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Towards Digital Capital Markets

How and why cutting-edge technologies can reshape global markets for the better

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Contents

Abbreviations

AI	Artificial Intelligence
AML	Anti-Money Laundering
API	Application Programming Interface
APAC	Asia Pacific (region)
BdM	Banco de México
BoE	Bank of England
BIS	Bank for International Settlements
CBDC	Central Bank Digital Currency
CCP	Central Counterparty
CHAPS	Clearing House Automated Payments System
CLS	Continuous Linked Settlement
CSA	Credit Support Annex
CSD	Central Securities Depository
dApps	Decentralized Applications
DeFi	Decentralized Finance
DLT	Distributed Ledger Technology
DTC	Depository Trust Company
DvP	Delivery-versus-Payment
ESMA	European Securities and Markets Authority
EUR	Euro (currency)
FCA	Financial Conduct Authority
FED	Federal Reserve (US)
FX	Foreign Exchange
GBP	Great British Pound (currency)
GFC	Global Financial Crisis (2008-2009)
HKMA	Hong Kong Monetary Authority
HQLA	High-Quality Liquid Assets
ICMA	International Capital Markets Association
ICSD	International Central Securities Depository
KYC	Know Your Client
LDI	Liability-Driven Investment
LSEG	London Stock Exchange Group
MXN	Mexican Peso (currency)
PC	Personal Computer
PvP	Payment-versus-Payment
NFT	Non-Fungible Token
RTGS	Real Time Gross Settlement (Central Bank payment system)
SEC	Securities and Exchange Commission
SPEI	Sistema de Pagos Electrónicos Interbancarios
SSA	Sovereign, Supranational, and Agency (SSA) Bonds
TradFi	Traditional Finance
T+1 / T+'x'	Trade date +1 day, and so on
UK	United Kingdom (country)
US	United States (country)
USD	United States Dollar (currency)

Infographics

Executive summary

'Towards Digital Capital Markets', offers a comprehensive perspective on how next-generation technologies, particularly Distributed Ledger Technology (DLT), have the potential to transform global Capital Markets for the better.

We begin by analyzing the limitations and inefficiencies within incumbent Capital Market structures and propose how and why a hybrid approach that combines advanced technologies with existing financial systems could, at scale, mitigate risk, achieve sustainable cost reductions, enhance operational efficiency, and improve transparency and resilience across the market.

Today's Capital Markets operate through a complex web of platforms, processes and procedures, each governed by distinct regulations and procedural frameworks. This fragmentation results in substantial operational friction, relatively high and opaque costs, and elevated risks especially for cross-border business.

Existing Capital Markets also depend heavily on intermediaries, for example across Foreign Exchange (FX) businesses. This reliance inflates costs and ties up liquidity, as institutions must maintain large currency reserves to manage structural capabilities and constraints. Another challenge is the sequential nature of settlement cycles: this leads to delays between trade execution and settlement, driven by relatively inefficient processes within legacy systems. Furthermore, regulatory fragmentation across jurisdictions compounds issues, increasing costs and complexity for cross-border transactions while opening the door for unfavorable forms of regulatory arbitrage, which can compromise market integrity.

To address these inefficiencies, this report proposes a hybrid model that blends Decentralized Finance (DeFi) innovation with Traditional Finance (TradFi) structures, leveraging DLT and aspects of Artificial Intelligence (AI) as key enablers to drive compelling business model change towards Digital Capital Markets.

DLT could help standardize and consolidate transaction processes across fragmented market structures and markets as a whole. Through offering permissionable, interoperable, and scalable databases, DLT can, for example, offer real-time recording of transactions, reducing the role of intermediaries and accelerating settlement times. DLT applications within a hybrid model are particularly promising for tokenization,

Applied in the right way, institutional digital business models can mitigate and even remove risks at scale, and unlock widespread optionality, optimization and revenue potential through new solutions to industry-wide challenges and opportunities. The fundamental advantages of blockchain-based, digital business models include enhanced controllability, streamlined connectivity of processes and assets across Capital Markets, and can deliver the potential for immediacy in specific commercial, organizational, and market circumstances.

where financial instruments, such as bonds and cash, are represented digitally on a blockchain.

One further result of moving to DLT-based business models is faster, more secure transactions, and with the use of smart contracts we can automate settlement processes and enforce compliance with more targeted human-led intervention. Moreover, DLT can potentially shorten settlement cycles from multiple days to near-instantaneous 'atomic' settlement, allowing, where desirable, assets and payments to be exchanged immediately and irreversibly. Such capability could streamline complex processes like bond settlements and associated lifecycle events, removing, for example, the need for ex-dividend periods and reducing related operational costs.

Another key component of Digital Capital Markets is programmable digital cash, which allows institutions to settle transactions with relatively greater control and precision on DLT networks. Smart contracts could also streamline complex financial processes by embedding predefined instructions into digital assets, triggering payments or actions based on real-time data, such as market prices. This capability can furthermore help focus and direct human oversight, mitigate settlement risks, and offers the potential for processes between and within counterparties to occur seamlessly and efficiently.

Supplementary to DLT, Artificial Intelligence (AI) could add another layer of efficiency and insight by monitoring and processing vast datasets in real-time. AI-powered analytics models can, for example, aggregate and analyze fragmented market data to help institutions manage risks and uncover commercial opportunities. Additionally, it could significantly improve trade reconciliation by automatically addressing discrepancies between trade and settlement data, reducing operational errors and counterparty risks. Regarding regulatory compliance, AI-driven systems could also scan transactions to ensure regulatory adherence, alerting institutions to potential violations in real time. Again, cutting-edge technologies can be leveraged to adapt incumbent business models and processes for the better.

Despite clear advantages of leveraging emerging technologies to adapt business models and processes, the report emphasizes that the move toward Digital Capital Markets will not, and should not be an instantaneous or binary step-change but rather a gradual and methodical evolution: a phased approach allows for structured testing, iteration and refinement, and regulatory adaptation as new technologies are integrated into institutional infrastructures while maintaining market stability and protecting investors.

In summary, this white paper explains how transitioning to Digital Capital Markets presents compelling benefits. Enhanced transparency is a primary advantage, as is improving systemic resilience and stability. Also, by streamlining intermediaries, reducing settlement delays, and mitigating liquidity buffers, the transition to digital business models can significantly reduce risk and cost. Furthermore, the enhanced speed, scalability and connectivity made possible by emerging technologies allow for broader and faster adaptation across business models and the financial sector as a whole.

Ultimately, our report shows that a balanced integration of TradFi and DeFi, underpinned by pragmatic and progressive regulation, offers a promising path forward for Capital Market evolution. Achieving this vision will require strategic investment in technology and processes, regulatory co-operation and development, and a commitment from a wide range of market participants to plan for and drive targeted, sustained and meaningful innovation: moving to digital means we can do what we do, just better.

Introduction

Capital Markets are seemingly efficient and stable until they are not. They are a culmination of decades of globally intertwining architectures, systems, processes, regulations and learned behaviors, forged into an industry that functions in spite of its widespread structural anomalies and constraints. But it does not have to be this way, and if we were to design a global Capital Markets model today, the brief would — and arguably should — deviate significantly from what we currently have.

By carefully and methodically introducing new means for connectivity, control, and transparency by leveraging cutting-edge technologies like distributed ledgers (DLT), smart contracts, and aspects of Artificial Intelligence (AI), regulated incumbent business models can evolve responsibly at scale. Collectively, our model for Capital Markets can then realize the promise of a 'middle ground': a scalable and composable network of networks that is technologically sound yet in touch with what we do and why we do it.

In this paper we first unpack selected structural limitations of incumbent Capital Markets, explaining what they are, why they exist and why, in fact, they are relatively constrained and limited. Focusing on themes such as structural fragmentation, operational friction, inadequate interoperability, and evolving regulation, we seek to bring not only fresh insight to help isolate the opportunities across today's model, but also offer a perspective on what an updated approach to Capital Markets could look like.

In the latter stages of this paper we then turn to how as an industry, we could move towards and realize the benefits of truly digital Capital Markets. Building trust through well-thought-out regulation will set the foundations for technologies like DLT and aspects of AI to address many of the structural challenges that incumbent markets face today. And by combining the best aspects of both Traditional Finance (TradFi) and Decentralized Finance (DeFi) and designing for enduring interoperability, we can move to a system of much faster settlements, improved liquidity management, enhanced transparency and controls, and reduced regulatory complexity: we can do what we do, just better.

Under-designed, under-refined, but it's how we do it here

Given network effects, we are bound by the lowest common denominator

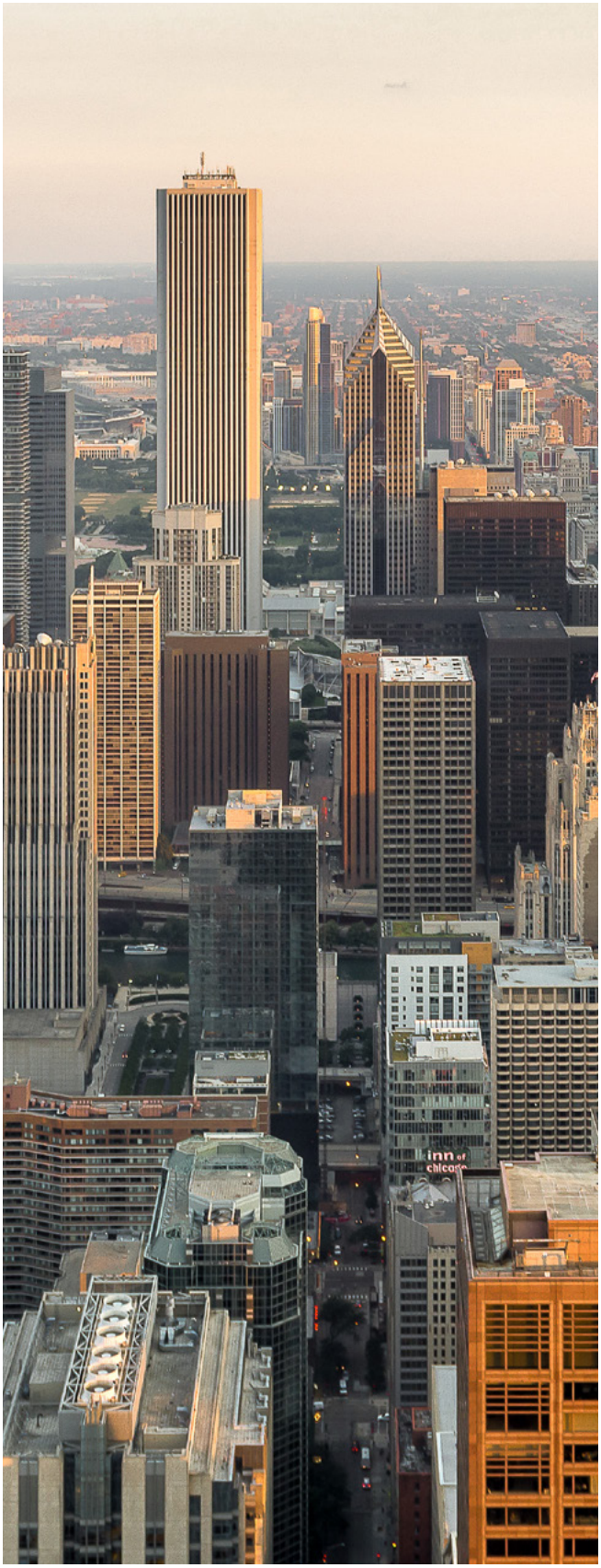
Different business models within Capital Markets may seem like isolated systems serving specific needs, but this would be as inefficient as having a unique road network for different daily activities. Instead, like shared roads, Capital Markets rely on interconnected and co-dependent infrastructures, rules and systems. Seemingly disparate transactions — such as a Foreign Exchange (FX) forward or a security purchase — use the same underlying systems and shared routing. Just as we try to optimize our daily routes and routines, Capital Markets also aim to optimize capital, balance sheets, risk management and the so-called rules of the road.

For example, a client executing a collateralized GBP/USD FX forward may have done so to hedge a bond purchase, triggering a series of interconnected actions. Comparably, the bank who is now long Gilts collateral may then enter into a Repurchase (Repo) transaction to optimize their funding, and become a motivated, potentially urgent, buyer of GBP in the FX forward market to hedge their risk.

In short, an action in one market affects others, much like heavy traffic or roadworks in one area of the road network can be directly — or indirectly — impactful to our daily commute elsewhere. As this paper explains, like seemingly unexplainable traffic jams, road or market congestion is primarily solvable only when considering, adapting and potentially re-designing the system as a whole.

Structural friction means accepting unnecessary complexity, cost and risk

Capital Markets must continually adapt to a fast-changing environment, yet seldom, if ever, have they been fundamentally redesigned and reinstated at scale. Similar to how some cities have been transitioning from ad-hoc, quaint streets towards planned, purposeful and interconnected hubs, Capital Markets have largely evolved from independent, inward-facing markets into a set-up for global trade. This shift is especially evident in cross-border payments and FX markets. What may seem like a simple FX transaction to the uninitiated onlooker — two payments in different currencies between two parties — is, in reality, far more complex, largely due to the fragmented payment systems and regulations that underpin and enable this line of business.



Complexity behind the scenes

If banks, acting as payment service providers, could hold master accounts at all local central banks, cross-border FX flows would only be marginally more complicated than a single-currency transaction. However, with in the region of 50,000 banks[1] and almost 200 central banks[2], enabling all banks to independently manage FX flows would require around 10 million central bank master accounts. This approach is not economically or operationally feasible under the structure of Capital Markets; it would require each bank to maintain sufficient respective liquidity and connect to excessive different systems. Additionally, central banks may find it impractical and undesirable to supervise such an expansive network, especially given the opaque and sequential nature of much of the current global financial system.

Instead, today's system relies on a shared infrastructure of intermediaries, where local and regional banks with central bank access facilitate payments through cascading nostro and vostro accounts. Foreign banks hold local currency accounts at local banks, and vice versa (see Infographic 2: The necessary role of intermediaries).

For commonly traded currency pairs, the payment chain may be relatively short, enabling relatively quick settlement. However, for less frequently traded currency pairs, these transactions often involve an elongated, opaque and costly network of intermediaries, leading to settlement complexity and elevated cost.

This really matters, as unpacking it gets to the nub of why the current model drives both credit and liquidity risk. Banks that have more foreign currency nostro accounts can support faster payments for their clients (because the payment chains can be shorter), at the cost of more trapped liquidity, whereas those with fewer nostro accounts may attract a narrower client base, and have to pay greater fees to enlist the services of other correspondent banks.

The balances within each nostro account have to be sufficient to be able to support expected client flows especially given the time that can be required to increase these balances. The process to fund and de-fund these accounts can be time consuming, and may involve the process of raising funding domestically, limiting the ability for these balances to be dynamically managed. For perspective, the size of these balances can be significant, with some estimates suggesting that outstanding balances are in the region of USD30 trillion.[3]

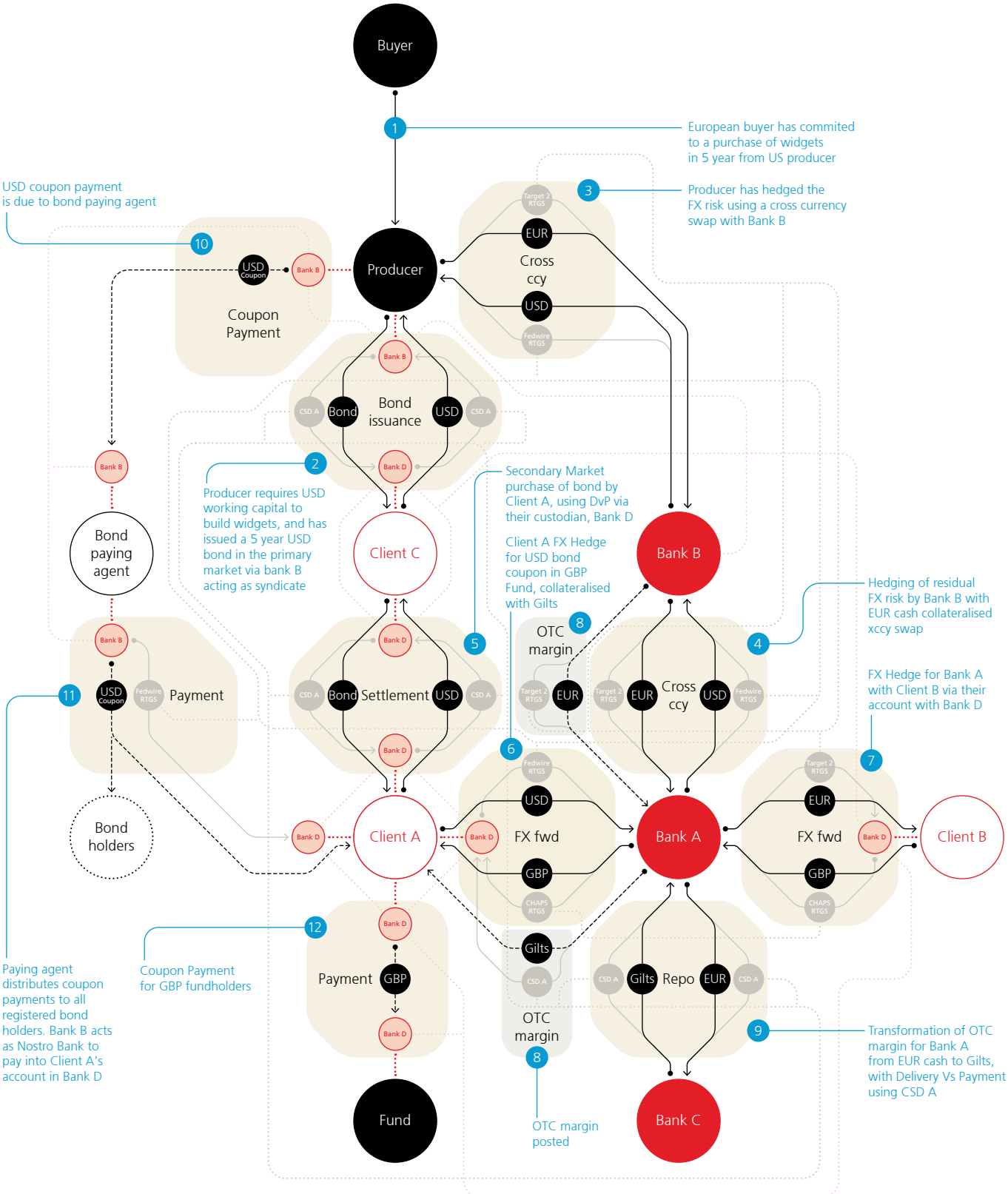
The integral and perhaps unexpected complexities of relatively straightforward FX is but one area where the day-to-day process of a business line is driven by the overarching structure — Infographic 1 offers a perspective on the wider challenge at play. Superficially, the current system works, as we have made it work. But when viewed through an expertly focused lens it is not without evident inefficiencies. Likewise, viewed from a backdrop of leveraging digital technology, the current system has widespread and compelling opportunities for planned evolution and sustainable optimization.

1 Moody's Analytics (2023) BankFocus brochure
2 BIS (2024) Central bank and monetary authority websites — Central bank hub
3 McKinsey (2016) Global Payments 2016: Strong Fundamentals Despite Uncertain Times — Financial Services Practice

Infographic 1

A perspective on the complexity of Capital Markets

Mechanics and flows related to a collateralized GBP/USD forward transaction between Client A and Bank A.



Source: JD Risk Solutions, UBS IB Strategic Ventures

Some modernization has added structural complexity: Fixed Income

Capital Markets have evolved in a way similar to the transition from typewriters to PCs: while the QWERTY keyboard layout was initially designed to prevent mechanical jams, it was retained in electronic keyboards for the sake of familiarity, not efficiency.

Similarly, financial markets have moved from paper tickets to electronic records, and from physical securities stored in vaults to digital certificates in electronic vaults; this approach has led to a model that has grown organically over time. Despite advancements in technology, many processes remain outdated and relatively inefficient, a challenge that becomes particularly apparent in secondary bond markets, where the shift to Trade Date +1 (T+1) settlement highlights many points of friction.

Bonds are a critical instrument for driving and regulating the flow of Capital Markets, and the secondary market is highly active. ICMA's Secondary Market Practice Committee reports that — per week — at the end of H1 2023, the market observed over 200,000 sovereign transactions totaling approximately EUR 900bn, and nearly 130,000 corporate bond transactions amounting to EUR 95bn.[4] If we assume these volumes were evenly distributed across five trading days, with an equal split between bond sales and purchases, and each trade was facilitated by dealers acting as intermediaries (buying a bond from one client and selling it to another), the market requires continual and substantial liquidity to operate smoothly.

In this scenario, nearly EUR 100bn of securities would need to be borrowed each day in the Repo markets to support these transactions. This implies a daily need for EUR 100bn in intraday liquidity, which, at an assumed cost of 50 basis points, would amount to approximately EUR 500m across all dealers — this is just to keep the cogs turning. To add complexity to this expense, if the required bonds are unavailable in the Repo market, a settlement failure may occur. This would not only prevent the transaction from completing but also likely lead to significant financial penalties.

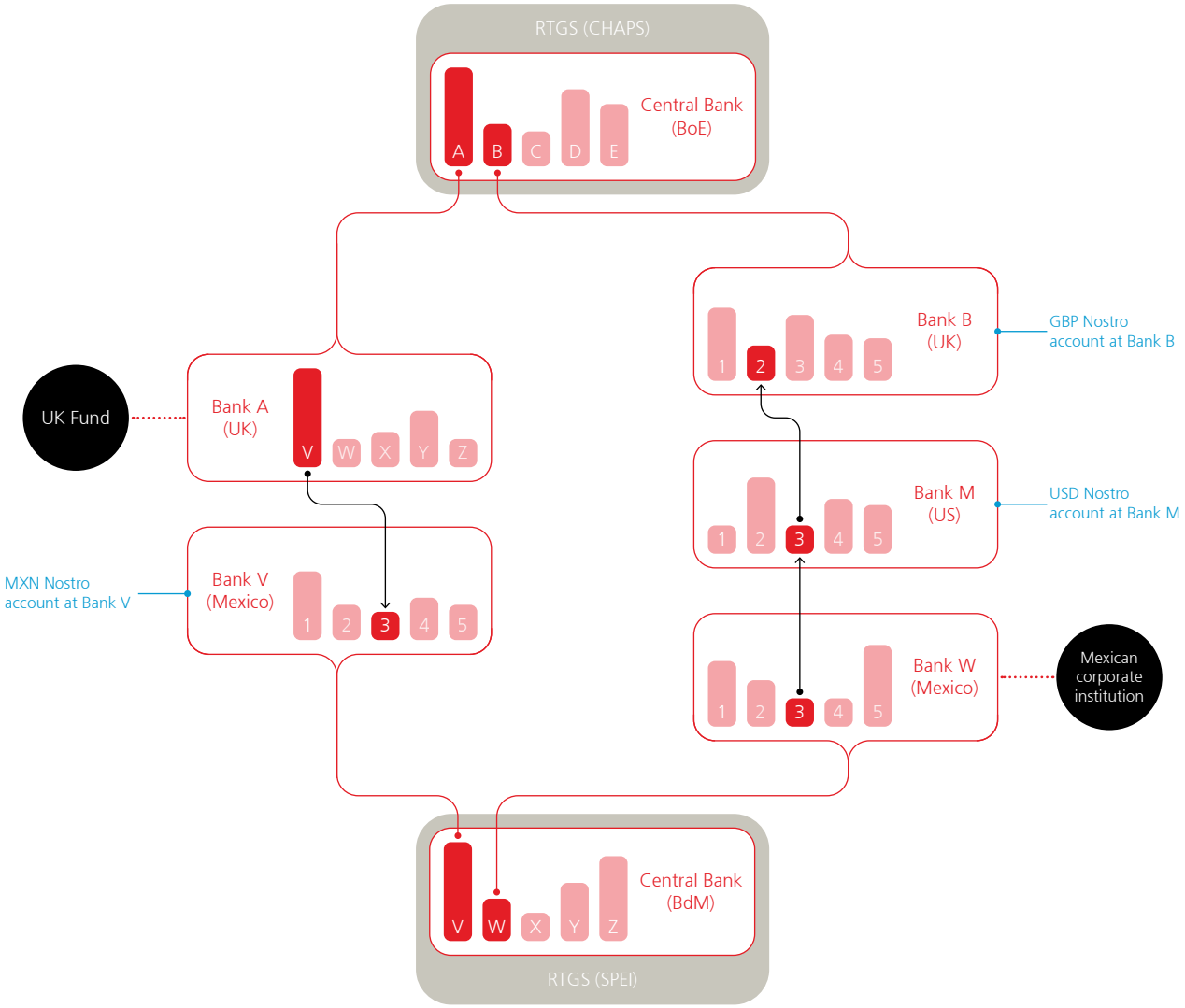
Furthermore, the settlement failures could have a contagion effect, creating issues for the receiving counterparty and potentially triggering a series of cascading failures elsewhere in the network, which could further disrupt market stability. As before, transacting one financial instrument — in this case a bond — is more involved and interconnected at the market level than simply buying or selling that respective asset, and highlights structurally-driven operational and liquidity challenges with how we collectively engage in Capital Markets business today.

4 ICMA (2023) European Secondary Bond Market Data — Secondary Market Practices Committee, H1 2023

Infographic 2

The necessary role of intermediaries

To highlight the role — and complexity — of intermediaries, consider a GBP MXN (Mexican Peso) FX spot transaction between a Mexican corporate institution with a bank account at a domestic Mexican bank and a UK fund with a UK bank account.



Source: JD Risk Solutions, UBS IB Strategic Ventures

Nostro accounts are key to the functioning of this intermediary model, and are essentially domestic currency accounts held by foreign banks. In the above example, a Mexican Bank, Bank W, holds a USD nostro account at US Bank M, and this account can be used to facilitate USD payments.

Some banks in the intermediary chain may be connected; it is often the case that intermediary banks where nostro accounts are held are distinct subsidiaries in the same organisation (bank) as the nostro account holder.

The requirement — and challenge — of stable and efficient Repo markets

Within the current market structure, the Repo market plays a vital — but not fail-safe — role in supporting market stability by providing short-term liquidity, reducing credit risk, and enhancing the efficiency of the financial system. While Repo can help financial institutions quickly access cash without liquidating assets and so help prevent excessive market dislocation, the theory does not work perfectly in practice.

Under normal market conditions, Repo markets prevent fire sales of assets, but if systemic metrics begin to flash red, Repo markets have a tendency to freeze-up and thus create the fire sales they are conceptually designed to prevent. The structural limitations — sequentiality, opacity, limited precision and control — restrict what can be achieved, especially when we need it most.

To try to make it work, central banks often intervene — with varying success — into Repo markets, such as with the Liability-Driven Investment (LDI) crisis in the UK in late 2022, and more generally use the Repo market to implement monetary policy, influencing interest rates and the money supply.

While during financial crises, such as the Global Financial Crisis (GFC) of 2008-2009, the Repo market does prove useful, its existence and widespread use highlights the issue. That Repo is an established function for these scenarios, and one that provides a sophisticated work-around, it is in fact a work-around — one that is created by the structurally-driven need to borrow to manage timing mismatches between payment and delivery of assets, and wider sequential nature of incumbent Capital Markets. In a market-level set-up that operates with relatively more transparency, and offers the possibility of immediacy and precision, the needs for such work-arounds diminish.

A question of timing

Sequentiality, and specifically elongated sequentiality, leads to timing mismatches across Capital Markets. These inefficiencies primarily stem from misalignments between trade execution, settlement timeframes, liquidity requirements, and market processes, and introduce significant challenges.

Liquidity constraints are one of the key issues: delayed settlement cycles, such as T+2 or T+3, force financial institutions to hold excess cash reserves to meet their obligations until trades settle — and this typically means holding multiple currencies within globally elongated payment structures. Specifically, this leads to inefficient use of capital and thereby unnecessarily high liquidity costs as firms likely need to secure overnight funding to bridge the timing gaps. When interest rates are at zero or close to zero, this may not be as problematic, but the rate environment is now in a completely different place, and this most certainly is a challenge.

Timing mismatches between the execution and settlement of trades, especially in cross-border transactions, also create operational risks. Settlement failures due to incorrect trade details or system errors can trigger penalties, disrupt market activities, and cause compliance issues. The additional risk management practices and liquidity buffers that institutions must hold to mitigate these risks furthermore result in increased operational costs.

In markets with fluctuating asset prices, credit risk is another by-product of timing mismatches. If a trade is executed but settlement occurs at a later time, interim price fluctuations can cause discrepancies between the actual value and cost of the transaction, increasing credit risk. This is particularly problematic for hedging strategies, where mismatched timings in different markets — such as derivatives or FX — can lead to unexpected risks and higher exposure: this all means excess cost.

Additionally, in cross-border transactions, time-zone differences create mismatches in settlement and liquidity flows. Take for example, an APAC-based client executing a trade in Europe; the client may face challenges in ensuring funds are available for settlement within the same trading day, leading to potential delays or liquidity shortfalls. FX mismatches, where FX markets of respective currencies are not open at the same time or are illiquid, further complicate the settlement cycle and ultimately increase transaction costs. In short, analogue sequentiality means friction, and friction at scale equates to significant systemic inefficiencies.

Ultimately, that payment and delivery of assets is spread out — and the fact that it currently has to be — reduces asset velocity, creates costs, introduces systemic risks, and contributes to a lack of transparency. Addressing timing mismatches through faster settlement cycles, enhanced precision and control, and better cross-border coordination, could then help reduce these existing structurally-driven challenges, leading to relatively more efficient, stable, and transparent markets: pragmatically-applied digital technology can go a long way to alleviate this stress.

Regulatory changes are exposing outdated infrastructure: Margin for derivatives

The strain on existing Capital Markets' infrastructure stems not only from decades of organic growth but from the regulatory changes that followed from the GFC of 2008-2009.

In response to the GFC, regulators introduced measures to mitigate systemic risks and increase market stability. One of the most significant changes was in the derivatives markets, where regulations now require daily margin posting to address credit risk in uncleared derivative transactions.

While these reforms aimed to reduce risk in one part of the system, as Capital Markets are a complex and ever-growing patchwork of highways, back-alleys and rules, they have created adjacent challenges.

The increased demand for margin and collateral, driven by intentionally supportive regulatory requirements, has placed pressure on Repo markets to maintain liquidity, enhance risk management, and improve overall efficiency. Moreover, this has led to a need for further adaptation of market infrastructure to handle these evolving legal requirements while ensuring financial stability across interconnected markets: conceptually, against the backdrop of the GFC, enhanced regulation makes sense, but the question is, to what extent can existing infrastructure adapt and expand to meet demands that it was never designed or intended to service?

The different characteristics of collateral eligibility has also come into focus. For cleared transactions, variation margin is almost always required to be cash, linked to the currency of the underlying transaction. However, for buy-side firms, the ability to post securities in lieu of cash for uncleared transactions can be valuable. This flexibility helps mitigate the risk of having to sell or Repo assets during periods of market stress in order to meet collateral obligations, even if the transaction costs are higher due to the additional leverage requirements of non-cash collateral for banks.

Nevertheless, even when cash is posted as variation margin, it may not be eligible for onward posting under the Credit Support Annex (CSA) terms with the counterparty. The discrepancy creates challenges for collateral re-use, as collateral often needs to be transformed — for example, from Gilts into GBP cash or from GBP cash to US Dollars — before it can be passed on to another counterparty. This transformation step usually involves activity in the Repo or FX markets, again highlighting the interconnectedness of activities.

The risk associated with this process is primarily time-dependent — the sequentiality creates friction, and the friction creates risk. A shorter time horizon between market moves and the completion of collateral transformations, the lower the aggregate risk for all parties involved: The challenge, however, lies in how much the current infrastructure can reduce this time window to better manage liquidity and credit risk — like with any machinery, there is only so much it can achieve even in the hands of skilled operators. More to the point, technologies like DLT are now sufficiently mature to offer solutions at scale.

Responsible regulation has added pressure on infrastructure: Margin requirements

Uncleared margin rules came into force in 2016 with separate requirements for initial margin and variation margin.

Variation margin for most types of transactions became a requirement for financial services firms from 2016, whilst initial margin requirements came into force over six phases depending on counterparties' gross notional value of derivative transactions. The key requirement for transactions subject to the variation margin requirements were that margin calls needed to be daily, with no thresholds being applied.

The challenge here is that the operational process required for margin flows typically requires one day. Given that both the client and the bank would need to start these processes on the same day to ensure the margin arrives to the recipient the following day, and given the lack of certainty on when the collateral being received will arrive, banks typically need to fund their posting requirements in the intraday or overnight markets to meet their obligations.

These amounts are significant. A review of margin practices, conducted by the BIS in 2022, showed that 24 dealers/ clearing members at the start of the COVID 19 pandemic in March 2020 needed to post USD 12bn in combined Central Counterparty (CCP) and uncleared variation margin (with the peak during the month reaching a staggering USD 43bn).[5]

It is reasonable to assume this would be exaggerated due to the start of the pandemic, but the Bank of England, in its report on the role of margin during the COVID-19 pandemic, showed that for this period, CCP margin requirements were 1.19x the January-February pre-pandemic average.[6]

If we were to assume that the same ratio could also be applied to uncleared margin requirements, this suggests the average daily variation margin posting requirements pre-pandemic were approximately USD 10bn across these 24 institutions. Without the ability today to reuse any incoming margin, all of these postings would have required some form of funding: again, inordinate levels of liquidity are trapped due to systemic inefficiency.

There is a high correlation with regards to market stress events and large market moves, which therefore drive large collateral calls. When banks (or any counterparty) are expecting large margin receipts, they are exposed to significant credit risk, and are at risk of losses should the client default.

In fact, the credit exposure builds up from the point markets move, and it is only at the close of the margin due date (one day after the margin call is sent) that the party will know if the if the positing party actually met its margin obligations, and if not, be able to issue a notice to close out their positions because of the failure of the posting party to deliver on its margin obligations.

Paradoxically, even collateral that has been posted to another counterparty can be subject to credit risk if market moves change the valuation such that the party holding collateral needs to return it to the original posting party.

All of the risk, opacity and complexity is structurally-driven; unless we modify the fundamental structure of how we conduct Capital Markets' business, this is a good example of how under the incumbent market structure we will need to continue accepting extreme risk and cost just to keep the markets ticking along.

5 BIS (2022) Review of margining practices
6 Bank of England (2022) What role did margin play during the Covid-19 shock? — Bank Overground

The story so far

Capital Markets are functional but could be much more efficient, especially when viewed through the lens of digital technologies. It is not that digital technologies somehow alleviate challenges by themselves — they do not. What is now possible, however, is that value at scale can be achieved through the application of carefully selected, cutting-edge technology, deployed in the right place and in the right way to augment, and in some cases fundamentally re-design, business models and operational structures.

A key issue is structural friction, where national and regional structures lack interoperability and standardization, leading to increased costs and elongated transaction lifecycles. Additionally, many financial institutions still rely on legacy systems, which face increasing difficulties in meeting the complexities of modern client and regulatory needs, resulting in unnecessarily enhanced risk and liquidity demands just to keep the markets moving.

Inefficiencies in collateral management add complexity across the board. The mismatch between available and eligible collateral and margin requirements causes liquidity bottlenecks, as seen during the GFC and recent LDI crisis in the UK. Collateral transformation — converting one form of collateral into another — is relatively slow and costly, particularly during market stress when near-term liquidity access can be critical, but the current system relies upon it.

Moreover, regulatory differences across jurisdictions further complicate matters, with potential for firms taking advantage of lower standards in some relatively less-stringent jurisdictions, creating global systemic risks. Opacity in markets, particularly in derivatives and fixed income, also increases perceived risk, complicating fair value assessments, and ultimately baking-in inefficient outcomes.

In conclusion, the structural challenges in Capital Markets, including outdated infrastructure, fragmented regulation, pricing inefficiencies, and collateral management issues, point to the need for reform. Modernizing market infrastructure, supported by harmonized regulatory frameworks, is essential. Leveraging digital technologies like DLT and aspects of AI to augment and responsibly redesign Capital Markets' business models to make them more efficient, transparent, and resilient, will collectively better position our system to meet the evolving demands of global finance: Section 3 of this paper describes what this middle ground could look like, and why it could offer compelling benefits for all concerned.

Joined-up thinking

New technologies offer fresh potential to do what we do, just better

When underpinned by responsible and progressive regulation, DLT and aspects of other emerging technologies, such as aspects of AI, can be leveraged to evolve and re-design Capital Markets' business models at scale, and move towards truly digital Capital Markets. In this section we offer a view on what the future could hold, and specifically address the challenges outlined so far.

Market fragmentation and the opportunity for seamless integration

Capital Markets today are fragmented across various exchanges, platforms, and clearing-houses, often operating in silos. Each market operates independently, governed by its own set of rules and regulations, leading to inefficiencies and barriers for cross-border transactions. Fragmentation increases costs, slows execution speeds, and creates difficulties in risk management, particularly for global investors who face obstacles in accessing different markets or aggregating their positions.

DLT-based business models, given DLT is effectively a secure, scalable and permissionable database, could offer a decentralized, joined-up and standardized framework for executing and settling transactions, which could significantly reduce market fragmentation and increase the efficient transfer of value.

It is important to view DLT as a means, and not an end in itself. DLT is a digital tool with which we can modify a range of Capital Markets business models, and if supported by appropriate regulation, it can facilitate more seamless cross-border interoperability and more effective means to transfer assets and information.

Tokenization, a core feature of DLT-based business models, allows existing financial instruments — including cash — to be digitally represented on blockchain, enabling smoother transactions versus incumbent analogue systems. Through smart contracts (see Infographic 3), DLT-based models could also automate a range of processes — for example, trading, clearing, and settlement — across selected, connected markets, promoting greater cohesion and mitigating the friction and opacity caused by manual or siloed operations.

For example, a DLT-based system could fundamentally enhance the settlement process of bond transactions, including the process of updating the registered ownership record in order to be able to accurately process coupons. In the UK Gilt market, the registered legal holder seven days before the coupon date is entitled to the coupon payment. The elongated nature of this process has implications on liquidity, and also in the availability of borrows in the Repo market, as participants retain ownership to ensure they are entitled to receive the bond coupons. As DLT-based systems could provide instant registration records, this could remove the need for an ex-dividend period entirely, which would drive efficiencies at scale.

Transactions recorded on a blockchain can also be made visible to all participants, reducing the possibility of discrepancies or disputes. By reducing settlement times from days to minutes or milliseconds, DLT also can manage down the risks associated with liquidity and credit during settlement windows. Moreover, smart contracts could further improve efficiency by automatically enforcing contract terms once predefined conditions are met, thereby reducing the need for costly and time-consuming manual intervention.

Further real-world examples include how smart contracts can improve conditional bond issuances. While most bonds have deterministic pay-outs, some, like Additional Tier 1 securities, may convert to equity or be written down if certain financial thresholds are breached. Smart contracts that could automate this process, adjusting pay-outs instantly without manual intervention, are beginning to fan-out across the market. For example, the Bank for International Settlements (BIS) and Hong Kong Monetary Authority (HKMA) proposed using smart contracts for green bonds. In this case, the pay-out of carbon credits as coupons could be automatically linked to energy output from renewable projects, reducing operational burdens, enhancing transparency, and potentially decreasing greenwashing risks.

Other emerging technologies can complement DLT. For example, by analyzing vast amounts of fragmented market data in real-time, intelligent data aggregation and analysis capabilities can identify patterns across multiple platforms, offering actionable insights that could help professionals make better decisions. AI-driven models could also provide real-time market sentiment analysis, augment a broad spectrum of human decision-making and identify otherwise opaque opportunities and risks in structurally fragmented markets.

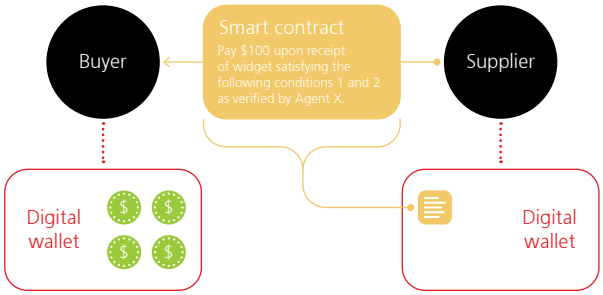
Collectively, cutting-edge technologies, when applied in the right way can fundamentally help us do what we do, just better.

Infographic 3

Smart Contracts and programmable cash

Unlike traditional payments which are only irrevocable once made, smart contracts are pieces of code deployed on a blockchain that can be used to embed logic and conditionality into transactions. The code can be made irrevocable on deployment, and when the conditions in the code are met the code (and contract) is executed.

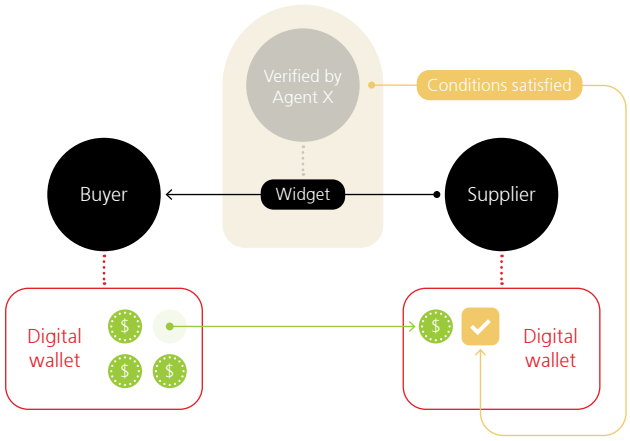
The first step is to precisely replicate the conditions of the agreement between the two parties into code — this step is essential as it may be the case, in time, the code becomes the golden source of the contractual terms between counterparties (rather than having a natural language contract).



Source: JD Risk Solutions, UBS IB Strategic Ventures

The second step, once the code has been deployed, is for it to run, waiting for the conditions to be met. Currently, the logic that can be introduced into smart contracts is limited, but there is an expectation that this will evolve. Clearly, a large part of the challenge is exposing the code to the data required to comprehensively and accurately evaluate conditions. For example, how can the smart contract 'see' and act upon relevant yet fragmented financial information? For more complex conditions, how can an external agent (which may be a human) verify that conditions have been met for the code in the blockchain — this challenge is clearly important, and one we are keen to resolve comprehensively and sustainably.

The final step is execution of the contract. Once the 'if or when' conditions have been met, the code must progress onto the 'then', and complete the transaction, which typically is the transfer of payment tokens from the buyer's digital wallet to the sellers, potentially triggering the delivery of a (digital) asset to a predetermined destination. The caveat to this is that the buyer's wallet must have sufficient funds to facilitate the transfer, which is why smart contracts alone cannot entirely mitigate credit risk.



Source: JD Risk Solutions, UBS IB Strategic Ventures

With the appropriate infrastructure and code, the ability to synchronise ownership transfer of the 'widget' with the payment could be developed, meaning that if there are insufficient funds in the buyer's wallet, the ownership transfer of the widget does not take place. But assuming that the required digital funds are available, this set up can form the basis of truly digital business models.

Emerging technologies can provide transparency and operational efficiency at scale

In many markets, particularly with derivatives, transparency around pricing, transaction execution, and risk exposure can pose challenges for a range of market participants. For some participants, the opacity can lead to inefficient price discovery, and can more broadly lead to market manipulation and increased systemic risk, as seen during the GFC when the true extent of risks was not immediately visible.

A DLT-based system can be set up to offer permissioned transparency, as every trade is recorded on a digital ledger that can be viewed by respective parties as required. This visibility could, if required, then promote better price discovery, as participants would be able to track all trades in real time and assess the fair value of assets relatively accurately. Blockchain's immutability also ensures that transaction data cannot be changed, reducing opportunities for illegal market practices.

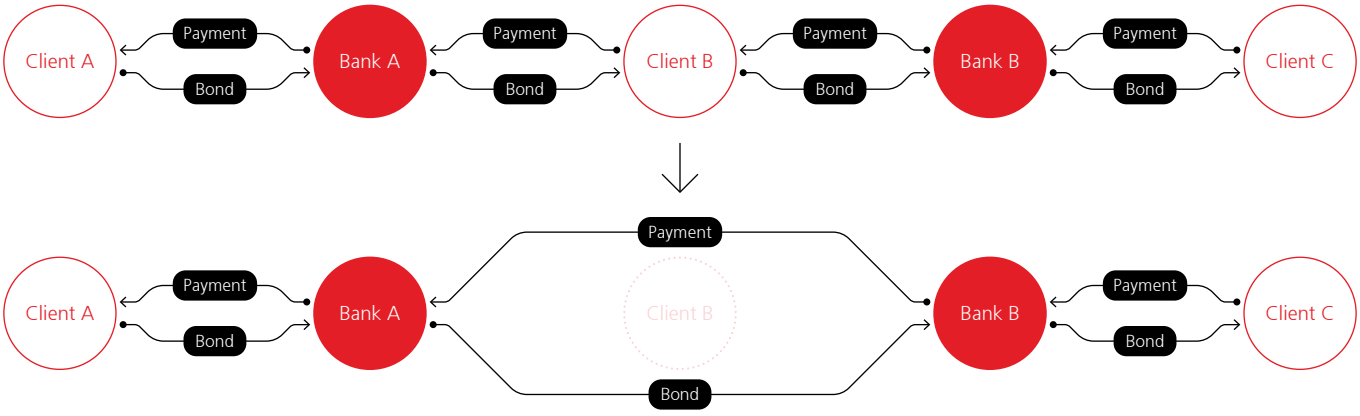
The increasing electronification and digitization of Capital Markets, while facilitating market expansion, has made them more vulnerable to cybersecurity threats, such as data breaches, and system failures. Cyber-challenges can disrupt market operations, compromise sensitive financial data, and undermine confidence throughout the market.

DLT-based business models can offer enhanced security due to their decentralized and cryptographic nature. The use of blockchain ensures that transaction data is distributed across multiple nodes, and protected from tampering: since there is no single point of failure in a blockchain network, it is much harder for the system's integrity to be meaningfully compromised.

Interconnected blockchains sometimes raise concerns that if one of the counterparties in a particular chain fails to perform on its obligations, the whole network is compromised. The concern is valid, but it is not something that is new to DLT-based operations — this happens today where a settlement fail often creates a downstream cascade of fails.

The difference with a DLT-based business model is the timeframe that this can happen within — minutes instead of days, and the relative transparency of the chain itself. And this is where the technology can offer significant benefits if implemented correctly.

With the whole picture of information and relative speed, a DLT-based system could identify the potential (or actual) failure within the chain and either provide the impacted node timely information to correct, or it could 'self-rectify', rerouting flows around the broken link in the chain.

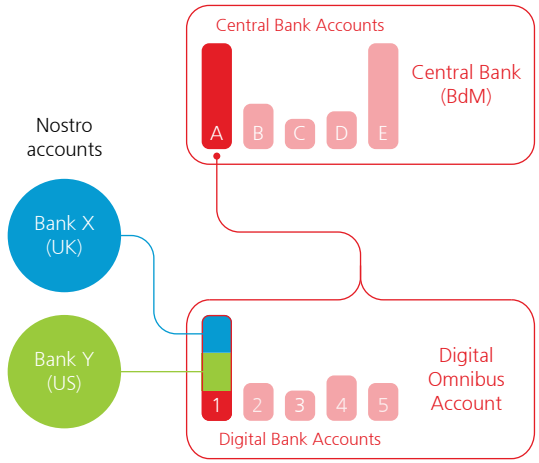


Source: JD Risk Solutions, UBS IB Strategic Ventures

Institutional digital (and programmable) cash

Truly digital business model at institutions require an institutionally-acceptable means of payment on blockchain. Without institutional digital 'cash' as the payment leg, so-called 'digital' business models are shackled with incumbent, analogue payment mechanisms and regimes, and so promising digital efficiencies cannot be realized. There is, in fact, a potential solution.

Assume a scenario where institutions can hold funds in a digital omnibus account at a central bank, these funds are digitally represented on DLT, and the digital account in one jurisdiction is itself part of an interconnected digital and global payment system of multiple and jurisdictionally-specific accounts. On the one hand every participant would then only be exposed to the credit risk of the central bank(s) underpinning the system, and via operating digitally, would be able to realize the capital, funding and operational benefits of relatively more precise and controllable settlement finality at scale.



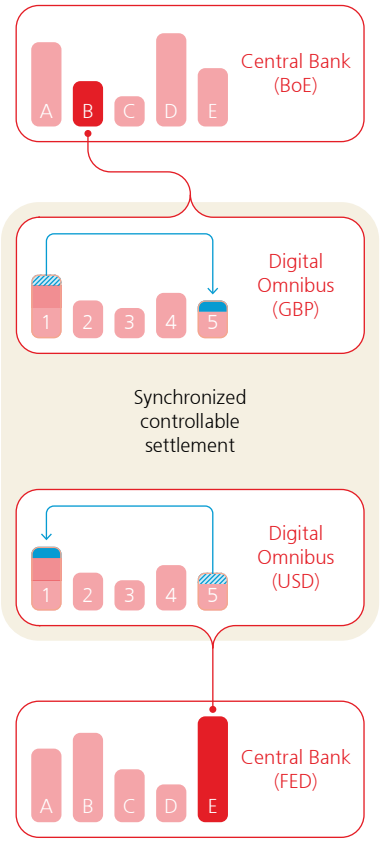
Source: JD Risk Solutions, UBS IB Strategic Ventures

For example, Bank 1 is a member of a central-bank-based digital payments system which holds account A at the Central Bank. Bank 1 also holds funds on behalf of Banks X and Y, and this is reflected in the digital omnibus account.

If a client of Bank X in the UK needs to make a cross-border payment to a client of Bank 5, the transfer can take place with control and precision across that digital payments system, with the key operational benefit of almost instantaneous settlement, and credit risk only to the central bank in Mexico, rather than a domestic banking institution and potentially other intermediaries in the same jurisdiction.

The scalability of this model comes to the fore when considering how an institutional digital payment network in one jurisdiction can be seamlessly linked to similarly structured networks in another to create a global and digital payment system for institutions.

A key practical application is in the FX business. The benefits described in one jurisdiction can extend internationally to mitigate credit and settlement risk in FX by synchronizing and, if desired, instantaneously settling in different currencies, thereby achieving true 'Payment-versus-Payment' (PvP).



Source: JD Risk Solutions, UBS IB Strategic Ventures

While the GBP and USD tokens are not fungible and transfers can only happen within the interconnected network, liquidity and funding requirements can still be significantly reduced. It holds that the model — like many institutional models — is a 'network play'.

With the ability to have a much broader network of banks operating within this type of network, it becomes possible to dynamically borrow and raise funding with instantaneous settlement for counterparties with excess funding, rather than having to maintain a static balance in each jurisdiction as is often done today. A key factor in the effectiveness of this model is the ability to synchronize settlement across different payment tokens and ledgers, given the inherent interoperability and scalability the technology offers.

An evolution is just that: step by step

DLT and other emerging technologies have the potential to address many of the structural challenges that incumbent Capital Markets face today. These technologies offer a way to streamline and modernize the financial ecosystem by enabling faster settlements, improving liquidity management, enhancing transparency, and reducing regulatory complexity.

By reducing the friction associated with current market processes, DLT-based business models can significantly enhance the efficiency, security, and resilience of global finance. Comparatively, the analytical and predictive capabilities of AI holds promise for optimizing complex workflows, improving decision-making, and reducing human error, all of which contribute to increased operational efficiency in financial markets at scale. However, it should be made abundantly clear that transitioning to these technologies is not a simple, overnight switch. Moreover, it should not be seen as a binary choice between TradFi and DeFi either. Rather, this shift represents an evolution where both systems can coexist, creating a hybrid model that combines the best features respectively.

In fact, a hybrid model is already beginning to take shape, signaling both a broader transition towards Digital Capital Markets, and making it clear that navigating the integration will require careful consideration of legal, technical, and operational complexities. The evolution is just that; is not a 'big bang' but a controlled, methodical and careful process where legacy systems gradually work in tandem with emerging technologies.

A recent example of this evolving digital landscape came in early 2024 when the City of Lugano issued a digitally-native bond.[7] The bond was managed by a consortium of Swiss banks, including Zürcher Kantonalbank, Basler Kantonalbank, and J. Safra Sarasin, and settled using Swiss Franc (CHF) denominated Central Bank Digital Currency (CBDC). The speed and efficiency of the transaction were striking: from book-building to settlement, the process took less than one hour. This digital issuance demonstrated the potential of DLT to dramatically reduce settlement times and improve interoperability between different financial entities. Over the past few years, other digital bond issuances have similarly showcased how DLT can transform traditional financial processes, likewise demonstrating enhanced speed, reduced counterparty risk, and greater transparency across how we collectively do business.

Despite these significant advances, however, it is important to recognize that primary issuance settlement is just one part of the broader financial lifecycle. Issuance networks extend far beyond the initial transaction, spanning various stages including secondary market trading, clearing, Repo, custody, asset utilization and final settlement. Without complementary digital tools and functional integrations across the entire ecosystem, several crucial aspects of the issuance lifecycle remain tethered to legacy systems. As such, while one part of the infrastructure may be modernized, delays and inefficiencies continue to persist in others, ultimately limiting the transition towards Digital Capital Markets and the benefits that offers: this is why it has to be a broad evolution.

To truly unlock the value of a Digital Capital Markets infrastructure, it is essential to complement DLT with other complimentary technologies, especially as we transition to Digital Capital Markets. Specific applications of AI could play a pivotal role in automating complex and time-consuming processes that have traditionally taken several days to complete, such as trade reconciliation and post-trade analysis and reporting.

For example, within incumbent models, AI can be used to proactively identify discrepancies between trade and settlement data, enabling faster detection and resolution of issues. This could significantly reduce operational errors, mitigate counterparty risks, and streamline the overall reconciliation process. By leveraging AI's predictive capabilities, financial institutions can increasingly improve their ability to anticipate market changes, explore how they could optimize liquidity management, and reduce the time required for post-trade final settlement. With DLT as a foundational layer, such emerging technologies have the potential to drive even deeper market efficiencies, whereby manual processes are streamlined, human error is reduced, and operational costs are lowered, all in favor of higher value-add activities and an inherently more robust market structure.

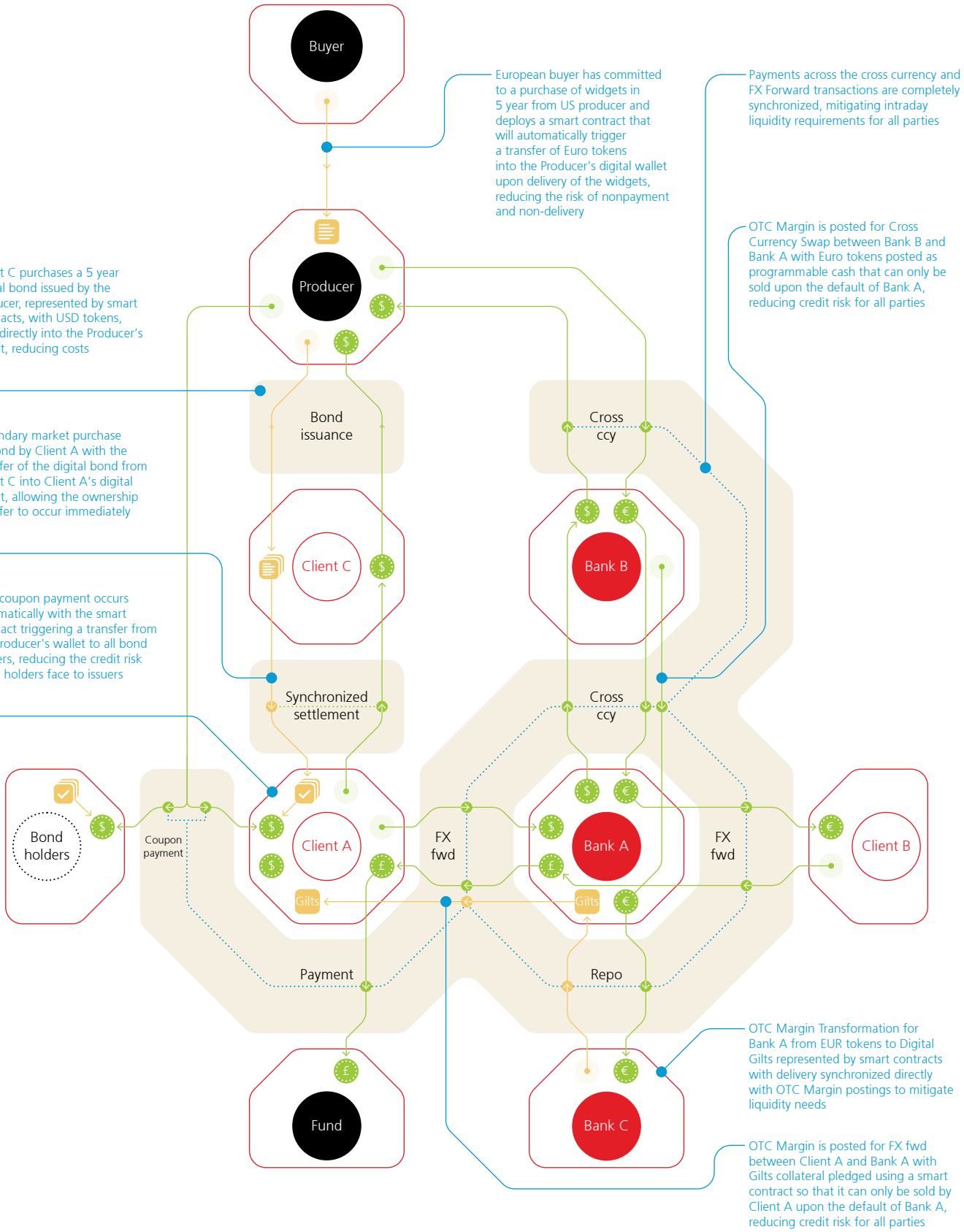
In conclusion, the integration of new technologies into Capital Markets is a transformative evolution that promises to address key inefficiencies in the current financial system. However, as with any significant technological change, the transition will require thoughtful planning, collaboration, and adaptation. By adopting a balanced, hybrid approach that draws from both TradFi and DeFi, stakeholders can build a more efficient, secure, and resilient global financial ecosystem. The incremental advances already underway, such as the City of Lugano's digital bond issuance among others, is indicative of the future and suggests that we are already undergoing a fundamental shift in how global finance operates. In the following section, this paper discusses more deeply a hybrid approach to Capital Markets, exploring how the integration of both traditional and digital elements can establish a compelling middle ground.

7 City of Lugano (2024) Deal Review

Infographic 4

A view towards Digital Capital Markets

How a fully integrated digital ecosystem could simplify the interconnected flows from infographic 1, creating efficiencies, and reducing risk for all parties.



How we evolve towards Digital Capital Markets

The combined 'middle ground' between TradFi with DeFi relies on blending aspects of digitally-native products and business models with selected and trusted structures and guardrails. To achieve this transition responsibly and collaboratively, we need careful and pragmatic innovation and regulation, and an increasing awareness of what the future could look like.

TradFi brings established regulatory oversight, institutional trust, access to capital, and a wide-ranging infrastructure that prioritizes investor protection and market stability. DeFi prioritizes something different: transparency, real-time settlement, reduced intermediaries, and programmable assets through smart contracts, and by doing so promises borderless financial services, increased efficiency, and lower costs.

The task for incumbent and influential market participants is clear: we take the best of what we have, and by leveraging powerful digital technology, we make what we have better, fill any gaps, and responsibly and transparently expand the scope where all respective parties are in agreement to do so.

Building trust through progressive regulation

Responsible integration of DeFi with TradFi relies upon permissive and pragmatic regulatory frameworks. TradFi markets are comprehensively regulated to protect investors, ensure market stability, and prevent systemic risks. DeFi, with its decentralized, permissionless nature, currently lacks these protections, which can lead to significant and institutionally-unacceptable risks.

To create a responsible blend of the two, we need flexible, adaptive frameworks that address the unique challenges and opportunities of DeFi without stifling its innovative potential. DeFi has created new financial instruments and services (e.g. decentralized exchanges, yield farming, liquidity pools) that need clearer legal classifications before TradFi institutions can participate and supervise accordingly.

A pragmatic, measured approach could see regulatory bodies and compliance professionals developing rules that do not seek to impose TradFi safeguards on DeFi approaches, but instead develop proportional oversight based on the risk and scale of the decentralized projects involved.

This may include different aspects and levels of regulation for different types of DeFi applications — for example, more comprehensive rules for larger, systemic platforms and lighter oversight for smaller, experimental projects.

A practical application of this approach would likely see wide-ranging and highly functional regulatory sandboxes as the baseline, where market participants collaborate with regulatory bodies like the SEC or FCA to test new and meaningful DeFi applications in controlled environments. This would enable banks to more readily explore innovative solutions that are pragmatic and cost-effective, while ensuring they are compliant.

Sandboxes should not just be about institutions and regulators either: digital natives should see these environments as crucial to developing DeFi protocols with governance models that ensure transparency, fairness, and accountability; creating governance standards for the middle ground needs to be a joint endeavor, and aimed at creating enough overlap for both approaches to thrive.

New techniques of appropriate regulation are not likely to emerge in isolation either. Currently, global Capital Markets' regulatory frameworks are not immediately comparable or interchangeable, with different jurisdictions enforcing localized rules around trading, compliance, and reporting. This creates compliance costs and challenges for firms operating in multiple regions and may also lead to regulatory arbitrage, where firms seek to take advantage of gaps or inconsistencies between jurisdictions.

DLT's transparency and immutability can simplify regulatory compliance by providing a shared, auditable record of all transactions, which can be seen in real-time by anyone with the appropriate permission. For example, regulatory bodies could monitor live data on transactions, and so reduce the complexity of empirical auditing and reporting. Furthermore, smart contracts could automate compliance checks, helping to ensure that transactions are only executed if they meet the regulatory requirements of the relevant jurisdiction(s). This could significantly reduce the compliance costs and risks associated with cross-border trading, and also enable regulators from different jurisdictions to collaborate more easily, fostering consistency across borders.

DLT-based models could also help with inclusion and exclusion based on verified participant status. For example, not all issuance is suitable for all types of investors, and market participants have a duty to ensure that issuance is only made available to those it is suitable for. Banks often have governance forums, and try to ensure through factors such as distribution channels, and issue size, that issuance such as certain types structured products can only reach qualified investors.

With digital issuance and smart contracts, issuers could directly enforce the eligibility requirements, and ensure that issuance is programmed to only settle into the wallets that that are permissioned to hold such securities.

> A responsible middle ground requires a hybrid approach that leverages the best of both approaches, underpinned by supportive and adaptable regulation.

Hybrid products and infrastructure

Tokenized assets are real-world assets that have been digitized and represented as tokens on a blockchain. These tokens are a digital representation of ownership or a stake in the underlying asset, such as stocks, bonds, real estate or art. Tokenization allows for easier transfer, fractional ownership, greater liquidity, and enhanced transparency, as all transactions take place and are recorded on chain. By breaking down an asset into smaller, tradable units, tokenization can also make it more accessible to a broader range of investors, positively impacting the dynamics of otherwise relatively illiquid markets.

Correspondingly, natively digital assets exist exclusively in digital form and have no physical counterpart. Examples include cryptocurrencies (like Bitcoin or Ethereum), Non-Fungible Tokens (NFTs), and other blockchain-based assets. These assets are created, stored, and traded purely in digital environments, leveraging decentralized networks for security and verification.

In the traditional financial system, assets are often held by custodians (such as banks or brokers), which provide a layer of protection and oversight. Integrating DeFi protocols with regulated custodians could provide benefits of decentralized transactions (e.g. mitigation of intermediaries, faster settlements) while maintaining the safety and oversight commonplace in TradFi; we could take the best of both worlds.

Similarly, hybrid models for lending and borrowing could make sense. DeFi lending platforms, which offer peer-to-peer transactions without intermediaries, could be blended with traditional credit markets to offer hybrid products with TradFi's security with DeFi's relative innovation, accessibility and inclusion.

It follows that hybrid exchanges could develop an important component of the middle ground: platforms that offer both centralized and decentralized trading, allowing clients to move between traditional assets and DeFi tokens easily while benefiting from liquidity from both ecosystems. Moreover, these exchanges could and should be regulated and meet market-making, trading, and clearing requirements for traditional financial institutions, while still offering the speed and relatively low-cost features of DeFi.

Furthermore, DeFi is not just about the 'asset' side of transactions. Institutional-grade digital payment rails are also crucial components of well-functioning Digital Capital Markets. Digital 'cash' — the payment leg of transactions – offers the potential for unlocking optimized business models across all business lines, and without it we risk shackling digital assets to the frictions and complexities of antiquated payments systems and regimes. With programmable digital cash suitable for institutions, the automated benefits associated with smart contracts and new technologies more broadly can be brought to life, and because of the technology, in a way that is transparent, interoperable and controllable at scale.

Digital compliance

It is not simply about TradFi getting more efficient with what it does; it is about blending the best of both approaches. DeFi protocols could be enhanced to support Know Your Customer (KYC) and Anti-Money Laundering (AML) procedures to ensure that transactions and users on DeFi platforms are compliant with (harmonized) financial regulations. This could be achieved by integrating digital identity solutions, which could be via working with specialist third-party identity verification vendors that comply with respective regulations.

Additionally, institutions could collaborate with regulators to collate whitelisted DeFi networks approved for institutional use. These networks could be designed with robust governance mechanisms that meet the standards set by financial authorities, such as ensuring transparency, fair pricing, and investor protection, and send a clear signal to the DeFi landscape about where, why and how institutions can participate at scale.

Digital compliance could also extend to products. DeFi protocols and smart contracts used for institutional transactions could undergo appropriately designed and multilaterally agreed audits to ensure compliance with standards and to minimize the risk of errors, fraud, or undesirable market practices, all of which would encourage a safe, transparent, and reliable environment for all market participants.

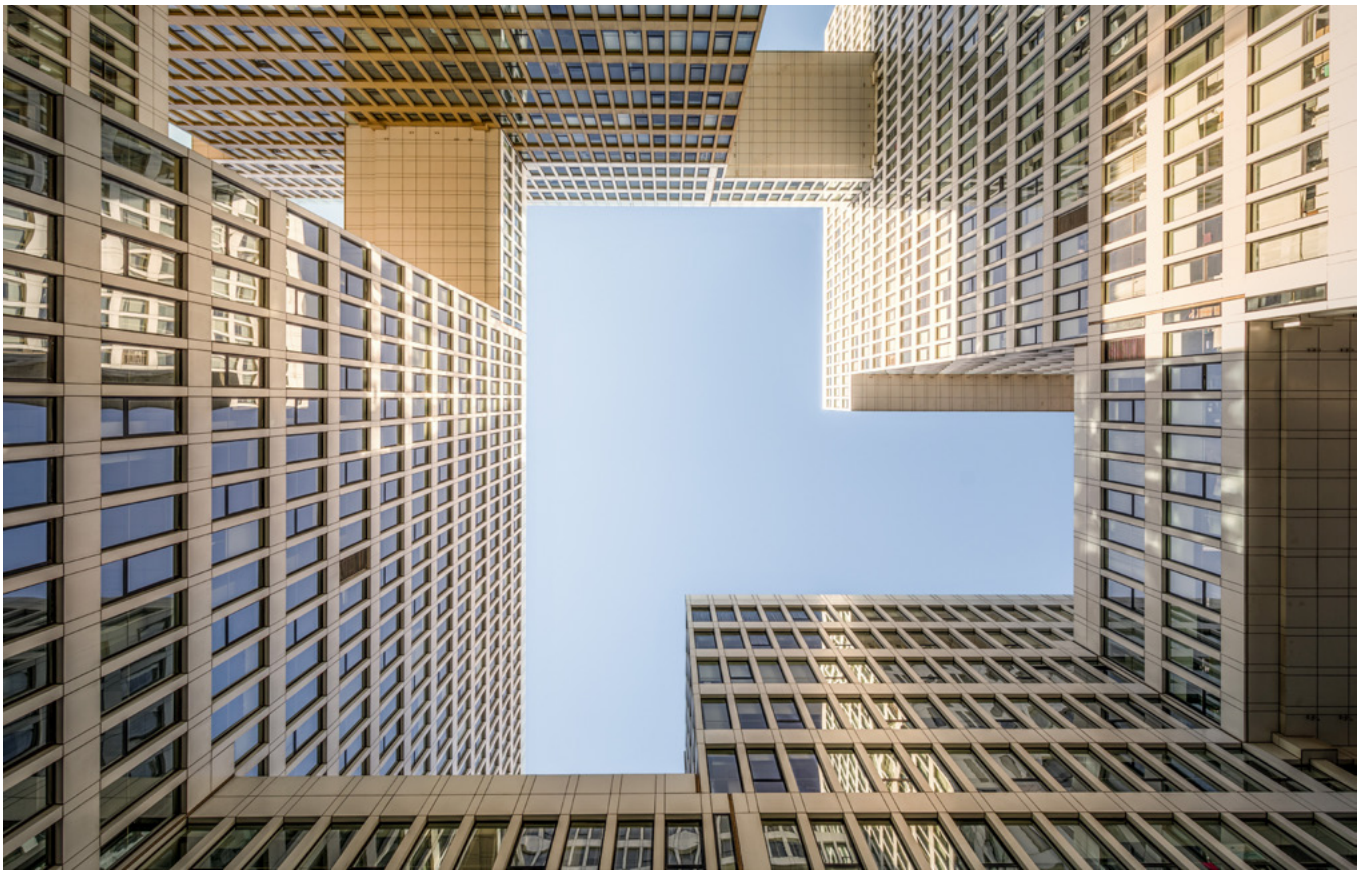
Furthermore, while natively DeFi systems lack time-served and widespread oversight, making it more difficult, for example, to identify and track fraud, institutions could use the increasing number of on-chain analytics tools to build systems that monitor DeFi markets for irregular market activities and so comply with incumbent market conduct regulations. By leveraging blockchain's transparency and immutability, TradFi can develop systems that offer real-time monitoring and risk analytics for enhanced business models that leverage DeFi's efficiencies.

Similarly, AI could enhance regulatory compliance by continuously scanning trading activity at scale and, when appropriate, automatically update systems and procedures to reflect the latest legal requirements. By moving towards digital compliance reporting and monitoring, AI-based functionality could help to identify the need for and direct manual intervention, making it easier for firms to navigate complex regulatory environments, and also flag activities that might violate standards, helping to maintain and promote market integrity.

Designing for enduring interoperability

The opportunity of combining aspects of DeFi with TradFi presents a fundamental challenge: achieving interoperability between two financial systems that, in their current forms, largely operate independently. TradFi is deeply rooted in legacy systems that are not designed to communicate with decentralized platforms, while DeFi thrives on blockchain-based technologies that are designed for interoperability and scalability.

As the financial landscape evolves, a combined future needs solutions that bridge this gap. Achieving enterprise-grade interoperability will require the creation of secure and real-time-enabled infrastructure, standardized data formats, and synchronized transaction processes across the market.



Creating intelligent infrastructure for sophisticated connectivity

A fundamental step in achieving interoperability between TradFi and DeFi is the development of more sophisticated infrastructure, particularly including Application Programming Interfaces (APIs). These APIs would serve as a bridge — information highways in a streamlined road network — allowing traditional financial institutions to interface seamlessly with decentralized platforms, enabling the exchange of information and the execution of transactions in controllable timeframes. While APIs would facilitate connectivity, of course this would need to be married with robust security measures, given the sensitivity of the throughput.

One critical feature of connected technologies is their ability to authenticate and validate transactions across both TradFi and DeFi platforms. Traditional financial systems rely heavily on centralized databases and trusted third parties for transaction validation, such as custodians, clearing-houses, or third-party banks. On the other hand, DeFi operates on blockchain networks, where transactions are validated by consensus mechanisms and smart contracts. The connectivity that facilitates interoperability need to account for these differing validation methods by offering hybrid solutions — combining cryptographic techniques to validate blockchain transactions with traditional methods of verification used in the financial world.

For instance, consider a traditional bank engaging in decentralized lending: the bank's internal system may need to interact with a DeFi platform that allows users to borrow funds against digital assets. The architecture and processes would ensure that when a loan is issued on the blockchain, the transaction is simultaneously reflected in the bank's records, with real-time information syncing between both systems. This prevents issues like double-spending or transaction delays. The hybrid connectivity, working in unison with other intelligent components, would also facilitate and manage the security protocols ensuring that both parties have confidence in the process.

Furthermore, for these connections to be effective, financial institutions need to ensure that the full stack of technology components are scalable and able to handle high transaction volumes without compromising performance. As decentralized finance grows, institutions must be able to manage growing traffic demands, which could exceed the capacity of existing infrastructure. Modules of the new financial architecture that are not only secure but also scalable will be a crucial aspects of achieving interoperability.

Finally, the ability to execute real-time transactions is paramount. One of the key benefits of blockchain-based business models are their ability to provide near-instantaneous settlement. To facilitate this, financial institutions must adapt their internal processes to accept and act on real-time data from DeFi platforms, minimizing the sequentiality associated with settlement cycles. By designing infrastructure that accounts for real-time execution, both TradFi and DeFi can realize the promise of instantaneous, borderless transactions.

Standardizing data formats and transaction architecture

For DeFi and TradFi to coexist and exchange value effectively, one of the foundational requirements is the standardization of data formats and transaction structures between these currently distinct systems.

At present, a significant challenge lies in how tokenized assets — such as stocks, bonds, commodities, and other financial instruments — are represented on blockchain networks. In TradFi, these assets are held in centralized databases, managed by custodians or clearing-houses. Conversely, in DeFi, tokenized assets exist as digital representations of traditional assets, or as natively digital assets.

This difference in representation can create significant friction in attempts to exchange or transfer value between TradFi and DeFi systems. For example, a tokenized bond issued on a blockchain might not be directly compatible with an instrument stored in a traditional clearing-house, even though both are intended to represent the same underlying asset. To bridge this divide, standardization and interchangeability are key. Financial institutions, regulators, and blockchain developers must collaborate to define common data formats that can effectively represent tokenized assets across both systems. These standardized formats would ensure that a tokenized stock or bond issued on a blockchain can be easily integrated into traditional financial infrastructures, such as any settlement systems or centralized ledgers that remain in a hybrid market structure.

Such standardization would also improve the efficiency and accuracy of transactions, ensuring that information is consistently interpreted across both systems. For example, a standard format for representing digital securities would allow banks to easily access and process the data behind tokenized securities, eliminating the need for custom-built solutions or workarounds that are commonplace in today's markets.

The challenge of interoperability extends beyond just data representation. The underlying transaction structures between DeFi and TradFi systems must also be aligned. In traditional finance, transactions often rely on established processes for trade execution, clearing, settlement, and collateral management. These processes are highly regulated and often occur within a series of intermediaries who ensure that trades settle efficiently and without risk. By contrast, DeFi platforms rely on smart contracts to automatically execute trades, settle them in real time, and manage collateral, all without intermediaries.

To achieve interoperability, DeFi systems will need to adapt their transaction structures to meet the operational needs of TradFi, and comparably, TradFi stands to benefit from modifying its approaches to forge the middle ground. For example, while a DeFi transaction may be executed and settled immediately via a smart contract, TradFi systems typically require a more step-by-step approach. Standardizing transaction structures to reflect this difference will be necessary for enabling smooth interactions. This could involve designing smart contracts that allow for off-chain processes, such as a bank's internal reconciliation systems, to interact with on-chain data in a way that mirrors the regulatory and procedural frameworks of TradFi systems.

Moreover, interoperability in transaction structures will also require addressing issues like trade execution protocols, collateral management, and settlement finality. DeFi platforms typically rely on automated, permissionless processes, while TradFi systems involve a layer of institutional control and regulatory oversight. By ensuring that transaction structures are compatible, financial institutions can provide a seamless experience for their clients while maintaining the security and compliance standards necessary in the traditional finance world. This meeting somewhere in the middle would also help to reduce the complexity and cost of cross-system transactions, enabling faster, more reliable execution of trades between the two currently disparate sectors.

Achieving synchronization

Another significant challenge to achieving true interoperability is ensuring synchronization across multiple elements of the new, hybrid ecosystem. The DeFi ecosystem is vast and rapidly evolving, with numerous decentralized applications (dApps) and blockchain protocols built on different platforms such as Ethereum, Solana, or Polkadot. These platforms often use different consensus mechanisms to regulate the respective protocol, and their transaction protocols may not align perfectly with one another. As such, achieving synchronization between various platforms and systems is essential for ensuring that transactions occur seamlessly and consistently across the entire ecosystem.

Take, for example, the emerging field of CBDCs. As countries and currency areas begin to issue their own CBDCs, these digital currencies must be able to interact with existing DeFi platforms to enable seamless cross-border payments, liquidity provisioning, and the tokenization of traditional assets. However, without regulatory and technical harmonization, CBDCs may be issued on entirely different networks, potentially using different protocols than those used in established DeFi platforms. To unlock the full potential of DeFi, it is critical that digital assets can be synchronized across networks to facilitate instantaneous ('atomic') settlement—the simultaneous, final transfer of digital assets between counterparties.

Moreover, synchronization across DeFi implementations would enable true Delivery vs. Payment (DvP), a promising feature for digital financial transactions that ensure both the asset and the payment are delivered at the same time. In a traditional financial system, DvP is achieved, albeit sequentially, through intermediaries like clearing-houses, but in the world of DeFi, this is accomplished by ensuring that transactions settle atomically and instantaneously across different platforms. Developing cross-chain interoperability standards will ensure that different blockchain systems can 'talk' to one another, allowing for the frictionless transfer of assets, and the associated digital efficiencies.

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Fostering a culture of sustained and sustainable innovation

For the financial sector to progress effectively, there needs to be an industry-wide dialogue that bridges the gap between TradFi and DeFi. Banks and other key stakeholders can act as both owners and facilitators, structuring and advancing discussions between regulators, institutions, specialist vendors and DeFi initiatives. The goal should be to develop a shared understanding and framework that allows both approaches to coexist and thrive. This dialogue should be focused on specific, real-world commercial and organizational use cases, ensuring it resonates across the broader market.

In particular, initiatives contributing to Digital Capital Markets could be curated around near-to-mid-term milestones. For example, institutional digital payments may be the initial primary focus, followed by the integration of digital collateral functionality, digital issuance models, digital Repo transactions and so on. Given the interconnected nature of Capital Markets — one that will likely become more seamless in a digital world — it is essential that the industry at large has a clear direction of travel. Without a unified and inclusive approach, meaningful and sustainable progress may remain elusive.

A crucial aspect of this transition is education, both within financial institutions and across the wider market. Much of DeFi — and TradFi for that matter — is potentially too complex unless that market or process is the day-to-day focus: this does not need to be the case. There is a pressing need to create educational content and opportunities for organizations, clients and wider market participants that highlight DeFi's potential while emphasizing the importance of regulated, compliant approaches commonplace across TradFi. The focus should not be on adopting new technology for its own sake, but on how this technology can drive real commercial and organizational outcomes. To support this, there must be advocacy for bridging the gap between TradFi and DeFi: we need a cultural as much as a technological evolution.

To help drive the transition, the adoption of innovation within organizations needs to be supported at the highest levels. Innovation aimed at delivering commercial and organizational benefits should be at the core of market participants' strategy roadmaps, and progress needs organizational leaders to actively champion this change. Business models should evolve with digital technologies at the center, not as an afterthought or a side project. This may require a shift in mindset in some areas of the market, which in part means understanding that the investment required today might not pay off immediately, but is necessary for future growth. Senior leadership could also encourage and equip teams to experiment with technologies to enhance operational efficiency and scalability, ensuring that innovation becomes an integral part of 'the way we do it here'. Additionally, attracting and retaining talent will be crucial to driving this transformation.

Finally, regulatory bodies can also play an important role in fostering innovation. Broadly functional and incentivized market-level mechanisms could be developed to allow institutional players to collaborate on meaningful use cases that advance the industry commercially, organizationally and culturally. This could mean establishing formalized networks that provide vetted technology and specialist insight, and fostering partnerships between TradFi and DeFi players to build trust and encourage collaboration. Bridging the gap between the two systems may require a guided approach; the middle ground is a necessarily multilateral endeavor where all parties can and should contribute.

Summary

Capital Markets are relatively efficient and seemingly stable, but complexity, fragility and inefficiencies often emerge in times of growing and widespread dislocation and stress. Global Capital Markets are the product of decades of increasingly interconnected systems, architectures, processes, regulations, and learned behaviors, creating an industry that functions despite its many structural challenges and limitations. However, viewed through the lens of powerful digital technologies, this does not have to remain the way we operate as an industry: If we were to design a global Capital Markets model, the blueprint would — and arguably should — differ substantially from the current setup.

By introducing new tools for connectivity, control, and transparency through advanced technologies like DLT, smart contracts, and well-chosen applications of AI, traditional and regulated business models can evolve responsibly and at scale. With these advancements, our Capital Markets model can achieve a valuable 'middle ground': a scalable, adaptable network of networks that is both technologically robust and aligned with core needs and objectives across the market.

The responsible integration of DeFi with TradFi requires a thoughtful, balanced approach that combines innovation with responsible, collaborative and methodical progress. By leveraging the strengths of both approaches — DeFi's relative efficiency and innovation, and TradFi's relative security and oversight — we can create a hybrid financial system that offers greater efficiencies, and instead of compromising on stability, serves to enhance it.

A key aspect of combining DeFi and TradFi is achieving interoperability between the two. In its current form, DeFi is largely distinct from TradFi, and equally TradFi is predominantly based on siloed, legacy systems that are not built to communicate with emerging business models that are potentially better ways of conducting business.

A unified future needs solutions that bridge this gap. This includes creating intelligent infrastructure and functionality that would allow traditional financial institutions to embrace new ways of working that, for example, enable transactions that are both secure and real-time. To aid this, having 'industry standard' ledgers acceptable to all parties would be a pragmatic step forward.

To ensure smooth interaction between traditional and decentralized systems, data formats and transaction structures should also be translatable. This includes ensuring natively digital, and digital asset representations on blockchain (e.g., tokenized stocks or bonds) are, as much as practically possible, interoperable with incumbent systems across existing markets.

To successfully do so, banks need to strategically select and leverage cutting edge technologies — such as DLT and aspects of AI — in the right way and in the right places, along with playing a significant role in helping to carefully evolve regulatory frameworks, financial architecture, and market structures.

All of this change necessitates navigating complex legal, technical, operational and human-centric challenges, but if we get this right, the rewards in terms of systemic functionality, control, transparency and inclusion are compelling.

Pragmatic regulation, well-thought-out guardrails, and transparency is going to be essential for ensuring that this digital evolution broadly benefits market participants and contributes positively to the global financial ecosystem, and insomuch, part of the challenge is cultural.

For example, DeFi practices and products are largely still viewed as risk-on activities — but it is not necessarily that way. If viewed from the perspective of TradFi, using TradFi parameters and metrics, then DeFi may well seem too risky and potentially misunderstood. But it may be because the lens through which DeFi is being evaluated is not the right lens: DeFi is fundamentally different to TradFi, and if we measure it in the same way, the actual risk may be that TradFi misunderstands it, and misses the opportunity to leverage everything that it could offer for the development of better functioning and more inclusive Capital Markets.

The reality is that by adapting business models with DLT and aspects of AI, we have the potential to address many of the structural challenges that incumbent Capital Markets face today. By enabling faster settlements, improving liquidity management, enhancing transparency, and reducing regulatory complexity, these technologies can significantly enhance the efficiency, security, and resilience of global finance. At the same time, it should be made abundantly clear that it is not a simple step-change, and moreover not a binary choice between TradFi and DeFi; this fundamental and directional shift is an evolution where we can blend the best of both approaches.

To practically make progress, the industry at large would likely benefit from the assortment of institutionally-led initiatives related to Digital Capital Markets being refined and directed towards industry-wide milestones. For example, this could mean a phased approach towards institutional digital payments models, followed by digital collateral, then digital issuance, and so on until we, as an industry, have the components of Digital Capital Markets in use at scale and working in harmony.

Primarily due to the interconnected nature of Capital Markets — which is likely to remain true in a digital future — the risk is that if there is not an industry-level direction of travel with specific and tangible milestones, demonstrable and actually beneficial progress remains in question. This in turn will potentially limit the opportunity for the industry to operate in a fundamentally better way for all.

Appendix

The challenges and opportunities of faster settlement

The implications of T+1

Settlement failures often result from operational issues, such as incorrect account details, rather than an inability to find a borrow. These issues can usually be resolved within the settlement window, but moving to T+1 settlement reduces the time available for remediation, making it harder to avoid costly fails. Cross-border transactions also introduce additional complexity, particularly due to the FX requirements. For instance, an APAC client placing an overnight order to buy US Treasuries may only learn of their fills the next morning. If they need to fund the transaction with FX, they would face the challenge of same-day settlement, which is operationally intensive and lacks the protection of CLS, significantly increasing risk.

The alternative — pre-funding US dollars — comes with higher costs. To address these challenges, some APAC counterparties have established global operations functions to manage funding outside of standard market operating times. Despite these operational hurdles, compressing settlement lifecycles offers significant benefit, primarily through reducing credit exposure by limiting the time between execution and settlement.

The importance of Repo markets

The global Repo market is estimated to be USD 15 trillion, with daily turnover around USD 3 trillion.[8] Its importance is evident, as it serves as a critical component of financial market activities, often acting as a barometer for market health and stress. It is also a key tool for central banks to manage the money supply and implement monetary policy. Repo transactions provide essential funding and liquidity for both buy-side and sell-side participants, allowing them to raise short-term cash by using assets as collateral. The market is particularly important during times of market dislocation, as central banks often intervene to stabilize conditions and ensure proper collateral management and transformation for all market participants.

The Repo market also enables borrowing of assets to facilitate short selling — where assets are borrowed and sold with the expectation that their prices will fall, allowing them to be repurchased at a lower price. Furthermore, the market offers an opportunity for buy-side firms, especially those with excess High Quality Liquid Assets (HQLA), typically sovereign bonds, to generate revenue. These firms can engage in 'upgrade trades' with banks, providing lower-quality collateral in exchange for HQLA that meet regulatory liquidity requirements, such as those imposed under Basel III requirements. This dynamic helps banks comply with various regulatory ratios while creating a market for firms to monetize excess assets.

8 ICMA (2018) How big is the repo market? — Frequently Asked Questions on Repo

The move to T+1

The Repo market involves two legs: a cash leg and a securities leg, which settle through separate infrastructures — payments and secondary market trading systems, respectively. For Repo to be effective, it must settle one day faster than the securities settlement timeline in the jurisdiction. In the US, the Repo market has traditionally settled on T+0, facilitating the relatively smooth transition to T+1 settlement in May 2024. The US benefits from a centralized custody system, with a single International Central Securities Depository (ICSD) handling US Treasury transactions, which has been crucial for supporting T+0 settlement.

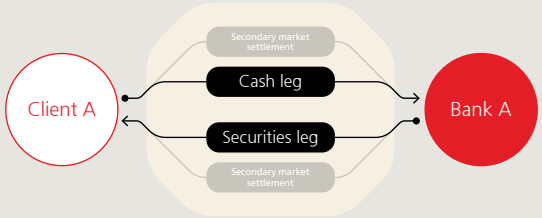
In contrast, the European Union consists of multiple member states with their own Central Securities Depository (CSD), each managing localized custody and settlement, particularly for primary government issuances. As the demand for European government securities grew beyond national borders, securities began transferring across CSDs. Most of these CSDs have been acquired and integrated into either Euroclear or Clearstream ICSDs, with interoperability between the two becoming critical. To enable this, Clearstream and Euroclear operate a bridge for securities transfers in batch processes within specific time frames with cash and securities accounts with each other, but this setup was never intended for large-scale T+0 Repo settlement.

Achieving efficient T+1 securities settlement in Europe would require a reliable T+0 Repo market, but the current infrastructure, which settles Repo at T+1, presents significant structural challenges, which are potentially insurmountable. Without a T+0 Repo model, there would be a high risk of cascading settlement fails, increased costs for participants to hold additional securities on balance sheets, or a reduction in liquidity in secondary markets. The current set-up is necessarily intermediated to make it work: a model based on DLT could alleviate these structural inefficiencies at scale.

The Repo settlement process

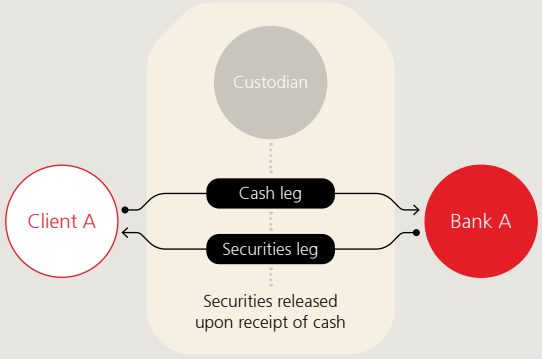
A Repo transaction is an agreement to sell and then repurchase securities from a counterparty at some future date.

Repo transactions can be settled using the standard secondary market trading infrastructure, but given the large volumes that can be involved, this set up can result in a large quantum of settlement risk for the buyer of the Repo if the seller fails to deliver on the cash leg.



Source: JD Risk Solutions, UBS IB Strategic Ventures

An alternative is to use a custodian to settle the transaction 'Delivery vs Payment' (DvP). In this model, both the cash and the securities leg go through the custodian, and the custodian only releases the securities into the seller's custody account when the cash has been received.



Source: JD Risk Solutions, UBS IB Strategic Ventures

The structural inefficiencies of Issuance

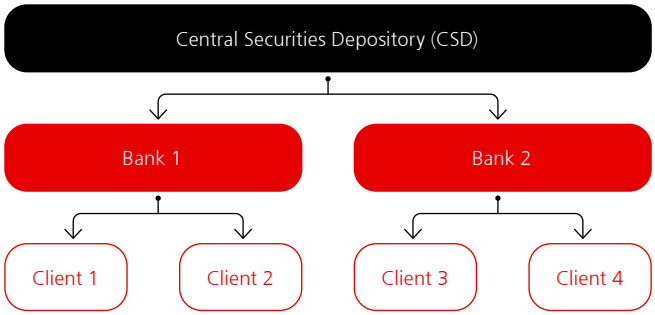
The need for banks to fund at scale

The issuance process involves several stages, with a critical window between the pricing of the issue and final settlement, typically lasting five business days. During this period, issuers face settlement risk, which can be mitigated if the issuance is underwritten by a bank. In this scenario, the bank absorbs the settlement risk of the issuer by purchasing the bonds and then seeking to distribute them to clients in the secondary market. However, this comes with significant funding costs. For example, underwriting a USD 1bn deal, with the bank funding overnight at an interest rate of 5%, could result in nearly USD 700k in costs over the five-day settlement period. These costs can escalate quickly if settlement failures occur, often due to operational issues such as incorrect client details.

In addition to overnight funding costs, there is the challenge of timing mismatches between incoming payments from bond purchasers and outgoing payments the banks must make as part of their regular activities. This uncertainty about the exact timing of incoming payments requires the bank to rely on intraday liquidity to manage balances on settlement day. The scale of these costs is considerable: in 2023, nearly 17,000 underwritten investment grade corporate deals totaling more than USD 4 trillion were issued.[9] Using the same five-day settlement period and 5% overnight funding rate, this would result in approximately USD 2.7bn in funding costs that would ultimately be passed on to the issuer. These substantial costs highlight the financial strain involved in the underwriting process, especially when settlement issues arise.

Inefficiencies extend across post-trade

The issuance process is just the beginning of the operational tasks tied to a bond issue. For most bonds, the issuer must make regular coupon payments to all bondholders. For US Treasuries alone, this can range from USD 40bn to USD 170bn in coupon payments per month.[10] In addition, corporate actions such as debt buybacks or bond calls often require payments or other actions for every registered bondholder. Bonds are typically held in a custody model, where ownership records are not centralized but distributed across a cascade of nodes, with each node maintaining records for the one directly below it.



Source: JD Risk Solutions, UBS IB Strategic Ventures

In this model, the CSD as the custodian, holds ownership records for banks (like Bank 1 and Bank 2), which in turn maintain records for their clients. Each node in the chain, including the CSD, typically holds a cash account for the node below. When a coupon payment is made, it is sent to the CSD and cascades down to the banks, which then distribute it to their clients. This structure can involve multiple layers of sub-custodians, global and regional banks, funds, and retail clients.

The process requires only one payment from the issuer to the CSD, and then each node updates its ledger to reflect the cash balance changes. In jurisdictions like the US, the concept of beneficial ownership is applied: the custodian is the registered owner, but the beneficial interest belongs to the end purchaser. This model facilitates faster secondary trading, as ownership changes are recorded within each node without physical transfer of securities.

The cascade of payments works efficiently downwards, ensuring that beneficial owners receive coupon payments by the end of the day. However, this system struggles when dealing with corporate actions, especially those where options are presented to bondholders. These actions must be communicated upwards through the chain, which relies on each node to gather and aggregate information from below. The election choices (e.g., stock or cash payments) create complications, as the distribution needs to cascade back down based on each holder's selection.

The lack of a standardized method for issuers to disseminate corporate actions further complicates this process, creating an operational burden on each node. As bond issuances become more complex, with variable coupons and other factors, the risk of operational gridlock increases.

What we currently face is an issue of timely and accurate transfer of information and value. Viewed through the lens of digital technologies, it does not have to be this way: DLT offers a way to make the issuance lifecycle so much easier.

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