



Post-trade made easy



Blockchain in Capital Markets

The Prize and the Journey

February 2016

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Executive summary

The blockchain concept, most known for being the technology underpinning Bitcoin, has generated a huge amount of interest within capital markets.

Blockchain (or distributed ledgers) offers a new approach to data management and sharing that is being proposed as a solution to many of the inefficiencies afflicting the industry. The prize on offer is a new architecture, where all capital market participants work from common datasets, in near real-time, and where supporting operations are either streamlined or made redundant.

Technology experts in Fintech start-ups, incumbent market infrastructure providers and banks are working on the underlying technology and its potential uses.

However, the journey from today's system to a new technological paradigm will take time. The obstacles to be overcome are significant, and it is far from clear what will ultimately emerge.

We see three routes to the adoption of the technology:

- Challenger disruptions developed outside of the core capital markets ecosystem. We expect to see these in the next 18 to 24 months.
- Collaborative efforts to shift the existing value chain to blockchains. While such efforts are already starting, with potentially massive benefits, it is likely to take more than ten years to overhaul core parts of the system.
- Mandated policy where supervisors direct the industry to introduce new market infrastructure, so that costs are reduced or that operational or systemic risk is lessened.

In order to work together to shape a new future, the industry needs to take a collective view on the potential of the technology. It must embrace this potential, show patience with its development and invest in various innovative solutions to bring it to bear.

It is up to major established players in the market to work with innovators to develop standards, while also preserving the existing strengths of the ecosystem, and navigating the complex worlds of regulation and legal oversight.

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Introduction

The aim of this joint report by Euroclear and Oliver Wyman is to help leaders in capital markets to understand the potential of the technology, lay out the paths for its adoption, and present the decisions that are required by capital markets firms today.

We first **unpick the component parts of the technology**. We believe the conceptual case for distributed ledger technology is compelling. It is a genuinely new and more efficient way to organise financial transaction data. Blockchain technology encompasses a range of innovations that build upon each other, and need to be understood separately. We also show how some of the potential benefits could be achieved by existing systems and technology.

Secondly, **we look at how blockchain could be applied to capital markets**. We describe a utopian view of capital markets, built upon blockchains and associated innovations. We look at the benefits that would be realised, and the impact on different parts of the value chain and participants.

We examine some of the major hurdles that will need to be overcome – in terms of technology, industry coordination, standards and governance, laws, regulation and policy.

Then **we look at potential uses, and paths to adoption**. Uncertainty that the market will ever be able to move towards a blockchain-based system will rightly persist until practical means of application are developed, the technology is operating at scale, and benefits are realised and quantified.

Finally, **we look at the next steps for the industry**. We make seven recommendations for capital markets firms to consider over the next 12 to 18 months.

A note on terminology: the industry now uses the phrases 'blockchain' and 'distributed ledgers' interchangeably:

Blockchains: most known for underpinning the Bitcoin protocol, the term is used to describe a process of adding blocks of cryptographically signed data to form perpetual and immutable records.

Distributed ledgers: a term which describes a database architecture where all nodes in a system collaborate to reach a consensus on the correct state of a shared data resource.

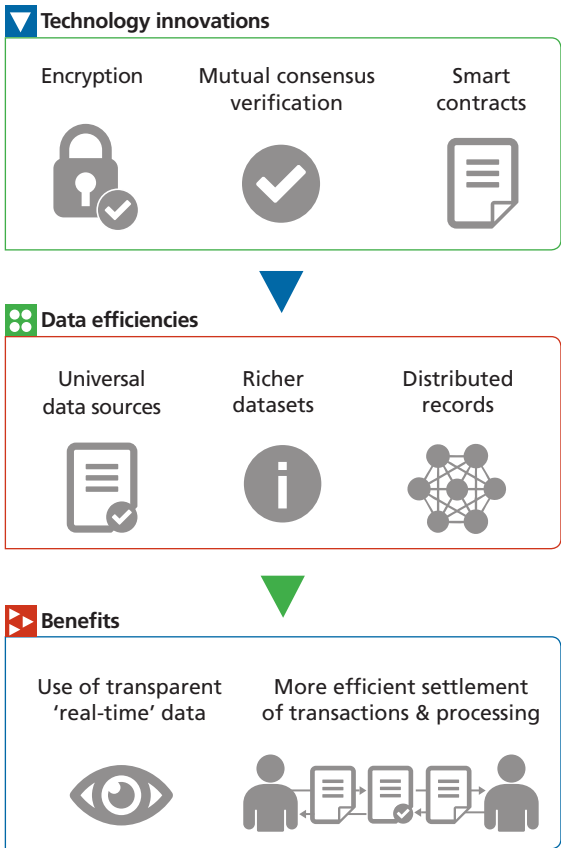
Not all distributed ledgers necessarily use the blockchains. However, for the purpose of this report, we assume that distributed ledgers in capital markets will be variations on the blockchain theme and so we use the terms interchangeably.

What does blockchain technology offer?

Unpicking the components

Blockchains are built on a series of innovations in organising and sharing data. The objective is to create a single version of the truth, used by all participants, containing a much richer dataset than exists in any one system today. This will in turn enable new industry processes to be developed, based on the use of transparent real-time data, immediate settlement of transactions and the expansion of auto-executing 'smart' contracts, with business logic encoded into the ledger.

The separate innovations that make up blockchains are shown in the figure below.



Technology innovations

New methods and applications of **encryption** technologies can enable the security and anonymity of highly sensitive data in a shared-access environment. They can allow users to reveal information selectively to others as needed.

Mutual consensus verification protocols allow a network to agree updates to the database collectively, with a certainty that the overall dataset remains correct at all times without the need for a central governing authority. There are a number of different approaches to consensus protocols, but a common requirement is that there are adequate safeguards to prevent malicious manipulation (or cyber risk) and ensure that no single point of failure exists.

Smart contracts are programmes or code uploaded to a ledger, rather than basic passive data entries. Smart contracts are programmed to generate instructions for downstream processes (such as payment instructions or moving collateral) if reference conditions are met. Like passive data, they become immutable once accepted onto the ledger.

Figure 1: Simplified view of Distributed Ledger approach

Data efficiencies

These new technologies make it possible for a group of independent parties to work with **universal data sources**, automatically reconciling between all participants. In principle, any stored data record could be represented on a blockchain, from ownership of assets to contractual obligations, credit exposures or static data.

A multitude of data types can be 'hashed', encrypted and entered into the ledger to create **richer datasets** than today. For example, ownership data could be entered which shows multiple levels of beneficial ownership, collapsing the hierarchies that exist in various custody arrangements.

Distributed records are stored locally by participants as their golden source of information. Many of their existing systems that are currently used to track and maintain their records of holdings and transactions could be retired. The need to interrogate centralised databases or send messages to other participants to ensure data alignment is removed.

Benefits

Transparent real-time data would create major operational benefits for users. It could remove the need for data enrichment (such as aligning trade data with settlement data), reconciliations and disputes amongst counterparties. Participants could selectively reveal trusted data to another counterparty ahead of trade time to provide greater certainty of their own worthiness, thereby reducing risk and/or credit exposures. Finally, once placed on a blockchain, assets not typically traded (such as invoices) could be more easily considered as reliable sources of value to be used as collateral, or as a demonstration of worthiness.

More efficient settlement of transactions and processing would occur as everyone sees the same data, and updates are quickly circulated across the market. Cash transactions could settle in (near) real-time since the trade is complete when the next update to the blockchain is agreed, embedding the transfer of ownership of an asset or other agreement. This would remove the need for post-trade affirmation or confirmation and central clearing during the settlement cycle (which has in some cases been shortened to minutes or even seconds). Since all participants would now use the same underlying dataset for trade-related processes, the blockchain reduces the scope for data errors, disputes and reconciliation lags, speeding up the end-to-end process.

Other ways to achieve these benefits

Some of these benefits might be achievable with existing technologies, or indeed with no actual technology at all.

Adoption of blockchain technology will be reliant upon aligning industry standards for the process, data terms, contractual documentation and so on. Regardless of technological innovation, this standardisation can improve settlement times and cut costs even using existing market practices and infrastructure.

A central authority could maintain a single universal source of the truth database recording asset transactions which all participants use as their golden source: essentially an expansion of the role taken by a Central Securities Depository (CSD) in a traditional infrastructure. Likewise, features could be built into the existing market infrastructure, allowing the auto-execution of coded logic embedded into smart contracts. Indeed, smart contracts already exist in basic form. Finally, real-time settlement of asset transactions occurs today in

some circumstances. It is a market choice that a settlement cycle no shorter than two days is standard for cash equities in European markets. The industry operates at the speed of the slowest trades.

However, there are additional benefits to blockchain that are not feasible with existing technology. Having all participants operating from their own local version of the golden source reduces system duplication, with the associated cost and risk of errors. There is no mass demand placed on any central authority, reducing the risk of it being overloaded. Counterparties can bilaterally reveal information to each other without querying the centre. With no central authority, there is no single point of failure. Entries into the blockchain are irrevocable once agreed, so there is a reduced risk of manipulation (to change an entry, one needs to change all subsequent versions of the ledger, although this presents certain challenges that are discussed later). Distributed ledger functionality also allows more sophisticated smart contracts to be used, and the full benefits to be realised.

In addition, activity around blockchain technology is creating energy for further improvements to the system. A common barrier cited for some innovations is how to agree on a lead provider to hold central responsibility and power in an essentially monopolistic position. Perhaps the only way for the industry as a whole to agree *who* should develop such solutions is if they *all collectively* develop and own it together as in the case of blockchain.

Reach of blockchain applications

A broad range of innovators are creating solutions using blockchain technology. The most prevalent are active in the ecosystem of cryptocurrencies (and associated tools such as wallets). These essentially offer a form of retail payments. A range of applications across financial services are being considered, particularly relating to wholesale payments/correspondent banking, trade finance and other forms of transaction banking. In this report, we focus on applications in capital markets and associated activities such as post-trade and securities servicing.

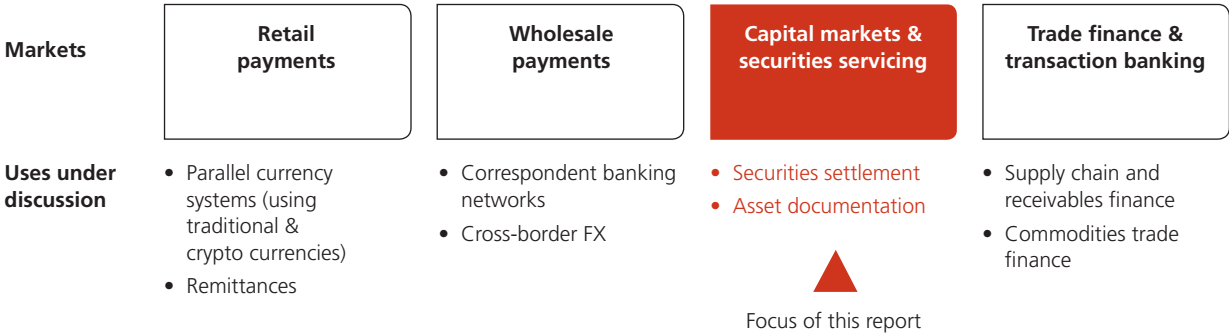


Figure 2 – high-level blockchain application in financial services

In the next section, we examine what blockchain technology could achieve in the capital markets industry.

A blockchain-based capital markets system

Storing and agreeing datasets of financial obligations and ownership forms the basic core of capital markets operations. The current methods are highly complex, utilise fragmented IT and data architectures and suffer from a lack of common standards. This creates the continual need to reconcile data with massive systems and process duplication, leading to high costs and protracted time to execute tasks. Could blockchain be the structural change the market needs?

What does utopia look like?

If we started from a blank sheet of paper today, with access to efficient, well-architected blockchain technologies, we would expect the market structure and processes to look very different.

The record of each security would be held on a flat accounting basis - that is, with multiple levels of beneficial ownership in a single ledger. There would be no need to operate data normalisation, reconcile internal systems, or agree exposures and obligations. We would have standardised processes and services, shared reference data, standardised processing capabilities (such as reconciliations), near real-time data and improved understanding of counterparty worthiness. For privileged participants such as regulators, we would have transparent data on holdings, among many other improvements.

To bring this ideal scenario to life, we lay out below a stylised 'capital markets utopia' based on blockchains and smart contracts.

1. Securities transaction

Client A and Client B are matched on an execution venue, and automatically verify that the other has the means to complete the transaction. (For example, Client A demonstrably owns the security on the asset ledger, and Client B demonstrably owns cash on the cash ledger). Client A and Client B jointly 'sign' the transaction by applying their private keys to unlock their asset or cash, and then by transferring ownership to the recipient via their public key. The signed transaction is broadcast to the distributed ledger to be validated and recorded in the next update, along with a simultaneous update to a cash ledger.

2. Asset servicing

For new issues, assets are issued directly onto the asset ledger. In fact, securities themselves could be unbundled so that the individual cash flows, and the rights they encapsulate, could be transferred separately.

Mandatory events and distributions can be managed via smart contracts embedded within the securities. Complex events can be structured as simple Delivery Versus Payment (DVP) transactions between issuers and investors. Fund managers will have perfect visibility of their pools of investments in securities (the asset side of their balance sheet), and will be able to manage investors' holdings in their funds via units created as tokens on a fund ledger.

With flat accounting, the multiple custody layers are shrunk to a single function. Currently, a single security may be held in as many as five or six layers of custody (stockbroker, sell-side bank, local custodian, global custodian, CSD, etc.) each with their own accounting views. Here the asset is held by a form of wallet provider recording the final beneficial owner.

3. Derivative transaction

The utopian setup for derivatives represents the biggest change. In the first instance, unbundled securities could enable new approaches to financial engineering, enabling specialists to construct bespoke instruments consisting of individual cash flows that meet precise needs in terms of timing and credit risk. These instruments could be financed by issuers selling their own instruments that match the cash flows they expect to achieve, in essence creating swaps without the need for balance sheet intermediation.

Moreover, derivatives will be created as pre-programmed smart contracts, capturing the obligations of the two counterparties (such as margin agreements or swap conditions).

Novating the trade via a Central Counterparty Clearing House (CCP) would continue to allow dealers to net their exposures. Posting collateral to the CCP in the form of initial and variation margin can be done either by escrowing cash on a cash ledger, or by allocating assets held on other asset ledgers to a collateral ledger. In the future, if a central bank issues freely available electronic currency on demand, it would allow dealers to pledge the eligible portion of their inventory to the central bank and use central bank cash collateral when trading.

The smart contract can automatically recompute exposures by referencing agreed external data sources that recalculate variation margin. Interoperable derivative and collateral ledgers would automatically allow the contract to call additional collateral units on asset ledgers to support these needs. At maturity, a final net obligation is computed by the smart contract, and a payment instruction automatically generated in the cash ledger, closing out the deal.

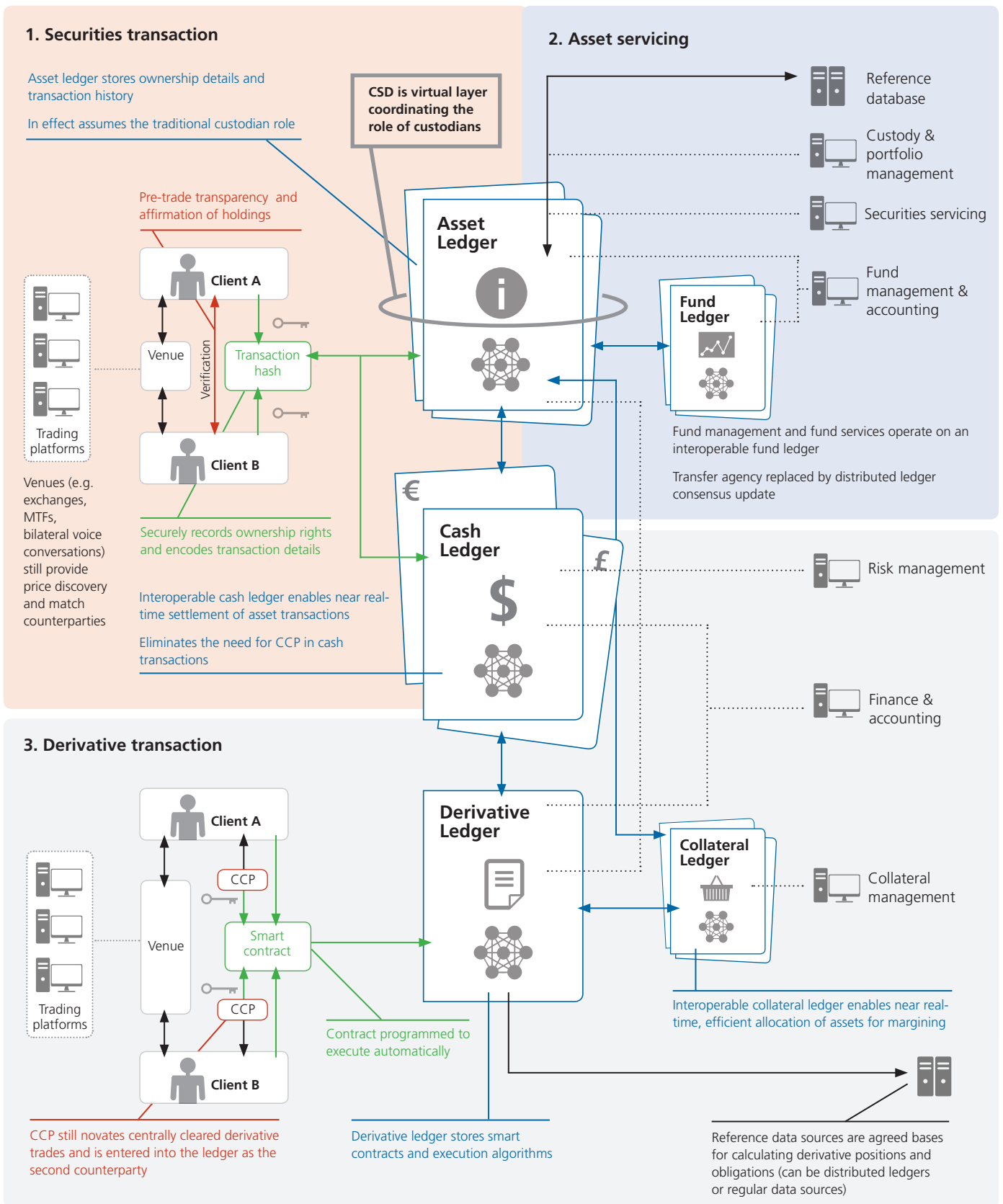


Figure 3 – Utopian view of capital markets using blockchains

Potential benefits for capital markets

The blockchain vision is clearly a massive change to the structure of capital markets. Why would the industry want to begin to go down this route? To understand the level of interest, it is worth thinking about the benefits across pre-trade, trade, post-trade and securities servicing.

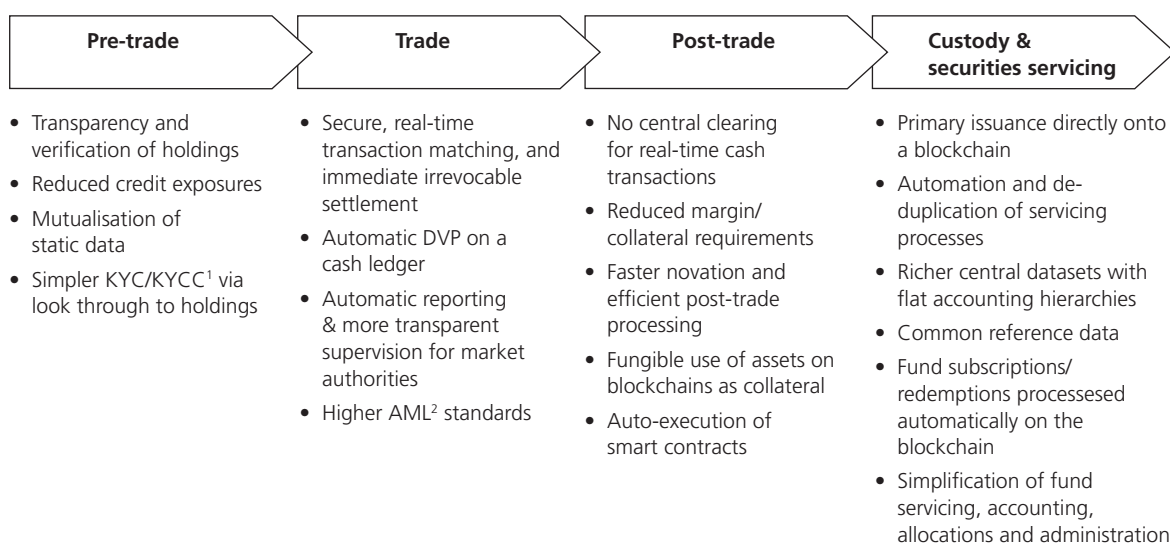


Figure 4 – benefits of adoption

¹ KYC – Know Your Customer, KYCC – Know Your Customer's Customer

² AML – Anti-Money Laundering

What are the implications for market structure?

With such a fundamental change to the system, the role of market participants would change, with profound impact on their business models.

Clients

Many clients (particularly on the buy side) will expect to accrue the most benefit, from the reduction in costs of capital markets dealing and securities servicing. Retail and wholesale investors may transact more among themselves, now with guaranteed execution on open markets.

Dealers

Dealers will still play a valuable role in the market by being better at sourcing liquidity for assets, or taking

principal risk where liquidity is thin. Their primary value will be in price setting, advising on transactions and execution management, rather than in providing market access.

Private trading companies

A near real-time settlement process would have major implications for private trading companies, particularly market-makers and High-Frequency Traders (HFTs). If trading moves to pre-trade validation of ownership prior to the asset being sold,

HFTs will need to wait (for even just a few seconds) for each settlement cycle before they can transact again. This would give rise to a substantial slowdown in their rate of activity, which may mean that the scope of blockchain is limited only to post-trade processes in markets where HFT is insignificant, or in markets which could operate on hybrid models, enabling HFTs to trade on credit lines that are regularly cleared through the blockchain consensus cycle.

Venues

Execution venues may remain much as they are today, facilitating price discovery and matching counterparties who wish to deal. The cryptographic signature data formed at the time of transaction also serves as the data required for settlement, increasing the value of the role provided by venues. However, given that trading strategies such as HFT account for such a large share of traded volumes (and hence fee revenue), profound changes to market structure may have a knock-on impact on exchanges and other venues.

CCPs

In a near real-time asset transaction settled for cash, there is no longer a need to clear the transaction centrally (as both sides have pre-trade transparency that their counterpart will be able to meet the terms of the transaction, and settlement happens almost instantly). However, transactions with a longer lifecycle (such as derivatives) still need the advantages of CCP novation to achieve netting benefits and reduced future counterparty credit risk (replacement risk).

Custodians

Distributed asset ledgers with flat accounting structures could remove some of the role that custodians and sub-custodians play today. Custodians' role may change to that of a 'keeper of the keys', managing holdings information and ensuring automated securities servicing operations are performed correctly. It may lead to the

unbundling of accounting from the other services provided, and erode their stickiness for clients and the ability to cross-sell other services (such as collateral management).

CSDs

The need remains for coordinated oversight of asset issuances and ensuring orderly functioning of the market. As for the custodian, the ledger may become the primary destination of asset issuances, although we might expect traditional CSDs to play the role of operational governance, responsible for coordinating the evolution of the ledger protocols, managing the introduction or cancellation of tokens on the ledger, regulator interface, and so on.

Hurdles to adoption

The path to adoption for blockchains in capital markets requires clearing a number of hurdles. The technology requires further development to be truly scalable, as well as common standards to be agreed. Sufficient investment is needed to develop applications and run implementation programmes. An industry unaccustomed to cooperation will need to reach agreement on a wide range of challenging issues regarding implementation.

Below, we outline six major areas that need to be addressed before widespread adoption will become feasible.

Scalability of the technology

Blockchain technology remains nascent, even if it is developing quickly. Questions over the scalability and throughput capacity of blockchains are starting to be successfully answered, with order of magnitude improvements over the original Bitcoin platform, although the current standard of technology remains some way behind the levels required to support adoption in capital markets. Much larger datasets will need to be handled if any core part of the capital markets system is to be replaced.

Moreover, there will be very high standards set for the security, robustness and performance of blockchains used for major industrial purposes. Integration with existing non-blockchain systems (such as risk management platforms) will also be a requirement for the foreseeable future.

Regulation and legislation: Fitness for purpose

Disrupters in other industries (such as Airbnb and Uber) have adopted an 'act first, seek forgiveness later' approach to regulation. Innovations in financial markets, however, require the explicit blessing of regulators well ahead of time. New regulatory principles may be needed where blockchain technologies become an integral part of the market infrastructure, and where consensus protocols are run through an international network of nodes. For example, the responsible parties for system integrity would need to be decided.

A considerable number of aspects of law will also need to be reinterpreted or changed through

primary legislation. These issues include the legal definition of the finality of settlement which presupposes existing market processes and central data sources held at the CSD. Similarly there currently exist geographic territorial requirements concerning where data is physically maintained as golden source, a concept that does not fit with copies of the ledger being distributed to nodes on a global basis.

Finally, as the mechanisms currently stand, records are irrevocable once entered into a blockchain, and amendments require changes to all subsequent blocks. This is one of the inherent security features of the blockchain concept. However, this has implications for judicial interventions in the event of disputes or outcomes of other legal proceedings. Regulators will not accept a mechanism that prevents their lawful intervention.

Therefore, the design of the system needs to incorporate features (at least for assets) that allow for a change in ownership to be enforced in the absence of compliance with the existing owner. This could be achieved by a multiple skeleton key approach (perhaps with the combination of keys held by the CSD and the issuer, or regulator), or by enabling a process to cancel assets in an issue and introduce replacements when mandated by a legal authority.

So far, several regulatory bodies have expressed interest in blockchain technologies. Because they see the potential to reduce inefficiency and costs, they are ostensibly keen to work with the industry.

The need for a robust cash ledger

Short of fiat currency being recorded on a blockchain (as the Bank of England has already imagined in a research white paper)*, an interoperable cash ledger will require some intermediary step. The inability of existing cryptocurrencies to be perceived as stable sources of value will need to be tackled.

There are a number of ways to innovate in this area, but fundamentally, cash would be just another asset class on a ledger. Commercial enterprises could create specific cryptocurrencies for interbank use (with a permanent par value, and underpinned by near risk-free or escrowed cash holding). Another, simpler way, is to use existing accounts at banks where participants deposit liquidity for trading in segregated accounts, with changes to the cash ledger reflected on the balance in their trading account.

Common standards and governance

Industry alignment will be required on certain design points, such as: whether systems are completely open (as with Bitcoin) or use permissioned-base access requirements; the principles for suitability in interacting with the ledger; and the interoperability between different networks, which may potentially run different consensus protocols and safeguards against coding errors, creating unforeseen knock-on effects (particularly with smart contracts). These will all be important to agree and enshrine in the initial scoping of new systems and standards for interoperability. There will need to be clear agreement on how blockchains will be managed and improved once they are live. This would involve governance processes, update approvals, roles and responsibilities, and so on.

Operational risks of transition

Operational risks come into play through the adoption of new technologies, either by running parallel infrastructures whilst disruptive solutions grow, or from more substantive 'lift and shift' migrations. A significant amount of work will need to go into ensuring that these operational risks are minimised. The risk of technical failure during implementation will require participants to be able to recover quickly, or be able to revert to the traditional ecosystem as a fallback.

Managing anonymity

Anonymity is a critical requirement for many processes in capital markets. Cryptography could go a long way in protecting anonymity in a blockchain. However, it will require meticulous key management records, maintained separately from the blockchain for each participant, to decrypt and reference back the entries they hold an interest in. Furthermore, the ability to reveal selective information to counterparties for credit assurance, for instance, makes it extremely difficult to prevent errors that result in major data breaches. And overarching all these considerations is the question of how to link cryptographic identities to real world identities. Some people envisage Know Your Customer (KYC) assessment to be a responsibility of the validation nodes in a permissioned network. Others imagine a more far-reaching change, where identity management is a service offered independently of data validation.

In addition, there is a degree to which regulators are likely to require perfect views of unanonymised data in the ledger in order to perform adequate market surveillance and maintain anti-money laundering and anti-terrorist financing processes.

**Innovations in payment technologies and the emergence of digital currencies – Quarterly Bulletin, 2014 Q3*

Where can you start?

Initial use cases

Any journey towards a capital markets system based on blockchain technology will be a step-by-step adoption rather than a big bang reorganisation. The system is simply too big, complex and important. This means individual use cases for the technology need to be identified and solutions developed. Initially, these use cases need to be standalone – that is, they can be adopted within or alongside today’s architecture without being dependent on a critical mass of assets already being on blockchains.

Figure 5 below lays out an initial range of potential use cases. Technical specialists in banks, market infrastructure firms and Fintech start-ups are working on software to support these concepts and are looking for institutions with whom to cooperate and adopt prototypes. Once single use cases prove themselves, the technology will no doubt be adopted in unexpected ways.

Type	Use case	Capital markets examples	Other industry examples	Rationale for adoption
First order adoption – works as standalone	<ul style="list-style-type: none"> Tokenising assets not currently on a common ledger (new blockchains or tokens on Bitcoin) 	<ul style="list-style-type: none"> Pre-IPO equities Syndicated loans Depository receipts 	<ul style="list-style-type: none"> Physical objects e.g. diamonds, paintings 	<ul style="list-style-type: none"> Proof of ownership/provenance Settlement efficiency
	<ul style="list-style-type: none"> New blockchains to share data between participants 	<ul style="list-style-type: none"> KYC data sharing Collateral ledger to support efficient margining Reference and market data 	<ul style="list-style-type: none"> Supply chain data invoicing Trade finance 	<ul style="list-style-type: none"> Efficiency of information collection
	<ul style="list-style-type: none"> New blockchains to process transactions 	<ul style="list-style-type: none"> Corporate finance bookrunning Fund portfolio management 	<ul style="list-style-type: none"> Inter-bank blockchain to support cross-border banking payments Intra-bank blockchain to support cross-bank accounting 	<ul style="list-style-type: none"> Disintermediation of actors Simplified data and infrastructure
Second order adoption – reliant upon critical mass of assets on blockchains	<ul style="list-style-type: none"> Monitoring of richer datasets 	<ul style="list-style-type: none"> Concentration monitoring Market surveillance Pricing data 	<ul style="list-style-type: none"> Trade flows, transit data 	<ul style="list-style-type: none"> Powerful understanding of data
	<ul style="list-style-type: none"> Processing using blockchains 	<ul style="list-style-type: none"> Securities servicing Regulatory reporting 		<ul style="list-style-type: none"> Efficient processing capabilities

Figure 5 – potential use cases

Challengers, collaborations or mandated policy?

The way blockchains are developed will shape the future landscape and the role of today's capital market participants. Is an application being introduced by existing participants, or is a new entrant looking to displace incumbents? Is the new infrastructure replacing existing processes, or is it creating a rival system?

We divide the potential adoption paths into three types: challengers, collaborations and mandated policy.

Innovation type	Lead innovators	System created	Adoption path
Challengers	<ul style="list-style-type: none"> • Fintechs • Competitors from other parts of the value chain 	<ul style="list-style-type: none"> • Competing with the existing system 	<ul style="list-style-type: none"> • Customer by customer
Collaboration	<ul style="list-style-type: none"> • Existing participants, market infrastructures • Industry consortia 	<ul style="list-style-type: none"> • Parallel to the existing system 	<ul style="list-style-type: none"> • Firm by firm based on each individual's economic interests
Mandated policy	<ul style="list-style-type: none"> • Policy makers 	<ul style="list-style-type: none"> • Replacements to the existing system 	<ul style="list-style-type: none"> • System-wide (or by sub-segments) • Mandated by policymakers or regulators

Figure 6 – adoption paths

Challengers

The challenger approach aims to force or attract the use of blockchain technology. Some niche and truly novel solutions may find successful applications quickly. However, the capital market industry is characterised by a high level of concentration among major players, conservatism and stringent regulation.

There is currently a frenetic level of activity across the industry in developing use cases. Due to the reliance on the formation of a network of users before benefits can be realised, developing a business model that can be monetised is difficult. Challengers will need strong levers to increase market adoption and overcome inertia, based on reducing users'

costs, risk, or capital consumption. This is particularly challenging in a networked business where the business case for any participant depends on adoption by several of its counterparties. We expect to see a number of start-ups drop out of the market as their cash resources are eroded by years of development, and by the difficulty in securing users in the concentrated capital markets space and viable revenue streams even from those uses that do gain traction. Failure rates are likely to be over 90%; a typical proportion for any new technology.

Successful applications will create new parallel ecosystems with a base of incumbent users or completely new actors. An example might be a

*90% of startups fail – Forbes, 16 January 2015

corporate bond ledger looking to introduce cheaper and more efficient ways to trade bonds. This initiative could start as niche applications focusing on issuers priced out of existing mechanisms. However, if it proved cheaper and more efficient in time, issuers might be attracted to the cheaper ledger. After a while, the market could reach a point where the bond ledger becomes so attractive to all issuers that bonds are only issued using the technology.

Collaborative innovations

The collaborative approach relates to adoption by existing incumbents. The need to achieve consensus (at least of a critical mass of the industry) is time-consuming and typically hampered by the competing preferences and positions of the actors in the value chain, disagreement on technical issues and inertia.

One example of non-technological innovation in capital markets was the introduction of International Swaps and Derivatives Association (ISDA) agreements for trading swaps. This innovation eventually brought enormous benefits to the industry, but only after a lengthy adoption process.

Existing participants are already working on uses for the technology, both for internal purposes and for working on in consortia with other participants. This investment is likely to continue, and consortia will get together to align the industry on issues such as standards, technical protocol choices, and legal and regulatory questions. Early examples include firms such as R3 CEV, or the Post Trade Distributed Ledger initiative.

Mandated innovation

Policy maker intervention is typically initiated to reduce costs for end customers or to lower systemic risk. This approach is the slowest. It starts with a policy desire to implement change, which may be resisted by market incumbents in rounds of public consultation, before evolving into a final directive to adopt a new process. In the blockchain sphere, this eventuality will probably only occur once the technology is proven and has been used in parallel in a range of markets, although the recent announcement by the Australian Stock Exchange that it is considering building its next generation CSD using blockchain technology potentially points to a new willingness for infrastructures to get ahead of the technology curve.

The implementation of TARGET2 Securities (T2S) in Eurozone settlements, led by the European Central Bank, is a recent major example of mandated change. Earlier examples include the creation of CREST in the UK, directed by the Bank of England. Interestingly, the implementation of CREST occurred very rapidly, in part because the prior collapse of an earlier attempt to create a dematerialised settlement system, led by the London Stock Exchange, created the conditions in which the market accepted that change was necessary and inevitable.

Adoption timelines

It is important that practical uses of the technology, in controlled non-critical processes, are seen in the next 12 to 18 months. This will ensure ongoing investment and the ability to upgrade and scale the technology in a live environment. The focus needs to be on discrete, actionable 'first order' use cases, where only a small number of initial participants is required to gain the necessary critical mass. These first innovations will be in niche applications. Alterations to narrow areas of existing processes, and/or bold transformations of smaller markets, are most likely to be successful.

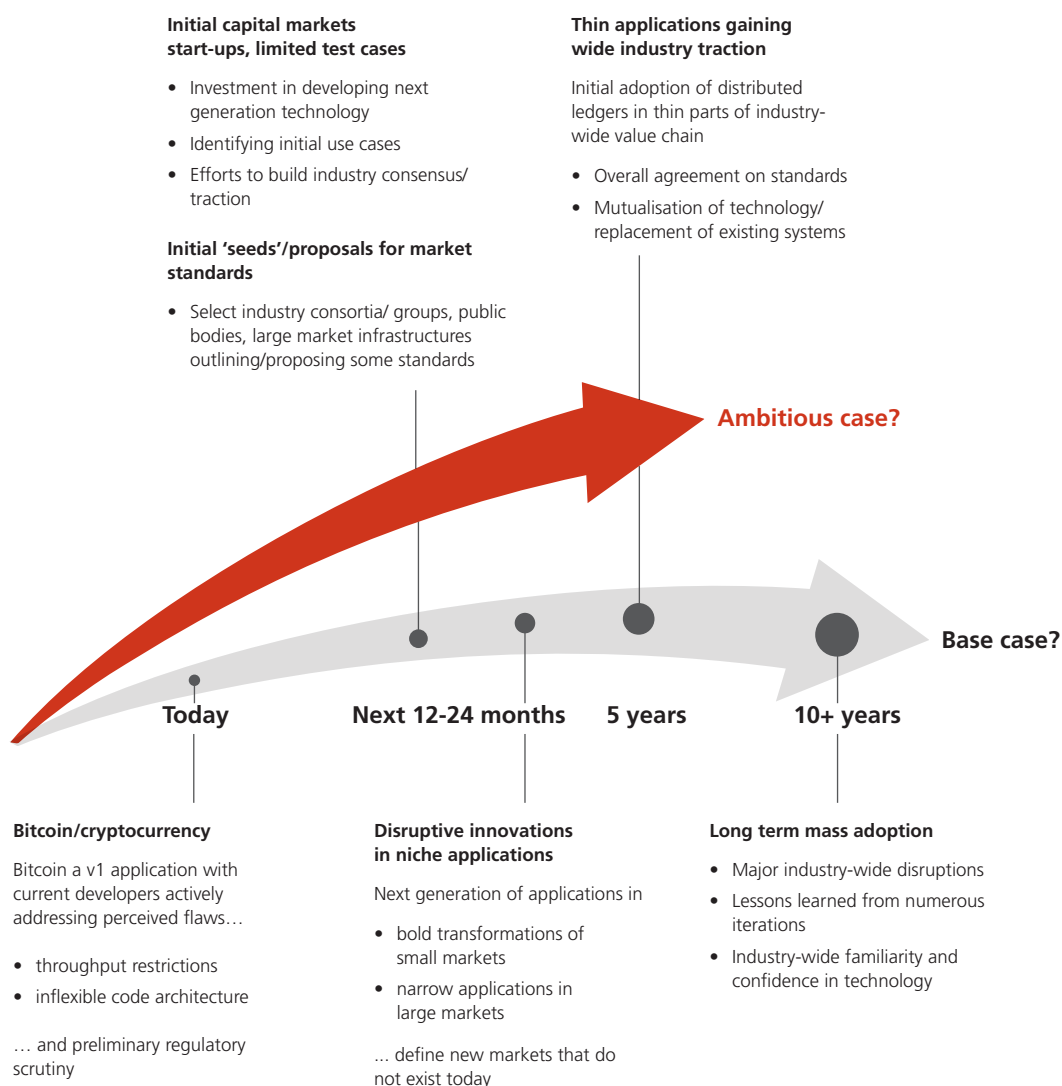


Figure 7 – potential adoption paths

After a 3 to 5 year period, it is possible that substantial applications will start to be used by the majority of large players in an important market. This expansion will stem from the growth of initial niche successes, or from second generation ideas emerging from previous failures.

Long-term mass adoption across multiple markets, processes and asset classes is only achievable if the following elements are present: extremely robust technology offerings; deep familiarity with, and great confidence in, technology solutions; and massive investment of time and resources by a large number of market participants in both commonly agreeing the standards to be used by every participant, and in implementing the technology into existing systems front-to-back. Given the adoption paths of similarly enormous endeavours (and we would argue the scope of such a radical transformation could easily

dwarf the ambition level of T2S in Europe), this is unlikely to hit the planning boards before 2020, and deployment will probably be many years after that.

We note the possibility that technology advances far faster than we could imagine. Disruptive forces have appeared to revolutionise other markets in the blink of an eye. However, in this instance, such a pace seems unlikely due to the fundamental role of capital markets in the world economy and the level of regulatory oversight.

Potential savings

Moving to a market infrastructure built on blockchain will be an enormous undertaking. It will require huge investment to achieve anything close to the utopia described earlier, both from those creating the infrastructures and tools, and from the participants in the network.

Two aspects of the cost base are under attack. Firstly, the internal costs of operations and IT systems, including capital costs, maintained by banks and other market participants; and secondly, the fees paid to external providers of services, such as post-trade solutions or back-office outsourcing.

IT and operations expenditure in capital markets is currently close to USD100-150 billion per year among banks¹. On top of that, post-trade and securities servicing fees are in the region of USD100 billion². Significant capital and liquidity costs are also incurred as a result of current delays and inefficiencies within market operations.

Direct savings from blockchain would need to come from the decommissioning of redundant or duplicative systems, reduced operational overheads and cost-sharing across institutions. Reducing firms' financial resource requirements (e.g. by reduced counterparty credit risk) may also help to drive down economic costs of business.

¹Oliver Wyman analysis

Next steps for the industry

In the face of uncertainty about the technology, vaguely developed use cases and only conceptual promises of enormous cost saving, industry participants would be forgiven for taking a wait-and-see approach. This may be unwise. If adopted in a widespread fashion, the new technology will bring fundamental changes to the role of different market participants and could shake up each part of the value chain.

We would make seven measured suggestions to the industry.

1. Work on concrete proofs of concept

Innovators need to clearly define their use case, show why distributed ledger technology is necessary, and articulate why this will bring benefits to the industry and value for clients. The greatest innovations anticipate needs that customers did not even know they had (no one 'needed' an iPhone in 2006).

2. Challenge service providers to innovate

Where economics are not necessarily attractive for developers, or worse, where a better solution actually cannibalises service providers' revenues (and reduces customer costs), customers need to challenge participants to invest in the innovation to bring about a better ecosystem.

3. Understand current quantification of operational costs, isolating savings from blockchains

To drive the ultimate decision whether to develop and/or adopt new blockchain solutions, participants need to compile an accurate picture of specific challenges and operational costs, and isolate the areas where new solutions will be impactful.

4. Continue industry-wide engagement, turning hype into collective endeavour

There is a risk that the hype peters out, investment dries up, and what was once considered promising technology innovation falls on to the industry scrap heap. A persistent failure to overcome initial barriers is likely to sap momentum in the industry, and participants excited by what may lie ahead need to continue driving the industry forward by means of their engagement and collaboration.

5. Participate in prototypes and embrace 'learn by doing'

Initial solutions are likely to be imperfect, and further solutions will benefit from the lessons learned by others. Participants need to embrace nascent technology solutions so that areas requiring refinement are exposed, and that successes breed further innovations and better solutions.

6. Bring the business mind to technological start-ups

There is no substitute for the deep collective knowledge held by the major participants in capital markets. Everything from significant industry

conventions to detailed regulatory requirements need to be well understood by the technical specialists. It is up to established players to ensure that this knowledge is disseminated and used.

7. Prepare the narrative for regulators and supervisory bodies

Regulators and supervisors are critical stakeholders in the industry's adoption of the technology. Regulatory working groups are already being set up, and participants must look to engage fully with authorities to ensure that they are thoroughly briefed on all issues, and that their concerns on security, robustness, legal measures and a multitude of other subjects are actively considered and addressed.

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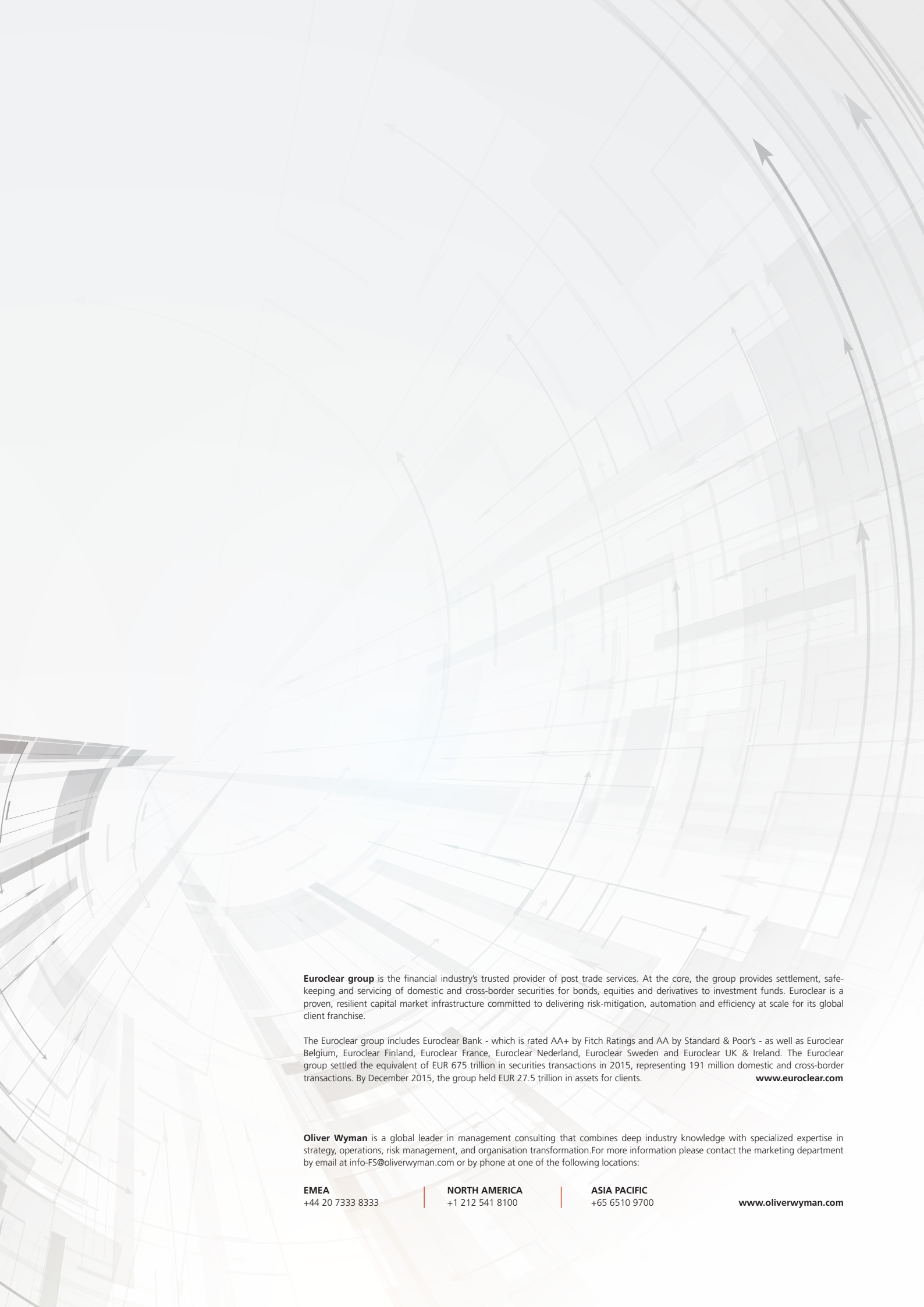
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