g. Kshetri 2018)

[120] The following analysis is our own, identifying various benefits culled from many sources (including IBM 2018; M. Casey et al. 2018; Rauchs et al. 2018; Forrester 2018) and assembling them into our own categorization.

[121] For example https://www.blockchain.com/charts

Because records are only added, never removed, distributed ledgers provide a complete record of past changes of data on the ledger and of who instructed these changes. In this sense data provenance is known (though provenance of data from outside the ledger is not automatically established). This in turn reduces possibility of dispute about the data records.

(iv) Simplified data operations: supporting automation and reducing operational risk.

Once users agree on sharing data through a ledger, this ensures consistency of data for different users, a 'single source of truth'. This consistency can then support greater automation and reduced need for costly manual intervention, in for example reconciling invoice or transaction data before fulfilling payment and transfer obligations, and reduces delay or mistakes in data operations

*Efficiency Benefits in Financial Transactions*

(v) Reducing operational cost and risk

This is the most widely promoted benefit from moving the records of asset ownership and of financial contracts onto a distributed ledger. Provided that both the contracts and the cash or investment assets they refer to are all recorded on the same ledger, then operations can be carried out automatically with lower cost and with lower operational risks. The catch is the word 'all': in practice it can be difficult to have every aspect of the ownership or financial contract captured on one ledger.

(vi) Reducing uncertainty through automated pre-commitment to asset transfers on the ledger through 'smart contracts'.

'Smart contracts' are code on the ledger that self-execute to update data records on the ledger, when specified conditions are satisfied ("If …. then ….").[122] This feature can help build trust in the obligations of other participants. For example, payment in a supply chain can be triggered automatically without having to go through the slow and uncertain process of issuing an invoice and awaiting payment, once fulfilment of the supply contract is confirmed.

(vii) Removal or simplification of layers of financial intermediation, leading to increased competition and lower charges to final customers

Modern financial services are characterized by multiple layers of intermediation. An example is chain of intermediation supporting investment in securities investment (investor – pension fund, bank or retail broker – fund manager — custodian – depository – issuer). Other complex chains of intermediation appear in commercial banking and in insurance. Each link in these chains

[122] The label 'smart contracts' is a misnomer. They are more accurately labelled 'dumb contracts' because no intelligence, learning or human intervention is involved in their initiation or execution. Potentially some forms of artificial intelligence software could be used together with a distributed ledger to initiate request for the execution of financial transaction, but this is not what is currently understood by the term 'smart contracts'.

applies their own charges. These charges are opaque and contribute substantially to overall customer costs.[123]

Data management using distributed ledger technologies could allow major simplification in the recording of investments, transactions and financial contracts. This could in turn remove the opaqueness of charges and support greater competition and, potentially, consolidation or elimination of the different stages of intermediation.

(viii) Overall reduction in transaction costs, supporting innovation in financial services and promoting financial inclusion

Many of the 'good news' stories about distributed ledgers are about their potential use in meeting currently unmet needs for financial services or reducing substantially high levels of charges imposed on the vulnerable or excluded. There is a widespread problem of, high contractual and transaction costs, relative to the size of the financial obligations and transactions of lower income, resulting in high charges or the failure in market provision of a financial services at all. In principal the use of distributed ledger technologies to support data transparency and reduce the costs of financial transactions should promote the development of new financial services and financial inclusion.[124]

These benefits are widely recognized and widely discussed. What is not so widely recognized is that (as we discuss in the next section) the realization of these benefits does not require the adoption of a complete distributed ledger solution. These benefits are the benefits of digitizing of data operations and they can also be achieved using conventional databases each maintained by a single operating entity. The perception that a distributed ledger is necessary in order to achieve these benefits is false; but several of component technologies employed in distributed ledgers can be used to help achieve the benefits of digitisation.

One related DL myth is that these new technologies achieve efficiency in processing, with for example DLT providing "through put" efficiency gains by eliminating hierarchies of financial intermediation. This is putting the cart before the horse. The simplification of hierarchies of financial intermediation may support greater efficiency of processing, but this is delivered by the structural change itself not by the supporting database technology. It is a secondary question whether such change is best implemented using DLT.

Having multiple operators of a single distributed ledger has advantages. As we have noted it is more secure and it avoids users relying on a single entity that may not always act in their interest. But it also introduces additional costs of system change and of collective ledger governance. It is therefore unsurprising that, as we find, in practice fully distributed ledgers with no central organization responsible for updating records are being adopted only in a few specific contexts where the balance of costs and benefits favours their adoption.

[123] Lack of transparency in asset management makes it impossible to establish charges precisely (Pitt-Watson et al. 2014); but in UK equity fund management hidden charges are said to add an additional 1.4% to the already high disclosed total expenses of 1.7% (according to a 2011 report by Christopher Sier cited in Powell 2016).
[124] See e.g. (Gallo, Jumamil, and Aranyawat 2017; Kewell, Adams, and Parry 2017).

## 4.2 Costs and benefits of adoption

Adoption is a cost-benefit decision. Table 5 summarizes the costs and benefits. Overall this suggests there can be substantial barriers to adoption.

**Table 4: the benefits and costs of DL adoption in financial services**

| **Benefits** |
|---|
| • Data management benefits from shared common data |
| • Low cost rapid execution of financial transactions with immediate finality; |
| • Reduced uncertainty through automated pre-commitment to payments or other asset transfers through 'smart contracts'; |
| • Removal or simplification of layers of financial intermediation, leading to increased competition and lower charges to final customers; |
| • Overall reduction in transaction costs, supporting innovation in financial services and promoting financial inclusion. |
| **Additional Social Benefits** |
| • Improved regulatory oversight as data is moved onto distributed ledgers |
| • Reduced systemic risk from failure of centralized institutions |
| **Private Costs** |
| • Reengineering of business processes in order to participate in the ledger<br>• Costs of governance: both the costs of participation in governance and the potential costs of being obliged to comply with adverse collective decisions<br>• Falling business margins as new competitors take advantage of the transparency of the ledger to compete in core business activities |

Note. The costs listed in this table do not include the high resource costs and slow speed of confirming transactions in cryptocurrency ledgers. The table is designed for assessing commercial applications of distributed ledgers, where real world identities are known. As a result, the operational inefficiencies of 'proof of work' – which arise because real world identities are unknown – do not need to be considered.

Operational costs in global capital markets are substantial – though we know of no credible breakdown of those costs between those associated with long term equity investment and short term proprietary trading or between different categories of security, derivative and foreign exchange transactions.[125] Distributed ledger technologies could achieve substantial reduction, but exactly in what way and how large are the resulting benefits is still unclear.

There are also major barriers to adoption. There are not yet clear positive return to investment (RoI) in most areas of financial services.[126] Network effects can make it difficult for challengers to employ distributed ledgers to disrupt existing business models. Simplifying layers of intermediation and increased competition lowers margins and profits. Where adoption is a collective decision (where there is no 'first mover' advantage as can often be the case in network industries) then losers may block technical innovation.[127]

[125] According to Oliver Wyman the aggregate revenues of the capital markets firms servicing the specific activities that can directly utilise mutual distributed ledger – clearing, securities settlement, collateral management and custodian services – together amount to some $40bn to $45bn (cited in Mainelli and Milne 2016).
[126] See (Crossman 2018)
[127] A common them in the economics of financial infrastructure, see (Milne 2006; Milne 2007)

## 4.3 Radical versus limited adoption

Adoption is a matter of degree. To illustrate consider equity ownership and trading (Figure 2)

**Figure 10: The current hierarchy of ownership in a trading environment.**

| Buyer (asset manager, cash only institution such as an insurance fund or a leveraged institution such as a hedge fund) | | Seller (asset manager, cash only institution such as an insurance fund or a leveraged institution such as a hedge fund) | |
|---|---|---|---|
| Investment accounts | Trading accounts | Trading accounts | Investment accounts |
| Cash and security accounts with Commercial Bank/Custodian<br>⬇<br>Cash and security accounts with Central Bank/CSD | Security Accounts with Security Broker<br>⬇<br>Security accounts with CSD | Security accounts with Security Broker<br>⬇<br>Security accounts with CSD | Cash and security accounts with Commercial Bank/Custodian<br>⬇<br>Cash and security accounts with Central Bank/CSD |

Note: Adapted from Figure 3 of (Milne 2015) The ownership of both cash and securities is in a tiered hierarchy. Cash is held in accounts with commercial banks who in turn hold reserve accounts for settlement of cash transfers with a central bank. Similarly, investors hold security accounts with custodian banks who in turn hold so called 'omnibus' accounts with central securities depositories or CSD (for example Euroclear UK and Ireland in London Markets or DTCC in US markets). The key difference is that cash accounts held at commercial banks accounts are fractionally reserved, so there is no need for them to be backed 1:1 with reserves at the central banks; custodian banks on the other hand must match the total held in omnibus security accounts with the total of their client accounts i.e. they are fully reserved. This allows the CSD to keep the ultimate record of issued equities or bonds.

Beginning from this starting point, who might benefit from sharing moving records of equity ownership on distributed ledgers? Potential beneficiaries include 'buy side' institutions, notably asset managers whose funds under management account for the large majority of securities investments (but there are many other buy side participants as well, ranging from retail investors to hedge funds). Also, in the context of the clearing and settlement of securities transactions, beneficiaries may also include the brokers who execute transactions on behalf of buy side clients. How might they benefit?

This depends on how a distributed ledger is employed. We distinguish two illustrative possibilities, for altering Figure 10 (variations of these are possible):

1. (Radical re-engineering) Moving all records of cash and security ownership in a given jurisdiction (US, UK) onto a single distributed ledger (Figure 11).

Such radical re-engineering is conceivable. This seems to be what commentators promoting the transformative impact of distributed ledger on financial services have in mind, for example those claiming the transparency of distributed ledgers can substantially improve corporate

governance.[128] There have been practical experiments with 'issuance of securities on a blockchain', exploring the legal and operational issues involved in moving the ultimate records of securities holdings out of CSDs/ Custodian Banks onto a distributed ledger, so this is technically feasible.[129]

**Figure 11: Radical re-engineering of asset ownership using distributed ledgers**

| Buyer (asset manager, cash only institution such as an insurance fund or a leveraged institution such as a hedge fund) | | Seller (asset manager, cash only institution such as an insurance fund or a leveraged institution such as a hedge fund) | |
|---|---|---|---|
| Security accounts | Cash accounts | Security accounts | Cash accounts |
| Security accounts on single distributed ledger | Cash accounts on single distributed ledger | Security accounts on single distributed ledger | Cash accounts on single distributed ledger |

Proof of concept, showing that all the various transfer and corporate action operations involved in securities transactions and security investments can be carried out on a distributed ledger, demonstrates only that such radical re-engineering is feasible not that it is desirable. Making the case for radical reengineering requires also demonstrating that the benefits in terms of lower operational costs and risks and greater transparency justify the costs of systems migration.

Compare this clear and specific benefit to individual adopters with the more uncertain benefits of radical change illustrated by Figure 3. It is difficult to assess what operational cost reductions would follow from moving ultimate records of equity ownership onto distributed ledger. The major custodians already benefit from substantial economies of scale. While substantial reduction in operational costs, especially those associated with reconciliation of data from multiple sources, could be achieved by shifting securities from the half a dozen institutions that account for the bulk of custody assets onto a single ledger, it is unclear that other approaches – for example standardization of data fields could not achieve much the same outcome. Custodians will still continue to supply tax, corporate actions and portfolio information services

This is not to argue that benefits of radical change illustrated by Figure 3 are small.

- Buy-side participants in security markets could benefit from much lower operational costs and greater competition in custodian services, from holding assets on a single distributed ledger rather than with a range of custodian banks.[130] Standardization would

[128] See (Yermack 2017) pg 2: "Perhaps most importantly, blockchains could provide unprecedented transparency to allow investors to identify the ownership positions of debt and equity investors (including the firms' managers) and reduce the opportunity for rent-seeking or corrupt behaviour …." This seems overstated. Putting ownership on distributed ledger would not, of itself, ensure transparency of ownership without some ex-ledger mechanism to force investors to reveal the identity of ultimate beneficiaries, i.e. a broader institutional shift towards transparency of ownership in global securities market. Yermack also argues that investors will benefit from holding securities on distributed ledger because this will support greater liquidity in securities trading, but this also is unclear since it does not obviously change market and credit risks.

[129] For example the bond issuance reported in (Cohen et al. 2018)

[130] (Powell and Hobson 2018) use cost and revenue data for the six largest global custodian banks (acknowledging considerable uncertainty in their estimates) to support a judgement that universal adoption of distributed ledgers would reduce the costs of these custodians by $6bn per year and reduce their revenues by $13bn per year. This does not take account of dynamic competition effects, which could further reduce their margins.

make it easier to compare and switch between custodian banks, encouraging greater competition and innovation in custodian services. This though underlines a key challenge: achieving critical mass. A distributed ledger competitor to custodian banks with low uptake would not have the economies of scale to compete effectively with incumbent custodians in terms of either cost or service quality, but without a compelling business case in terms of better cost of service quality few asset managers will transfer asset holdings from the custodian to the distributed ledger.

- Operational cost reductions would be particularly large for international investment, which must rely today on the relatively cumbersome processes, either of issue of a depository receipt in an overseas equity market or of an overseas custodian employing a sub-custodian in a domestic market. Having all equity ownership on open distributed ledger could support direct international ownership without these additional layers of intermediation.

- Equity trades in the major financial centres are guaranteed by central counterparties, to maintain trading anonymity; to maximize netting; and to minimize the impact of trade settlement delays. The employment of distributed ledgers, managed by the central counterparty but open to external monitoring and governance alongside a cash distributed ledger similar to that supported by utility settlement coin, could minimize the systemic risk associated with these centralized infrastructures.

Unlike the case of utility settlement coin however, these are all social not private benefits.[131] The relatively low private benefits from such a major change in the architecture of global financial markets suggests that, however desirable, this cannot come from private initiative alone. If it is worthwhile (and this would be controversial) then it will have to be mandated by regulators or result from a collective agreement amongst buy-side clients. We return to this possibility in our discussion of public policy in Section 6.

Turning to a more limited possibility of reform in equity holdings and transactions, we might have:

2. (Limited application in security transactions) Operating distributed ledgers alongside the existing arrangements for investment, with security and cash ownership transferred onto a distributed leger for trading purposes but not for investment (Figure 12).

[131] As (Powell and Hobson 2018) make clear custodian banks appear likely to lose not gain from radical adoption.

**Figure 12: Distributed ledger limited to security transactions**

| Buyer (asset manager, cash only institution such as an insurance fund or a leveraged institution such as a hedge fund) | | Seller (asset manager, cash only institution such as an insurance fund or a leveraged institution such as a hedge fund) | |
|---|---|---|---|
| Investment accounts | Trading accounts | Trading accounts | Investment accounts |
| Cash and security accounts with Commercial Bank/Custodian<br>⬇<br>Cash and security accounts with Central Bank/CSD | Cash and security accounts on distributed ledger<br>⬇<br>Cash and security accounts with Central Bank/CSD | Cash and security accounts on distributed ledger<br>⬇<br>Cash and security accounts with Central Bank/CSD | Cash and security accounts with Commercial Bank/Custodian<br>⬇<br>Cash and security accounts with Central Bank/CSD |

Such an arrangement would require similar movements of cash and securities required for cross-border securities trading in the EU through the Target-2 securities settlement system platform sponsored by the European Central Bank.[132] In order for a security to be traded between two EU jurisdictions, the investor or their representative must have cash accounts with the central bank (Target 2) and also securities accounts with the shared platform (Target 2 securities). Once the cash and securities are in position, the two platforms ensure simultaneous delivery against payment (DVP) to settle the trade. So, prior to trade the investor's holdings of cash and securities must move, from commercial banks/ custodians investor accounts onto trading accounts (held via the ledger in Figure 4 or directly with the central bank/ CSD for current Euro area trading). There is a difference: the distributed ledger security accounts in Figure 4, would be held directly by investors not by brokers.

## 4.4 Distributed ledgers: not necessary to delivering all their perceived benefits

Distributed ledgers offer substantial perceived benefits through both improvement of data management and reduced costs of financial transactions (benefits (i)-(viii) listed in Section 2). Amidst all the excitement about distributed ledgers, it should though be recognized that distributed ledgers are just one implementation of modern information, communication and data technologies that might be used to realize these benefits.[133]

As we have seen, distributed ledgers are a means of sharing of secure permanent records of all data amongst a network of users. This directly delivers benefit (i). The reduced costs and uncertainties in operational processes i.e. benefits (ii)-(viii) are *not* a direct consequence of the adoption of distributed ledgers. They are the result of the associated digitisation of operational

[132] https://www.ecb.europa.eu/paym/target/t2s/html/index.en.html
[133] As one commentator on an early draft suggested, distributed ledgers are a "mash-up" of component technologies.

processes. Digital ledgers may require this digitisation but they are not necessary for achieving it.

How else might these other benefits be achieved without distributed ledgers? Benefits (ii) data transparency and (iii) data provenance are based on applying modern tools of cryptographic security. These can be applied to conventional database. They do not require a distributed ledger. It is true that the required transparency may be more easily implemented within a single software, but modern technologies, especially the use of application programming interfaces or APIs can support the retrieval of required data from range existing systems, provided there is sufficient comparability of underlying data. Data provenance is more difficult since the underlying systems may not record all the required information to trace the source of data, but still a complete replacement of an existing system with a distributed ledger may not be necessary.

Benefit (iv) – that of simplified data operations supporting automation and reducing operational risks – is largely a standardization challenge. When individual firms or government bodies use their own separate identifiers, classifications and data typologies in their own systems, then there will difficulties in automated processing of shared data. Even within individual institutions it is all too common to find incompatible systems and great difficulties with internal sharing of data at the granular level. A promising technology for sharing of data without replacing legacy systems are again application processing interfaces or APIs – but these depends on a minimum degree of comparability of identifiers, classifications and data typologies used in different systems.[134]

Turning to the more specific benefits of greater efficiency in financial transactions, none of these depend on employment of distributed ledgers. Benefit (v) low cost rapid execution of financial transactions can already be offered for both cash and securities recorded in conventional databases without employing any of the technologies used in distributed ledgers. There are several reasons why is not always already done.

- As already discussed, this is a deliberate feature for example in securities settlement providing counterparties with time to position for final settlement.
- It may be a consequence of legacy processes – for example for salary payments - that rely on batch processing. These processes are deeply embedded in the systems of both financial institutions and their customers. Introducing a distributed ledger will not change them and these can be changed without a distributed ledger.
- It may be a consequence of errors in input and exchange of transactions data that require checking and if necessary manual correction before a transaction can be completed. Automation of these operations requires changing the operational processes for inputting of data, but this is again something which could be done without a distributed ledger.

Moving all ownership onto a distributed ledger, with accompanying changes in legacy processes and in input and exchange of transactions data would then allow low cost rapid execution. But these changes do not necessarily require such a complete data migration.

[134] Financial services have generally co-operated quite well on establishing communication standards, with SWIFT playing a leading role, but have a much weaker record on development of data standards such as identifiers or consistent typologies (Houstoun, Milne, and Parboteeah 2015; Alistair Milne and Parboteeah 2015).

Similarly, benefit (vi) the use of 'smart contracts' to provide pre-commitment to fulfilment of financial obligations, could be provided from conventional databases supported by appropriate tools of data transparency and standardized definitions. Once again, a distributed ledger is not required to achieve this benefit.

There must be even greater doubts as to whether the more far reaching efficiency benefits claimed for applying distributed ledgers in financial transactions, i.e. benefits (vii) and (viii), are achievable through the adoption of distributed ledgers alone. The reasons for such complex and opaque chains of financial intermediation are as much institutional as technical. There are substantial network effects which make it difficult to establish new platforms or markets. Extensive regulation means that any operational innovation, including participation in distributed ledgers, is usually forced to align closely with existing business models.

Similarly, the high costs and limited provision of financial services to poorer and more vulnerable households, especially in middle- and low-income countries, are not easily corrected using distributed ledgers. These reflect a range of factors, including reliance on cash transactions without the transaction histories that can support credit or insurance and also weaknesses in information and legal infrastructures that would support the provision of financial services.

Yes, more transparent and simpler arrangements could be developed in which distributed ledgers might play a role. But such changes in systems incur considerable costs and risks to incumbents, are a major coordination challenge and could face resistance from some incumbents whose margins and business models are threatened. As we discuss below in Section 6, such fundamental change is likely to require state direction or compulsion.

## 4.5 Shared multiparty versus single party governance

We briefly discuss the choice between a database with many operators and shared governance (hence falling under our Definition 1 of a distributed ledger) and the more conventional choice of a database with a single operator and hence either representative governance representing various stakeholders or single party governance.

All databases, whether conventional or a distributed ledger, must ensure the consistency, accuracy and security of their data, with data available as needed to support business and administrative functions. Sometimes these ends will be better served by having limited access and a single entity responsible for maintaining the database (conventional database design) and sometimes collaboration amongst multiple users and entities (distributed ledger).[135] The choice is context dependent: it depends on the trade-off of between (i) the benefits of reduced reliance on a third parties, agreed standards and more open access; and (ii) the costs of investment in new shared systems and of collective governance and standard setting.

[135] A familiar example of data sharing relying on a single entity are what are referred to as global distribution systems (or GDS) in the terminology of the airline industry, developed in the 1990s for sharing flight reservation data amongst airlines and travel agents, for example Amadeus, Galileo International and Sabre; these GDS capture, combine and maintain mirror records of reservation data held by the individual airline's computer reservation system (see Buhalis 2004 for review of how these and internet bookings have impacted the airline industry).

This perspective is reflected in the following advice offered by IBM on the adoption of distributed ledgers, (because of their practical experience in advising on the implementation of distributed ledgers, this is well worth quoting; note that they use the label blockchain where we prefer distributed ledger).

> *"There are four key questions in evaluating the need for blockchain; they can uncover how closely your use case aligns with the purpose and value proposition of blockchain itself.*
> *"1. Does the solution require trusted data to be shared across multiple parties without a central authority? The fundamental value of blockchain lies in its shared ledger, an append-only distributed system of record across a business network. If a use case doesn't require a shared ledger and a network of participants, blockchain technology probably shouldn't be used….*
> *"2. Are assets being transferred between parties? At its core, a blockchain solution should manage the transfer of anything with tangible or intangible value. Assets can be physical ones like a piece of fruit; digital like an electronic file or data, or intangible like a letter of credit or contract. Blockchain is used to record the transaction of these assets between multiple parties in a business ecosystem; without asset transactions, you're likely better served by a traditional database.*
> *"3. Is there a need for privacy among participants in the current business network? One thing that separates permissioned blockchain from traditional distributed databases and some cryptocurrency-based blockchains, such as Bitcoin, is its ability to permission the data. Participants can transact privately across the network to ensure that confidential information is not broadcast. Their identities won't be linked to the transaction either, further ensuring their confidentiality.*
> *"4. Is there the need for greater trust inside the current business network? Heavy regulation and frequent audits are typically a strong indicator of distrust within an industry. Because blockchain assets have a verifiable audit trail and cannot be modified, inserted or deleted, the network's shared ledger becomes the trusted source of information for all parties. Transactions are also electronically endorsed on a case-by-case basis by mutually-selected members of the business network, fortifying trust even further."* (IBM 2018 pg 9)

While agreeing with this advice, we would suggest even greater caution than these IBM recommendations on adoption of distributed ledger for digitisation of operational processes:

(i) Even if trusted data must be shared (IBM's question 1) it must still be asked if this best done with or without a central authority or repository. A key question here is governance (the top layer of our database 'stack'): are the additional costs of shared governance arrangements justified?

(ii) We already have many systems for recording and transferring of financial and other assets (IBM's question 2). So here, the key question is whether these already exist and whether the costs of introducing a distributed ledger sufficiently improves these systems.

(iii) Privacy (IBM's question 3) can be achieved in conventional databases using modern tools of cryptographic security. As we have already discussed this is not itself a reason for using a distributed ledger.

(iv) Trust in data (IBM's question 4) may be achieved more directly, using other approaches, promoting open data access, greater technical standardization and automated data exchange.

A further key issue is governance of shared data. A distributed ledger may be appropriate when participants in the ledger are disadvantaged by relying on a single entity to operate the ledger and either controlling or having excessive influence over the governance and software layers of the database. Otherwise the benefits of distributed ledgers are more appropriately pursued by digitisation with data shared through a single entity not a distributed ledger.

## 4.6 The challenges of data management.

Digitisation of operational processes – whether this is undertaken to support the adoption of a distributed ledger or not – requires addressing a range of all too familiar and all too often messy issues of data management. The collective effort to adopt a distributed ledger can support automation and improve operational efficiency; but they are not a 'magic bullet' for solving underlying data problems.[136]

<u>The need for external data interfaces</u>

A principal reason is that any application of distributed ledgers in business and public administration require external data interfaces i.e. data that is either imported (an incoming data interface) or exported (an outgoing data interface).[137] The exception are the original blockchains supporting Bitcoin and other crypto assets. Their only purpose is secure transfer of a native asset within their network and so do not require any external data interface. This limited application means that the ledger can work on a permissionless basis with the software alone ensuring data integrity.[138] But this does not generalize to other applications.

As an example of data import, consider a distributed ledger developed to provide supply chain transparency and authenticate product origin. In order to use a distributed ledger to verify the origin of, say, a particular artisan cheese, the identity of the data provider has to be known for checking data accuracy and penalizing inaccuracy.

For data export, consider the use of distributed ledger to record the holding of securities such as bonds or equities. Corporate actions on these security holdings, such as payment of coupon or dividends or proxy voting at annual meetings, requires knowing real world identities of holders of ledger assets.

The requirement for distributed ledgers to be based on real world identities is reinforced by the application of financial regulation, such KYC/AML requirements, customer protection and

[136] For example it is commonly asserted that business process and technical standardization is a key to digital automation (we agree) and that DL together interoperability between DLs and existing systems will deliver this desired outcome (we disagree, it is the other way around, there is no easy route to adoption of agreed business process and technical standards but these are required in order to obtain the benefits of DL).

[137] For related analysis see (Rauchs et al. 2018) especially their landscape map (Figure 25) comparing distributed ledgers along two dimensions: (i) ledgers where data is entirely endogenous and does not exist outside of the network (i.e. no external interface) vs. ledgers with exogenous data generated from outside the network (i.e. with an incoming data interface); and (ii) the degree of centralization (from centralized, through semi-centralized to decentralized). They show that distributed ledgers without external interfaces are typically 'unpermissioned' (anyone can join) and fully decentralized; while distributed ledgers with an incoming data interface are typically 'permissioned' (there are restrictions on joining) and only partially decentralized.

[138] This data consists of the amounts of assets involved in each transfer together with matching public and private keys. (Narayanan et al. 2016) provide detailed description. The holder of a private key can receive a transfer to the corresponding public key and then, subsequently, initiate the further transfer of that asset holding using the corresponding private key. Since all data is internal to the network, the keys need not be linked to real-world identities and the network can be open to anyone without identification or other requirements.

securities regulations for investor protection. As we discuss later in this section, crypto asset ledgers brought within the ambit of these financial regulations will also need to employ real world identities.

*Adoption requires addressing a range of related data management issues.*

Because practical business and administrative application of distributed ledgers requires external data interfaces, they cannot avoid dealing with a range of familiar data management concerns. Over the past two decades, data management (previously viewed as a narrow information systems responsibility) has become a central strategic concern in both business and public administration. Many large companies, including most large financial services firms, now have a chief data officer. Most have developed explicit data strategies, with goals such as: reducing costs of internal data management through greater automation; ensuring that a firm's data is viewed as an asset and exploited effectively for commercial advantage; and maintaining the security of data and compliance with regulation such as the EU General Data Protection Regulation GDPR.

This perspective has been reinforced by the growing perception of the need to take advantage of the opportunities from 'big data' i.e. the increasing availability of digitized data from the internet and from internal information systems, which continue to grow rapidly in volume, variety and velocity.[139]

Internal data in organizations is typically fragmented and of uncertain quality, posing substantial management challenges even when this data is not shared with others.[140] While these problems of data fragmentation and data quality may sometimes be usefully addressed using distributed ledgers, they do not then go away. Having agreed to share data through a ledger, users need to more explicitly and consciously address data management than before, rather than leaving it to ad hoc solutions at lower levels of their organizations. Placing internal data into any form of distributed ledger for sharing with multiple users on a commercial scale is therefore not something to be done lightly.

*Distributed ledgers support, do not replace, data governance*

[139] Originating in analysis by the technology consultancy Gartner, these three 'Vs' of volume, velocity and variety are broadly accepted as the defining characteristics of big data. Many commentators e.g. (Corrigan 2013; Chessell et al. 2014) add a fourth V 'Veracity' though this is more a challenge than a characteristic. (Ward and Barker 2013) survey the range of different definitions of 'Big Data'.

[140] This judgement is based on a brief look at some of the business handbooks and reviews for practitioners, drawing on both the extensive academic literature on information systems management and on practical experience. Four of these that struck us as most useful are (Dallemule and Davenport 2017; Simon 2014; Smith et al. 2016; Carruthers and Jackson 2017). Dallemule (who is Chief Data Officer at the global insurer AIG) and Davenport describe the challenge as follows "*More than ever, the ability to manage torrents of data is critical to a company's success. But even with the emergence of data-management functions and chief data officers (CDOs), most companies remain badly behind the curve. Cross-industry studies show that on average, less than half of an organization's structured data is actively used in making decisions—and less than 1% of its unstructured data is analysed or used at all. More than 70% of employees have access to data they should not, and 80% of analysts' time is spent simply discovering and preparing data. Data breaches are common, rogue data sets propagate in silos, and companies' data technology often isn't up to the demands put on it.*" They distinguish defensive approaches focusing on improving data quality and lowering costs and offensive approaches seeking competitive advantage (Dallemule and Davenport 2017); the need for 'eternal vigilance' (Simon 2014); the benefits of an organisation-wide data strategy (Smith et al. 2016 who discuss in detail what this might look like) and working out how to overcome fierce cross-organisation competition for resources to get to a better data future (Carruthers and Jackson 2017).

Data governance within organizations is a major current challenge.[141] It refers to agreement on standards, processes and procedures for securing, updating and accessing data.[142] Data governance is also central to the design and operation of distributed ledgers:

- Ledgers require governance of both imported and exported data. Participating organizations need to agree and comply with common standards, to facilitate data exchanges and assure the quality of their own data. Ledgers need institutional arrangements to ensure users agree on and implement these shared design and operational arrangements. There may be a need for collective responsibility for exported data.
- Ledgers can support data governance. They can provide precisely defined permissions for reading and writing of data. There can be many categories of user, each with their own tailored permission levels. Some, e.g. regulators, might be given broad permissions, effectively a master key that allows surveillance of all aspects of the data. Others more restricted, perhaps read only, or writing permissions that need to be countersigned by other users. Through appropriately designed permissions, distributed ledgers can support checks and controls on data quality.

As already discussed, business and public administration applications of distributed ledgers require real world identities. This means that data governance on the ledger can be reinforced by conventional institutional mechanisms of law, regulation and command, penalizing misbehaviour with legal or administrative penalties.

Agreement amongst multiple users for a scheme for sharing the storage and processing of data records – i.e. the adoption of a distributed ledger – is more than just an adoption of a new technology; it is also a decision to contribute to and comply with standardization and collective governance of both ledger itself and the data it contains, and committing to invest in supporting processes and procedures.

This means that adoption of a distributed ledger for sharing the storage and processing of data records amongst multiple users is costly. The business benefits of distributed ledgers require careful assessment, balancing their benefits (operational efficiencies, transparency for business decision making and public policy) against the costs of collective governance and complying with agreed ledger standards.

*Distributed ledgers do not automatically create trust*

Our discussion is inconsistent with the frequent claim that distributed ledgers create 'trust'.[143] This claim neglects the challenges of *inter alia* security, accuracy, timeliness, completeness, and accessibility of data (i.e. of data governance) when there are data interfaces with the world outside of the ledger. The relationship between trust and distributed ledgers is better viewed

[141] Data governance is a major aspect of effective data management *within* organizations, as discussed in many white papers and blog, including from SAP, IBM, BI Surveys and others; there is relatively little research on organisational data governance in peer-reviewed journals, a brief search turned up only (Korhonen et al. 2013).

[142] A lot is involved in this, for example (BI Surveys 2018) identify ten different topics under data governance: Documents and Content; Data security; Data Storage and Operations; Data Modelling and Design; Data Architecture; Data Quality; Meta-data; Data Warehousing and Business Intelligence; Reference & Masterdata; and Data Integration and Interoperability

[143] For example (Goldman Sachs 2017): "*Blockchain has the potential to change the way we buy and sell, interact with government and verify the authenticity of everything from property titles to organic vegetables. It combines the openness of the internet with the security of cryptography to give everyone a faster, safer way to verify key information and establish trust*".

the other way around: trust between different organizations and entities is necessary to share data effectively through a distributed ledger and enjoy the consequent operational efficiency and transparency benefits they can yield. Participation in a distributed ledger may though promote increased trust: there can be a virtuous circle with cooperation on a ledger promoting trust and encouraging further co-operation.

Confusion has been engendered, because distributed ledgers *do* establish trust in one special case: that of cryptocurrency blockchains developed for secure transfer of 'native' assets (i.e. assets that never leave the blockchain, see Appendix 2 for discussion). There is no import or export of data, no trusted third party holding the data and blockchain technologies ensure that changes to data cannot be reversed. All (or at least most) of aspects of trust can be established without any institutional arrangements, other than the open source software supporting the blockchain, with ledger protocols fully coded in the software and data governance is unnecessary to establish 'truth'.[144]

This view – that trust is required in order to use distributed ledgers rather than distributed ledgers creating trust – reinforces our previously expressed scepticism about the disruptive impact of distributed ledger. This suggests that there may be little truth to utopian claims of how blockchains/ distributed ledger technologies will change society, supporting a decentralized 'peer to peer' transformation of economics society and politics without need for political, business or financial institutions.[145]

[144] We qualify "or at least most" because the proof of work used in cryptocurrency blockchains requires quite substantial time delays before transactions are added to the blockchain.

[145] For statements of this utopian view of blockchain see (Vigna and Casey 2016; M. J. Casey and Vigna 2018). The latter argue that "*A new form of bookkeeping might seem like a dull accomplishment. Yet for thousands of years, going back to Hammurabi's Babylon, ledgers have been the bedrock of civilization. That's because the exchanges of value on which society is founded require us to trust each other's claims about what we own, what we're owed, and what we owe. To achieve that trust, we need a common system for keeping track of our transactions, a system that gives definition and order to society itself.*" They then go on to state *"Many see the technology's rise as a vital new phase in the internet economy—one that is, arguably, even more transformative than the first. Whereas the first wave of online disruption saw brick-and-mortar businesses displaced by leaner digital intermediaries, this movement challenges the whole idea of for-profit middlemen altogether. The need for trust, the cost of it, and the dependence on middlemen to provide it is one reason why behemoths such as Google, Facebook, and Amazon turn economies of scale and network-effect advantages into de facto monopolies. These giants are, in effect, centralized ledger keepers, building vast records of "transactions" in what is, arguably, the most important "currency" in the world: our digital data. In controlling those records, they control us."*

# 5 Distributed ledgers and public policy

The attitude of public policy makers – in finance ministries, central banks and financial and competition regulators to the adoption of distributed ledgers and other digital automation in financial services – can be largely described as 'wait and see'. There are several reports, on cryptocurrencies and crypto assets, on the possibilities of central bank issues of digital currencies and on the appropriate regulation of distributed ledger based financial activities.

We have already discussed some of these specific issues. Here we make a few further points, beginning with more limited adoption of distributed ledger and other data technologies, then considering the possibilities for more radical reform.

## 5.1 The legal and regulatory treatment of crypto assets

We first provide a brief overview of the legal and regulatory treatment of crypto assets (see Appendix 2 for more detailed discussion and references). A major current challenge facing policy makers is the regulation of crypto assets held on distributed ledgers and traded on crypto exchanges.[146] Aside from some niche crypto assets whose selling point is that they are issued and transacted entirely outside of formal regulation, we argue that crypto assets will eventually merge with conventional mainstream financial assets.

Firstly, what are crypto assets?" There are three main categories:

1. Cryptocurrencies – of which Bitcoin is the first and still most important example. These are native assets on a distributed ledger (native in the sense that users cannot take them off or bring them onto the ledger) and only transferred from one user to another and hence potentially used for monetary exchange, without offering other services.

2. Crypto investments – these are native assets that provide rights to profit share, ownership or repayment of a fixed sum of money.

3. Crypto utility assets – these are native assets that can be exchanged for or give access to a product/service that is provided through the distributed ledger.

We suggest a relatively a narrow definition of crypto assets – restricting them to any of these three asset types that is (i) issued on an unpermissioned blockchain; and (ii) traded in one of the many cryptocurrency exchanges that have emerged in recent years to support crypto asset trading. The reason we propose this narrow definition is to restrict attention to the subset of assets on distributed ledgers that do not obviously fit within the ambit of current law and regulation. This is where the regulatory challenge is to be found.

We observe a tendency for the exchanges where these crypto assets are traded to separate into two groups: one group that want to be clearly inside of the regulatory perimeter and are engaging closely with regulators to ensure they are fully compliant with AML and other regulations; and another group that prefer to remain as far as possible outside of the regulatory perimeter and engaged only (or at least primarily) in exchange between different crypto assets.

We predict that eventually, over the next decade or two, most crypto assets will be eventually traded within the regulatory perimeter, in order to comply with investor protection and other

[146] Regulation is needed both for investor protection and to enforce know your customer and anti-money laundering regulation.

regulation, and as a result will become effectively indistinguishable from conventional assets. Their only distinguishing feature will be that ownership is recorded on a distributed ledger rather than in a conventional database. This will require "permissioned" ownership to replace the current "unpermissioned" ownership and the 'crypto' and 'conventional' assets spaces will merge. At the same time, it is likely that there will continue to be a distinct class of unregulated crypto assets that will continue as fringe assets outside of the mainstream, and some residual trading between the regulated crypto and unregulated crypto spaces.

We also note an emergent consensus on the regulation of crypto investments. In both the US and in the EU these are securities (in the case of the EU transferable securities) and issuers are obliged – if they are not to be entirely outside of the regulatory perimeter – to provide detailed investor information both at time of issue and subsequent to issue, consistent with applicable security laws.

There is less consensus on the legal and regulatory treatment of cryptocurrencies and crypto utility assets.[147] The existing cryptocurrencies such as Bitcoin seem destined to remain niche assets, outside of mainstream finance though perhaps still attracting some limited conventional investor interest. While there are arguments for defining and regulating them as private forms of money, this seems not to be a practical outcome (if they are for example brought within the ambit of the EU e-Money Directive it is unclear how its requirements on authorization could be enforced).

Interest in cryptocurrencies as standalone assets (in our terminology 'native' assets on a distributed ledger) has peaked and attention is now moving onto other assets such as stable coins that are non-native representations of assets outside of the distributed ledger. These alternative forms of cryptocurrency require a sponsoring organization to maintain the link between these assets and their underlying counterpart or ensure, allowing conventional financial regulation to be applied through this sponsor. Regulators will require permissioning to support AML regulation and will be able to monitor effective conduct of fiduciary responsibilities and market integrity in asset exchange.

We thus expect both crypto investments and cryptocurrencies to separate two groups: regulated assets effectively indistinguishable from established conventional financial assets and a periphery of alternative unregulated assets traded on venues well outside the regulatory perimeter. In the longer run 'crypto' will no longer be viewed as a distinct asset class at all.

## 5.2 Encouraging adoption

The discussion of Section 4 reveals the central role of data sharing and establishing and enforcing agreed standards for business processes, for taking full advantage of the opportunities for digitisation of financial services. This though faces the same problems as any other program of commercial standardization – difficulties in coordinating change, low private benefits relative to social benefits and resistance from industry participants who stand to lose their market position can prevent change. The situation parallels other industrial standardizations. Historically and relative to other industries financial services have not been especially good at standardization; where progress has been made in financial services

[147] We have little to say crypto utility assets, except that they are so limited in amount they can be probably be safely left as an unresolved regulatory loose end.

standardization this is in specific areas such as messaging standards where the mutual benefits are clear; and even here there are competing approaches.[148]

Regulatory authorities are in a position to represent the public interest (though whether they do so is another matter, they may not see this as their responsibility if it is not clearly represented in their legal mandates). Most obviously then should be able to act to promote technological standardization and encourage adoption of technologies that support regulation and supervision. Even here though the record is not particularly good.[149]

Looking at the range of potential applications of distributed ledger technologies, covered in Table 2 we see opportunities for the regulatory authorities to promote adoption. For example the adoption of the ISDA common domain model will directly support regulatory oversight – regulators should monitor adoption and, if it is incomplete, consider whether it is appropriate to take measures to ensure more uptake. More could also be done to support the adoption of ledger technologies in money markets, which can played such a substantial role in transmission of systemic financial risk in 2007-2008. The DTCC project of putting US start leg repo transactions distributed ledger was not carried forward. But have the social returns been properly considered? Arguably once the need for close monitoring of system risk is taken into account, this is a project where the overall benefits, private and social, exceeded the costs.

Similar co-ordination issues arise in relation to trade finance. Our concern here is that the large number of competing initiatives will fail because not one of them becomes the accepted platform for international trade finance. Failure of adoption could limit digitisation in an area where some of the biggest private and social gains are widely acknowledged to lie. Again this is an area that public authorities, perhaps working through the auspices of the G20, should be paying close attention.

More broadly, as we discuss above in relation to client on-boarding, KYC/ AML and regulatory oversight, regulators needs to question if they are themselves doing enough to support digitisation. This is now becoming a priority issue for regulators, especially in relation to the growing application of 'regtech' across financial services. There is increasing dialogue between regulators and industry on working together to promote technological adoption. But this is too often still fragmentary and un-coordinated. At the same time other officials are busy writing new regulations according to old processes that are not easily automated.

## 5.3 Radical reform?

We complete this discussion with a consideration of how public policy might support radical reforms using distributed ledger technologies. We mention four possibilities:

1. As already discussed, lack of transparency and associated high levels of fees is a major concern in asset management, especially for retail investors persuaded to invest in actively managed investment vehicles. Modern distributed ledger technologies could

[148] For discussion of the challenges of standardization in global capital markets and comparison with other industries see (Houstoun, Milne, and Parboteeah 2015; Milne and Parboteeah 2015)
[149] See (Chan and Milne 2019) for a discussion of the relatively weak support given by regulators to the adoption of the global legal entity identifier for use in global capital markets.

allow *all* managed investment funds to operate on a 'wallet' basis, in which individual investors would directly participate in ownership of securities.[150] This would then force complete transparency on asset managers, the funds would have to levy explicitly stated charges, so avoiding the sometimes substantial hidden fees that can eat up most of the real return. Custodians would have their business model altered, but not entirely changed, they would no longer offer securities accounts off their balance sheets but would provide much of their existing services as investor representatives. This radical reform could arguably also promote more investor involvement in corporate governance (though would not entirely remove 'free riding' problems, even with direct ownership it will rarely be worth the time and effort for a small investor to be closely involved in monitoring firm behaviour).

2. As also already discussed in relation to international payments, in our view the success of the Ripple business model depends on them persuading central banks to allow Ripple to act as an agent providing banks worldwide with direct access to deposits with the central bank. This is a radical reform that is not going to happen without extensive public policy debate and policy makers will certainly not give Ripple a monopoly in this activity. However, this may be a way for policy makers to address the troubling problem of lack of competition in international payments and reduce some of the associated high costs and poor service. More limited privately led reform, such as the SWIFT gpi and J.P. Morgan's Interbank Information Network will help, but policy makers should examine properly the possibility of going further.

3. A further possibility would be to take this opening up of central bank balance sheets as step further and use the framework of distributed ledgers to enforce 100% reserved banking – essentially requiring any payment that is instructed for transmission through a domestic payment system whether from a household, firm or non-bank corporate – to be from an account at the central bank.[151] If this was done then banks could be allowed to suspend withdrawals or fail without disruption to the payments systems, serving to radically reduce the need for a bank safety net. Distributed ledger technologies are especially relevant because the employment of smart contracts could provide the necessary elasticity of the supply of money that has been regarded as the principal objection to previous schemes for 100% reserved banking.

4. Another potentially radical public policy application would be to replace central counterparties with distributed ledgers, supported by smart contracts that would, in the event of a single member defaulting, reallocate all exposures amongst remaining participants. The main problem there is determining the rule of allocation. Yet another, related, radical public policy application would be to develop a distributed ledger that handles all collateral obligations in the event of the default of capital markets participant. We are not aware any detailed exploration of these possibilities, or if they are feasible even in theory. But they represent the kind of radical application of distributed ledger technologies that public authorities should be prepared to consider.

[150] Much as they already participate as direct investors in loans through alternative lending platforms such as Zopa, Lending Club or Funding Circle, see (Milne and Parboteeah 2016).

[151] This possibility is described in more detail in (Milne 2017, 2018). This would be an extremely radical implementation of central bank issue of digital currency (CBDC), requiring all transactions to be conducted using the CBDC. The practical implementation of CBDC being currently considered by a number of central banks worldwide is much less radical than this. Broader discussion is provided by (Kavuri, Milne, and Wood 2019)

Finally, we note the key responsibility of public policy makers for supporting identity solutions that can in turn promote financial inclusion and counter fraud. The Aadhaar project in India, that has now issued well over 1.26bn identities and is projected to be a foundation for digitisation of business and of financial and public services in India, is one example of what can be done. We are not saying that this model need be exactly followed in other countries, a range of approaches perhaps relying on artificial intelligence applied to a broad range of identity related data rather than a single point of registration is likely to be more suitable for most developed countries. But the key point remains, that ensuring adequate identification of individuals and of legal person remains both a public sector responsibility and a key support to the digitisation of the public and private economy. More reliable identification will in turn be a boost to the adoption of distributed ledger technologies. Identify solutions are public good, they are (to use the economics jargon) 'non-rival', an effective identity solution can be used many times, and they are characterised by substantial fixed costs. For both these reasons substantial public sector involvement, in design and approval of identity systems, can be economically justified.

# 6 Conclusions

This report is the outcome of a twelve month long research project that has been written for decision makers in private industry and public policy institutions, examining the extent to which distributed ledger and associated crypto assets can be the foundation for a major technology-based change in the value chains in banking, capital markets and insurance. We have provided a conceptual analysis of distributed ledger in Sections 2. In Section 3 we provide a close examination of the range of applications, current and potential across the full range of banking and financial services, including domestic and international payments, security and derivative trading, loan intermediation, supply chain finance and asset management and insurance. This section also reviews seven leading case studies of application of distributed ledger technologies in financial services. Section 4 considers the adoption decision: when do the benefits of investment in distributed ledger technologies justify the costs of adoption? Section 5 is an analysis of policy issues.

Our analysis offers a number of insights. Perhaps most important is the plural in our title *distributed ledger technologies.* It is a fundamental misunderstanding to think that there is one cohesive distributed ledger or blockchain technology that will come to be widely used across financial services when it has matured to the appropriate level. No: distributed ledgers are composites that combine a number of technological elements most of which are already mature. The main interest is the component technological opportunities, which will often be applied independently, not their combination into distributed ledgers.

Combining these technologies into a distributed ledger – with no single responsible institution having control over the ledger i.e. a distributed ledger as narrowly defined in our Definition 1 – is useful for support data sharing in those specific and in our judgement rare situations where users are reluctant to give responsibility for maintaining the data to a single entity. It is also appropriate when participants in an industry wish to use standard shared arrangements to outsource processing responsibilities which lie outside their core competences.

Whether relying on a distributed ledger or using a more conventional ledger under institutional control, it is still essential to address challenges of data management and data governance. In most applications other than basic asset transfer, distributed ledgers just like conventional databases rely on the quality of imported data introduced from outside the ledger. If incorrect data is introduced from the outside, then the ledger is no longer reliable. It is therefore a mistake to believe, as some claim, that distributed ledgers promote trust.

While our assessment of distributed ledgers is more sceptical than many other commentators, we still believe that there is revolution in prospect through digitisation of financial services over the next two decades; a revolution in which the various consortia that have been established to develop and promote distributed ledger technologies will play prominent roles. The technologies are revolutionary even though distributed ledgers are not.

We also find – in our review of fourteen areas of application and our seven case studies – that the adoption of distributed ledger in financial services continues to be at the very least patchy. But we need to be clear here: digitisation is a pressing issue, across the industry, to lower costs and to respond to new technology based competitors; digitisation and automation of business process is an ongoing revolution across financial services; but digital ledgers – defined narrowly as most commentators have perceived them according to our Definition 1 in Section 2 – are

not finding much application. Only a small minority of initiatives are being taken beyond proof of concept (against the hundred plus initiatives documented in our Appendix 1, we found only seven case studies of commercial scale application worth reviewing and only three of these are really distributed ledger at all).

In short distributed ledger technologies are part of a broader disruptive technological transformation of financial services, but distributed ledgers themselves (or as some prefer to call them blockchain) are not revolutionary. A focus on distributed ledgers – especially on rather utopian claims for them as 'truth machines' – is in our view simply a distraction from the key business process issues being faced in the industry. It is tempting to collapse complex operational issues into a single phrase "distributed ledger" but this is fundamentally misleading. It is necessary instead to address the potential of the component technologies (immutability, cryptographically secure, sharing of data, smart contracts with automated processing) and consider carefully their application in business context.

We also downplay the importance of crypto assets – viewing these as a further distraction. Yes, they offering potential short term profits for financial institutions that are early movers into providing investment and exchange services, but the asset class is small and highly risky. We argue that as regulation is brought to bear the crypto assets will eventually merge with not remain distinct from conventional financial assets. There is too much attention to crypto assets and not enough attention to the challenges of ensuring digitisation supports competition, lower costs, lower risks and helps the industry meets new currently unmet financial needs.

While the supporting technologies continue to develop, we view a further key challenge as being around governance of those technologies and of the data sharing they support. From the fourteen areas of application we have examined and our six case studies, the full exploitation of digitisation requires agreement on standards and interoperability and focus on longer term goals of improved customer experience, not just costs and returns.

We also make recommendations and suggestions for public policy, arguing that public authorities have a responsibility for promoting the digitisation of financial services and achieve the resulting benefits from cost and risk reduction as fully as possible. Many of these benefits are social not private and even where the gains are private public policy makers have a role to play co-ordinating change and helping to overcome vested interests. We are seeing the beginnings of a digital revolution in financial services.

We envisage the possibility of ultimately quite radical change, using digital technologies to support a redesign of the architectures of asset management and banking to promote transparency and financial stability. In this respect our views are aligned with those of enthusiasts for cryptocurrencies and digital ledgers. Where we differ is that we do not find that such radical transformation will be the outcome of market forces. Such radical change will lead to substantial loss of earnings for many incumbent financial institutions. Network effects mean these incumbents are strongly entrenched in most (though not all) of their markets and will not be displaced by start-ups employing new technologies. As a result such change will have to be led by public authorities with strong political backing. We also judge that such radical change will seem too risky to be pursued in the immediate future. It will only be real possibility once the technologies supporting secure data sharing and automated data processing, i.e. the technologies underpinning digital ledgers, are much more widely used and understand.

## Appendix 1: Announced distributed ledger initiatives in banking and capital markets

The table provides a summary of announced distributed ledger initiatives and their choices over distributed ledger technology in the financial industry. Also included is relevant initiatives in slightly different areas and regulatory initiatives. The initiatives are placed in chronological order. The first date of the article initiative was proposed is used for the chronological placing (i.e. not the date of the updates). In the implemented column, 'No' signifies intentions/plans to do something. `Yes' is placed for pilots, up and running implemented DLT projects etc. In addition, in that column, we highlight between whether the initiative is proof of concept or commercial operation. When easy to simplify, the words in bold provides the area of the distributed ledger initiative.

| | Name | Date | Web link | Alliance/ POC/ Implemented | Crypto/ Real/ Infrastructure | Summary |
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| 1 | Visa, Citi, Nasdaq investment in Chain | 9 September, 2015 | https://www.forbes.com/sites/laurashin/2015/09/09/visa-citi-nasdaq-invest-30-million-in-blockchain-startup-chain-com/#33f26353199c<br><br>More information below https://chain.com<br><br>Sept 10, announced merger to form Interstellar, see https://blog.chain.com/chain-and-stellar-are-joining-forces-ecd44fb4c474<br><br>And (not a Nasdaq opinion) https://www.nasdaq.com/article/stellar-based-lightyear-acquires-chain-forms-new-entity-cm1020781 | P | R | Visa, Citi, Nasdaq $30 million investment in Chain.<br>Chain is working with Nasdaq to test trading with shares in private companies with DLT.<br><br>**Trading with share**<br><br>$44 million |

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| 2 | Symbiont<br><br>**Syndicated loans** | 3 March, 2016 | https://www.finextra.com/pressarticle/63423/ipreo-and-symbiont-team-on-blockchain-for-syndicated-loans<br><br>More information below<br><br>https://symbiont.io/solutions/<br><br>Demonstration on 20 March, 2017<br><br>http://www.synapsloans.com/press-releases/ | P | R | Symbiont working through Synaps, a joint venture with IPREO. Synaps uses Symbiont blockchain technology and smart contracts for data management and trade settlement in the syndicated-loan market.<br><br>Note that article on 6 June, 2018 in waterstechnology suggested the project has gone quiet.<br><br>**Syndicated-loan market** |
| 3 | Manifold Technology | 13 April, 2016<br><br>24 July, 2018 | https://www.americanbanker.com/news/rbc-applies-blockchain-as-a-loyalty-boost<br><br>See below for more information<br><br>https://www.manifoldtechnology.com<br><br>https://www.prnewswire.com/news-releases/amazon-announces-manifold-serverless-blockchain-partnership-300685234.html<br><br>and<br><br>https://s3-us-west-2.amazonaws.com/manifold-technology/AWS-serverless-blockchain.pdf | I | I | Royal Bank of Canada and Manifold technology is working together.<br><br>Manifold specializes in highly scalable blockchain infrastructure.<br><br>Manifold Technology is now available as a cloud software on Amazon Web Services (AWS). Corda also available on AWS. |

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| 4 | Barclays test derivatives | 19 April, 2016 | https://www.cnbc.com/2016/04/19/barclays-used-blockchain-tech-to-trade-derivatives.html | P | R | Barclays test of trading derivatives using smart contracts and blockchain technology. Barclays used Corda (developed by R3). |
| 5 | Merrill Lynch, HSBC letter of credit | 10 August, 2016 | https://www.gtreview.com/news/asia/banks-blockchain-innovation-letters-of-credit/ | P | R | Bank of America Merrill Lynch (BofAML), HSBC and the Infocomm Development Authority of Singapore (IDA) applies letter of credit on blockchain. |
| 6 | Barclays's live letter of credit | 7 September, 2016 | https://www.finextra.com/newsarticle/29400/barclays-executes-live-letter-of-credit-transaction-using-distributed-ledger-technology | P | R | Barclays Bank and Wave completed a live Letter of Credit transaction between Ornua (the Irish Dairy Board) and Seychelles Trading Company on a DLT. |
| 7 | PeerNova's blockchain for capital tracking | 21 September, 2016 | https://bitcoinmagazine.com/articles/state-street-and-peernova-trial-new-blockchain-prototype-for-capital-tracking-1474469105/ | P | R | PeerNova and State Street have been trailing a blockchain-enabled platform for the tracking and monitoring the flow of funds. |

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| 8 | Visa and Chain partnership | 27 October, 2016<br><br>11 November, 2017 | https://distributed.com/news/visa-partners-with-chain-to-process-b-b-transactions-globally-using-blockchain-technology/<br><br>Update below:<br><br>https://community.developer.visa.com/t5/Blogs/Blockchain-Based-Visa-B2B-Connect-APIs-in-Action/ba-p/7043 | P | R | Visa partnership with blockchain company Chain to develop a secure way to process B2B payments. It will provide a pilot to financial firms.<br><br>The update of Visa B2B Connect Product is available for developers through trial. Also, will be available to other partners soon including Commerce Bank in the United States, Shinhan Bank in South Korea, Union Bank of Philippines and United Overseas Bank in Singapore.<br><br>**Process B2B payments** |
| 9 | PricewaterCoopers | 17 November, 2016 | https://distributed.com/news/pwc-launches-vulcan-a-compliance-oriented-blockchain-for-banks-and-governments/ | P | I | PwC launched a Digital Asset Digital Services called Vulcan, a new blockchain-based platform with emphasis on identity verification and compliance services. PwC is keen on making Vulcan attractive to banks and financial services.<br>Vulcan's services include digital asset wallets, international payment processing and investment and trading services.<br><br>**Identity verification** |
| 10 | Hong Kong Trade Finance platform | December, 2016 | https://www.ledgerinsights.com/hong-kong-trade-finance-blockchain/ | | | HK trade finance Platform PoC initiated December 2016.<br>Now Launched. |
| 11 | Xaurum | 2017 | https://xaurum.org/Whitepaper.pdf | P | C | Xaurum is a Slovenian firm that offers the ability to exchange tokens for physical gold. |

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| 12 | Depository Trust & Clearing Corporation (DTCC) | 12 January, 2017<br><br>25 May, 2017<br><br>5 September, 2018 | https://distributed.com/news/major-wall-street-clearinghouse-dtcc-develop-operational-blockchain-network-derivatives/<br><br>https://distributed.com/news/dtcc-launch-blockchain-credit-defaults-swaps-reporting-early-2018/<br><br>More information below<br>http://www.dtcc.com/blockchain<br>https://axoni.com/press/<br><br>Update below:<br>https://www.waterstechnology.com/infrastructure-technologies/3845566/dtcc-blockchain-platform-scheduled-for-early-2019-launch | P | R | Depository Trust & Clearing Corporation (DTCC) partnered with R3, IBM and Axoni to provide a DLT for post-trade derivatives processing including credit default swaps.<br><br>Aim to provide permissioned distributed ledger network for derivatives, governed by DTCC, with peer nodes at participating firms.<br><br>DTCC plans to go live in first quarter of 2018 with blockchain-driven platform for credit swaps reporting.<br><br>At the end of Nov 2018, DTCC announced that it has continued to conduct in-depth industry-wide testing with clients. Their focus remains on delivering a solution that is efficient, cost-effective and that protects the safety, resiliency and stability of the global financial system. The firm continues to engage with clients in the test process, getting feedback and evolving their approach based on learnings to ensure the solution meets the needs of the industry and other key stakeholders.<br><br>DTCC Blockchain platform scheduled for late 2019<br><br>Credit derivatives information warehouse |
| 13 | Juzhen Financials<br><br>(China) | 18 January, 2017 | https://www.coindesk.com/chinas-biggest-blockchain-startup-will-release-new-tech-2017/ | P | R | Juzhen Financials plans to launch its own blockchain tech for banks in 2017. Juzhen Financials is the largest China-based blockchain start-up in history raised $23 million in Sep. 2016. Juzhen worked with ChinaLedger blockchain consortium.<br><br>No updates on the blockchain developments. |

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| | | | | | | **Blockchain tech for banks** |
| 14 | Generali and Reinsurance Group of America (RGA), insurance companies, join B3i | 9 February, 2017 | https://distributed.com/news/insurance-giants-generali-and-rga-join-blockchain-insurance-industry-initiative-b3i/<br><br>More information<br><br>https://b3i.tech/home.html | P | R | Generali and R (insurance companies) join B3i.<br><br>B3i was launched in October 2016<br><br>B3i looks to explore the uses of DLT in the re/insurance industry.<br><br>Members include Achmea, Aegon, Ageas, Allianz, Generali, Zurich Insurance Group among many more.<br><br>**DLT in the re/insurance industry** |
| 15 | Enterprise Ethereum Alliance<br><br>**Customize Ethereum for industry.**<br><br>Monax | 28 February, 2017<br><br>8 June, 2017<br><br>2 May, 2018 | http://fortune.com/2017/02/28/ethereum-J.P. Morgan-microsoft-alliance/<br><br>Update below:<br><br>https://distributed.com/news/latest-additions-move-enterprise-ethereum-alliance-toward-mainstream-disruption/<br><br>https://www.coindesk.com/enterprise-ethereum-alliance-isnt-dead-got-roadmap-prove/<br><br>https://monax.io/company/ | A | R | 30 big banks and tech giants including Chase, Microsoft, and Intel united to build business-ready versions of the software behind Ethereum.<br><br>86 new members want to be part of organization. E.g. Monax joins the Enterprise Ethereum Alliance. The firm is concentrated in creating smart contracts.<br><br>The alliance is built to customize Ethereum for industry.<br><br>Still work continuing on Enterprise Ethereum Alliance. |

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| 16 | Orebits Corp and Symbiont | 15, March 2017 | https://www.businesswire.com/news/home/20170315005332/en/Orebits-Symbiont-Deploy-Distributed-Ledger-Technology-Digitize<br><br>See more information below<br><br>http://orebits.io | P | C | Orebits Corp., a provider of digitisation services for unrefined commodities and Symbiont, (DLT company) have partnered to provide clients the opportunity to invest in unrefined gold via smart certificates. |
| 17 | Wanda Feifan Technology Research Center<br><br>(China) | 15 March, 2017<br><br>12 March, 2018 | https://news.8XRP.com/wandas-polaris-platform-aims-to-lead-the-chinas-blockchain-industry<br><br>Update below:<br>https://www.chinamoneynetwork.com/2018/03/12/dalian-wandas-tech-arm-forms-partnership-new-zealand-blockchain-firm-centrality | P | I | Wanda's Polaris platform aims to lead the China's blockchain industry. Wanda is the blockchain's platform Polaris for smart supply chains, pharmaceutical management, finance and invoicing.<br><br>Wanda officially joined the Linux Foundation's Hyperledger project in August, 2016 Wanda drafted the Chinese version of the white paper for blockchain.<br><br>Wanda signed in as Vice Chairman Unit of Blockchain Industry and Technology Forum in September, 2016.<br><br>Dalian Wanda's tech arm Wanda Internet Technology Group has formed strategic alliance with Centrality (Auckland-based blockchain firm) to develop an ecosystem that connects consumers and retailers, and serves Wanda Group's enterprise merchants. |
| 18 | Natixis, IBM and Trafigura blockchain for U.S crude oil | 28 March, 2017 | https://www-03.ibm.com/press/us/en/pressrelease/51951.wss | P | I | Natixis, IBM and Trafigura introduce first-ever Blockchain solution for U.S. crude oil market. |

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| 19 | Tokenization of real world assets: initiatives | 30 March, 2017 | https://distributed.com/news/how-tokenization-putting-real-world-assets-blockchains/<br><br>Tether converts cash into digital currency:<br><br>https://tether.to | P | C | Tokenization is the process of converting rights to an asset into a digital token on a blockchain i.e. diamonds, gold, real estate, oil. General information.<br><br>Many ways of doing it. However, note that if buyer needs to be certain that token is properly linked to the real asset, otherwise the value of the token will drop to zero.<br><br>**Tokenization** |
| 20 | 10 Chinese insurance companies test blockchain | 7 April 2017 | https://www.coindesk.com/insurance-firms-blockchain-test-insurance-china/<br><br>See below for Shanghai Insurance Exchange http://www.sigchina.com/index.php?m=content&c=index&a=show&catid=99&id=98 | A | R | Shanghai Insurance Exchange partnered Cathay Life Insurance, Meiji Yasuda Life Insurance, AIA Group, China Continent Property & Casualty Insurance and Minsheng Life Insurance to test blockchain.<br><br>**Life Insurance** |
| 21 | Fidelity Investments join IC3 | 13 April, 2017 | https://distributed.com/news/asset-manager-fidelity-join-blockchain-group-ic3/<br><br>More information below<br><br>http://www.initc3.org<br>"IC3 is an initiative of faculty members at Cornell University, Cornell Tech, EPFL, ETH Zurich, UC Berkeley, University College London, UIUC and the Technion. It's based at the Jacobs Technion-Cornell Institute at Cornell Tech in NYC." | A | R | Fidelity Investments join IC3.<br>Faculty members at Cornell University, ETH Zurich, University College London, UC Berkeley among others.<br><br>The blockchain group focuses on the implementation of cryptocurrencies, smart contracts, and DLT into the financial system.<br><br>**DLT into the financial system**<br><br>$3million NSF grant. |

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| 22 | R3 news | 27 April, 2017<br><br>31 October, 2017<br><br>3 November, 2017 | https://www.reuters.com/article/us-J.P. Morgan-r3/J.P. Morgan-chase-co-leaves-blockchain-consortium-r3-idUSKBN17T2T4<br><br>Update below:<br><br>https://www.reuters.com/article/us-banks-blockchain-r3/top-banks-and-r3-build-blockchain-based-payments-system-idUSKBN1D00ZB<br><br>https://distributed.com/news/r-to-open-source-corda-patent-application-still-being-pursued-for-genuinely-new-distributed-ledger-approach/ | A | R | J.P. Morgan & Chase , Goldman Sachs, Morgan Stanley, NAB left in late 2016. JP leaves blockchain R3 consortium in April 2017. Differences over funding.<br><br>Banks, R3 build blockchain-based payments system<br><br>R3 to open source Corda<br><br>**Payments** |
| 23 | CME group's gold to a blockchain-based asset | 11 May, 2017 | https://distributed.com/news/move-over-bitcoin-cme-group-will-offer-real-digital-gold/<br><br>More information below<br><br>https://www.royalmint.com/invest/bullion/digital-gold/ | I | C | CME Group has partnered with UK's Royal Mint and is looking to bring physical gold to a blockchain-based asset. The new asset will be a token known as RMG (Royal Mint Gold) and backed by physical gold in the Royal Mint vaults. *Retail orientated.*<br><br>Updates at Sep. 2018, RMG appears to be available.<br><br>**Blockchain-based gold** |

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| 24 | AST's blockchain corporate proxy voting | 23 May, 2017<br><br>Jan, 2018 | https://distributed.com/news/blockchain-comes-corporate-governance-ast-proxy-voting/<br><br>Update below<br><br>http://www.nuarca.com/blog/blockchain-not-solution | P | R | AST partnered with NuArca to introduce a blockchain-enabled system for proxy vote tabulation.<br><br>Update in Jan 2018 on NuArca website.<br>Successful milestone for the voting, but still has not been released<br><br>**Proxy vote tabulation.** |
| 25 | Africa' Blockchain roundup | 15 June, 2017 | https://distributed.com/news/africa-next-hub-blockchain-development/<br><br>More information below<br><br>http://bithub.africa<br><br>http://landing.bitland.world<br><br>http://bankymoon.co.za | P | R | Africa's blockchain developing<br><br>BitHub.Africa was est. Dec. 2015 based in Kenya provides consulting to organizations working with blockchain particularly in financial services<br><br>Bitland is a blockchain-based land management system which will allow people to register property ownership via a blockchain.<br><br>Bankymoon is a South African company working to leverage Bitcoin and other cryptocurrencies to enable securities trading and electronic payments. |

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| 26 | Banks trade finance platform | 26 June, 2017<br><br>17 October, 2017 | https://www.gtreview.com/news/europe/seven-banks-to-go-live-with-hyperledger-blockchain-trade-finance-platform-in-2017/<br><br>Update below:<br><br>https://www.bankingtech.com/2017/10/ibm-and-eight-banks-unleash-we-trade-platform-for-blockchain-powered-commerce/<br>and<br>https://www.gtreview.com/news/fintech/we-trade-blockchain-platform-enters-production-environment/ | P | R | Digital Trade Chain will be built and hosted by IBM and powered by Hyperledger Fabric 1.0. Memorandum of understanding (MoU) signed in January between Deutsche Bank, HSBC, KBC, Natixis, Rabobank, Société Générale and UniCredit to collaborate on the development and commercialisation of the platform.<br><br>Changed name to we.trade.<br><br>Expected to operate in March 2018<br><br>**Trade finance platform.** Seeking to involve SME and corporate customers from late 2018 |
| 27 | Mastercard | 6 July, 2017 | https://distributed.com/news/mastercard-looking-stem-theft-through-blockchain-technology/<br><br>More information below<br><br>https://dcg.co | P | R | Mastercard and credit card companies are working on solutions to employ blockchains to end information thefts**.**<br><br>Mastercard has filed over 35 blockchain-related patents.<br><br>Mastercard have invested in Digital Currency Group and joined Enterprise Ethereum Alliance.<br><br>**Information thefts** |
| 28 | Natixis AM'S fund distribution | 6 July, 2017 | https://www.investmenteurope.net/investmenteurope/news/3720871/bnpp-blockchain-fund-trading | | | Natixis Asset Management purchased shares through blockchain-dedicated platform, FundsDLT.<br>FundsDLT developed by collaboration between Fundsqaure, inTech and KPMG Luxembourg |

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| 29 | SWIFT's blockchain pilot for international payments | 17 October, 2017 | Pilot announced: https://www.waterstechnology.com/infrastructure-technologies/3396031/swift-targets-interbank-balances-with-expanded-blockchain-pilot<br><br>Pilot undertaken: https://www.waterstechnology.com/industry-issues-initiatives/3435056/swift-mulls-lessons-from-blockchain-nostro-pilot<br><br>See more information below https://www.coindesk.com/swift-announces-successful-proof-of-concept-trial-for-dlt-platform/ | P | R | SWIFT announces a PoC to test distributed ledger in the interbank payments space. The PoC specifically examined how the system could meet requirements around governance, security and data privacy as they relate to the nostro (foreign-currency accounts other banks have with counterparties) reconciliation process. |
| 30 | BNP Paribas and CACEIS | 11 July, 2017 | https://www.caceis.com/whats-new/press-releases/press-releases/article/launch-of-liquidshare-the-european-blockchain-fintech-for-sme-post-trade/detail.html | P | R | BNP Paribas, CACEIS, Caisse des Dépôts, Euroclear, Euronext, S2iEM and Société Générale with the support of Paris EUROPLACE announce the creation of the European fintech venture LiquidShare.<br><br>The start-up will aim to develop a post-trading blockchain infrastructure for the Small and Medium Enterprise (SME) market. |
| 31 | Blockchain-based solution to liquidity: Hive project | 19 July, 2017 | https://distributed.com/news/blockchain-based-solution-liquidity-needs/ | P | R | Hive project platform applies blockchain technology to invoice factoring creating a distributed and highly efficient public ledger to open up new sources of finance to SMEs.<br><br>**Invoice factoring** |
| 32 | Delaware Blockchain Initiative | 20 July, 2017 | https://distributed.com/news/what-does-delawares-blockchain-legislation-mean-equity-markets/ | A | I | Delaware Blockchain Initiative coordinates govt. efforts around incorporating blockchain into land titles, birth, death certificates, professional licences, collateral claims and company filings. |

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| | | (launched July, 2016) | More information below<br><br>https://corpgov.law.harvard.edu/2017/03/16/delaware-blockchain-initiative-transforming-the-foundational-infrastructure-of-corporate-finance/ | | | Important change to foundational infrastructure of corporate finance due to leadership and value-added services.<br><br>**Regulation Impact** |
| 33 | CreditEase<br><br>(China's largest peer-to-peer lending service) | 28 March, 2017 | https://www.coindesk.com/lending-giant-creditease-launches-blockchain-supply-chain-service/ | P | R | CreditEase has launched a private blockchain service based on Ethereum.<br><br>Founded in 2006, Beijing-based start-up offers microfinance services. It connects small borrowers with lenders via a web platform.<br><br>The company also has a CreditEase Fintech Investment Fund.<br><br>**Microfinance** |
| 34 | Polymath Inc | 30 August, 2017 | https://business.financialpost.com/entrepreneur/fp-startups/its-about-to-become-even-easier-to-issue-blockchain-based-coins | P | C | Polymath is a platform for start-ups that want to launch own cryptocurrencies. The platform guides users from creation, to fundraising, to secondary-market trading and how to comply with strict regulations. |
| 35 | UBS and the Utility Settlement Coin | 3 September, 2017 | https://www.finextra.com/blogposting/14459/ubs-and-the-utility-settlement-coin | I | R | In September 2015 the Swiss bank UBS launched its first Utility Settlement Coin (USC) concept in collaboration with UK-based blockchain company Clearmatics. UBS is leading team. |

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| 36 | UBS, IBM, Bank of Montreal (BOM), CaixaBank, Commerzbank and Erste Group | 4 October 2017 | https://www.waterstechnology.com/operations/3430716/ubs-ibm-add-four-banks-to-blockchain-project<br><br>Update 19 April, 2018 below<br><br>https://www.ibm.com/blogs/blockchain/2018/04/blockchain-based-batavia-platform-set-to-rewire-global-trade-finance/ | P | R | BMO, CaixaBank, Commerzbank and Erste Group is added to the group who completed a successful PoC concept last year. The Batavia platform stated in 2016 with the aim of creating multi-party, cross-border trading networks for trade finance, developed using the Hyperledger Fabric Blockchain framework.<br><br>IBM highlight that corporate clients have now successfully completed the first live pilot transactions on the Batavia platform. **Cross-border trading networks** |
| 37 | BlackRock, Aladdin-based blockchains | 13 October, 2017 | https://www.ai-cio.com/news/blackrock-testing-private-aladdin-based-blockchain-custodians/ | | | BlackRock test private blockchain via Aladdin for custody partners. The money managing system Aladdin will lead to more transparent processing. |
| 38 | MasterCard's blockchain payments | 20 October, 2017 | https://distributed.com/news/mastercard-moves-toward-fast-blockchain-payments/ | P | R | Mastercard will allow developers to access its Mastercard blockchain API published on Mastercard Developers.<br><br>MasterCard's blockchain technology provides privacy ensuring transaction details are shared among participants<br><br>**Privacy** |
| 39 | Nasdaq's blockchain initiatives | 8 November, 2017 | https://business.nasdaq.com/marketinsite/2017/Blockchain-Forges-Ahead.html | I | R | 1) Blockchain technology to the NYIAX. Trading **advertising contracts, incorporating forwards...**<br>2) Nasdaq and Citi Treasury and trade partner to offer integrated payment solution that enables straight through payment processing and automates reconciliation using DLT |

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| | | | This seems to be the Nasdaq Linq project announced May 2017 https://www.nasdaq.com/article/nasdaq-and-citi-announce-pioneering-blockchain-and-global-banking-integration-cm792544 but not as far as we can tell interbank… | | | 3) Collaborating with SIX using software from Chain (partner), to provide DLT for a Minimum Viable Product (MVP) for SIX's OTC structured products business. |
| 40 | Visa | 17 November, 2017 | https://www.coindesk.com/visa-launches-first-phase-of-blockchain-b2b-payments-system/ | P | R | Visa starts first phase of blockchain B2B payments<br><br>**B2B payments** |
| 41 | | | | | | |
| 42 | ASX Ltd (Australia)<br><br>*Note: Alistair Milne personal communications reveals that the technology may not be blockchain.* | 6 December, 2017<br><br>4 September, 2018 | https://uk.reuters.com/article/us-asx-blockchain/australias-asx-selects-blockchain-to-cut-costs-idUKKBN1E037R<br><br>Update below:<br><br>https://www.reuters.com/article/asx-blockchain/australias-asx-delays-blockchain-transition-by-6-months-idUSL3N1VQ1KI | I | R | Australia's ASX Ltd will replace its registry, settlement and clearing system with blockchain technology to cut costs for customers.<br><br>Delayed switchover to blockchain by 6 months<br><br>**Settlement and clearing system** |
| 43 | | 3 December, 2017 | https://www.calastone.com/news/calastone-to-bring-mutual-funds-market-onto-blockchain-in-2019/ | P | R | In June 2017, Calastone successfully completed the first phase of its blockchain-enabled distributed market infrastructure PoC. This saw Calastone test and verify the feasibility of using the technology to create a global marketplace for the trading and settlement of mutual |

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| | | | | | | funds. Calastone announced that 2019 it will bring the technology to the market place.<br><br>**Trading and settlement of mutual funds** |
| 44 | Currency of the Internet (COTI) | 23 December, 2017 | https://www.forbes.com/sites/rogerait ken/2017/12/23/bitcoin-beyond-how-digital-currencies-can-solve-consumer-payment-needs/#6218f68d2e74<br><br>See more information | P | C | The main part of COTI is Trustchain. Trustchain lies on a multi-DAG (directed acyclic graph) to increase scalability.<br><br>The Proof-of-Stake algorithm reduces fees for those with good scores.<br><br>**Payments** |
| 45 | LDC, ING, agricultural commodity transaction | | https://www.gtreview.com/news/fintech/major-banks-and-traders-test-blockchain-platform-for-commodity-trade/ | | | The first live agricultural commodity transaction on the blockchain undertaken by Louis Dreyfus Company, ING, Societe Generale and ABN Amro. This transaction saw 60,000 tonnes of soybeans shipped from US to China. |
| 46 | SETL | 11 January, 2018 | https://setl.io | I | R | SETL has worked on numerous projects. These include with OFI Asset Management. OFI Asset Management has successfully used the IZNES system, the pan-European record-keeping platform for funds using blockchain technology in a series of trials with selected clients. IZNES is now started to process live transactions.<br>Four asset management companies are using IZNES. Furthermore, SETL worked with Deloitte and Metro Bank among others. |
| 47 | Cognizant's mortgage lending *Cognizant Technology Solutions founded many years ago* | 18 January, 2018 | https://www.cognizant.com/perspectives/revitalizing-trade-finance-with-blockchain-part-1-of-5 | P | R | Blockchain-powdered peer-peer mortgage financing<br><br>**Peer-peer mortgage financing** |

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| 48 | Guardtime and Metaco | 24 January, 2018 | https://guardtime.com/blog/guardtime-and-metaco-launch-silo-the-crypto-asset-custodian-solution-for-financial-institutions | I | C | Guardtime and Metaco launch SILO.<br><br>Guardtime specialize in anti-tamper hardware.<br><br>SILO is constructed for exclusively for financial firms allowing trading of cryptocurrencies, with protection of assets and liquidity. |
| 49 | SmartTrade's post trade solution | 1 February, 2018 | https://www.smart-trade.net/2018/02/01/blockchain-based-post-trade-solution/ | P | R | SmartTrade Technologies (multi-asset electronic trading solutions provider) launched a blockchain-based post trade solution. The solution captures and sends post-trade data to a private and permissioned distributed Ledger. This guarantees all trades are recorded and cannot be altered.<br><br>**Post trade** |
| 50 | FactSet and CG blockchain partnership | 8 February, 2018 | https://www.waterstechnology.com/industry-issues-initiatives/3491731/factset-pairs-its-oems-with-cg-blockchains-distributed-ledger | P | C | DLT provider CG Blockchain and FactSet entered into a partnership to enable FactSet's order and execution management system to access CG Blockchain's products through the latter's app store, BCT Fundstore. |
| 51 | Northern Trust , Unigeston and IBM | 22 February, 2018 | https://www.reuters.com/article/northern-trust-ibm-blockchain-idUSL1N1G61TX | | | Northern Trust is using IBM to record information by private equity fund, Unigeston. |
| 52 | Credit Suisse Group AG and ING Groep NV | 1 March, 2018 | https://uk.reuters.com/article/uk-blockchain-securities/banks-complete-25-million-euros-securities-transaction-on-blockchain-platform-idUKKCN1GD4DW | P | R | Credit Suisse Group AG and ING Groep NV have completed a 25 million euros securities lending transaction using blockchain-based software |

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| 53 | Nasdaq's blockchain insurance marketplace | 1 March, 2018 | https://business.nasdaq.com/mediacenter/pressreleases/1694790/nasdaq-and-extraordinary-re-sign-market-technology-agreement<br><br>See below for more information<br><br>https://www.extraordinaryre.com | P | R | Start-up Extraordinary Re has signed a market technology agreement with Nasdaq, in order to build out a marketplace for the trading of insurance-linked securities (ILS).<br>Nasdaq will provide a matching engine to Extraordinary Re.<br><br>Extraordinary will use DLT and a private cloud as part of the technology foundation for its platform (within a Bermuda-domiciled reinsurer). |
| 54 | Bloom's credit app | 2 March, 2018 | https://venturebeat.com/2018/03/02/blooms-blockchain-credit-app-sees-record-signups-after-more-bad-news-from-equifax/<br><br>More information below<br><br>https://distributed.com/news/blockchains-could-be-answer-fairer-lending-systems/ | P | R | Bloom is an Ethereum-based decentralized app that promises security to personal data. Bloom saw record signups<br>Credit-score app<br>Bloom allows traditional and digital currency lenders to work with individuals who are unable to get a bank account or credit score, or to keep financial data secure.<br><br>**BloomID: Secure identity**<br>**BloomIQ: Tracking**<br>**BloomScore: Rating**<br><br>**Credit-score app** |

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| 55 | Nasdaq' Sweden pilot real estate Swedish government property sales | 15 March, 2018<br>23 April, 2018 | https://www.nasdaq.com/article/swedish-mapping-authority-pioneering-blockchain-based-real-estate-sales-cm935347<br><br>https://www.thestreet.com/investing/nasdaq-all-in-on-blockchain-technology-14551134<br><br>https://www.wsj.com/articles/a-pioneer-in-real-estate-blockchain-emerges-in-europe-1520337601 | P | R | The Swedish government agency Lantmäteriet has been testing ways to record property transactions on a blockchain since 2016. The agency is looking for volunteers who want to pioneer the practice of buying or selling property using the blockchain-based platform in the next few months.<br><br>The Swedish government agency Lantmateriet the national mapping, cadastral and land registration authority likely to be one of the first government agencies to test using blockchain technology for conducting property sales.<br><br>The agency is working with Telia (telecommunications), Kairos future (consulting firm), Chromway (blockchain platform) in conducting the property sales in 6 months' time-however, still no updates on progress.<br><br>**Conducting property sales**. |
| 56 | TMX's Shorcan announces Cryptocurrency initiatives | 22 March, 2018 | https://www.tmx.com/newsroom?id=650 | I | C | TMX Group wholly-owned subsidiary, Shorcan Digital Currency Network has entered into an agreement with Paycase Financial (Paycase), to launch a new cryptocurrency brokerage service focused on Bitcoin and Ether.<br><br>**Cryptocurrency brokerage** |
| 57 | Spring Labs' funding raising | 27 March, 2018 | https://www.forbes.com/sites/jeffkauflin/2018/03/27/blockchain-startup-spring-labs-raises-15-million-in-vc-four-months-after-its-founding/#3ff8fe452dfc | I | R | Spring Labs' raises $15 million four months after founding<br><br>Products make possible for lenders, banks and data vendors to exchange and verify data without any party taking a central position. **Verify data** |
| 58 | Tradewind's blockchain for gold | 28 March, 2018 | https://www.waterstechnology.com/exchanges-trading-venues/3556366/tradewind-launches-blockchain-for-gold | I | C | Tradewind went live with their blockchain-based gold trading platform called VaultChain on 23 March, 2018. VaultChain digitize gold on a blockchain. |

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| | | | | | | **Digitize gold** |
| 59 | Tradewind Markets | March, 2018 | https://www.ledgerinsights.com/blockchain-gold-royal-mint-tradewind/ | | | Tradewinds Markets launched an industry focused platform in March, 2018 |
| 60 | Santander's mobile App | 12 April, 2018 | https://ripple.com/insights/santander-launches-first-mobile-app-for-global-payments-using-ripples-xcurrent/<br><br>See below: https://www.cnbc.com/2018/04/12/santander-launches-blockchain-based-foreign-exchange-using-ripple-tech.html | P | R | Santander launched One Pay FX and becomes first bank to provide a blockchain-based international payments service to retail customers.<br><br>One Pay FX is a Ripple-enabled mobile app for cross-border payments using xCurrent (Ripple product).<br>(cryptography)<br><br>**International payments service (foreign exchange service)** *I presume this is limited to Santander customers at both ends.* |
| 61 | R3 | 13 April, 2018 | https://www.coindesk.com/beyond-banking-r3-expanding-vision-global-blockchain/ | A | R | R3 is looking to expand Corda to wide range of businesses not only financial.<br><br>R3 financed by consortium of banks- Corda enables institutions to transact directly using smart contracts |
| 62 | AXA Lab Asia<br><br>Shanghai-based Global Risk Exchange | 16 April, 2018 | https://www.digfingroup.com/gre/ | P | R | XA Lab Asia is in talks with Shanghai-based Global Risk Exchange (GRE) to develop a blockchain-based solution to let agriculture producers protect against extreme-weather risks, among other solutions. |
| 63 | Fusion LenderComm | 24 April, 2018 | https://www.finastra.com/news-events/press-releases/finastras-fusion-lendercomm-now-live-based-blockchain-architecture | P | R | Finastra's Fusion LenderComm is now live.<br>It is an app on R3's Corda platform. Finastra worked closely with banks to develop it.<br>The application will streamline information exchange between agent banks and lenders in the **syndicated loan market.** |

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| 64 | Nuggets' China visit | 19 April, 2018 | https://distributed.com/news/uk-institutions-promote-nuggets-blockchain-project-secure-e-commerce/ | P | R | Nuggets, start-up focused on payment and identity, has been endorsed by UK's dept. for international trade and city of London and has been invited on visit to China.<br><br>**Payment and identity** |
| 65 | Secruitize's security tokens | 27 April, 2018 | https://www.forbes.com/sites/nguyenjames/2018/04/27/australian-investors-need-to-watch-cryptocurrency-closely-even-if-theyre-not-buying-it/#202a24987058<br><br>See more information below: https://securitize.io | P | C | The company provides tokenized security |
| 66 | IntellectEU's platform for financial services | 2 May, 2018 | https://distributed.com/news/intellect eu-launches-catalyst-platform-integrate-distributed-ledgers-financial-services/ | P | I | IntellectEU is launching Catalyst platform to connect business applications, financial market infrastructures and blockchain networks.<br><br>Catalyst platform built for financial services industry<br><br>**Connect business applications** |
| 67 | BBVA issue loan using DLT | 3 May, 2018 | https://distributed.com/news/bbva-indra-test-first-corporate-loan-using-blockchain/ | P | R | BBVA is first global bank to issue a loan using DLT<br><br>75 euro corporate loan in collaboration with Spanish technology company Indra |
| 68 | J.P. Morgan files blockchain to process cross-border payments | 4 May, 2018 | https://www.finextra.com/newsarticle/32061/J.P. Morgan-files-blockchain-interbank-payment-patent | P | R | J.P. Morgan filed a patent for the application of blockchain technology to speed up the process of cross-border payments.<br><br>J.P. Morgan believes smart contract platform Quorum has potential to transform interbank payments business.<br><br>**International bank payments.** Regulation focused. |

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| 69 | Vaultoro's gold exchange | 4 May, 2018 | https://finance.yahoo.com/news/vaultoro-bitcoin-gold-exchange-implements-124718037.html | I | C | The world's first crypto-to-physical-gold exchange launched first bitcoin exchange. |
| 70 | Monero<br><br>Consumer payments | 9 May, 2018 | https://distributed.com/news/how-blockchain-solutions-can-transform-payments-industry/<br><br>see more information below<br><br>https://getmonero.org | I | C | Monero is a cryptocurrency with a focus on private and censorship-resistant transactions. |
| 71 | Broadridge awarded patent for proxy voting | 11 May, 2018 | https://www.finextra.com/newsarticle/32090/broadridge-awarded-blockchain-patent-for-proxy-voting | P | R | Broadridge, is a major provider of investor-related services. The company was awarded a patent for applying blockchain technology to the proxy voting process. **Proxy voting** |
| 72 | HSBC world's first blockchian-based trade finance | 14 May, 2018 | https://www.cnbc.com/2018/05/14/hsbc-makes-worlds-first-trade-finance-transaction-using-blockchain.html | P | R | HSBC issued a letter of credit for U.S. food and agriculture firm Cargill using blockchain. HSCB used a platform developed by blockchain R3 called Corda.<br><br>The trade finance transaction involved a shipment of soybeans from Argentina to Malaysia. The letter of credit was issued from HSBC to ING. |

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| 73 | Harbor's tokenized secruities | 18 May, 2018 | http://fortune.com/2018/05/18/security-token-harbor-ceo/<br><br>See more information below:<br><br>https://harbor.com | P | C | Harbor is a compliance platform for tokenizing securities including real estate, investment funds, fine art.<br>Habor raised $28 million from Andressen Horowitiz, Craft Ventures, Funders Fund, Pantera Capital, Signia |
| 74 | Tzero | 22 May, 2018 | https://www.reuters.com/article/brief-tzero-and-box-digital-markets-anno/brief-tzero-and-box-digital-markets-announce-joint-venture-to-launch-industrys-first-security-token-exchange-idUSFWN1ST0K4<br><br>See below for more information:<br><br>On 22 December 2016 raised equity https://globenewswire.com/news-release/2016/12/22/901152/0/en/t0-platform-successfully-employed-in-the-world-s-first-public-issuance-of-a-blockchain-equity.html | P | C | Tzero and box digital markets joint venture to launch first security token exchange.<br><br>More information on firm below:<br><br>https://www.tzero.com |
| 75 | Nasdaq's Sweden Mutual Funds | 24 May, 2018 | https://business.nasdaq.com/marketinsite/2018/MT/How-Blockchain-Will-Revolutionize-Swedens-Mutual-Fund-Industry.html | P | R | Nasdaq is discussing with SEB on applying blockchain in the Swedish mutual fund industry.<br><br>**Mutual Fund** |

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| 76 | Akamai and Mitsubishi UFJ Financial Group (MUFG) | 29 May, 2018 | https://distributed.com/news/akamai-and-japanese-bank-mufg-developing-new-blockchain-based-payment-network/ | P | R | Akamai and MUFG announced plans to offer a blockchain-based online payment with next-generation scalability and throughput.<br><br>Online payment will support global network for processing credit cards.<br><br>Note Akamai is world's largest cloud delivery platform. Expected released 2020 with support for current payment processing, pay-per-use, micropayment and Internet of Things enabled transactions.<br><br>**Online payment** |
| 77 | Digital Asset Group (DAG) and GMEX Group (GMEX) | 30 May, 2018 | https://www.gmex-group.com/press-release-digital-asset-group-and-gmex-group-form-a-strategic-alliance/<br><br>See below for information on DAG http://dag.global | A | I | GMEX is a provider of services in financial markets and DAG is a financial service provider in the digital space.<br><br>The collaboration will involve the delivery of Exchange initiatives with post-trade services including digital registry; Blockchain clearing house; decentralised depository and custody; Digital and Crypto Banking; Crypto Fund Management and emerging technology incubation.<br><br>**Post-trade** |
| 78 | Paxos funding | 31 May, 2018 | https://uk.reuters.com/article/us-crypto-currencies-paxos/blockchain-and-cryptocurrency-startup-paxos-raises-65-million-idUKKCN1IW1RW | P | C | Paxos raised $65 million from investors including venture capital firms RRE Ventures and Liberty City Ventures<br><br>**Paxos is blockchain and cryptocurrency** |

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| 79 | American Express (Amex) | 31 May, 2018 | https://www.americanbanker.com/news/has-amex-found-a-data-gold-mine-with-its-rewards-blockchain | P | R | Amex has built a distributed ledger that merchants can use to link card rewards to products they want to sell more off. e.g. burger place want to sell more burgers can offer Amex reward points to make items more appealing. |
| 80 | TrustToken and HybridBlock to bring TrueUSD | 3 June, 2018 | https://www.reuters.com/brandfeatures/venture-capital/article?id=38316<br><br>TrustToken raised $20 million, see below:<br><br>https://uk.finance.yahoo.com/news/trusttoken-receives-20-million-funding-220957845.html?guccounter=1 | P | C | TrustToken created compliant stablecoin TrueUSD partnered with HybridBlock, a cryptocurrency trading and education platform.<br><br>TrueUSD recently listed on Binance.<br>HybridBlock will soon undertake a public token sale. |
| 81 | DESICO's security tokens | 11 June, 2018 | https://www.newsXRP.com/press-releases/security-tokens-platform-desico-ranks-among-top-3-prestigious-ico-race-competition/<br><br>https://medium.com/@desico.io/desico-hailed-by-forbes-for-providing-step-forward-for-the-global-crypto-ecosystem-a8c92c50bd15<br><br>See more information below<br>https://www.desico.io/en | P | C | ESICO will operate an in-built exchange. This exchange will provide immediate liquidity to any security tokens issued by any business listed on the DESICO platform, and be subject to the regulatory supervision of the Bank of Lithuania.<br><br>Token crowd sale moved to November, 2018. |

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| 82 | Tether's manipulation of bitcoin prices | | https://www.reuters.com/article/us-cryptocurrency-tether/cryptocurrency-tether-used-to-boost-bitcoin-prices-study-finds-idUSKBN1J92U0 | P | C | Tether converts cash into digital currency. There is evidence that Tether, may have been manipulating the price of bitcoin. |
| 83 | OneGram's blockchain | 15 June, 2018 | https://onegram.org | P | C | OneGram is a Shariah-compliant FinTech start-up. OneGram uses blockchain technology to create a new kind of cryptocurrency, where each coin is backed by one gram of gold**.** First transaction on the OneGram blockchain has been made and validated at the end of Ramadan, in Dubai June 15, 2018 |
| 84 | Akropolis's ICO<br><br>**Pension fund** | 16 June, 2018 | https://www.reuters.com/brandfeatures/venture-capital/article?id=39518<br><br>See more information below:<br><br>https://akropolis.io | P | C | Token sale of 900 million in the 3rd quarter of 2018. Akropolis are looking to be the largest smart contract-based pension fund infrastructure on the blockchain. |
| 85 | BN Amro Clearing, EuroCCP, Euroclear and Nasdaq joint proof-of-concept | 19 June, 2018 | https://www.waterstechnology.com/trading-floor-technologies/3705816/banks-and-bourses-join-forces-on-blockchain-drive | P | R | BN Amro Clearing, EuroCCP, Euroclear and Nasdaq completed a joint proof-of-concept to make the transfer and processing of collateral used to meet margin calls more efficient, by using distributed-ledger technology (DLT).<br><br>This is buy-side. Technology from Chain is used. |

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| 86 | UTRUST partner with Pundi X | 21 June, 2018 | https://www.reuters.com/brandfeatures/venture-capital/article?id=39928 | P | C | Pundi X's market-leading blockchain-based point-of-sale solution provider. UTRUST is the first cryptocurrency payments platform in the world to implement consumer-focused cryptocurrency solutions, including buying and selling cryptocurrencies. Deal to promote cryptocurrency payments in stores and secure them with consumer protection. |
| 87 | Digital Asset | 22 June, 2018 | https://coincentral.com/digital-asset-holdings/<br><br>More information on digital asset below:<br><br>https://www.digitalasset.com | A | R | Digital Asset is working on projects including with Australian Securities Exchange and Swiss SIX Exchange on how stock exchanges conduct and record financial transactions.<br><br>For instance, Australian Securities Exchange suggested they will go live in 2020 with the platform. |
| 88 | Ant Financial launch blockchain-powered cash remittance (Hong Kong) | 25 June, 2018 | https://uk.reuters.com/article/us-ant-financial-strategy/ant-financials-hong-kong-venture-launches-blockchain-based-remittance-service-idUKKBN1JL143 | P | R | AlipayHK, Hong Kong based joint venture of Ant and CK Hutchison Holdings will allow real-time transfers of cash between individuals in Hong Kong and the Philippines, in a digital wallet service –first of its kind globally<br><br>**Real-time transfers of cash** |
| 89 | People's Bank of China's digital currency wallet<br><br>**Digital Currency** | 26 June, 2018 | https://cointelegraph.com/news/people-s-bank-of-china-files-patent-for-digital-currency-wallet | P | I | The Digital Currency Research Lab at the People's Bank of China (PBoC) has filed a new patent with China's State Intellectual Property Office (SIPO) on Friday 22, June, 2018.<br><br>Digital wallet could be used to track transaction data in coordination with a centralized digital currency issuance registration agency. |

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| 90 | Slice Market and StraightUp<br><br>**Real estate** | 26 June, 2018 | https://www.prnewswire.com/news-releases/real-estate-investment-platform-straightup-announces-merger-with-slice-a-blockchain-powered-platform-for-cross-border-investors-300671917.html<br><br>See more information below:<br>https://slice.market<br>https://www.straight-up.com | P | R | Slice Market is the first blockchain-based REIT for investors around the world.<br>Slice Market pools together small investments to enable investors to invest without huge capital. The investors earn dividends.<br>StraightUp is a real estate equity platform that allows investors to participate in New York real estate. |
| 91 | OTC Exchange Network (OTCXN) | 27 June, 2018 | https://otcxn.com/wp-content/uploads/2018/07/OTC-Exchange-Network-Completes-Live-Test-Trade-of-Fiat-and-Cryptocurrency.pdf | P | C | OTCXN is a blockchain-powdered capital markets infrastructure. It completed its first live trade. This exchange is a tokenized US Dollars and tokenized Bitcoin between two separate trading accounts over an electronic trading platform. The assets are held at a neutral custodian and digitized on blockchain.<br><br>OTCXN delivers an institutional P2P trading platform. Pooled liquidity from multiple exchanges. |
| 92 | Thomas Reuters BlockOne ID for Ethereum BlockOne IQ<br><br>**Identity-mapping service** | 6 July, 2018 | https://distributed.com/news/analysis-thomson-reuters-blockchain-baby-steps-are-significant/ | P | I | Thomas Reuters' BlockOne ID (released in Sep. 2016) for Ethereum is an identity-mapping service for blockchain, allowing digital identities to be mapped onto Ethereum addresses.<br><br>BlockOne IQ (released Jun. 2018) is an oracle service to deliver data to smart contracts. Service supports Ethereum, R3's Corda but more is likely in the future. |
| 93 | Citrusexchange, invoice financing | 10 July 2018 | https://www.finextra.com/newsarticle/32366/citrusxchange-launches-blockchain-based-supply-chain-financing-platform | | | Canadian start-up Citrusexchange launches blockchain-based supply and invoice financing. |

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| 94 | Otonomos: Blockchain chartered company | 13 July, 2018 | https://distributed.com/news/will-blockchains-reshape-corporate-entities/<br><br>https://otonomos.com | P | C | Otonomos provides owners with mechanism to form offshore corporations in places like Cayman Islands, to transfer equity peer-to-peer to attract co-founders, pay collaborators, garner crowdfunding etc.<br><br>**First blockchain chartered company** |
| 95 | Workchain.io | 13 July, 2018 | https://medium.com/workchain-io/a-look-inside-the-workchain-io-protocol-286225e13f69 | | | WorkChain.io uses blockchain to automate payroll making it instant and real-time. |
| 96 | MasterCard's patent<br><br>**Payments** | 23 July, 2018 | https://www.fool.com/investing/2018/07/23/mastercard-secures-a-potentially-game-changing-cry.aspx<br><br>See information on general area (7 July, 2018) 'Stem Theft'<br><br>https://www.nasdaq.com/article/mastercard-is-looking-to-stem-theft-through-blockchain-technology-cm988015 | P | C | Mastercard obtained a patent from U.S Patent and Trademark on July 17, 2018 that would provide for linkage of blockchain-based assets to fiat currency accounts. The patent creates a hybrid system where blockchain currencies can be used on traditional payment platforms.<br><br>Update below 10 August, 2018<br><br>https://siliconangle.com/2018/08/10/patents-apis-show-mastercards-earnest-embrace-blockchain-tech-guestoftheweek/ |
| 97 | Landesbank Baden-Wuttembrg's loan (Germany) | 27 July, 2018 | https://distributed.com/news/schuldschein-and-blockchain-powered-transactions/ | P | R | Landesbank Baden-Wuttembrg's issued a $114 million loan to Dainler AG via blockchain.<br>Shuldschein **loans** have fewer regulations that sometimes make blockchain-based transactions difficult. |

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| 98 | Banks test blockchain app store<br><br>LedgerConnect<br><br>**Customer compliance** | 30 July, 2018 | https://uk.reuters.com/article/us-banks-blockchain/cls-ibm-and-banks-test-blockchain-app-store-idUKKBN1KK0VI | P | I | Nine financial institutions (including Barclays PLc and Citigroup Inc) and foreign settlement provider (i.e. CLS), IBM are testing LedgerConnect that will offer apps in areas such as customer compliance checks, sanctions screening and collateral management. |
| 99 | Hedera Hasgraph | | https://venturebeat.com/2018/08/01/hedera-hashgraph-raises-100-million-for-fast-and-secure-blockchain-alternative/ | | | Hedera Hashgraph raises $100m via token sale from institutional investors to create a new network based on its hashgraph consensus technology |
| 100 | JD.com's blockchain technology platform<br><br>(China)<br><br>**Consumer finance** | 20 August, 2018 | https://www.thedrum.com/news/2018/08/20/jdcom-launches-open-blockchain-technology-platform | P | R | JD Blockchain Open Platform will enable customers **to track the movement of goods** and charity donations. It will ensure authentic certifications, property assessment, transaction settlements, digital copyrights. Note that JD a leading online retailer for consumer finance applications. |
| 101 | Shanghai Stock Exchange (SSE)'s partnership with | 22 August, 2018 | https://cryptovest.com/news/shanghai-stock-exchange-to-bring-blockchain-in-assets-pension-funds/ | P | R | Shanghai Stock Exchange partnered with Insurance Asset Management, Association of China, Changiang Pension Insurance Company, Tokyo Maritime Sunshine, Sumitomo Mitsui Marine and others to build a distributed data platform. SSE is looking to bring blockchain to asset management and pension funds. |

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| | insurance companies<br><br>(China)<br><br>**Asset management** | | | | | |
| 102 | World Bank's blockchain bond | 23 August, 2018 | https://uk.reuters.com/article/uk-worldbank-cba-blockchain/world-bank-launches-world-first-blockchain-bond-idUKKCN1L80DZ<br><br>https://distributed.com/news/world-bank-issues-79-million-bond-permissioned-blockchain/ | P | R | First public bond using only Blockchain in a A$100 million deal. Commonwealth bank is the sole manager of deal.<br><br>World bank will manage Bond-I which is a two year bond using a permissioned blockchain based on Ethereum. |
| 103 | Swarm<br><br>**Tokenized security trading** | 30 August, 2018 | https://financialit.net/news/blockchain/swarm-announces-market-access-protocol-map-security-token-trading<br><br>See below for more information:<br><br>https://swarm.fund | P | C | Swarm (blockchain private equity firm) released Market Access Protocoal (MAP) for tokenized security trading. |
| 104 | Foxconn<br><br>(Chinese producer of Apple's iPhone) | 4 September, 2018 | https://www.bankingtech.com/2018/09/foxconn-and-friends-form-100m-vc-fund-in-us/ | A | R | Foxconn and friends form $100 million venture capital fund in US. Advocate Aurora Health, Northestern Mutual, Johnson Controls and Foxconn will contribute $25 million each.<br><br>The fund is looking to develop products and **services for financial services** among other sectors. |

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| | | | | | | Note that Foxconn is involved in supply chain finance. |
| 105 | The Institutes RiskBlock Alliance<br><br>**Risk management and insurance** | 12 September, 2018 | https://www.theinstitutes.org/about-us/media-center/articles/institutes-riskblocktm-alliance-launches-canopy-risk-management-and<br><br>Nationwide tests RiskBlock, a product.https://www.insurancejournal.com/news/national/2017/12/27/475346.htm | A | R | The Institutes RiskBlock Alliance is a blockchain consortium that represents 31 risk management and insurance companies.<br><br>They launched Canopy a blockchain framework using Corda blockchian platform. |
| 106 | Komgo | 26 September, 2018 | https://www.gtreview.com/news/fintech/major-commodity-players-to-bring-blockchain-platform-into-production-this-year/ | | | Komgo, based on Quorum (version of Ethereum) aims to make commodity operations more efficient. |
| 107 | HSBC India and ING Bank Brussels Trade Finance | 5, November, 2018 | https://www.finextra.com/pressarticle/76237/hsbc-and-ing-carry-out-blockchain-trade-finance-transaction | | | HSBC India and ING Bank Brussels blockchain trade finance transaction with Reliance and Tricon Energy. Executed on R3 Corda program. |
| 108 | Signature Bank launches blockchain real time payments | 5 December, 2018 | https://www.pymnts.com/news/b2b-payments/2018/signature-bank-real-time-blockchain-corporates/<br><br>https://www.ledgerinsights.com/signature-bank-launches-blockchain-real-time-payments/ | | | NY-based Signature Bank has approved NY State Department of Financial Service for its real-time blockchain-based payment platform. |

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| 111 | Broadridge blockchain proxy PoC in Japan | December, 2018 | https://www.ledgerinsights.com/broadridge-execute-blockchain-proxy-poc-in-japan/ | | | Broadridge in November 2018 finished blockchain proxy voting proof of concept (PoC) in Japan. |
| 112 | FINTEUM | 29 January, 2019 | https://www.euromoney.com/article/b1cqvzxf1vv71v/dlt-perfect-solution-to-deliver-real-time-liquidity-management | | | FINTEUM and R3 working together as they see DLT as ideal solution to deliver real-time liquidity management. |
| 113 | HIS Markit, MarkitSERV and Cobalt' FX work | 30 January 2019 | http://www.cobaltdl.com/ihs-markit-teams-with-cobalt-to-re-engineer-fx-post-trade/ | | | HIS Markit announced that MarkitSERV and Cobalt are collaborating to accelerate delivery of new post-trade processing services for foreign exchange markets.<br><br>HIS Markit has integrated Cobalt post-trade FX blockchain with its platform |

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| 114 | LSE, blockchain, Nivaura | March, 2019 | https://www.ledgerinsights.com/london-stock-exchange-blockchain-nivaura/ | | | LSE invests in blockchain Nivaura.<br><br>Nivaura worked with Allen & Overy. |
| 115 | IBM world wire<br><br>Network payments | 18 March, 2019 | https://www.forbes.com/sites/rachelwolfson/2019/03/18/ibm-launches-a-blockchain-based-global-payments-network-using-stellars-cryptocurrency/#2f38613a53ec<br><br>See more information on IBM world wire<br><br>https://www.ibm.com/blockchain/solutions/world-wire | | | IBM launches a blockchain World Wire which is a blockchain based global payments network using Stellar protocol (Cryptocurrency). |
| 116 | Deutsche Börse, Swisscom | March, 2019 | https://www.ledgerinsights.com/blockchain-deutsche-borse-swisscom-sygnum-digital-asset-exchange/ | | | Deutsche Börse, Swisscom and one of its IT providers Sygnum plans to launch digital asset exchange this year. |
| 117 | SWIFT blockchain for proxy voting | March, 2019<br><br>6 March, 2019 | https://www.ledgerinsights.com/swift-blockchain-proxy-voting/<br><br>https://www.swift.com/news-events/press-releases/swift-launches-dlt-e-voting-poc | | | SWIFT launches DLT e-voting PoC in the Asia-Pacific region. |

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| 118 | Thai stock exchange plans | March, 2019 | https://www.ledgerinsights.com/thai-stock-exchange-set-digital-asset-blockchain/ | | | Thai stock exchange plans a digital asset platform to go live in 2020. |
| 119 | Stuttgart stock exchange and Axel Springer | March, 019 | https://www.ledgerinsights.com/digital-assets-blockchain-boerse-stuttgart-axel-springer/ | | | Stuttgart stock exchange, Axel Springer, and finanzen.net plans a joint venture to construct a digital asset platform. |
| 120 | Klienwort Hambros | April, 2019 | https://www.ledgerinsights.com/societe-generale-kleinwort-hambros-enterprise-blockchain-investment/ | | | Societe Generale's Kleinwort Hambros announced a blockchain note (Luxembourg exchange traded note) which will invest in blockchain related stocks. |
| 121 | Northern Trust , legal contracting and private equity blockchain | April, 2019 | https://www.ledgerinsights.com/northern-trust-blockchain-private-equity-smart-legal-contracts/ | | | Northern Trust incorporates legal contracts and smart contracts into its private equity administration |
| 122 | Baton Systems | 15, April, 2019 | https://www.batonsystems.com/2019/04/15/baton-systems-wins-best-distributed-ledger-technology-project-at-sell-side-technology-awards/ | | | Baton's (DLT post-trade and payments) wins award for its innovative work on the sell-side. The company is working with Citi banks, CME etc. for settlement of margin collateral and foreign exchange. |

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| 123 | Accenture, Generali, Launch blockchain | April 2019 | https://www.ledgerinsights.com/blockchain-captive-insurance-generali-accenture-employee-benefits/ | | | Accenture, Generali launch blockchain-based reinsurance service for capitves. Solution uses R3's Corda. |
| 124 | EY plans secure private transactions on public blockchain | April, 2019 | https://www.ledgerinsights.com/ey-to-launch-privacy-tech-for-enterprises-to-use-public-blockchains/ | | | EY plans to enable private transactions on Ethereum. |

# Appendix 2: the legal and regulatory treatment of 'crypto assets'.

In this appendix, we discuss the law and regulation of crypto assets.

## A. What are crypto assets?

What are crypto assets? There is no standard or even widely accepted definition. Our working definition of a crypto asset is as follows

***Definition A: a crypto asset is a native ledger asset on a blockchain which can be transferred between network participants and is widely exchanged on crypto exchanges at a prevailing market prices, either for other crypto assets or for conventional state fiat money.***

This is a deliberately narrow definition. The reference to "native ledger asset on a blockchain" and to "widely exchanged at prevailing market prices" excludes what others might regard or claim to be crypto assets:

- It is restricted to 'native assets'. These are a numerically limited set of ledger entries that with holders identified by public and matching private key, and transferred from one holder to another with the private key initiating the transaction and the public key used to identify the recipient. They are native because they cannot be transferred off the ledger. They do not represent anything else and there is no market maker or other institutional arrangement to guarantee an exchange value against other crypto or non-crypto assets.

  Under this definition so called 'stable coins' – similarly transferrable ledger entries with a guarantee of value in terms of conventional state fiat money or some other physical or financial asset – are *not* crypto assets. This is because they are not native assets to their supporting blockchain – instead the guarantor takes them off or adds them to the supporting blockchain exchanging against their underlying asset to maintain their guaranteed value.

- It is restricted to blockchains i.e. unpermissioned distributed ledgers in which a real-world identity is not required for network participation and holding of the assets.

- It excludes some assets that purport to be crypto assets, but are not actively traded – for example on this definition the 'Petro', the virtual currency created by the Maduro government of Venezuela, is not a crypto asset because it is not traded on cryptocurrency exchanges

Why such a narrow definition? This is for two reasons:

1. We choose this definition in order to limit crypto assets to assets traded in the 'ecosystem' of crypto-exchanges that has emerged for online exchange of cryptocurrencies for fiat currencies and cryptocurrencies for other crypto assets. A defining feature of a crypto asset is that it is traded on a number of these exchanges.

If it is not so traded then it is best regarded as akin to a limited-edition work of art, not in any way a financial asset.[152]

2. Our definition is framed to include only native blockchain assets i.e. those assets which pose the most substantial challenge for existing law, regulation and accounting. When an asset traded on a crypto exchange is not native to a blockchain but is instead a representation of an external financial or physical asset, then there is relatively little difficulty in applying conventional existing law, regulation and accounting. There are still concerns, associated with asserting legal rights and obligations when ownership is anonymous i.e. in a 'permissionless' blockchain where participants need to have real world identities. But aside from anonymity of ownership, such blockchain assets are not in any substantive way different from conventional assets.

We will not attempt a full discussion of the rapidly changing landscape of crypto exchanges. There are more than two hundred crypto exchanges worldwide trading several thousand trading pairs (cryptocurrency against fiat, cryptocurrency against other crypto assets).[153] The services offered vary substantially: some focused more on novice investors dipping into the world of crypto assets, others catering for more sophisticated traders looking to do active trading between crypto assets; some focusing on exchange of cryptocurrencies for conventional fiat currency and others on exchange amongst crypto assets. Liquidity is an issue, apart from a few standard trades such as Bitcoin XRP against US dollar USD it can be difficult trade even low quantities of many crypto assets at low cost without impacting on market prices and exchange prices for trading pairs can vary markedly from one venue to another. In order to provide liquidity most of the more active exchanges operate in a centralised fashion, maintaining holdings of both fiat and crypto assets on behalf of customers and hence putting customers at risk if they were to fail.

We do though need to highlight regulatory concerns about crypto exchanges. There are substantial differences between them in terms of both their transparency of their operations and the extent to which they engage with regulatory authorities and comply with regulations. There are also questions about the real nature of the exchanges reported by these exchanges. It appears that much of the apparent volume are not trades between independent buyers and sellers, but rather artificial trades generated by the exchanges themselves, perhaps in order to climb published rankings of exchange volume.[154]

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[152] Examples of excluded assets are 'cryptokitties', cute if rather crude virtual cat images. Cryptokitties are unique items in the sense that blockchain based transactions establish unique ownership of each cryptokitty. They can be freely copied but each has only one owner. They are not exchange traded so, by our definition, they are not crypto assets.

[153] Well established exchanges offering narrow spreads and liquid trading in Bitcoin include Coinbase, Kraken, Bitstamp, Bittrex, Poloniex and bitFlyer.

[154] As of 23rd March 2019, https://coin.market/markets/info reported 236 exchanges with 24h volume of $8.9bn on 8,387 crypto trading pairs. However, analysis presented to the SEC by Bitwise Asset Management (in the context of their case for launching a Bitcoin ETF), suggests that 95% of this reported volume is either fake or non-economic (Bitwise Asset Management 2019). This implies that genuine daily trading volume is less than $0.5bn per day compared with the daily $5.1trillion of global foreign exchange trading reported in the most recent April 2016 BIS triennial survey of foreign exchange i.e. crypto asset trading is less than 0.01% of global foreign exchange trading.

Within the overall category of crypto assets, we follow recent regulatory reports, distinguishing three different sub-categories of crypto assets (there is an overlap, a particular asset may offer both the prospect of future payments and future products or services, i.e. be included in both 2. Or 3.):[155]

1. Cryptocurrencies: a native ledger asset on a blockchain which can be exchanged or transferred between network participants – but offers no other benefits.

2. Crypto securities: a native ledger asset on a blockchain which, in addition, offers the prospect of future payments - for example a share of profits.

3. Crypto utility assets: a native ledger asset on a blockchain which, in addition, can be redeemed for or give access to some product or service.

Here by a 'native asset' we mean a claim that can be transferred on the ledger but cannot be moved off or onto the ledger, and if used in exchange for products or services only through the execution of software coded into the ledger.

Issues in the second or third categories are commonly referred to as "ICOs" or initial coin offerings. ICOs – because they make a promise of some future payment or service – are conceptually distinct from cryptocurrencies. The promise is made by some issuing or sponsoring enterprise, which is providing or at least plans in future to developing some online business or service. The use of the term ICO is a conscious analogy with conventional IPOs or initial public offerings of publicly traded equity. ICO issues – of which there were many in the second half of 2017 and the first half of 2018 seeking to take advantage of the speculative rise in the values of Bitcoin and other crypto assets – have in some cases provided quite substantial funding for enterprise development.

The sponsoring entity for an ICO may be a legal entity – in which case the usual mechanisms for enforcing applicable financial regulation such as fines may be used. It may though on occasion not have any clear legal status. It may never be known which individuals have created the software supporting the asset offered in the ICO and have persuaded crypto exchanges to provide a venue for its exchange against other crypto assets.

The software supporting the ICO can be a self-standing "virtual enterprise" or "decentralized autonomous organization" or DAO, functioning like an enterprise but with almost no institutional arrangements. To those not steeped in the world of crypto assets this may seem far-fetched, but this possibility has been a central issue in the world of cryptocurrencies, especially for users of the Ethereum software and its cryptocurrency Ether. A focus of the Ethereum community has been on supporting the development of decentralised autonomous organisations or DAOs, arrangements for the release funding for a specified project or projects following an initial ICO.[156] A DAO protocol has been developed that allows for the 'entrepreneurial team' i.e. those

[155] For example (Bank of England, Financial Conduct Authority, and HM Treasury 2018; ESMA 2019; EBA 2019) and also (Hacker and Thomale 2017).

[156] The very first Ethereum DAO was hugely problematic, aimed at providing an automated system for venture capital funding, it succeeding in attracting some 15% of all outstanding Ether, but a hack (associated with the interface with fiat currency, not internal to Ethereum) allowed a substantial proportion of these funds to be diverted and lost. Dispute over how to resolve this situation led to the hard fork between Ethereum and Ethereum Classic. See (del Castillo 2016).

responsible for bringing a project to the DAO to request funding and to trigger a vote amounts ICO holders on whether or not to approve allocations of funds.[157]

While such decentralized organization seems workable for relatively simple decisions (e.g. fund or not fund), and there have been efforts to extend the concept; it is unclear that this can be used to support much more sophisticated decision making.[158] From our perspective, we would emphasize again the challenge of data management. If the only decision is allocating funds to nominated outside projects then the 'direct democracy' of the Ethereum DAO structure looks workable, but it is questionable whether more complex decisions over transfer of assets or processing of data can easily be decided by voting amongst ICO holders. To date the issue of ICOs by virtual enterprises or DAOs is a highly niche issue that need not trouble the world of mainstream finance.

What is of real concern is the lack of regulation of ICOs when compared to public securities. As a result many have been based on misinformation about the prospects for the issuing enterprise and in some cases have been fraudulent with no underlying profit stream or business service.[159]

## B. Legal and regulatory classification of crypto assets

A major issue for regulators dealing with crypto assets is determining whether they fit within existing regulatory classifications and are therefore subject to existing regulation. We review how this issue has been addressed in the US and in Europe, focusing on what we define as crypto assets, i.e. native blockchain assets that are traded on crypto exchanges.

In the US this question has been addressed by the Securities and Exchange Commission (SEC) and the Commodities and Futures Trading Commission (CFTC). A central question is whether crypto assets are securities (and therefore regulated at federal level by the SEC). Legal precedent has established the Howey test – from the SEC v. W.J. Howey Co. Supreme Court case of 1946 – as the standard for determining whether an asset is a security. According to this test an asset is a security if there is an affirmative answer to four component questions: (i) is it an investment? (ii) is there an expectation of profit? (iii) is there an investment in a common enterprise? and (iv) do profits come from a promoter or third party? If a crypto asset is a security then the further question arises of how the issue should be registered with the SEC, in order to adequately inform potential investors.[160]

The SEC has been active in developing an appropriate regulatory regime for crypto assets, concerned to both support new avenues for raising of capital but at the same time provide adequate investor protection and enforcement action when required. [161] What we term above "crypto securities" i.e. ICOs that offer a future profit are clearly securities under the Howey test. They do not need to be issued by a legal entity. On July 25, 2017, the SEC determined that tokens sold by a "virtual organisation" or DAO qualified also as securities.[162]

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[157] See (DAOX team 2018)
[158] See (Shavit 2018) for discussion.
[159] The most notorious example being OneCoin whose promises of 'get rich quick' apparently fooled unsophisticated investors into parting with several billion dollars worldwide, see (Maina 2019)
[160] See https://www.sec.gov/news/public-statement/digital-asset-securites-issuuance-and-trading .
[161] See (Clayton 2018) and https://www.sec.gov/ICO . There have been numerous SEC enforcement actions and lawsuits on ICOs in the US (Carlson and Selin 2017) which centre on their classification as securities. For instance, the actions surrounding the Tezes ICO which raised $232 million in July 2017 for Dynamic Ledger Solutions (DLS). The lawsuit alleged that the issued "Tezzies" are securities.
[162] https://www.sec.gov/news/press-release/2017-131

Cryptocurrencies – our first category of crypto asset – may also be considered as securities if their promotion is based on raising funds and the subsequent success of a "common enterprise" (in the wording of the Howey test). A difficult question, on which the SEC has not yet reached a clear determination (and could in any case be subject to legal challenge) is whether cryptocurrencies that are associated with a 'common enterprise' and have been sold to investors are securities. Former CFTC chair Gary Gensler has argued that on these grounds Ripple Lab's cryptocurrency XTC, and possibly also Ethereum Foundation's Ether, should be treated as a securities.[163] This is a difficult decision with possibly disruptive impact on the nascent market for crypto assets that the SEC seeks to support.(Baker 2018)

If not securities, then what? The CFTC have stated that they regard virtual currencies as commodities, giving them the same regulatory authority under the commodities exchange act as they have over physical commodities such as gold or copper.[164] This gives the CFTC authority to investigate and sanction fraud and manipulation in spot and derivative markets for virtual currencies and in addition to impose a range of regulatory requirements on trading of virtual currency derivatives e.g. forward or future contracts.

The classification of crypto assets, including cryptocurrencies, has been less of a concern for the Federal Reserve or other US banking regulators. Their position can be described as "taking a watching brief", monitoring closely but not seeing as yet any substantial concern about crypto assets potentially falling outside of their 'regulatory perimeter'.[165]

Similar issues of classification of crypto assets arise in the EU, but here the response has naturally depended on the rather different structure and content EU financial law and regulation.[166] What classifications are possible under EU financial regulation? They could be financial instruments

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[163] (Russo 2018). Some go even further: (Hazen 2018a) argues that all cryptocurrencies should be considered as securities. Others interpret the SEC as viewing all ICOs are securities unless proven otherwise (Zinman et al. 2018). However, it is important to note that although SEC uses the Howey test to determine whether an asset is a security, it has not provided an official test for such classification (Henderson and Raskin 2018). (Henderson and Raskin 2018) believes such a defined test would be beneficial. They propose a test which they call the "Bahamas test" . The first part of the test determines whether a digital asset is decentralized and the second part of the test determines whether there is the "expectation of profit". (Hacker and Thomale 2017) highlight that resulting from ICOs being potentially subject to securities regulation in the US, issuers have attempted to avoid securities regulation by modelling them so as to restrict citizens from investing. In addition, the SEC v. Shavers, 2013 WL 402182 at *2 (E.D. Tex. Aug. 6, 2013) the district court determined that Bitcoin could be a security (this did not exclude it being a currency) (Hazen 2018b) However, it suggested that the jury would make the final decision.

[164] (Giancarlo 2018). There are a wide range of views. The (Internal Revenue Service 2014) suggests that it will treat cryptocurrencies (Any currency that is not stamped on paper, on coins, metals, on physical objects etc.) as a property for tax purposes. There are others who believe virtual currencies are a new asset class. (Zellweger-Gutknecht 2018) argues that cryptocurrencies are assets with "rivalrous and excludable" data. The paper argues that rules governing entitlement to assets deposited with a trusted party should be applied to this new asset of "value data." (Burniske and White 2017) from Coinbase and ARK invest argue that bitcoin qualifies for a new asset class. The analysis finds that bitcoin adheres to investability but differs distinctly from other asset classes in terms of "economic profile, price independence, and risk-reward characteristics."

[165] See for example (Brainard 2018).

[166] https://ec.europa.eu/info/business-economy-euro/banking-and-finance/financial-reforms-and-their-progress/regulatory-process-financial-services/regulatory-process-financial-services_en There is no EU wide securities regulator: rather securities regulations are transposed into national law, from EU directives; at the same time the Parliament and Commission may create regulations that apply across the EU. Supervision and enforcement of national law and EU regulations is a national responsibility. In addition "level 3" authorities -- the European Securities Markets Authority, ESMA, the European Banking Authority EBA and the European Insurance and Occupational Pensions Authority, are responsible for advising EU authorities, preparing technical standards and issuing guidelines for national authorities on the application of EU law and regulations.

under the Markets and Financial Instruments Directive (in the current version MIFIDII applicable since January 2018). If so they might then be classified as transferable securities; and if not whether they might instead be classified as 'e-money' under the e-Money directive of 2009.

MiFiD II defines both transferable securities and financial instruments. Transferable securities include both bonds, equities and other securities traded on capital markets and also some traded participations in collective investment schemes (but exclude money market instruments of maturity of less than 12 months).[167] Financial instruments are a broader category, including not only transferable securities but also money market instruments and a variety of derivative instruments. Payment instruments (of which e-Money is one example) are defined as distinct from financial instruments and covered by different directives, such as the Payment Services Directive PSD and the e-Money Directive.

The classification of crypto assets are discussed in recent advice given by the European supervisory authorities ESMA and the EBA to the European Commission.(ESMA 2019; EBA 2019). ESMA has conducted a survey of EU national supervisory authorities, asking for their view on the classification of six representative crypto assets. While the responses were not entirely uniform, this survey makes clear that what we have classified above as "Crypto investments" i.e. offering some prospective profit share or payment and traded on crypto exchanges – would be classified as transferable securities by most EU national authorities. This outcome is very similar to the position taken by the SEC and implies that they should meet with the requirements (broadly equivalent to SEC registration and filing) such as the Prospectus Directive and the Transparency Directive.

The EBA finds that, in some situations cryptocurrencies may qualify as e-money under EU law, in which case the issuer is required to have authorization as an electronic money institution.[168] This leaves though unresolved questions. The relevant legal definition in EU law is "stored monetary value" but "monetary value" is not defined: does for example Bitcoin qualify as a measure of monetary value?[169] Or is monetary value restricted to fiat currencies (in which case, according to our narrow definition of crypto assets a crypto asset cannot be e-money)? Also, even if a cryptocurrency i.e. a native blockchain asset is classified as e-money, it remains unclear how the requirement for authorization could be applied to the open source software code supporting the cryptocurrency blockchain. The EBA seem to be making a theoretical rather than a practical recommendation.

## C. Other regulatory concerns

We conclude this section with brief summary of other regulatory concerns about crypto assets.[170] These are: their treatment for purposes of know your customer KYC and anti-money

[167] As in Section C of Annex I of MIFID II, reproduced in the FCA handbook https://www.handbook.fca.org.uk/handbook/glossary/G1519.html

[168] (EBA 2019) paras 23. And 24.

[169] This is a difficult legal question to which the answers can vary. While most central banks and regulators take the view that cryptocurrencies are not money, the German Federal Financial Supervisory Authority (BaFin) suggests Bitcoin is a unit of account and is therefore money (Demertzis and Wolff 2018). (Omlor 2018) argues that Bitcoin should not be classified as money for legal purposes as it is not considered as a universal medium of payment nor there is '*normative recognition of bitcoins in German law'.* On the other hand the risks of bitcoin obligations are similar to what one would expect in monetary debt and a debtor can repay a bitcoin debt in euros under German law suggesting it is money.

[170] See the various regulatory documents cited here and also (Board 2018) .

laundering AML regulation; ensuring market integrity on venues for the trading of crypto assets; oversight of fiduciary responsibilities of custodian institutions and wallet services; and potential prudential and financial stability concerns arising from holdings of crypto assets by banks and other regulated institutions. In writing this we are aware that the G20, under the current Japanese presidency, is making regulation of crypto assets a priority issue for international policy co-ordination. New regulatory initiatives may emerge by the time of the June 2019 G20 summit.

A major challenge for regulators is the 'pseudonymous' participation and absence of institutional governance structure in permissionless blockchains. These makes it all but impossible to identify holders or enforce effective institutional responsibility and hence apply KYC and AML requirements. The only effective application of KYC and AML regulation would appear to be at the interface between the crypto assets and conventional financial system i.e. in the venues for trade between crypto assets and fiat currencies. Virtually all regulatory authorities are stressing the importance of effective KYC and ALM regulation for crypto exchanges – with increasing scrutiny of the sources and uses of funds.

A closely related problem is with enforcement of regulations to promote market integrity and prevent market abuse. Crypto assets do not have a clear status from the perspective of market abuse regulation.[171] Even if this status is clarified, it is uncertain how crypto exchanges operating entirely outside the regulatory perimeter can be policed.

How will this play out in practice? While the 'eco-system' of crypto exchanges is rapidly evolving, there does seem an emergent separation between: those exchanges that seek to engage fully with conventional financial institutions, offering exchange between fiat and crypto and ensuring full compliance with applicable regulation; and other exchanges that seek offer a venue for trading only in the alternative cryptocurrency world, that may operate entirely online for crypto-to-crypto exchange and have little need to pay attention to financial regulation because the regulatory authorities have no easy means for enforcing this regulation even when it applies. Still regulators are likely to want to ensure strong enforcement of AML and other regulations on all forms of crypto exchange.[172]

There has been recent interest in the potential creation of regulated digital exchanges for trading crypto assets. This include announcements by SIX, HQLAZ, TASE and ICE. SIX (owner of Swiss Stock Exchange) aims to launch SIX Digital Exchange (SDX) mid 2019 using DLT to provide digital asset trading, custody service and settlement. The goal is to 'tokenize' existing security and non-bankable assts.(Ledger Insights 2018e) HQLAX was launched last year to make it easier for banks to hold High-Quality Liquid Assets (HQLA).The first live trade was between Credit Suisse and ING. Credit Suisse swapped a bundle of securities valued at EUR25 million.[173] HQLAX is also working with Deutsche Börse[174] on a Blockchain Securities Lending Platform. (Cointelegraph 2019b) Tel Aviv Stock Exchange (TASE) Accenture and TheFloor (FinTech) is constructing a securities lending blockchain.(Ledger Insights 2018d) The firms will utilize Hyperledger Sawtooth. Intercontinental Exchange (ICE) (parent company of New York Stock Exchange) suggests it will spend an additional

[171] As discussed by (Keidar and Blemus 2018)
[172] See (Østbye 2018) for related analysis.
[173] Digital Collateral Receipts represents the securities and is held with a third party. There is no need to securities to move. HQLAX uses R3's Corda technology. See below for more details
(Ledger Insights 2018f)
[174] Deutsche Borse has been active on related project. In March 2019 , Deutsche Borse, Swisscom and Sygnum announced that they will build a trusted digital asset ecosystem.
(Ledger Insights 2018c)

$20 million this year building Bakkt (bitcoin futures trading and custody platform). (Coindesk 2019c) Bakkt recently raised $182 million and will go for more funding (i.e. $50 million) over the course of 2019.

This separation of crypto exchanges, between those either clearly inside and those clearly outside the regulatory perimeter, also has implications for the regulatory responsibility for ensuring market integrity. For those exchanges clearly inside the regulatory perimeter the task is similar to that required for ensuring market integrity in securities trading, derivatives trading and in foreign exchange, regardless of whether this trading takes place on formal exchanges or in more loosely organized 'over the counter' markets. Regulators need to keep abreast of market practice and be ready to take action against individual participants or co-ordinated efforts to manipulate market prices or of conflicts of interest between brokers and clients. The existing framework of regulation should apply and the challenge is collecting the evidence for effective enforcement actions.

Existing regulations should also apply to those institutions providing custodian or wallet services to holders of crypto assets or launching exchange traded or mutual funds investment in crypto. The key issues will be transparency and also ensuring adequate arrangements to protect investors in the event of operational or financial difficulties. We expect to see reputable firms wanting to be situated clearly inside the regulatory perimeter to promote trust in their services. In this case application should be comparatively straightforward.

There are at present only limited concerns amongst regulators about crypto asset transactions leading to either prudential risk or financial instability. Conventional institutions, banks, insurance companies have next to now exposure. Where trading and investment services are offered, this is primarily as a service to clients not on a proprietary or market making basis. The aggregate scale of crypto investment remains much too small to pose a real threat to financial stability.

Suppose we are correct and crypto asset activity, both exchanges and custodian services, separate into those clearly inside and those definitely outside the regulatory perimeter. This then raises one final question, one on which we have no definite answer. What then will be the relative importance of the two worlds of regulated and unregulated crypto assets exchange? One possibility is that the desire to conduct financial transactions, both payments and investments, outside of the framework of state regulation will allow both to co-exist. Another possibility is that customer and investor demand for regulatory protection will drive most activity within the regulatory perimeter. Whichever way this turns out, however, will have little impact on regulatory policy making. Regulators can only regulate what they can regulate. An unpermissioned crypto exchange that offers only exchange in crypto assets can put itself effectively outside of conventional regulation (enforcement only possible through substantial intervention in personal liberties, for example through seizing of computers and substantial punishment for individual participation in prohibited unregulated financial activity).

What we do predict is that – in a decade or two from now – regulated crypto asset exchanges will be effectively subsumed into conventional finance. There will likely be some limited opportunity still for regulated transactions in unpermissioned native cryptocurrencies as a distinct investment asset. But most regulated transactions will be in assets (on permissioned blockchain i.e. distributed ledgers) that are essentially identical to conventional securities or money (securities that just happen to be transacted using a permissioned distributed ledger

technology, or stable coins that represent either fiat money or actively traded commodities.) For most purposes the distinction between crypto and conventional financial assets will disappear.

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