

In collaboration
with Accenture



Modernizing Financial Markets with Wholesale Central Bank Digital Currency (wCBDC)

INSIGHT REPORT
APRIL 2024



Contents



Foreword	03
Preface	04
Executive summary	05
Introduction	06
1 Foundational key concepts	07
2 Wholesale financial markets use cases	10
3 The digital money continuum	12
4 wCBDC initiatives	16
5 Industry challenges	19
6 Areas of differentiated value	22
7 Persistent industry challenges	41
8 Trade-offs and considerations	58
9 RTGS systems	62
10 Alternative payment instruments	64
11 Multi-token and multi-system future	73
Conclusion	75
Contributors	76
Endnotes	79

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Foreword



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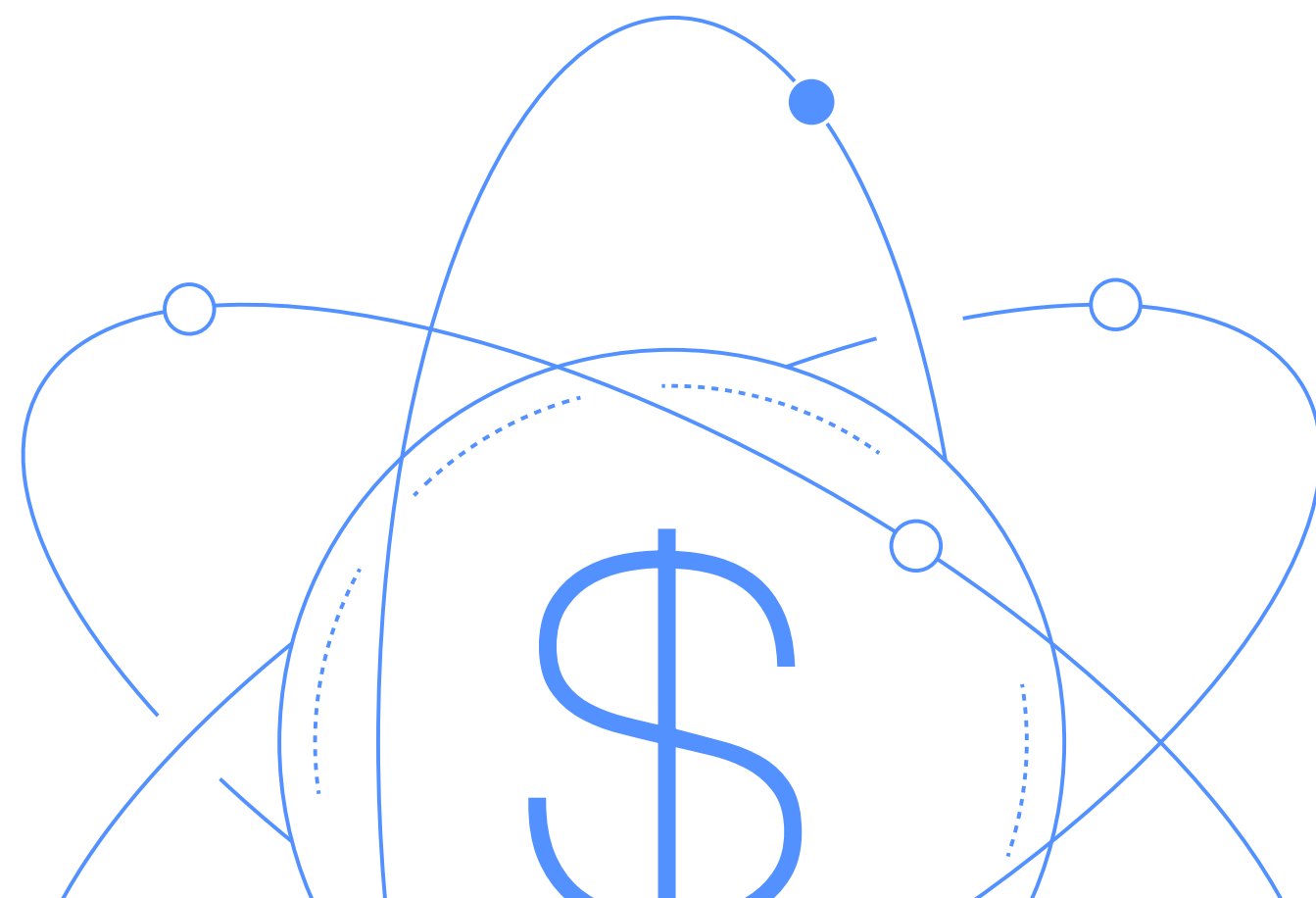
Over 98% of the global economy's central banks are researching, experimenting, piloting or deploying central bank digital currency (CBDC) to determine how to modernize the capabilities of and improve access to central bank money (CeBM).¹ An opportunity exists to make use of ongoing innovations in CeBM to modernize wholesale financial markets by enhancing systemically important payments between institutions. These markets demand secure and efficient settlement infrastructure from participants to promote financial stability, enable domestic and international trade, and create economic opportunities.

Central banks are modernizing real-time gross settlement (RTGS) systems – the predominant wholesale funds transfer system – and wholesale CBDC (wCBDC) represents an opportunity to address existing and emerging industry

challenges across interbank payments and securities transactions. Meanwhile, non-CBDC payment instruments are arriving on the scene – reserves-backed digital currencies (RBDCs), deposit tokens (DTs) and fiat-backed stablecoins (FBSs). These instruments are continually challenging our collective view of digital money.

With this backdrop and a recent survey finding that there could be 24 live CBDCs by 2030, the importance of clarifying the role of CeBM and wCBDC in the next generation of wholesale financial markets is underscored, and this report intends to deliver upon that goal.² Central banks, commercial banks and financial market infrastructures (FMIs) like custodians, depository institutions, exchanges, clearinghouses and settlement agents seek to better understand wCBDC's value proposition.

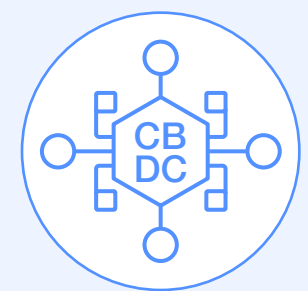
In this context, the World Economic Forum has collaborated with Accenture to articulate how a wCBDC might provide differentiated value. We took a holistic view of the relevant industry challenges to produce practical insights for policy-makers and the private sector's planning efforts to realize the full potential of wCBDC, if pursued. Importantly, deep public-private sector collaboration is necessary to modernize wholesale financial markets securely and efficiently.



98%

of global central banks are exploring CBDC to enhance CeBM access and modernization.

24



live CBDCs are projected by 2030, underscoring the need to define CeBM and wCBDC's roles in future wholesale financial markets.

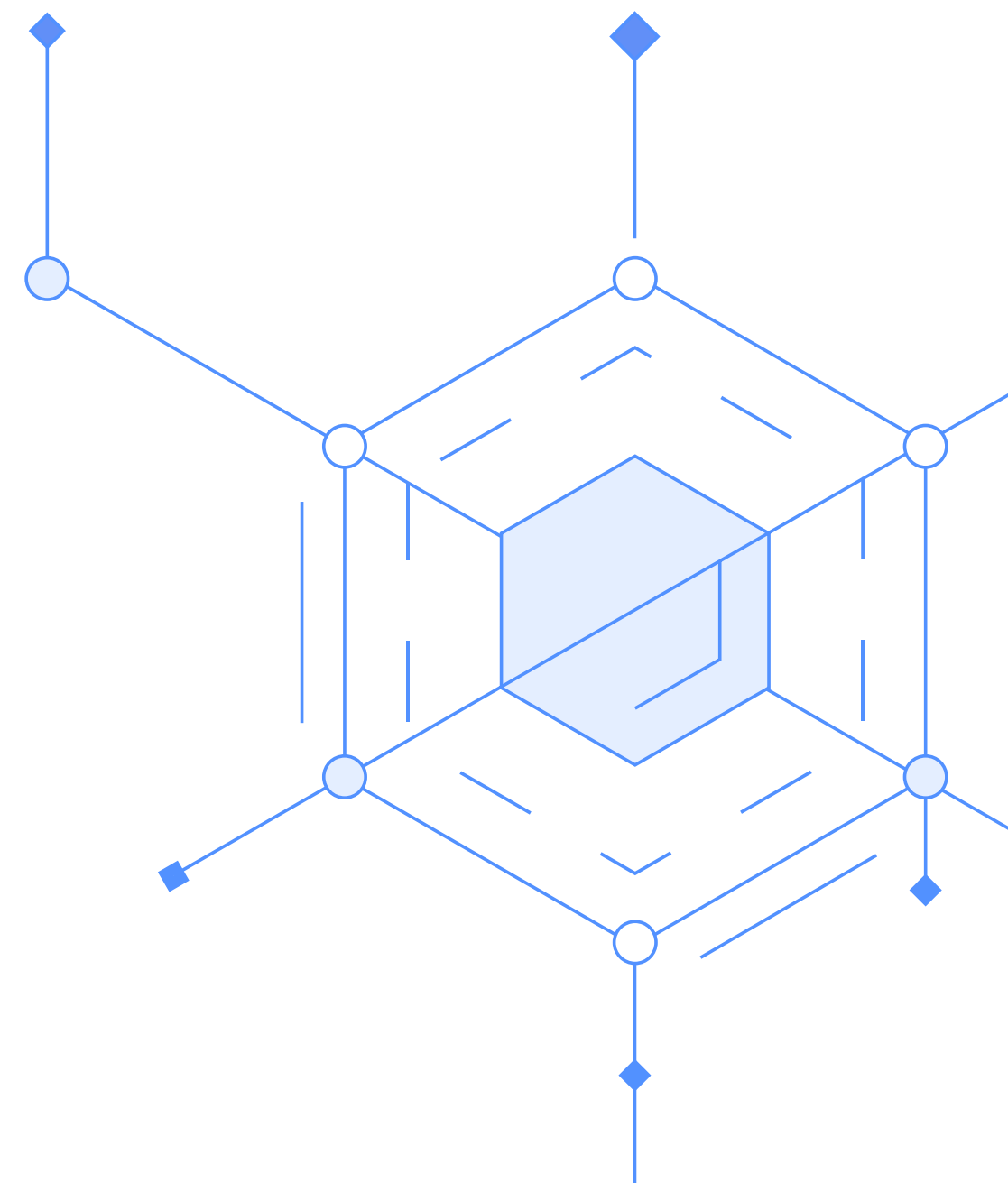


wCBDC represents an opportunity to address challenges in interbank payments and securities.

Preface

The financial sector is on the precipice of the next phase of wholesale central bank digital currency (wCBDC). In late 2023, Switzerland saw the first-ever live wCBDC issued to settle a digital bond transaction as part of a limited-phase pilot. In Asia and the Middle East, Project mBridge is redefining cross-border payments using wCBDC by expanding its observing members to 25 central banks and institutions ahead of its minimum viable product launch this year. The European Central Bank (ECB) has also begun testing wCBDC on distributed ledger technology for securities and foreign exchange transactions. The Bank for International Settlements (BIS) general manager, Agustín Carstens, stated that wCBDC should be “taken for granted”, noting its expected broad adoption.³ With more than 200 central banks, over 130 regulated financial market infrastructures (FMIs) and a large proportion of economic activity that relies on wholesale financial markets, the question of wCBDC’s value proposition comes to the forefront.

While wCBDCs are already being used in limited cases, wCBDC systems are still a new concept. The broad availability of wCBDC systems will depend on policy choices focused on financial stability and safe and sound market practices. The legal and regulatory elements that will govern the possibility of widespread use of wCBDC have an unknown timeframe. Thus, private-sector solutions may grow alongside wCBDC development, and the outcome of regulations will influence the future mix of payment instruments.

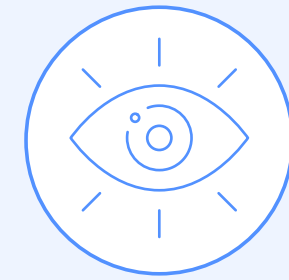


Executive summary

This report explores the potential of wholesale central bank digital currency to address challenges in financial markets through a global multistakeholder approach.

Central bank money (CeBM) is crucial for interbank payments and securities transactions because it is virtually free of credit and liquidity risk, enables institutions to reach settlement finality and promotes financial stability. CeBM is ideal for systemically important transactions despite the emergence of alternative payment instruments. Wholesale central bank digital currency (wCBDC) is a form of CeBM that could unlock new economic models and integration points that are not possible today. wCBDCs promise to preserve the role of CeBM as a credit risk-free payment instrument by providing a foundational layer for digital payments in the next generation of financial markets.

Four areas of differentiated value for wCBDCs are highlighted:



Realizing a global settlement window by harmonizing foreign exchange (FX) and securities markets settlement times to overcome operational hour disparities among key trading corridors.



Expanding payment-versus-payment arrangements through cost-effective solutions that can support a diversity of currencies to enhance currency liquidity.



Mutualizing data across parties by securely transmitting settlement data across parties and jurisdictions to support automation, reduce settlement risk, and enhance trade and post-trade activities.



Tokenizing credit risk-free settlement media for settling tokenized securities and supporting emerging tokenized payment instruments.

These findings suggest wCBDC systems are well-positioned to modernize cross-border transactions, especially those involving multiple parties and assets like FX or securities.

There is a set of persistent industry challenges that require modernization beyond introducing a new payment innovation. Further evidence is needed to conclude whether wCBDC can effectively address: liquidity management optimization, CeBM accessibility, compliance by design and new and existing system interoperability. This report offers a set of calls to action for the industry to consider and continue advancing the global dialogue in these areas.

Real-time gross settlement (RTGS) systems and legacy infrastructure are being modernized to meet evolving demands, and these systems will exist in parallel with wCBDC. Likewise, privately issued reserves-backed digital currencies (RBDCs), deposit tokens (DTs) and fiat-backed stablecoins (FBSs) are examined to distinguish their potential role with wCBDCs and envision a digital payments ecosystem where a diverse set of payment options coexist.

Policy-makers, financial market infrastructures and private sector leaders should apply these insights to their respective jurisdictions to ensure a more efficient, responsible and secure financial future.

Introduction

Through a global multistakeholder approach, this report explores how wholesale central bank digital currency could address challenges in financial markets.

Scope: This report proposes areas where wholesale central bank digital currency (wCBDC) could uniquely generate differentiated value and considers what role other emerging payment systems may play.



Select the tabs to cycle between texts

Research methods:



Desk research

that analysed 200+ industry reports to establish a baseline of findings.



Expert interviews

with more than 50 experts representing public and private sector stakeholders.

Community:



Steering committee

of ten leaders from leading institutions to advise on strategic direction.



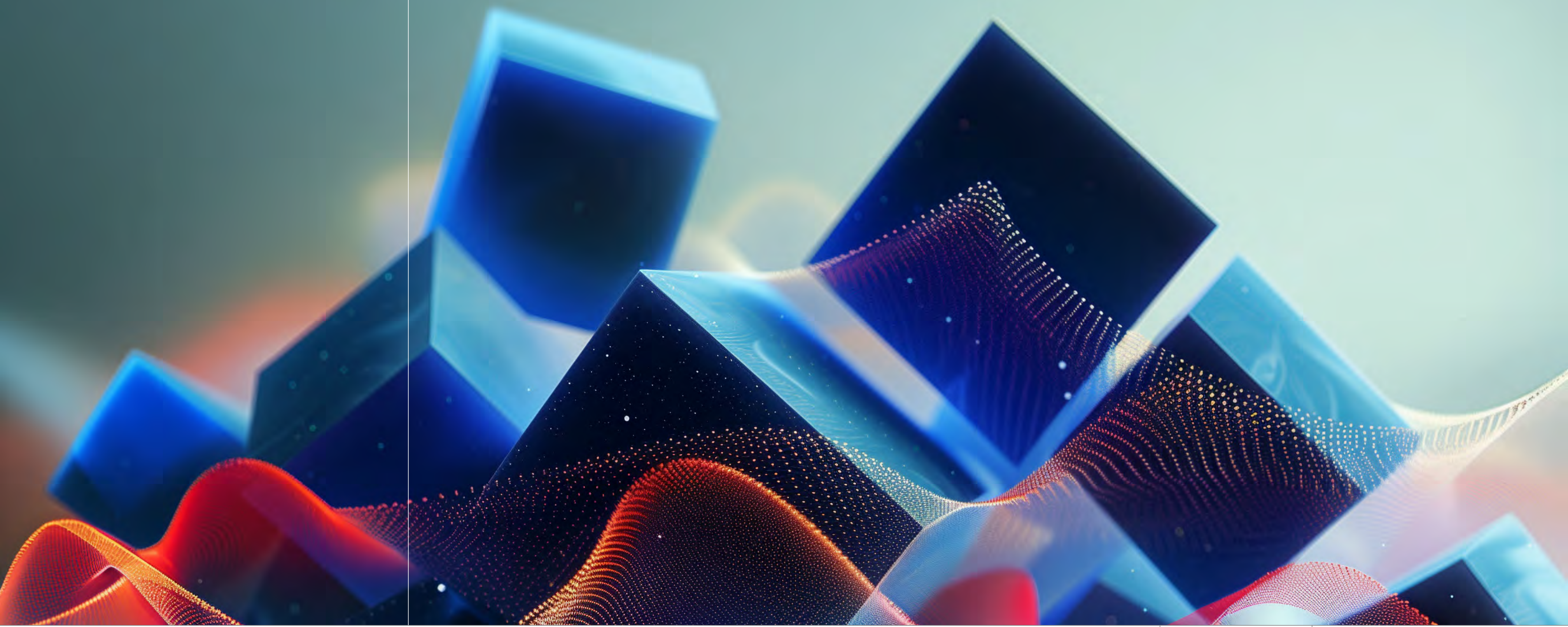
Community

of over 100 expert members representing more than 60 institutions.



1

Foundational key concepts



This report mentions a wide range of industry terms that are summarized here in alphabetical order.



Atomic settlement

The Bank for International Settlements (BIS) defines atomic settlement as the “use of a smart contract to link two assets to ensure that the transfer of one asset occurs if and only if the transfer of the other asset also occurs.”⁴ It is important to note that atomic settlement includes both the instant and simultaneous transfer of assets. Atomic settlement can also be achieved **without** distributed ledger technology (DLT) through programmatic functions and codified rules. The two types of atomic settlement relevant for this report are:



Delivery versus payment (DvP): the exchange or concurrent transfer of an asset like a security (delivery) for a cash leg (payment).



Payment versus payment (PvP): the exchange or concurrent transfer of two cash legs, typically foreign exchange (FX).



Central bank money

The BIS states, “A central bank issues public money via banknotes and central bank reserves.”⁵ Central bank money (CeBM), in the wholesale context, exists in the form of reserves held at a central bank on behalf of institutions and is accessed through an electronic system that manages participant obligations. M0 money includes CeBM and is the ultimate and final form of settlement because it is virtually free of credit risk, except for sovereign credit risk (e.g. a government could be unable or unwilling to meet its credit obligations, which impacts the value of its currency). With the proper legal backing to govern the transactions, commercial banks and other financial institutions (FIs) use CeBM to facilitate settlement finality.



Commercial bank money

A commercial bank liability in the form of deposits held at the commercial bank, which can be used for settlement purposes.⁶ This money constitutes a significant portion of the global money supply and is a form of private money created when banks extend loans.⁷



Deposit tokens

For this report, deposit tokens are defined as a form of money that is a commercial bank liability and represented as a token that operates within the know-your-customer (KYC) boundaries of the issuing bank(s). This instrument is reserved for commercial and retail use, intra-bank payments, such as a bank making internal book entries, and payments between two or more banks.



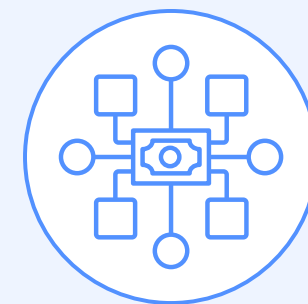
Fiat-backed stablecoins

A form of privately issued money representing fiat currency values commonly found on blockchains (distributed ledgers). They maintain 1:1 convertibility with the underlying currency through the issuer. This instrument is backed 1:1 by reserves of high quality and liquid cash-like assets such as short-term treasury bills (T-bills), treasury repurchase agreements (repos) and balances at commercial bank deposits. The total supply of the tokens will at least match how much they have backed by cash and cash equivalents (backing can have an additional capital buffer).⁸



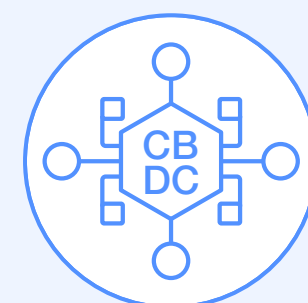
Reserves-backed digital currencies

A privately issued payment instrument backed 1:1 by central bank reserves, and a bankruptcy-remote digital currency secure from other creditors in the case of operator and participant default. Sometimes colloquially known as a “synthetic CBDC”, which is a misleading term because it implies central bank backing. **RBDC is not CeBM.** Per its community, this report proposes a more accurate designation: reserves-backed digital currency.



Real-time gross settlement (RTGS) system

The predominant central bank-supervised or -operated settlement system type that achieves settlement in CeBM in real-time and transaction-by-transaction.⁹



Wholesale CBDC

There are multiple definitions of wCBDC, but for this report, a wCBDC is defined as a tokenized CBDC designed for interbank payments and securities transactions between commercial banks, financial institutions and possibly certain global corporations.

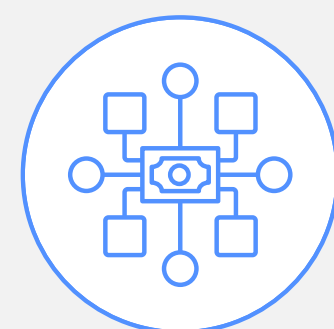


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Wholesale financial markets use cases

To examine opportunities to modernize financial markets, this report focuses on interbank payments and securities transactions.

While there are many relevant use cases, this report focuses on two wCBDC use case areas: interbank payments and securities transactions because these represent fundamental areas of wholesale financial markets.



Interbank payments

Interbank payments involve payments in CeBM made between FIs.

1 Domestic payments

Settle payment obligations between banks and other FIs within a jurisdiction, whether a single payment leg (P) or two payment legs (PvP).

2 Cross-border payments via nostro accounts

Settle cross-border payments between central banks, banks and other FIs located in different jurisdictions (P, PvP).

3 Cross-border payments via central bank accounts

Provide currency liquidity across jurisdictions using central bank infrastructure arranged by a market maker or dealer to fund cross-border payments (PvP).



Securities transactions

Securities transactions represent payments in CeBM as the “cash leg” in transactions.

1 DvP for securities settlement

Settle securities trade activities involving equities and fixed-income instruments domestically and cross-border, including tokenized securities (DvP).

2 Collateral and liquidity management

Serve as a payment instrument to be posted as collateral or used to purchase or acquire intraday liquidity (PvP, DvP).

3 Post-trade operations

Facilitate post-trade settlement and operations for securities, which is a core subsequent process to DvP for securities settlement (PvP, DvP).

3

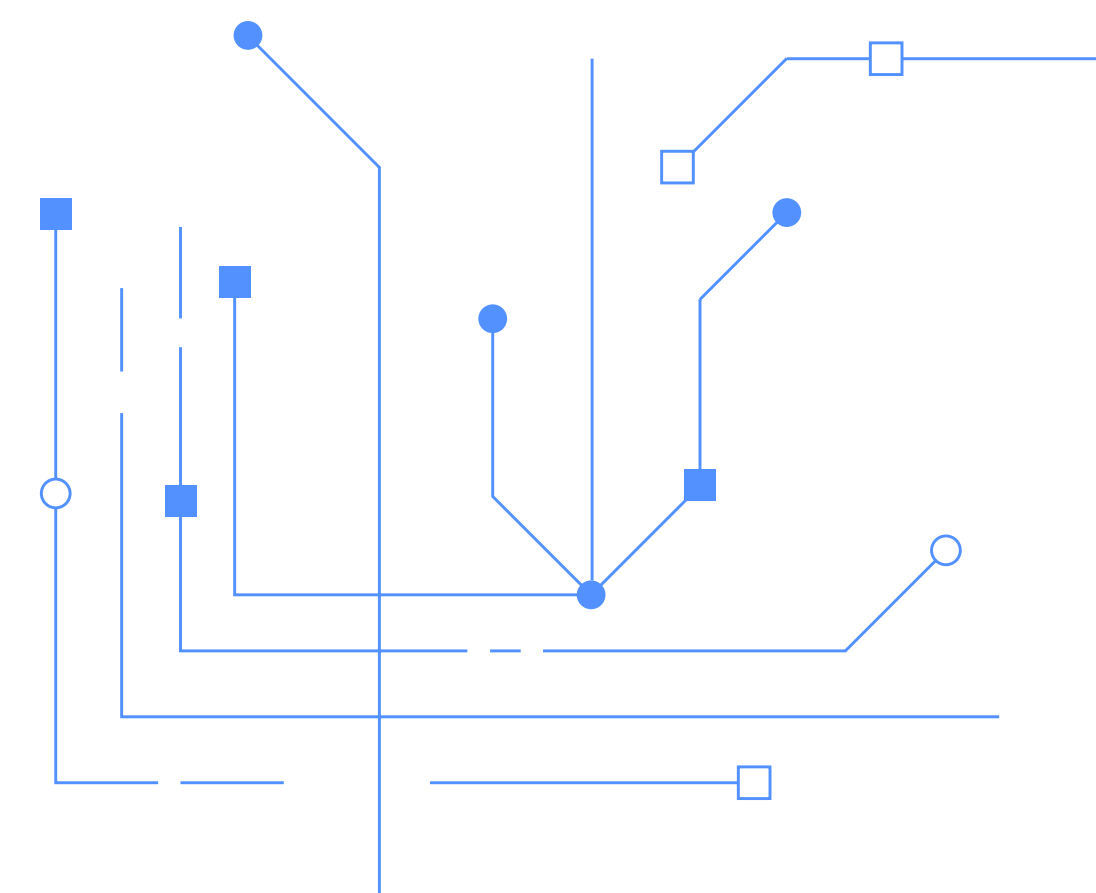
The digital money continuum



3 The digital money continuum

Money takes many forms, and the ongoing digitization of cash is creating alternative payment instruments that are increasingly challenging the status quo.

Money is often considered a payment instrument issued by a sovereign entity, like a central bank issuing public money. However, money can also be private, including when commercial banks take customer deposits and extend credit for loans, thus creating commercial bank money. Further, non-bank money is another form of private money whereby licenced FIs, like money transmitters, can issue money.



CeBM is most suitable for **interbank payments** and **securities transactions** because it:

- **Carries no credit or liquidity risk:** The Principles for Financial Market Infrastructures (PFMI) advises CeBM for systemically important transactions where practical and available to avoid credit and liquidity risks.¹⁰
- **Facilitates settlement finality:** A bankruptcy-remote payment instrument with the proper legal backing governs the transactions to facilitate settlement finality, which is the irrevocable and unconditional transfer of an asset or financial instrument.¹¹
- **Maintains financial stability:** CeBM promotes the relevance and role of a virtually credit-risk-free payment instrument in financial transactions and supports existing credit creation processes.

Note: This table represents an aspirational classification of digital monies that are pegged to fiat currencies. The exact designation of digital monies will vary depending on the relevant rules and regulations in a given jurisdiction. Many instruments, such as crypto-assets, are intentionally excluded.

*Reserves-backed money incorporates elements of both public and private money. While they are categorized as private money in this table, given that the issuing parties would be private entities, the issuance is backed by public money, comprising central bank reserves that are part of the bank's balance sheet.

TABLE 1

The digital money continuum

	Public money	Private money		
	Central bank money	Reserve-backed money	Commercial bank money	Non-bank money
Description	A central bank liability can be used for settlement purposes in both physical and digital formats.	A liability of a licenced non-bank FI or commercial bank backed by reserves in an omnibus account held at a central bank.	A commercial bank liability in the form of deposits held at the bank, which can be used for payment purposes.	A liability of a non-bank FI that holds a licence to issue e-money and can be used to settle commercial transactions.
Issuer/operator	Central banks	Commercial banks or non-bank FIs	Commercial banks	Non-bank FIs
Risk	Virtually credit risk-free	Bankruptcy-remote	Carries credit and liquidity risk	Carries credit and liquidity risk
Users	<ul style="list-style-type: none"> – General public – FIs 	<ul style="list-style-type: none"> – Bank customers (commercial and retail) – Financial institutions – Financial market infrastructures (FMIs) 	<ul style="list-style-type: none"> – Bank customers (commercial and retail) 	<ul style="list-style-type: none"> – General public
Examples	<ul style="list-style-type: none"> – RTGS systems – Wholesale CBDC 	<ul style="list-style-type: none"> – Reserves-backed digital currency* 	<ul style="list-style-type: none"> – Deposit token 	<ul style="list-style-type: none"> – Fiat-backed stablecoin

Considering a tokenized wholesale CBDC

While there are still several views on this topic, this report proposes that tokenization differentiates wCBDC from conventional systems. Tokenization generally refers to using technology to create digital tokens representing an asset or an underlying asset that can then be issued, traded and managed on compatible platforms. DLT and blockchain are often conflated with tokenization; however, tokenization is also possible through centralized techniques. The desired business outcomes driven by tokenization are:



Proof of value: Provides evidence or verification that an asset has a certain value or uniqueness.



Proof of ownership: Establishes unambiguous ownership and assigns agency of the asset to the rightful owner.



Proof of transaction: Produces a verifiable record to provide transaction history and evidence of settlement.

TABLE 2

Conventional vs tokenized transactions



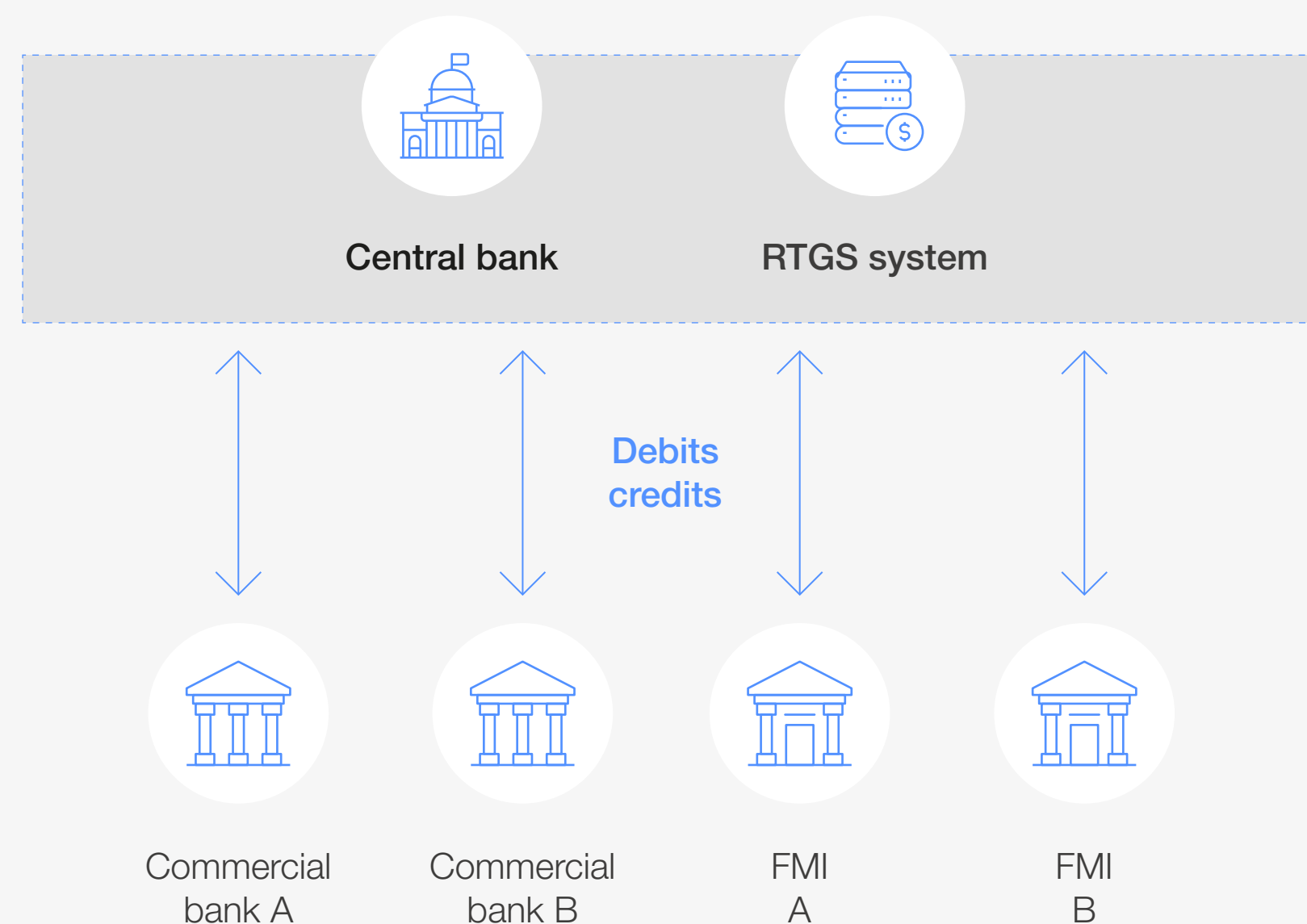
	 Conventional	 Tokenized
Proof of value	Value is proven through the transfer of physical assets or electronic book entries facilitated by trusted intermediaries.	Value is established by ownership and transfer of digital tokens, which are validated programmatically.
Proof of ownership	Ownership is evidenced by legal documents or centralized databases maintained by trusted intermediaries.	Ownership is encoded in digital tokens, ensuring permissioned access to the transfer records.
Proof of transaction	Transaction proof is generated through receipts or records by centralized entities like banks or payment processors.	Transactions are recorded on a shared system, providing evidence of occurrence to the involved parties.



FIGURE 1

Conventional vs tokenized wholesale payment and settlement

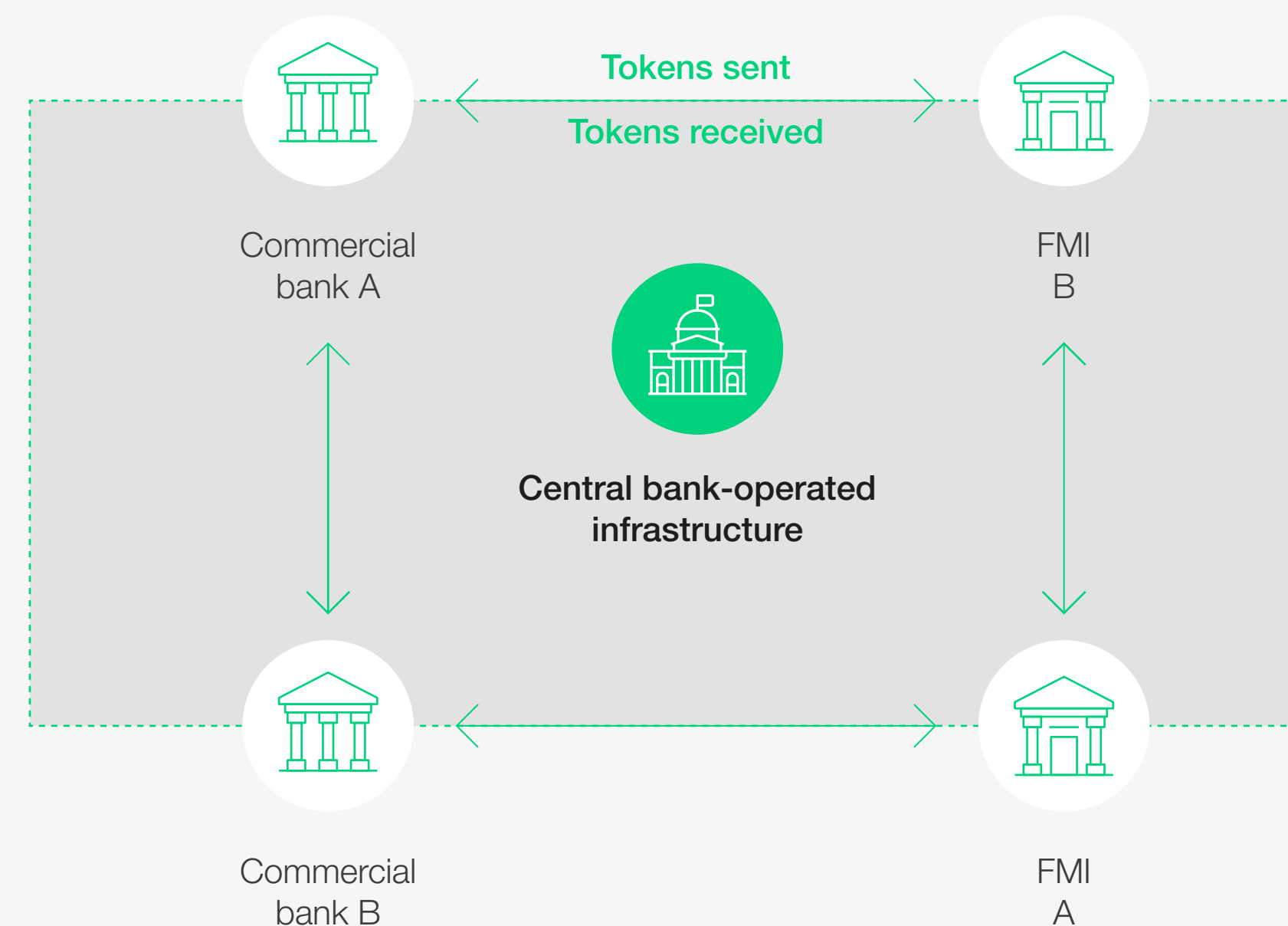
Conventional wholesale payment and settlement



Users of a book-entry-based RTGS system with designated accounts can initiate and submit transactions to the central bank-operated settlement infrastructure for validation.

The central bank validates the transactions and updates respective participant balances in the RTGS system, resulting in each participant updating their internal books and core banking systems.

Tokenized wholesale payment and settlement



Node operators of a token-based system can initiate and complete transactions among each other and validated natively by the network.

The central bank-operated infrastructure authorizes transactions based on the balances in the participant's institutional wallets or vaults, resulting in the transfer of value.

Note: This stylized diagram simplifies the comparison between conventional and tokenized by comparing the two in a domestic context. Also, the distinction between central bank-operated and -supervised infrastructure is jurisdiction-dependent.

4

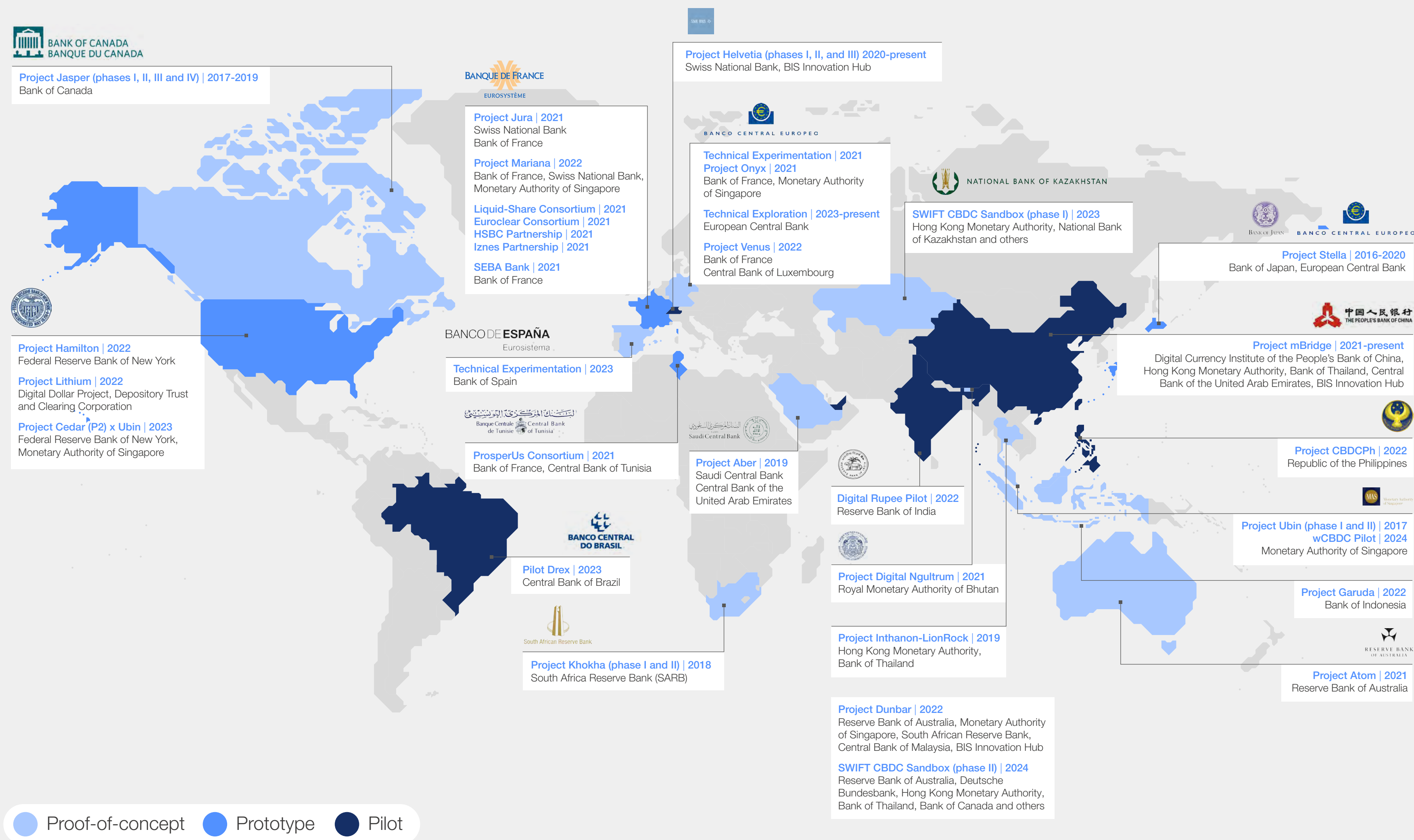
wCBDC initiatives



From 2017 to today, wholesale CBDC programmes are continuing to redefine financial markets.

Innovations in how CeBM is delivered are driven by a need to keep pace with the diversity of modern payment technology, address problems with current infrastructures and meet international standards (e.g. [Committee on Payments and Market Infrastructures \(CPMI\) – International Organization of Securities Commissions \(IOSCO\) PFMI](#)) for using CeBM in systemically important systems.

FIGURE 2
Global wCBDC efforts



4 wCBDC initiatives

A 2022 BIS survey found that there will likely be at least nine wCBDCs circulating by 2030, and the Swiss National Bank (SNB) issued a live Swiss Franc wCBDC to settle digital securities transactions as part of a limited-time pilot in December 2023.¹² In November 2023, the Monetary Authority of Singapore announced that they would pilot the live issuance and use of a wCBDC in 2024 to facilitate domestic interbank payments.¹³

Another notable initiative is Project mBridge (BIS Innovation Hub et al.), which has begun its MVP phase, and has transacted with real value wCBDC across the four jurisdictions in scope.

Most wCBDC experiments have focused on cross-border payments (e.g. Jura, mBridge, Dunbar, Mariana), as cross-border use cases are believed to be the strongest for transformation, including elements like governance, KYC/anti-money laundering (AML)/countering the financing of terrorism (CFT), data privacy, capital flows, monetary policies, cybersecurity and financial stability. According to the 2022 BIS survey of 86 central banks, advanced economies (AEs) and emerging market and developing economies (EMDEs) reported cross-border payments efficiencies as the primary motivation for pursuing wCBDC.

5

Industry challenges



Eight industry challenges were analysed to determine corresponding opportunities for wCBDC to address key pain points in financial markets.

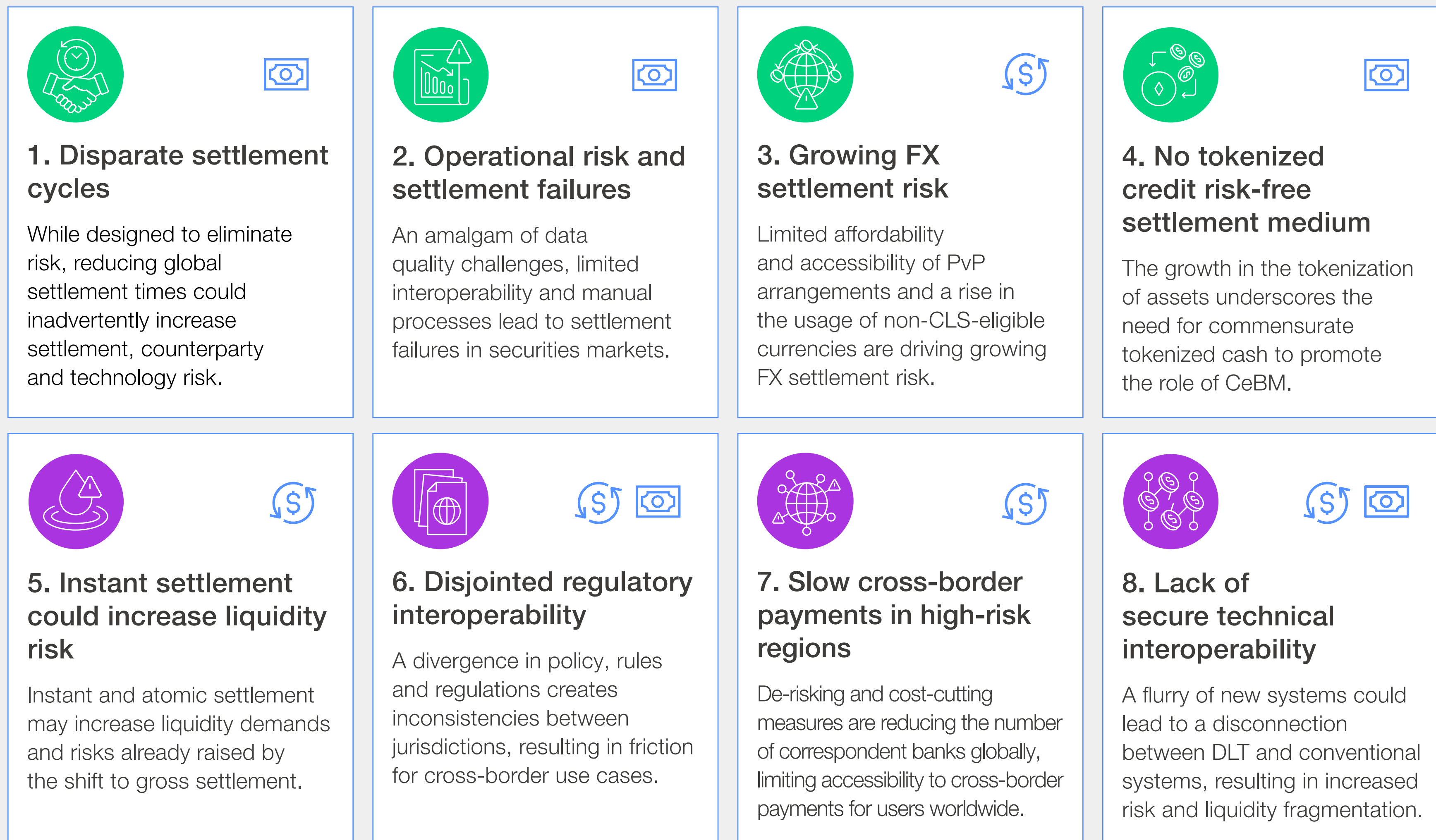
Taking a holistic approach, this report analyses the relevant challenges for wCBDC systems to derive insights into where and how differentiated value can be activated.

 Interbank payments

 Securities transactions

FIGURE 5

Identified financial markets industry challenges



Summary of findings

Each of these industry challenges were evaluated and a commensurate area for modernization was identified. Table 3 captures a summary of the findings for each area for modernization and discerns the persistent challenges from the areas of differentiated value.

An **area of differentiated value** is an identified challenge that wCBDC could uniquely address given its generally-understood core capabilities.

A **persistent challenge** is a barrier resulting from a challenge rooted in more than just the payment instrument but can include elements like regulation, compliance, geopolitics and long-standing trade-offs.

TABLE 3

Summary of areas of differentiated value and persistent challenges

Industry challenge	Area for modernization	Finding
Disparate settlement cycles	Realizing a global settlement window	Area of differentiated value
Operational risk and settlement failures	Mutualizing data sharing	
Growing FX settlement risk	Expanding PvP arrangements	
No tokenized credit risk-free settlement medium	Tokenizing credit risk-free settlement media	
Instant settlement could increase liquidity risk	Optimizing liquidity management	Persistent industry challenge
Disjointed regulatory interoperability	Ensuring compliance-by-design interoperability	
Slow cross-border payments in high-risk regions	Accessing central bank money	
Lack of secure technical interoperability	Interoperating with new and existing systems	

6

Areas of differentiated value

Areas of differentiated value were identified as ripe for modernization using wCBDC and should be considered as near-term focus area.

Click on an icon below to find out more about each area of differentiated value



Disparate settlement cycles

While designed to eliminate risk, reducing global settlement times could inadvertently increase settlement, counterparty and technology risk.

Lack of a “global settlement window”

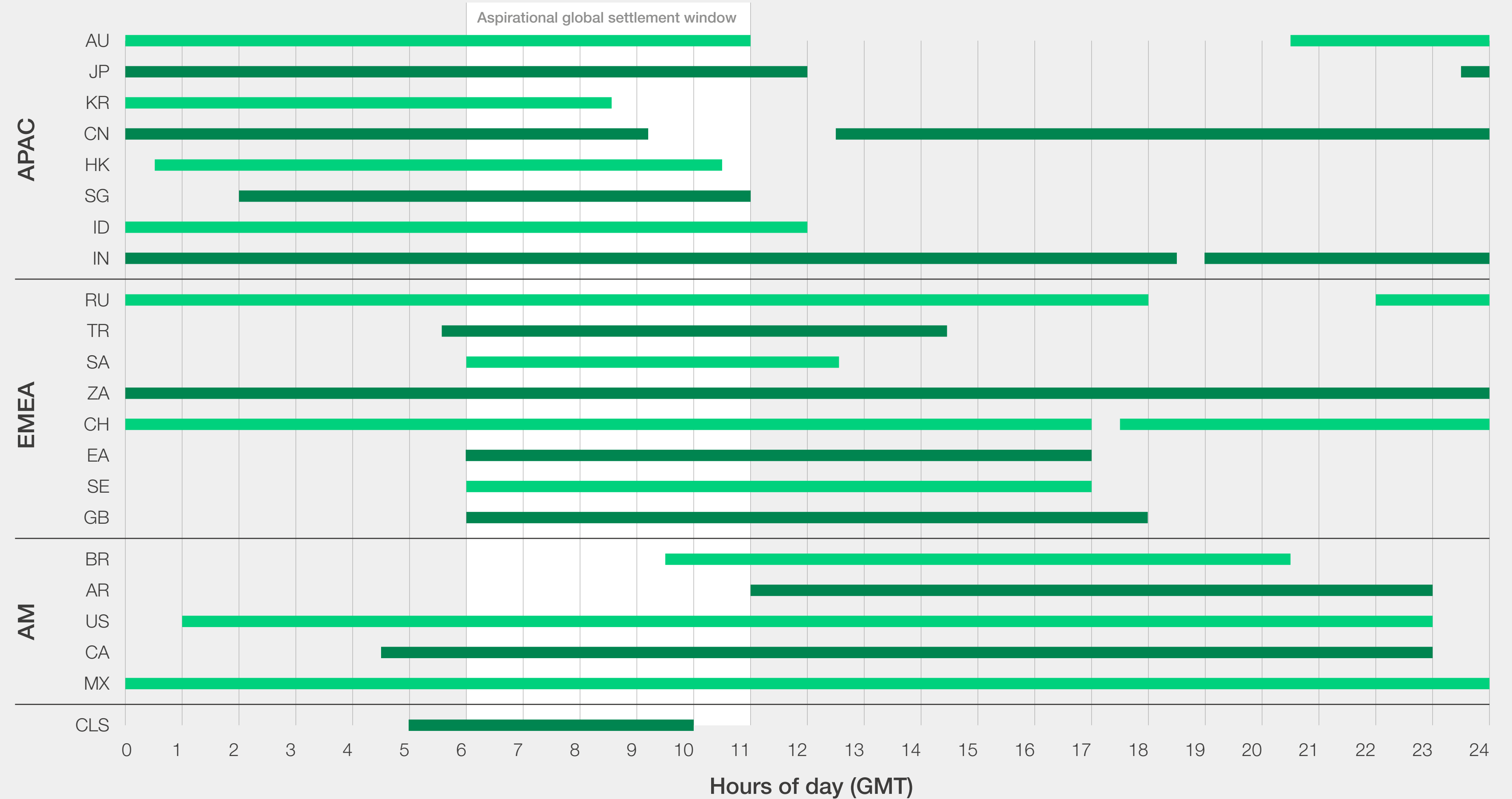
The global nature of capital markets has resulted in a need for harmonized settlement cycles across regions. “Settlement cycle” refers to the time elapsed between the date a trade is made (or executed) and the settlement date (when participants receive cash or the security that was purchased), at which point the transaction is deemed final. For example, when a trade occurs in Europe and aims to settle in Asia, there is a limited time zone overlap (2-4 hours) during RTGS system operating hours, complicating trade and post-trade processes. This disparity across regions can be attributed to operating-hour gaps due to policy objectives, time-zone differences, operational constraints and cultural differences in working hours. For example, some Islamic countries observe working days between Sunday and Thursday.

Extending RTGS systems’ hours globally could help meet the G20’s ambition of enhancing cross-border payments. However, just four of the 82 CPML jurisdictions surveyed reported having RTGS operating hours 24/7 or near 24/7. This gap impacts securities settlement and FX transactions; the former could benefit from wider settlement windows, while the latter calls into question the ability to hold overnight wCBDC (without any access to intraday overdrafts) to address the transmission

of cash around the clock. The BIS proposed the concept of a “global settlement window” to address this disparity. Figure 6 illustrates the limited overlap in RTGS operating hours between jurisdictions and the global window under discussion (6:00-11:00 GMT), which is a five-hour period where the highest number of RTGS systems operate concurrently across all jurisdictions in the survey.¹⁷ While not an explicit target, extending hours comes with personnel, system feasibility and challenges related to policy restrictions. While some technology limitations are at play, market norms are the predominant reason for limited 24/7 operations.

FIGURE 6

RTGS system operating hours on working days for CPMI jurisdictions



Notes: AM = Americas; APAC = Asia-Pacific; AR = Argentina; AU = Australia; BR = Brazil; CA = Canada; CH = Switzerland; CLS = CLS Bank; CN = China; EA = euro area; EMEA = Europe, Middle East and Africa; GB = United Kingdom; HK = Hong Kong SAR; ID = Indonesia; IN = India; JP = Japan; KR = Korea; MX = Mexico; RU = Russia; SA = Saudi Arabia; SE = Sweden; SG = Singapore; TR = Turkey; US = United States; ZA = South Africa. **Source:** Committee on Payments and Market Infrastructures, *Extending and aligning payment system operating hours for cross-border payments*, 2022.

Click on an icon below to find out more about each area of differentiated value



The race to T+1

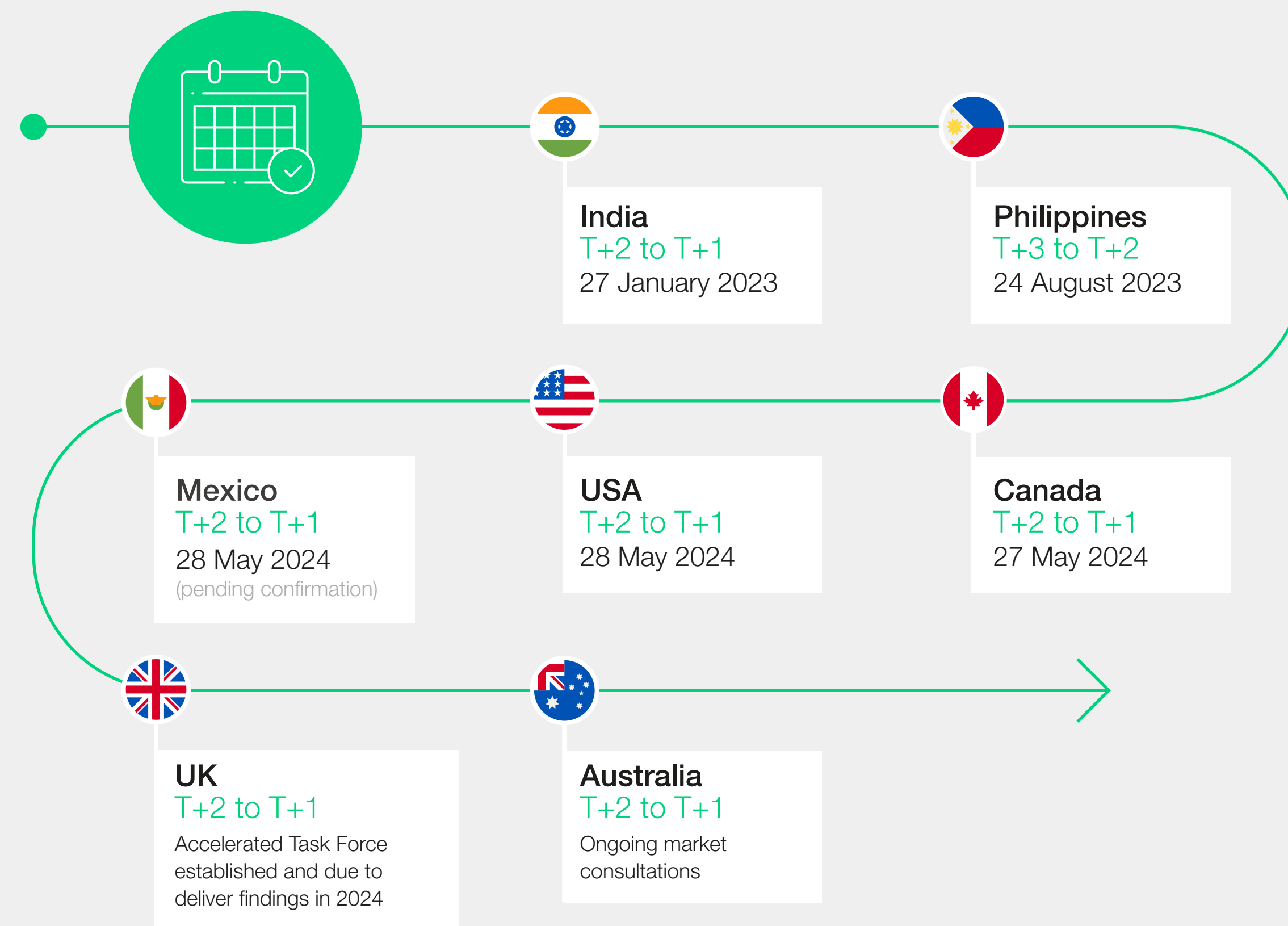
T+ is a convention used to denote a duration of time from T (trading day or the day a transaction took place) until settlement, where all parties' obligations are met. Conventional securities transactions follow a T+2 settlement cycle, settling two days after the trading day. This is primarily due to standard market practices and operational constraints. Challenges today include delayed pre-trade information, limited operational hours, counterparty risk and manual processing. Efforts to reduce market risk by shortening the settlement cycle have led to India adopting T+1 in 2023 and Mexico, the United States and Canada preparing for T+1 by May 2024. The UK and the Eurozone are also exploring T+1 and T+0.

Reducing the settlement cycle from T+2 to T+1 promises to:¹⁸

- Increase the availability of liquidity and the efficiency of deployed capital
- Decrease the length of exposure to counterparties and reduce counterparty risk
- Reduce daily margin requirements for clearing participants (T+1 could reduce this by 41%¹⁹)
- Lower market and liquidity risk.

FIGURE 7

Timeline of the implementation of compressed global settlement cycles



Source: Citibank, *Securities Services Evolution 2023: Disruption and transformation in financial market infrastructures*, 2023.

Click on an icon below to find out more about each area of differentiated value



However, shortening settlement windows strains post-trade operations and legacy systems attempting to meet the newfound demands for speed. Compressing the settlement window is also a risk-reward-based decision for each jurisdiction. Factoring in time zones relative to the sources of capital inflows for a jurisdiction could dictate to what degree settlement windows should be shortened. This would be to not unduly constrain or limit inflows by creating frictions on the time allowed to settle or locate liquidity, which can strain foreign investors. The Securities and Exchange Commission estimates US industry investments of \$3.5-4.95 billion to achieve T+1, with compliance costs at \$5.5 million per institution.²⁰ Citibank found that accelerated settlements and updating legacy technology platforms are top priorities for FMIs.²¹

T+0 as the likely next step

Many market participants anticipate T+0 as a possible industry standard for settlement windows once global markets have harmonized towards T+1. Broadly, there are three variations of T+0: gross, intraday and end-of-day, as illustrated in Figure 8. T+0 intraday and end-of-day are both forms of netted T+0.

FIGURE 8
T+0 considerations

Accelerated securities settlement: T+0 considerations

T+0 gross

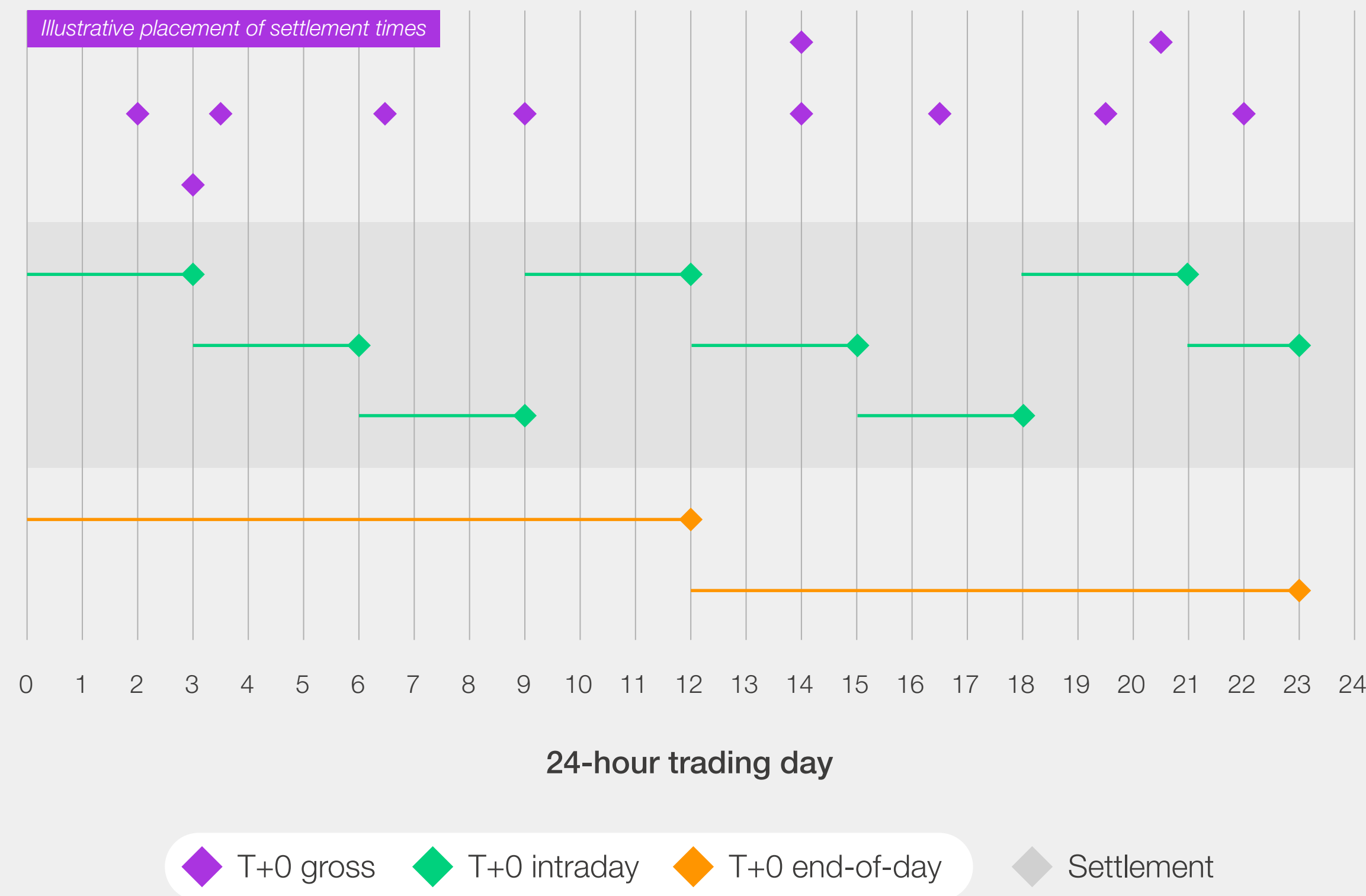
Like instant settlement, T+0 gross achieves settlement immediately on the trading day and relies on pre-funded accounts and securities to be on hand.

T+0 intraday (netted)

A form of netted T+0 intraday settlement refers to settling transactions within the same trading day, but in predefined intervals or cycles.

T+0 end-of-day (netted)

Involves a batch processing approach where transactions are bundled and settled at the end of the day using bulk settlement and netting.



Click on an icon below to find out more about each area of differentiated value



Click on an icon below to find out more about each area of differentiated value



Realizing a global settlement window using wCBDC

wCBDC could enable the aspirational 6:00-11:00 GMT global settlement window. Settlement windows globally pertain to three general areas: FX and PvP (also covered in detail

T+0 gross settlement would theoretically demand the most pre-funding and liquidity, representing a major business model shift for stakeholders, especially with today’s legacy infrastructure. While instantaneous settlement is possible at the central securities depository (CSD) level, according to State Street, instantaneous settlement is not possible down the custodial chain, and to achieve T+0, new technologies like DLT may be required to support features like atomic settlement.²² Additionally, pre-trade, trade and post-trade activities must be combined, and manual processes like trade matching must be automated. RTGS services would need to operate around the clock to support this degree of compression. Additionally, a fundamental overhaul of global clearing, payment, and settlement systems would be required to handle the increased pressure on liquidity and systems.²³ Therefore, implementing T+0 is likely not a near-term phenomenon but a trend worth considering in the spirit of future-proofing systems.

later in this report), securities transactions and DvP (jurisdiction-specific), and derivative-related transactions. wCBDC systems could represent a liquidity storage mechanism that runs 24/7 and addresses use cases without a limitation related to time zones or jurisdictional boundaries. For example, Project Jura demonstrated that wCBDC could be used to settle tokenized securities transactions across borders. In addition to around-the-clock operations, wCBDC could also support programmable payments and be designed to upgrade while operational. For example, Fedwire cannot upgrade while operational, a key constraint when discussing expanding from the current 22 hours five days per week to operations on a 24/7-basis. In contrast, the new retail and commercial real-time fast payment system (FPS) FedNow can be upgraded online because of its modern architecture and capabilities. Enabling 24/7 operations, programmable payments and upgradeability could provide several areas of benefits, including:

- Reducing liquidity and credit risk by eliminating the need for overnight credit extensions
- Maximizing the availability of settlement windows to meet variable requirements
- Allowing system upgrades to occur while the system is operational (around the clock)

- Maintaining liquidity bridges for inter-regional trade to optimize collateral deployment
- Orchestrating multi-asset and multi-party transactions across jurisdictions.

Differentiated value

While efforts are under way to enable RTGS systems to run at or near 24/7, wCBDC represents an opportunity to reach settlement finality at any time of day as a supplement to RTGS systems, if designed with this feature of automatic operations at its core, much like how many retail and commercial FPSs operate. It is worth noting that FPSs are generally intended for retail and commercial use cases only; thus, enabling 24/7 operations via FPSs has benefits limited to the jurisdiction in which it is deployed (e.g. FedNow in the United States and Unified Payments Interface in India). A key requirement to realize this value is the need for overnight wCBDC to support the around-the-clock settlement windows. Enabling a 24/7 or near-24/7 wCBDC system will also support jurisdictional policy objectives of shortening settlement cycles, like T+1 and eventually T+0. Certain regions may benefit from 24/7 operations, including major economic centres facilitating cross-border transactions or serving as bridge currencies in FX markets.



Operational risk and settlement failures

An amalgam of data quality challenges, limited interoperability and manual processes lead to settlement failures in securities markets.

Click on an icon below to find out more about each area of differentiated value



Settlement delays, failures and costs

While there have been improvements in the straight-through processing of securities transactions, challenges remain. Based on data from the Swift network covering cross-border settlement, about one out of every ten securities transactions requires correcting or will fail: 4.9% of settlement instructions are cancelled before or on the settlement date, and 4.8% of settlements are delayed.²⁴ These incidents are increasing, with a 9% growth in cancelled instruction rate and a 16% increase in late settlements from 2020 to 2022.²⁵ There are four causes of settlement failures:²⁶

- **Information asymmetry** and poor-quality data related to incomplete standing settlement instructions (SSIs) whereby counterparties to a transaction do not have shared visibility into error(s) encountered.
- **Market volatility** in times of increased trading volumes creates strain for exception-based trades (trades requiring manual intervention) and can drive counterparty and credit risks to rise substantially, challenging the securing of cash in time to settle on time.
- **Liquidity constraints** where cash or securities are unavailable, especially in transactions involving FX.

- **Legacy systems** focused on post-trade operations that suffer from many manual processes. Some systems require downtime for end-of-day or end-of-period batch processing. Settlement window closures like this could cause transactions to get “caught” waiting for the relevant RTGS system to open.

According to Swift, settlement failures and delays are on the rise because of unstable market conditions, heightened geopolitical tensions, cross-border transactions with long intermediary chains (more points of failure), multiple regulatory jurisdictions (covered later in this report) and incongruent messaging formats and data standards. Lastly, human error is another reason for increased failures or delays (e.g. keying in the wrong data for an SSI).

Less time to reconcile errors

Transitioning from T+2 to T+1 may not simply result in a 50% reduction in post-trade process time to mitigate settlement failures; it could yield an 83% reduction (12 hours today compared to two under T+1), which significantly reduces time to reconcile errors, locate funding and match trades.²⁷ Settlement costs are also rising in the form of funding and capital costs. Estimates suggest that settlement costs are rising approximately 14% each year, and 5-10% of trades fail each day, driven by

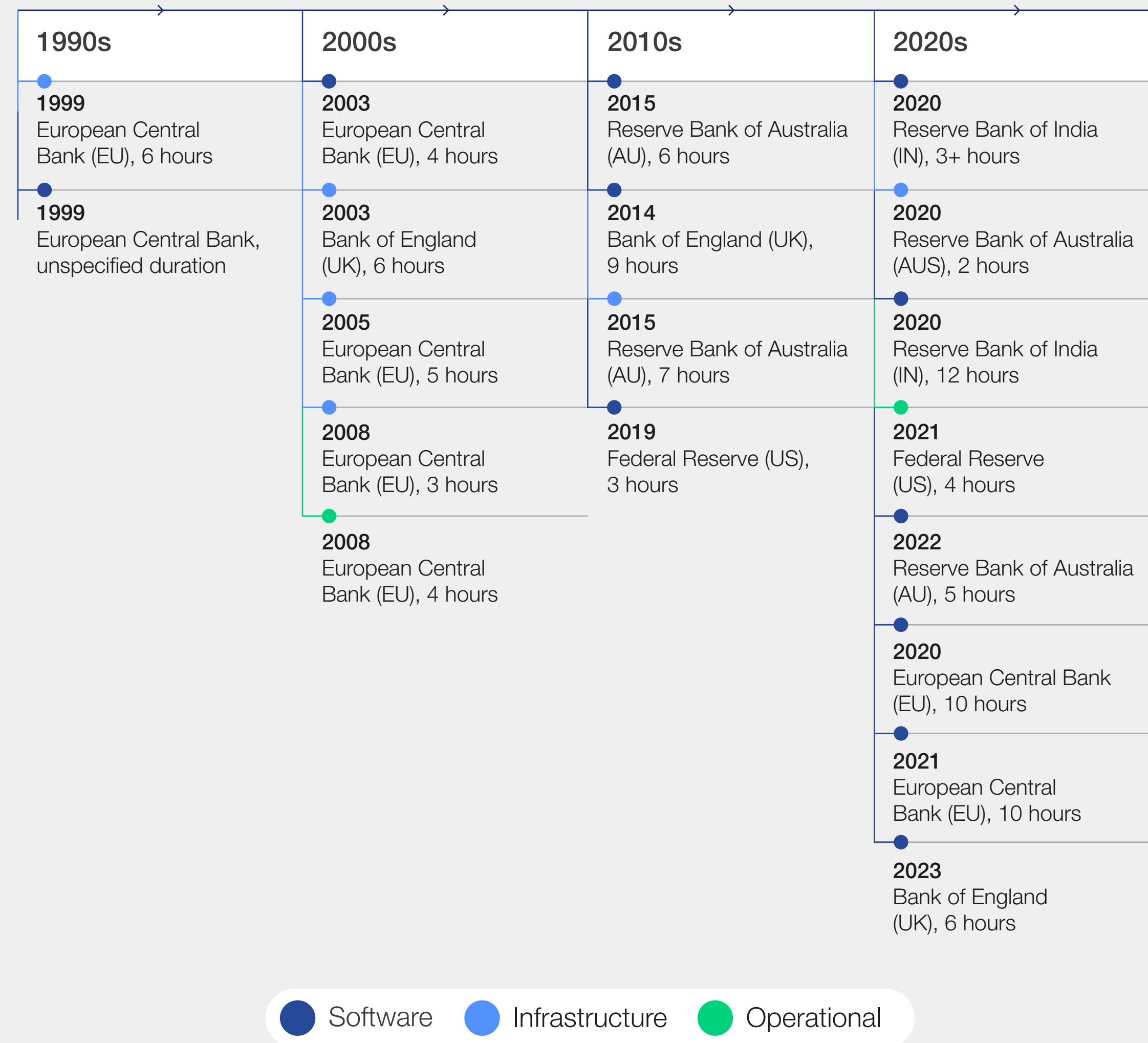
human error and the seven non-interoperable systems for which the average trade is routed.²⁸ These costs lead to operational risks for FIs, like penalties and manual reconciliation, and regulatory risks, like costly mandatory buy-ins.

RTGS system outages

RTGS system outages stem from software glitches and infrastructural or operational constraints. These disruptions lead to transaction delays, financial losses and increased vulnerabilities. Maintenance activities, hardware failures, transaction volume constraints and other external factors are often the leading contributors to such disruptions. Consequences include compromised integrity, participant confidence erosion and possible economic repercussions. Mitigating risks through cybersecurity measures, contingency planning, system reviews, stress testing, intraday monitoring and regulatory compliance is crucial for RTGS system reliability.

FIGURE 9

Key RTGS system outages (1990-2023)



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Mutualizing data sharing using wCBDC

Market participants could benefit from a trusted, operationally resilient platform that mutualizes (makes available across multiple parties) data to achieve settlement finality. As observed, a fundamental barrier to ensuring more effective settlement of securities is the information asymmetry of SSIs between counterparties, particularly when reconciliations are needed to rectify errors in the data. In today’s systems, high-quality SSI data is imperative to correctly transmit payment instructions and other important parameters generated during a trade and used during post-trade. It is often difficult to access when multiple parties are involved, as each party can only access their respective aspect of the instructions. A single source of truth has the potential to remove inefficiencies and reconciliation and ultimately accelerate the settlement cycle. Trusted, neutral FMIs interacting with wCBDC could address operational and settlement risk by:

- Mutualizing necessary data to facilitate compatibility of trade and post-trade across institutions
- Combining and automating trade and post-trade process automation techniques

- Ensuring access to necessary SSI data by applying robust permissions
- Mitigating the need for manual reconciliation caused by errors or data discrepancies
- Preserving privacy at all levels of a transaction to regulate and control access.

The BdF announced the lessons learned from its wCBDC experimentation involving using a cash DLT system to settle tokenized transactions. It found that DLT could enhance the straight-through processing of trade and post-trade activities and strengthen financial stability.²⁹ The Depository Trust and Clearing Corporation (DTCC), the Digital Dollar Project and Accenture found, as part of a CBDC pilot, that DLT offers the potential to achieve operational efficiencies and enhance transparency and reporting capabilities for securities transactions by facilitating orchestration between two networks: securities and cash.³⁰ This research also found that DLT could be uniquely positioned to bolster system recovery by “sharding” data across multiple nodes in the network. Sharding is a technique in data storage where large databases are partitioned into smaller, more manageable pieces (shards) distributed across multiple nodes or storage locations to improve scalability and performance. To preserve privacy, Project Tourbillon showed

that central banks can monitor the aggregate use of CBDCs in real time without seeing any personal information.³¹ Other elements, such as operational resilience and scalable performance in an outage, are foundational to addressing operational and settlement risks, ensuring smoother data-sharing processes and applying permissions.

Differentiated value

Given the propensity of settlement risk and failures in securities markets and reliance on M0 settlement infrastructure by banks and FMIs, wCBDC could provide a differentiated solution for addressing errors driven by data quality issues. Using a central bank-operated or -supervised infrastructure trusted among its participants, wCBDC could enhance trade and post-trade operations by permissioning access to necessary parties through trusted rails.

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Growing FX settlement risk

Limited affordability and accessibility of PvP arrangements and a rise in the usage of non-continuous linked settlement-eligible (non-CLS-eligible) currencies are driving growing FX settlement risk.

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CASE STUDY 1

Herstatt and FX settlement risk

The bankruptcy of Bankhaus Herstatt in 1974 marks a seminal event in the history of FX settlement risk and its importance. According to the International Monetary Fund, FX settlement risk equals the purchase currency's full amount. It lasts from when a payment instruction for the currency sold can only be cancelled if the currency purchased is received with finality.³² When it closed, Bankhaus Herstatt had already received payments in Deutsche mark but not yet sent US dollar payments – this unsynchronized FX activity led counterparties to incur losses. The failure highlighted FX settlement risk, also known as Herstatt risk.³³ The event caused panic in the market and was one of many bank failures that led to the formation of The Basel Committee on Bank Supervision.³⁴ The public sector called to mitigate FX settlement risk globally, and the industry established CLS in 2002 to provide PvP arrangements and allow the payment legs of FX trades to settle simultaneously.

CLS's settlement service provides settlement risk mitigation through PvP for 18 of the leading currencies. It offers multilateral netting and liquidity-saving features enabled by the daily settlement window. In December 2023, CLS announced that it settled a record value



of \$16.3 trillion of FX payment instructions with 99.5% net funding efficiency (less than 1% liquidity cost).³⁵ However, nearly 50 years after Herstatt, and as of 2022, nearly a third of FX turnover (\$2.2 trillion) remains subject to settlement risk. (The total FX turnover in 2022 was an estimated \$7.5 trillion, up from 6.6 trillion three years earlier.) This is an increase from an estimated \$1.9 trillion at risk calculated in April 2019.³⁶ FX settlement risk occurs because:

- **A lack of affordable PvP arrangements,** and market participants make cost-benefit decisions as to the risk exposure versus the value of the transaction.
- **Limited accessibility to PvP arrangements** based on time zone, peak liquidity hours and currency pairing.³⁷ This point materializes from an increased demand for emerging market economy (EME) currencies, which are largely not CLS-eligible.

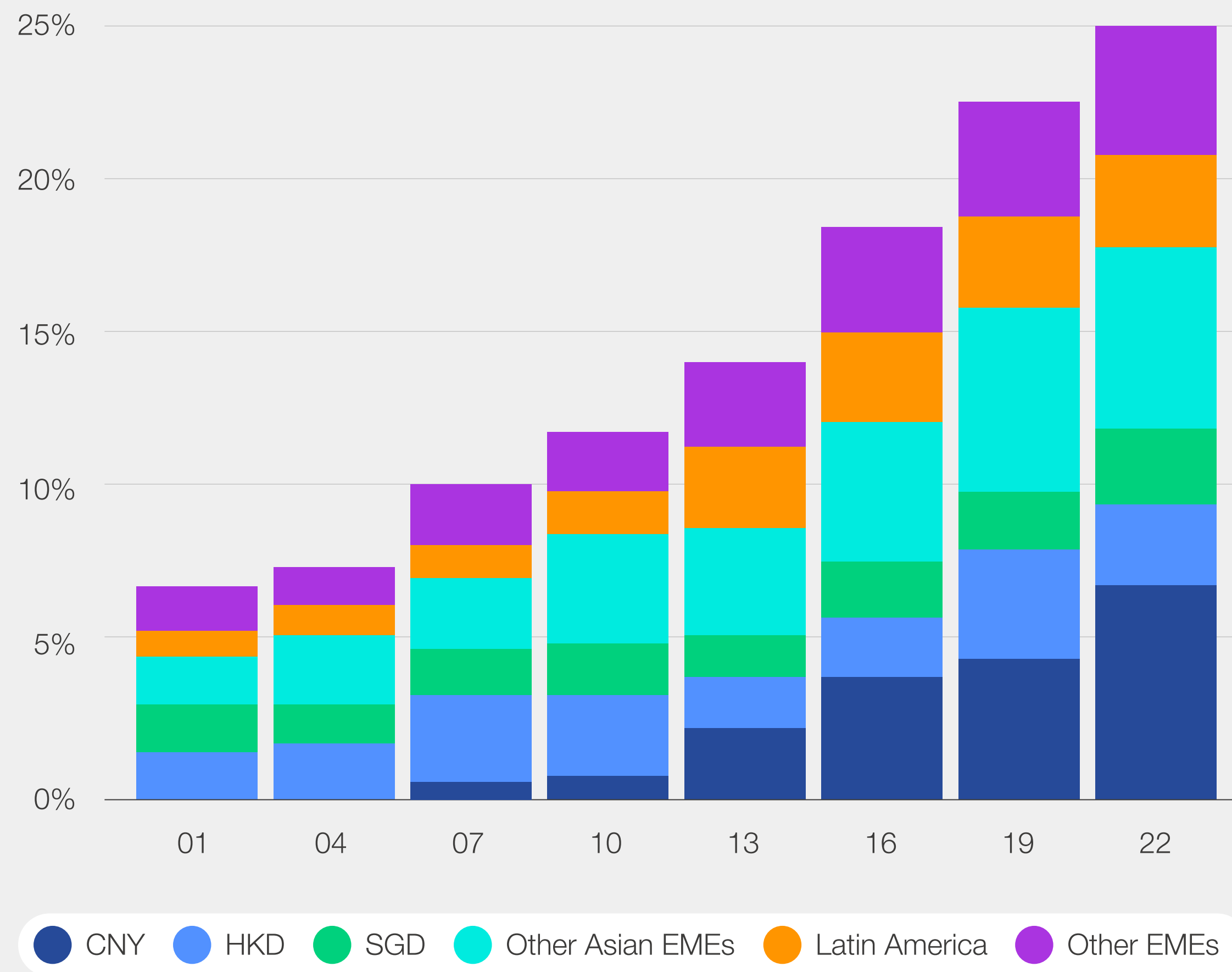
Increased EME currency turnover

Between 2016 and 2019, the average daily turnover of EME currencies, particularly in Asia-Pacific, surged by nearly 60% to nearly \$1.6 trillion. The trading in currencies like the Chinese renminbi, Indian rupee, Indonesian rupiah and Philippine peso more than doubled.³⁸ Yet, EME currencies face limited access to PvP arrangements, high volatility, low liquidity (due to limited availability) and dependence on bridge currencies, like dollars, to facilitate trades, creating reliance on another currency. This challenge is further exacerbated by de-risking, which is discussed later. Some currencies have capital (regulatory) controls applied to them, which hinder their ability to be traded freely in markets. Some jurisdictions are exploring CBDCs to improve speed and efficiency, reduce settlement risk (via PvP), and use local currencies for trade (e.g. Project mBridge).

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FIGURE 10
Total FX turnover in EME currencies (2001-22)



Notes: CNY (Chinese yuan), HKD (Hong Kong dollars), SGD (Singaporean dollars).

Source: Caballero, Julián, et al., "The internationalisation of EME currency trading", *Bank for International Settlements*, 2022.

The importance and declining use of PVP

The proportion of FX transactions settled on a PVP basis has steadily fallen from 50% in 2013 to 40% in 2019, increasing FX settlement risk.³⁹ Expert opinion indicates that it is plausible that many FX transactions occur “on-us” and are not captured in the global FX settlement risk statistics. These on-us orders include inter-affiliate book entries, clearing house book transfers and other methods. While the total number of FX transactions in both PVP and non-PVP is growing year-on-year, the percentage using PVP is declining. This can be attributed to an increased turnover in non-CLS-eligible and EME currencies, which settle a higher proportion of trades on a non-PVP basis.^{40,41} Countries with non-CLS-eligible currencies (around 10% of FX market value)⁴² report higher rates of FX settlement risk.⁴³

Market participants have several options to reduce and mitigate FX settlement risk, such as:


- **Pre-settlement** netting and bilaterally offsets payment obligations between participants
- **On-us settlement** to settle payment obligations across the books of the same legal entity or banking group

- **PvP arrangements** where the final payment of currency A occurs if the corresponding payment in currency B is fulfilled. PVP eliminates settlement risk because of atomic settlement.

While these options exist, the principal reason for a desire to conduct FX transactions on a PVP basis is the reduction of counterparty and credit risk.⁴⁴ Due to its ability to be applied to a wider set of trading scenarios than pre-settlement netting and on-us, it is more attractive to scale.

40% of FX transactions were settled via PVP in 2019, a decrease from 50% in 2013.

10% of the FX market involves non-CLS-eligible currencies, which involve higher settlement risk.

 FX transactions grow annually, but PVP settlement use is declining.

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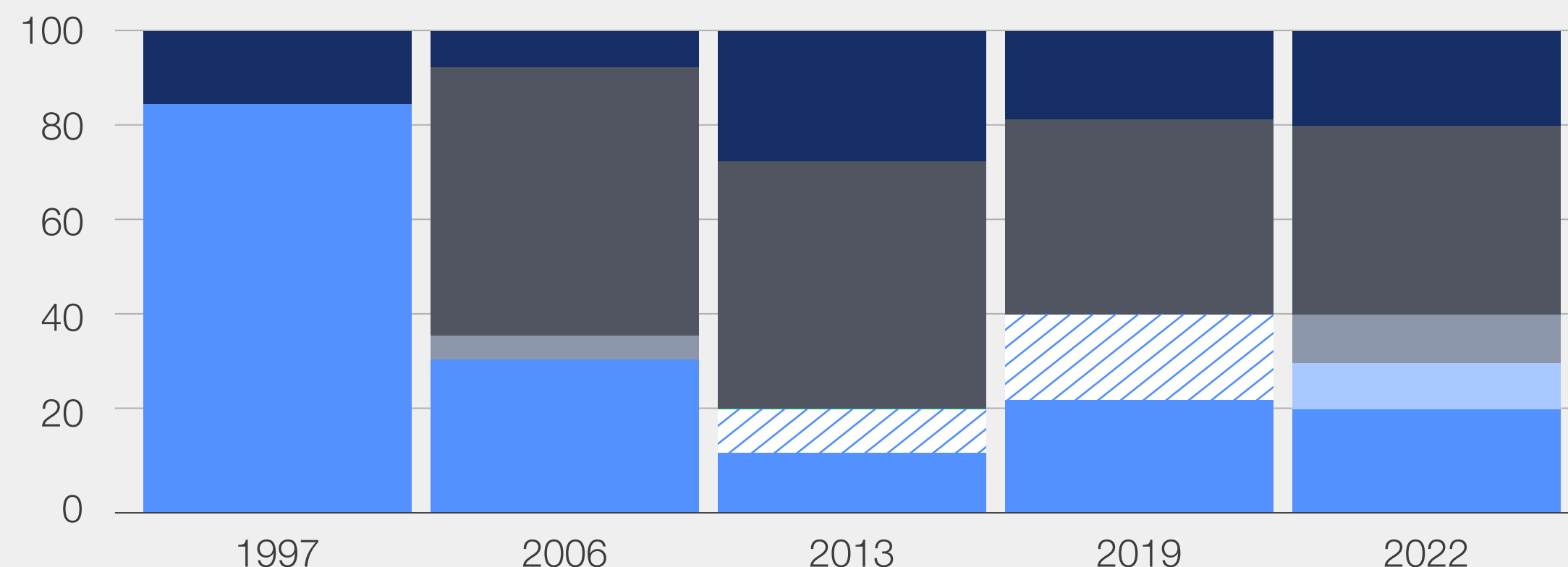
FIGURE 11

Settlement risk of FX turnover

Settlement of foreign exchange turnover

As a percentage of deliverable turnover

A. By settlement method over time



● Pre-settlement netting ▨ Via on-us lacking information on exposure to settlement risk

Settlement:

Without exposure to settlement risk:

● Via PvP arrangements ● Via on-us without exposure to settlement risk

Potentially at risk:

● Via on-us with exposure to settlement risk ● Via other non-PvP arrangements

Source: Bank for International Settlements, *Facilitating increased adoption of payment versus payment (PvP)*, 2023.



Expanding PvP arrangements using wCBDC

FX settlement risk is growing because of the limited accessibility and affordability of PvP arrangements globally in the face of increased turnover of EME or less liquid currencies not supported on highly efficient platforms. Despite this efficient model, EME regions often take on settlement risk when they use EME currencies. A wCBDC could help optimize FX markets by:

Facilitating affordable and accessible multilateral PvP arrangement mechanisms (if done cost-effectively)

- Reducing the barrier to entry for central banks and their respective banking communities
- Supporting flexible currency conversion arrangements for EME currencies
- Expanding access to non-domestic and non-bank institutions to trade currencies
- Facilitating simple onboarding and integrations with existing systems to manage liquidity
- Supporting variable settlement windows to expand access to various regions.

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While CLSNet supports more than 120 currencies, there are opportunities to gain additional efficiencies for EME currencies. Project mBridge shows that wCBDC could increase accessibility to PvP arrangements by facilitating direct bilateral connectivity between banks, supporting local currencies by allowing central banks to easily issue/redeem tokens and create liquidity pools, interoperating with conventional infrastructure, and reducing settlement risk. Project Mariana was a proof-of-concept to uncover the benefits of automated market makers (AMM) for currency liquidity.⁴⁵ Using a transnational network to integrate domestic platforms, Mariana found AMMs can:

- Combine FX trading and settlement into one step (atomic) to lower settlement risk
- Establish a common shared platform to optimize wCBDC liquidity
- Reduce reliance on settlement intermediaries to access currency liquidity
- Enable multi-token liquidity pools to expand currency liquidity.

Further, in the stablecoin context, Circle and Uniswap jointly found that AMMs can enhance currency liquidity and price discovery by enabling passive asset owners to act as liquidity providers.⁴⁶ However, AMMs typically

carry front-running trading strategies, smart contract risks and high slippage costs, which is the difference between the expected and actual trade prices due to limited liquidity. Considering relevant policies and regulations is paramount. In many scenarios, the use of a bridge currency, like dollars or euros, might still be necessary for compliance reasons. This requirement can lead to increased costs. The regional scope of solutions may lead to liquidity fragmentation, require pre-funding and do not offer optimal liquidity-saving features. A central intermediary may still be necessary for dispute resolution. Lastly, intermediaries' regulatory status impacts the degree to which they can onboard new currencies, such as banks under stricter supervisory rules than non-bank entities.

Differentiated value

wCBDC could offer a unique value model for accelerating the diversification of currencies if the costs to implement and adopt such PvP arrangements remain low.





No tokenized credit risk-free settlement medium

The growth in the tokenization of assets underscores the need for commensurate tokenized cash to promote the role of CeBM.

Dematerialization and tokenization of assets

Before the advent of computer-based systems, the ownership of securities was indicated by who held its physical certificate. Dematerialization is an ongoing trend but can be traced back to the 1960s when industry participants recognized the benefits of electronically recording security ownership on a computerized ledger.⁴⁷ By dematerializing securities, the industry saw efficiencies and improved security for investors. Different jurisdictions have adopted different models and paces for dematerialization.

In 2024, His Majesty's Treasury's Digitization Taskforce will report on using full dematerialization to further wider policy goals, including improving access to shareholder rights.⁴⁸ The City of London Law Society noted that dematerialization proposes to replace the legal function of signed stock transfer form and paper certificates, but that other interactions between companies and shareholders, like dividend payments and proxy appointments, must also be improved.⁴⁹ In assessing the means for affecting dematerialization, some have regarded it as too dramatic of a change to garner widespread market adoption, informed by the experience in Australia of its re-building of the CHESSE settlement system.⁵⁰

As with the Bank of England's (BOE) RTGS modernization programme, the intention is to introduce a fully digitized securities system that is future-proofed for incremental adoption of DLT.

The tokenization of assets involves creating digital tokens representing underlying assets like real estate, equities, digital art, intellectual property and even cash. Tokenization is a key use case for blockchain, with some estimates pointing towards \$4-5 trillion in tokenized securities on DLT by 2030.⁵¹

The primary drivers are the 24/7 accessibility of tokenized systems and the ability to democratize financial services by fractionalizing assets into more affordable units. The BIS proposed two models for bringing tokenization into the monetary system: 1) Bring CBDCs, DTs and tokenized assets on to a common unified ledger, and 2) pursue incremental progress by creating interlinking systems.⁵² They determined the latter option was more feasible given that the former requires a reimagining of financial systems. Experimentation with the unified ledger concept is ongoing.

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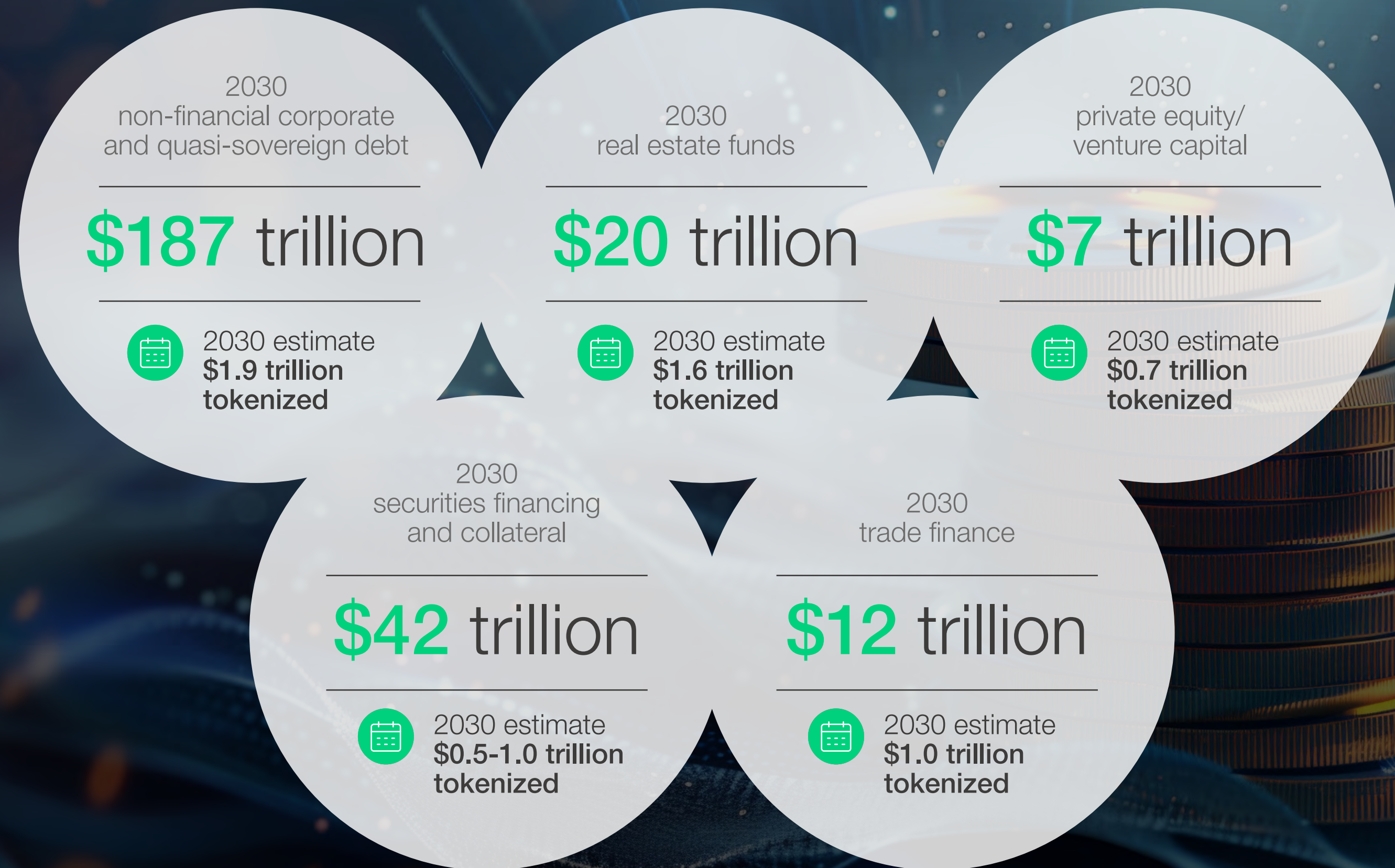


FIGURE 12

Tokenization total addressable market

Opportunity

Tokenization total addressable market (\$, trillion)



Source: Citibank, *Money, Tokens, and Games: Blockchain's Next Billion Users and Trillions in Value*, 2023.

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Tokenized assets gain traction

The bond market has seen an uptick in adoption, with tokenized bonds reaching \$3.9 billion globally, with nine-tenths of them issued between 2021 and 2023.⁵³ A leading example is Project Genesis 1.0, led by the Hong Kong Monetary Authority (HKMA) and BIS Innovation Hub (BISIH). These are two prototype digital platforms that aimed to enable investment in Hong Kong green bonds with higher transparency and greater access to retail investors were successfully developed.

In Project Genesis 2.0, the HKMA and BISIH explored using blockchain, smart contracts and other related technologies to demonstrate the technical feasibility of tracking, delivering and transferring digitized carbon forwards (also known as mitigation outcome interests).⁵⁴ Building on the success of Project Genesis 1.0, the HKMA commenced Project Evergreen in 2022, which used DLT to settle securities tokens on a DvP-basis. These transactions represented the green bond issued by the government (security token) and cash tokens representing a claim for Hong Kong dollars (HKD).⁵⁵ Additional examples in other regions include IDB Group’s bond issuances in Colombia and Spain.

There are more global examples of regulators clarifying the role of tokenization. In February 2023, the Korean Financial Services Commission

announced its plan to authorize issuing and circulating security tokens with strong private-sector interest in capitalizing on this nascent space.⁵⁶ In Indonesia, a new regulation was signed into law in early 2023, which transferred crypto regulatory powers from the commodities watchdog to the Financial Services Authority (Otoritas Jasa Keuangan), the country’s securities regulator. This indicated an acknowledgement that these digital assets could be treated as securities.⁵⁷ Money market funds (MMFs) are also seeing growth in tokenization, with Franklin Templeton’s tokenized MMF surpassing \$270 million in assets under management in April 2023.⁵⁸ The asset manager is pursuing a strategy to tokenize MMFs on multiple blockchains, including Polygon.⁵⁹ Further, the Bank of New York Mellon reported that 97% of institutional investors believe tokenization will revolutionize asset management by increasing efficiencies, reducing costs, fractionalizing ownership and broadening access.⁶⁰

In 2021, Euroclear led a consortium of banks to successfully deliver an experiment with the BdF involving the DvP settlement of a sovereign bond against a CBDC and POC, which laid the groundwork for the 2023 launch of a Digital Securities Issuance (D-SI) service, inaugurated with the issuance of a €100 million World Bank sustainable bond. Such initiatives have confirmed the potential of DLT to deliver some efficiencies to capital markets by, for example, removing

part of the reconciliation workload, helping the identification of end investors and reducing the settlement cycle. A core attribute of the D-SI is its full adherence to the EU’s Central Securities Depositories (CSD) regulation. To mitigate liquidity fragmentation caused by DLT systems, a D-SI issuance is fully integrated into conventional systems to support secondary trading. In the case of the World Bank’s issuance, trading was helped in secondary markets within minutes of primary distribution, and the bonds entered the collateral management systems that form the backbone of fixed-income flows. International CSDs Clearstream, DTCC and Euroclear are working towards production-grade interoperable systems that facilitate cross-border capital flows based on DLT. Observing that “individual and private explorations of DLT’s potential now need to become an industry-wide effort to consolidate and connect liquidity, based on common standards and processes,”⁶¹ these infrastructures have committed to tackling:

- Driving open market feedback around the required characteristics of DLT networks, data access, privacy and smart contracts
- Enabling greater interoperability across DLT protocols through the adoption of standards
- Enhancing operational resilience
- Accelerating production scale

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CASE STUDY 2

SDX's tCHF token

SIX Digital Exchange AG (SDX) offers a robust platform for primary and secondary digital securities markets as a digital central securities depository and exchange regulated by the Swiss Financial Market Supervisory Authority (FINMA). Since its launch in November 2021,⁶² SDX has issued almost a billion CHF worth of digital securities, including UBS's tokenized bond issuance on the SDX platform in November 2022, valued at CHF 375 million (Swiss francs).⁶³ To enable the settlement of digital securities transactions on chain, SDX issues its Swiss franc token called "tCHF" (tokenized CHF), which is created based on deposits SDX holds in a central bank account at the SNB. While tCHF acts like an RBDC, being backed by central bank reserves, it is different in that it is not fully bankruptcy remote.

SDX tCHF is a tokenized claim against SIX Digital Exchange AG, fully backed by central bank reserves and allows participants to deposit tCHF tokens and use them to trade intermediated securities within the SDX network. SDX participants can acquire tCHF tokens by transferring funds from their account in the Swiss Interbank Clearing (SIC) RTGS system to SDX's SIC omnibus account (RTGS system transfer) and receive that amount of tCHF tokens on the network to trade and settle tokenized securities. All participant funds are held collectively and frozen until participants detokenize their tCHF tokens, upon which the equivalent funds are transferred to the participant's SIC account.

While the SDX tCHF model is cutting-edge and offers customers a proxy to CeBM, the collateral paid into SDX's SIC account is a risk-exposed position and must be risk-weighted accordingly. This results in capital charges imposed by regulations, which are costs associated with

banks needing a buffer to absorb potential losses. This configuration results in a limitation observed by corporate treasuries as the funds are not completely riskless.

While still beneficial, a challenge persists: no credit risk-free cash is available to settle tokenized asset transactions.⁶⁴ To address this, the Swiss National Bank, with SDX, is undergoing phase three of Project Helvetia, where for a limited time, intraday wCBDC CHF is being used for selected primary market transactions on the SDX platform. The first transactions were completed in December 2023, and the project will continue through mid-2024.^{65,66} This is an intraday, not an overnight wCBDC. Intraday implies the wCBDC would be converted back to traditional reserves held at the central bank at the end of the. Meanwhile, overnight implies the token would remain intact and carry over to the next day in the same format, remaining a central bank liability.

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Tokenizing credit risk-free settlement media

Tokenized CeBM could derive value by traversing between regulated settlement platforms. wCBDC allows participants, including digital CSDs and digital asset exchanges, to deliver composable and programmable credit risk-free cash to eliminate counterparty risk. wCBDC could realize value by:

- Complying with the PFMI principle to use CeBM for tokenized transactions
- Settling large-value tokenized securities transactions natively and credit risk-free
- Promoting the singleness of money by expanding the role of CeBM
- Ensuring financial stability by serving credit risk-free composable money for transactions
- Interoperating with private DLT platforms natively, including reading/writing cryptographic proofs
- Providing evidence of transaction completeness to counterparties and possible intermediaries

- Reducing capital charges and bankruptcy risks associated with commercial bank money.

Project Helvetia has proven the feasibility of settling tokenized securities using a real, limited-phase wCBDC to eliminate credit risk and support system stability. The BdF experimented with the full interoperability solution to enable securities transactions with wCBDC, representing an innovative approach to interoperating with conventional systems.⁶⁷ For cross-border securities settlement, Project Jura in 2021 demonstrated the feasibility of clearing foreign currency as part of cross-border payments and securities transactions, signifying a transformative use of CeBM across jurisdictions. Additionally, Project Jura found that subnetworks and dual notaries can enable the safe issuance of wCBDC on private DLT platforms.⁶⁸

Differentiated value

As tokenized CeBM, wCBDC could offer immediate benefits for the growing tokenized securities market. wCBDC could provide M0 settlement for tokenized securities transactions to improve financial stability and reduce costs for market players who rely on privately issued monies, which are not bankruptcy-remote and carry capital charges.

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7

Persistent industry challenges



7 Persistent industry challenges

Persistent industry challenges were identified as areas that require more than a digital payment instrument enhancement because they are dependent on elements like regulation, compliance and geopolitics.

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Persistent industry challenge



Instant settlement could increase liquidity risk

Instant and atomic settlement may increase liquidity demands and risks already raised by the shift to gross settlement.

RTGS systems background

Before the 1990s, deferred net settlement systems boosted liquidity efficiency but introduced credit and counterparty risk if a party could not meet its obligations. To address these credit concerns, central banks transitioned to RTGS systems to ensure the settlement of each transaction individually (gross settlement) and minimize the risks associated with netting. Since their introduction in the 1990s, RTGS systems have grown to support payments in over 160 countries.⁶⁹ This approach reduced counterparty risk but heightened liquidity risk (i.e. insufficient funds to settle payments), necessitating increased pre-funding for intraday transactions, incurring additional bank costs.⁷⁰

Liquidity saving mechanisms

Effectively managing intraday liquidity prompted the development of liquidity-saving mechanisms (LSMs) to augment RTGS systems and help banks reduce their liquidity risks and costs.⁷¹ LSMs are financial tools that provide payment queuing facilities.⁷² LSMs allow banks to condition the release of queued payments upon receipt of offsetting payments, thus significantly reducing liquidity costs for participating banks. LSMs addressed growing

liquidity needs through transaction netting, queuing and offsetting. Despite LSMs, banks still hold excess liquidity for unforeseen events, resulting in idle funds that could prove costly in high-interest-rate environments with elevated borrowing costs. The industry continues to minimize intraday liquidity costs and risks while balancing settlement finality with liquidity optimization, like the provisioning of intraday liquidity by central banks in response to the needs of RTGS systems.

Exacerbating liquidity risk

Innovative settlement systems reinforce the value of instant and atomic settlement,⁷³ where transactions with multiple components settle instantly and simultaneously in seconds. While this approach offers advantages like concurrent transfers of an interbank payment for security (i.e. DvP), it can increase liquidity demands for certain trading scenarios as the point from trade to settlement is within seconds rather than days. If instant and atomic settlement is universally applied, it could increase the demand for cash and assets to pre-fund accounts for settlement. If deemed desirable for a trading scenario, instant settlement requires an increase of the cash holding limits to support increased liquidity demand. Conventional netting, queuing and novel methods like

resequencing may be necessary to mitigate these risks and costs and accommodate different trading scenarios.⁷⁴ However, more evidence of novel liquidity-saving techniques, such as instant and atomic settlement, is needed to conclude their efficacy.

Instant and atomic settlement represents a model whereby CeBM (P, for payment of cash) and an asset (D, for delivery of asset like a security) can be immediately and simultaneously exchanged, thus reducing counterparty and credit risk. This allows wholesale payment and settlement systems to facilitate more than just cash settlement by facilitating composability with assets.

Optimizing liquidity management

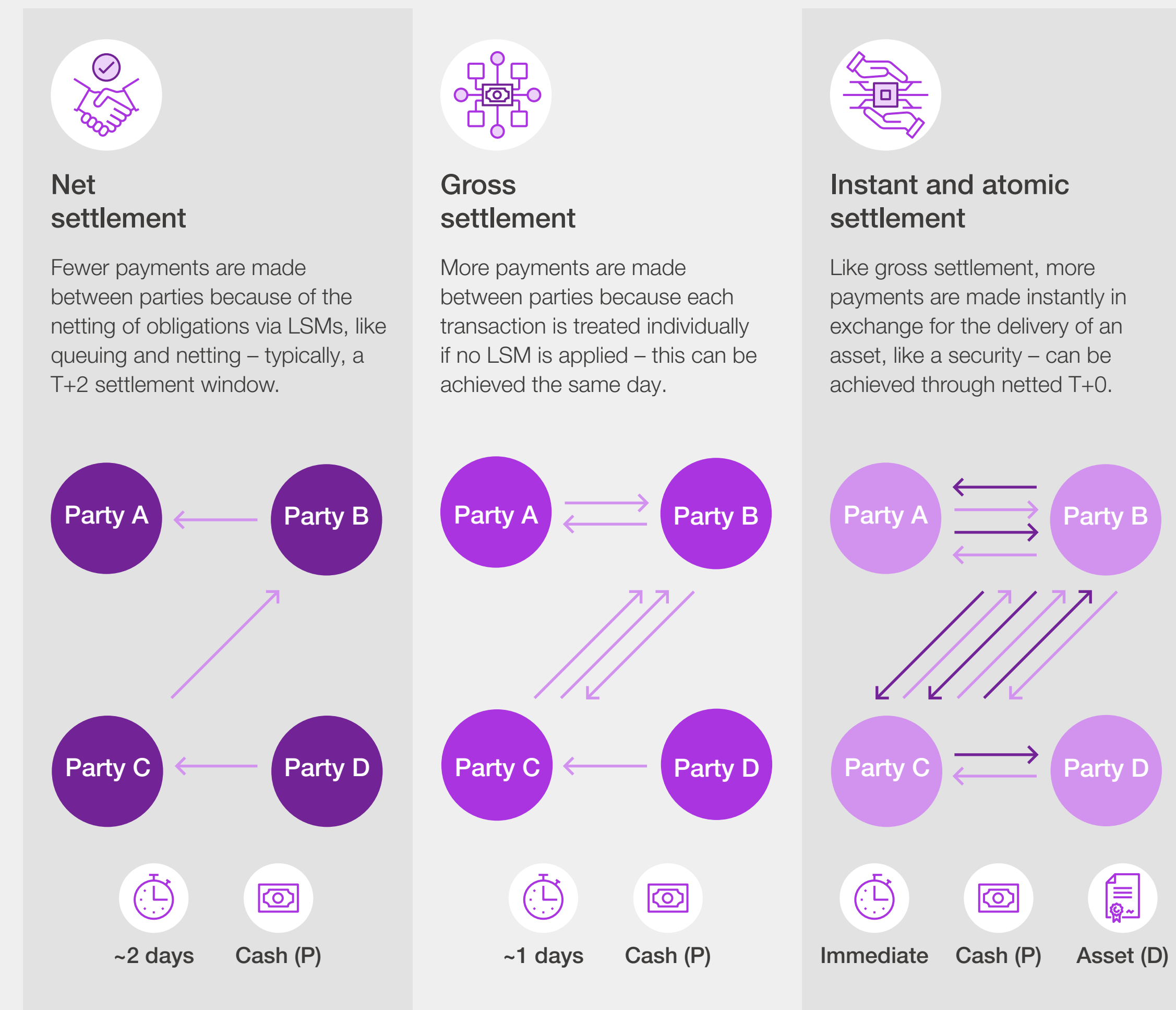
Netting, queuing and offsetting are fundamental in reducing liquidity costs, while intraday liquidity buffers will likely remain necessary. Certain trading scenarios, like FX, benefit from multilateral PvP. In contrast, others, like securities transactions that touch multiple parties, possibly across jurisdictions and asset types, may benefit from instant and atomic settlement to mitigate counterparty and liquidity risk. Due to limited consensus on the efficacy of instant and atomic settlement in resolving

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FIGURE 13

Stylized evolution from net to instant and atomic settlement



Source: Accenture.

7 Persistent industry challenges

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Persistent industry challenge



long-standing liquidity challenges, this report proposes areas where more research is needed to determine wCBDC's efficacy in mitigating liquidity risk:

- Test the efficacy of instant and atomic settlement to realize liquidity savings compared with traditional like netting and emerging techniques like resequencing⁷⁵ under trading scenarios that involve multiple parties, multiple assets and jurisdictions (i.e. cross-border)
- Explore whether LSMs, including privately operated LSMs, should be applied to wCBDC systems to offer settlement variability to market participants based on the trading scenario (the availability of techniques will vary by jurisdictional legal frameworks).

There is an ongoing debate about whether LSMs should be applied to wCBDC because it is envisioned to address a new set of use cases like atomic settlement. In 2021, BdF experimented with Euroclear France, Agence France Trésor, and primary dealers, where LSMs, such as recycling and auto-collateralization, have been successfully tested.⁷⁶ RTGS systems are often short-liquidity likely because they address a wide set of use cases; wCBDC systems could address fewer, specialized use cases and be more focused.

However, it is unclear if wCBDC could alleviate liquidity risks, and this report proposes methods to advance discussions. Any modernization would depend on policy-makers determining the appropriate balance between liquidity efficiency (permitting more LSM techniques) and system stability (reducing the number of interdependent relationships and, thus, points of failure).

Persistent industry challenge

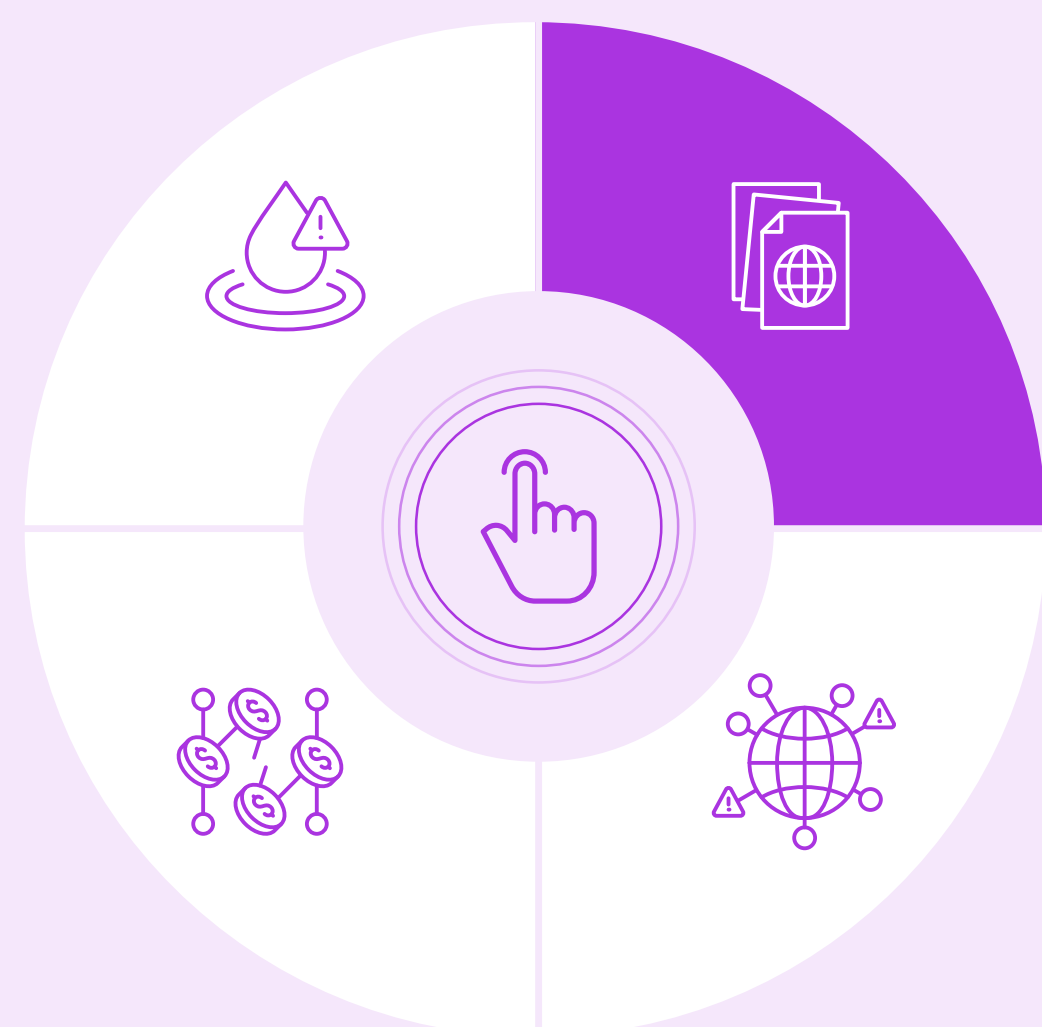
Historical liquidity risk challenges are likely to persist, and more evidence is needed to clarify how wCBDC or other methods of FMI modernization could alleviate these risks.



Disjointed regulatory interoperability

A divergence in policy, rules and regulations creates inconsistencies between jurisdictions, resulting in friction for cross-border use cases.

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Cross-border regulatory frictions

Inconsistent regulations and regulatory hurdles are another important challenge facing the industry regarding efficiency and speed. It is acknowledged that true and complete harmonization from a regulatory perspective is not achievable due to jurisdictions' sovereignty. In line with the ongoing efforts by the G20 and Financial Stability Board (FSB) to optimize wholesale financial transactions, regulatory friction is identified as a key hurdle to achieving harmonious and efficient cross-border payments. In a 2023 survey, the World Economic Forum identified four regulatory frictions:⁷⁷

- **Differences in regulatory and oversight frameworks** can be particularly pronounced for areas of innovation like using blockchain-based payments or for non-bank entities seeking to capture new market share.
- **Compliance with AML/CFT requirements** is a key driver for the de-risking phenomenon influencing the decline of correspondent banks willing to absorb the risk of non-compliant payments and face zero-tolerance enforcement.

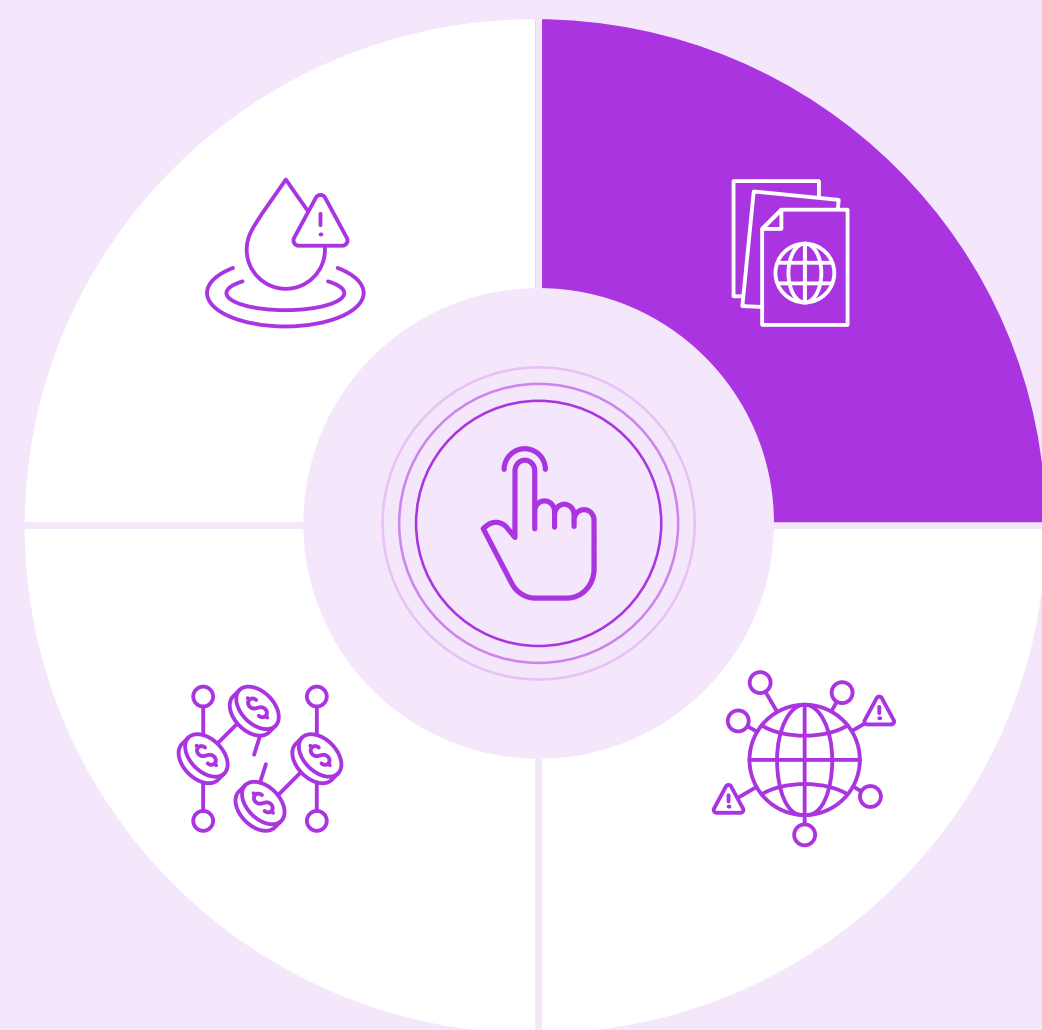
- **Data privacy and security regulations** create challenges for banks and non-bank FIs to securely share data across borders to comply with AML/CFT rules while balancing requirements like data localization. This friction could be especially pronounced when CBDC is traded across borders and held in foreign jurisdictions where the question of who has access to what data is underscored.
- **Regulatory barriers to accessing payment systems and infrastructure**, including 1) regulations may directly exclude non-bank FIs from participating in national payment systems, 2) regulations may set out eligibility requirements that non-bank FIs cannot meet (e.g. banking licence), and 3) access is often limited to FIs that hold licences locally.

Examples of players experiencing frictions

- Shariah-compliant finance is an example of a difference in oversight frameworks, as credit in its traditional sense is not allowed, and instead, a partnership model is required.
- Varied processing times for regional beneficiary leg transactions highlight diverse capital controls and checks. Relying on agencies like the Financial Action Task

7 Persistent industry challenges

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Force (FATF) for country risk reviews is time-consuming and costly. Correspondent banks, facing limited profitability and compliance risks, often bear the burden of these reviews, contributing to industry exits.

- China, Thailand, Indonesia and Sri Lanka are implementing comprehensive privacy laws for the first time, while others like Australia and Japan are amending theirs to be more globally aligned.⁷⁸
- Money transfer operators like MoneyGram and Western Union experience these challenges when facilitating cross-border remittances.

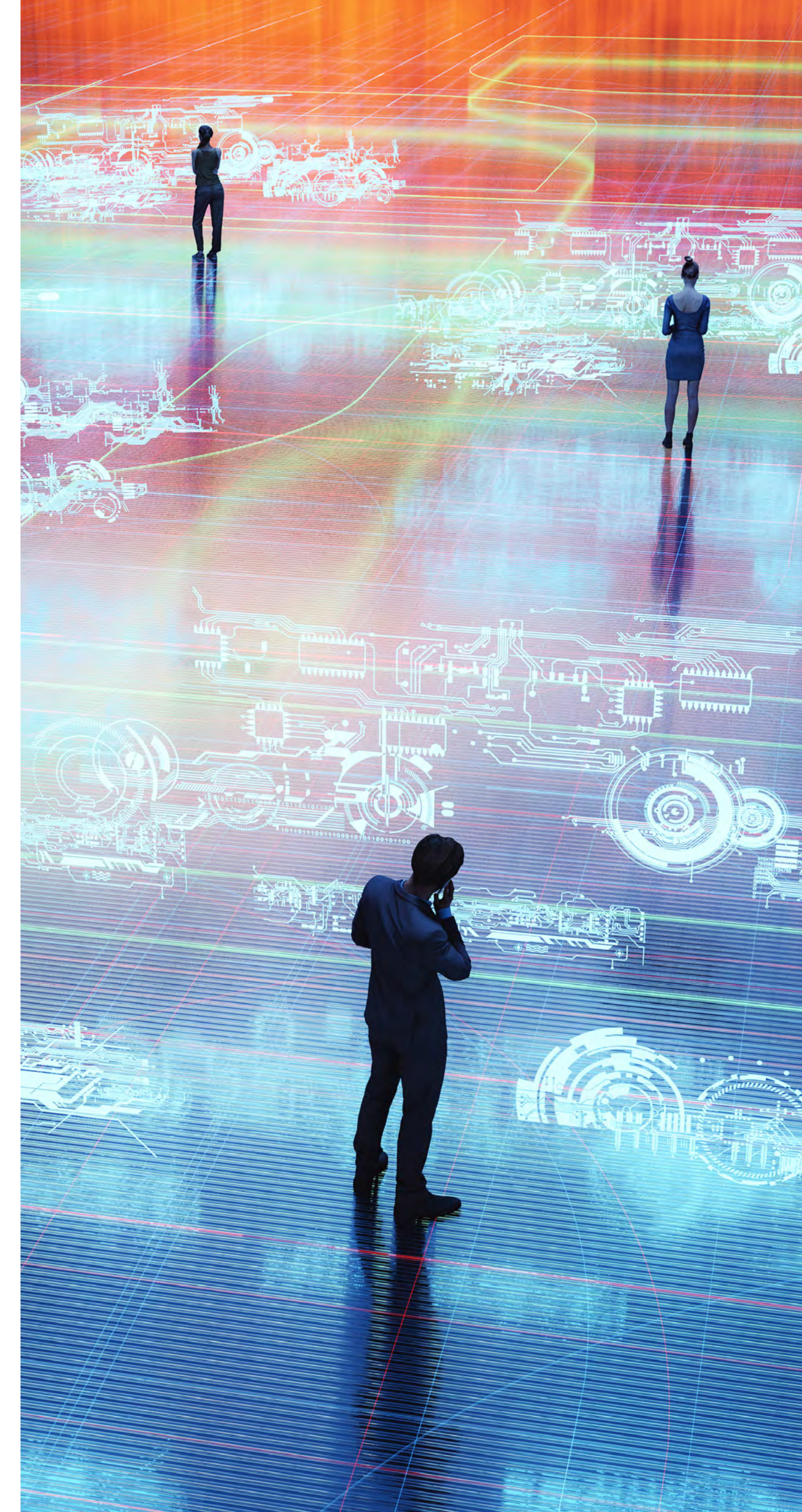
Compliance-by-design

The BISIH has examined these regulatory frictions in initiatives like Project Dunbar, which was focused on optimizing international settlements through a common multi-CBDC platform. The challenges related to governance, legal and compliance for cross-border payments are broader than regulatory frictions. Creating efficiencies in compliance proves challenging because requirements vary by jurisdiction, such as domestic watchlists or certain institutions being given access to national payment systems to alleviate friction. Therefore, centralizing

common processes might create process efficiencies but could introduce other gaps, such as missed checks.⁷⁹ To build upon Project Dunbar, the BIS Innovation Hub launched Project Mandala in October 2023, a proof-of-concept to explore the feasibility of jurisdiction-specific policy and regulatory requirements into a common protocol for cross-border use cases – also known as compliance-by-design architecture. This architectural model aims to automate compliance procedures, monitor real-time transactions and increase transparency and visibility into country-specific policies.⁸⁰ Additionally, disputes between institutions or inter-jurisdictional issues should be handled according to jurisdiction-specific requirements and by designated authorities.

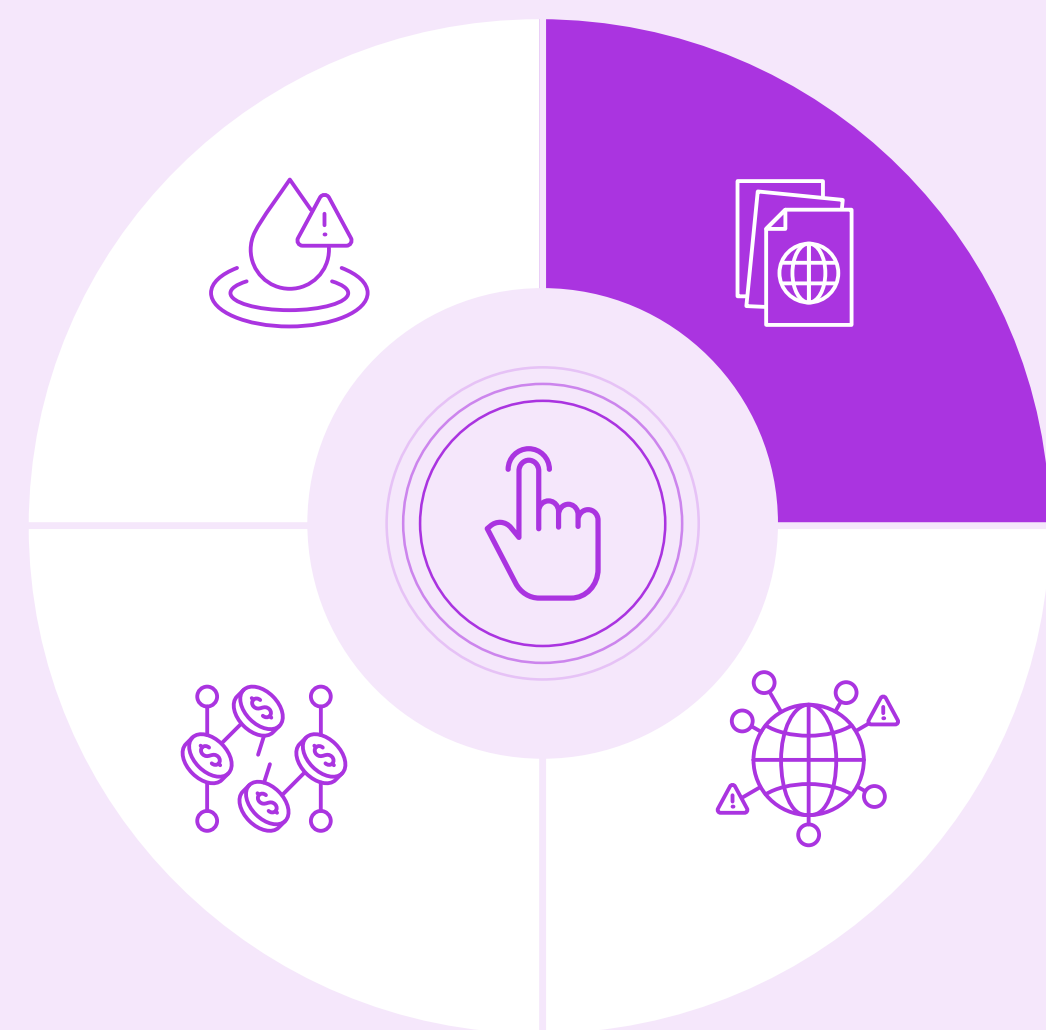
Ensuring compliance-by-design

LexisNexis reported that in key global markets alone, annual expenditures on financial crime compliance exceeded \$274 billion in 2022, with labour costs of compliance teams representing the largest portion.⁸¹ Novel approaches are unlocking opportunities to enable more efficient regulatory interoperability while safeguarding participants and the system through automation and embedded supervision. There is no widely accepted governance framework or





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model for cross-border use cases using CBDC. The system should offer flexibility to grant varying degrees of access for providers like orchestration service providers that can facilitate atomic settlement and possibly global corporations in jurisdictions where it is permitted. Disjointed regulatory interoperability is an ongoing challenge; thus, this report proposes areas where wCBDC systems should explore supporting in order to address this challenge.

- Continue codifying supervisory functions and build rulebooks to integrate legal procedures, automate corridor-specific compliance checks and build escalation protocols to remediate issues.

- Explore facilitating multiple access tiers to CeBM to configure permissions to grant access safely.

While these remain open questions, efforts are under way to establish compliance-by-design. The mBridge platform allows the governance of access to enforce legal aspects of cross-border trade and payments. It embeds compliance rules, such as balance and transaction limits set, into the underlying custom DLT through smart contracts. Embedded supervision is a model that uses DLT and smart contracts to automate financing and trading processes and data permissions while embedding checks to verify compliance.⁸² While these efforts

are ongoing, policy-makers determine the advancements in progress.

Persistent industry challenge

Inter-jurisdictional regulatory and policy interoperability complexities are not solvable overnight. Rulebooks and embedded supervision are concepts discussed in this report that could automate compliance checks and harmonize the market. However, these solutions largely require collaboration beyond wCBDC or other FMI modernizations.



Slow cross-border payments in high-risk regions

De-risking and cost-cutting measures are reducing the number of correspondent banks globally, limiting accessibility to cross-border payments for users worldwide.

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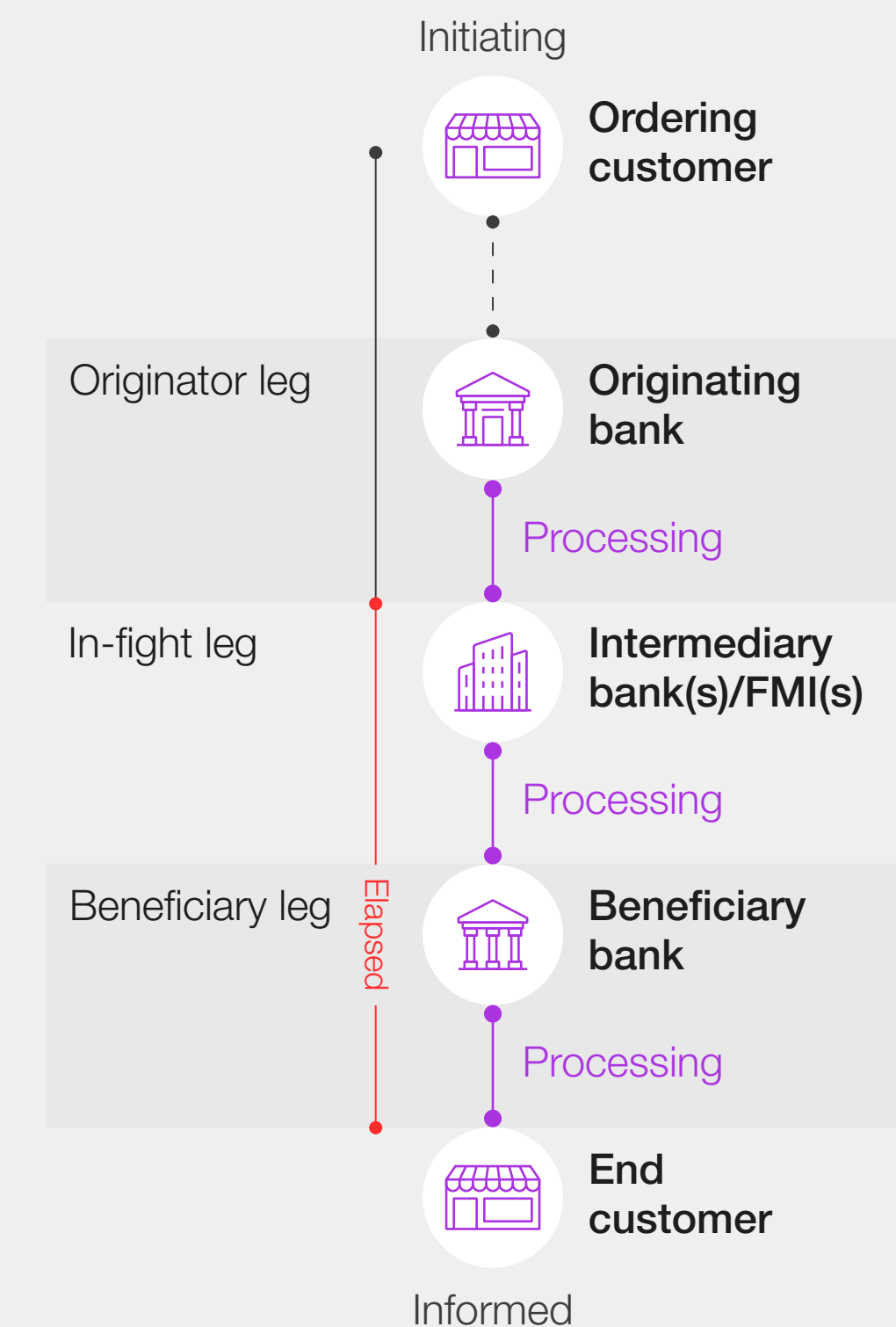


Correspondent banking and access constraints

The total value of global cross-border payments was \$150 trillion in 2017 and is projected to reach \$250 trillion by 2027.⁸³ For context, the World Bank estimated the global gross domestic product (GDP) to be \$100.88 trillion in 2022.⁸⁴ Correspondent banking involves banks holding accounts with each other and using central banks as settlement agents to achieve cross-border payments. According to the BIS, “correspondent banking requires the opening of accounts by respondent banks in the correspondent banks’ books and the exchange of messages to settle transactions by crediting and debiting those accounts.”⁸⁵ This ensures compliance but lacks efficiency by requiring the holding of liquidity in nostro accounts. “Nostro” and “vostro” are two different terms used to describe the same bank account. The terms are used when one bank has another bank’s money on deposit. Correspondent banking services are costly, with \$120 billion spent by global corporates on cross-border transactions, excluding FX costs.⁸⁶ Other costs stem from trapped liquidity, treasury operations, FX fees and compliance.

FIGURE 14

Stylized process of a cross-border payment on SWIFT gpi



Note: Data from the Swift gpi Observer track the in-flight and beneficiary legs, the blue and red parts of the processing time and elapsed time, respectively.

Source: BIS, *SWIFT gpi data indicate drivers of fast cross-border payments, 2022.*

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Another challenge to cross-border payments observed by this research is the limited accessibility of CeBM for foreign institutions and possibly global corporations that conduct significant international trade in key markets like oil and gas. The correspondent banking model was designed to facilitate a conduit between non-domestic and non-bank entities with the banking system because banks and FMs are traditionally the only ones with access to CeBM.

“De-risking”: declining correspondent banks

Banks reduced these correspondent relationships after the 2008 financial crisis, which disproportionately affected smaller economies.⁸⁷ Between 2011 and 2019, the number of correspondent banks decreased by 22%, even as payment values increased.⁸⁸ This decline was due to correspondent banks shouldering regulatory and reputational risks, pushing correspondent banks towards “de-risking”, or exiting the industry.⁸⁹ This was prompted by valid concerns, including the estimated \$1.6 trillion (approximately 2.7% of global GDP) in annual illicit financial activities.⁹⁰ There were ongoing cutbacks in correspondent banking relationships driven by a lack of profitability to cover compliance costs, exits from regions deemed to be too risky.

Risky regions include jurisdictions where customer bases or products and services pose a higher risk for AML/CFT compliance.⁹¹ A high-risk region is a jurisdiction with more strict KYC/AML/CFT rules, resulting in additional checks and criteria that could slow processing times.

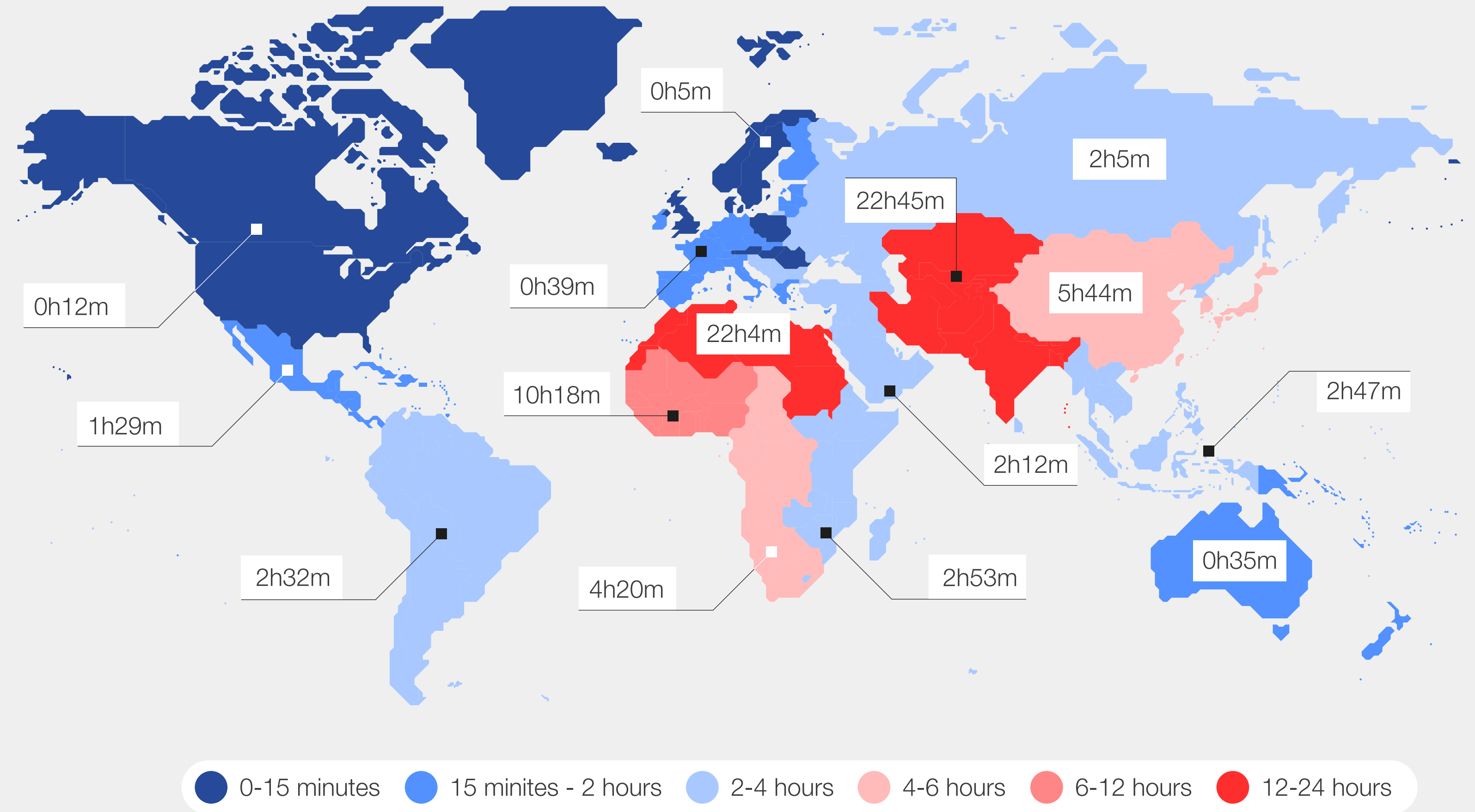
To mitigate the risk of facilitating illicit payments, larger banks withdraw from high-risk markets due to AML/CFT compliance worries, profitability issues and cyberthreats. Smaller banks now have fewer cross-border payment options, forcing reliance on more intermediaries, driving costs and hindering competition. A 2023 FSB report reveals that 84.3% of wholesale payments with larger banks do not have an intermediary or have only one, indicating a concentration of influence.⁹² De-risking disproportionately affects developing nations and could hinder financial inclusion and interoperability.⁹³ Moreover, “shadow payments” through unregulated channels can increase.⁹⁴ Against this backdrop, multilateral initiatives have emerged to address these concerns. For example, Project mBridge aims to tackle this pain point by creating a multi-country shared public good technology that could connect many countries, thereby addressing the reduced footprint of correspondents due to de-risking and other benefits.⁹⁵

Slow beneficiary regions

Cross-border payment processing has improved, with 89% completing within an hour, surpassing the G20’s target of 75% by 2027.⁹⁶ However, these are global averages, and de-risking has led to slower processing times in the Middle East, North Africa and Central Asia because of 1) fewer intermediaries willing to facilitate payments there because of the disproportionate compliance risks (outweighing the profit opportunity), and 2) additional manual processes to perform the appropriate screening on beneficiaries. From an economic perspective, these reasons are tightly correlated, as with fewer actors competing, there is less incentive to innovate. Technology differences and resource limitations also contribute to disenfranchisement, as payment system upgrades are costly. Countries with stricter capital controls, offline beneficiary banks and lower per capita income experience longer beneficiary legs (see Figure 15).⁹⁷ The decline in correspondent banks and local constraints affects higher-risk regions, slowing processing times.

FIGURE 15

Median end-to-end processing time by beneficiary region



Source: BIS, SWIFT gpi data indicate drivers of fast cross-border payments, 2022.

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Accessing central bank money

The challenge of crediting beneficiaries in high-risk regions relates much to regulatory interoperability, as there can be incongruent compliance processes and differences in policies regarding CeBM access. Illicit activity cannot be entirely thwarted by introducing a new payment rail. Therefore, for wCBDC systems to address slow cross-border payments in high risk regions, they should:

- Form regional and corridor-specific collaborative efforts to advance capabilities related to embedded supervision, including automating compliance checks and monitoring transactions.
- Use digital identity frameworks could enhance compliance with KYC/AML/CFT while preserving privacy.
- Dismantle barriers to entry by exploring the expansion of access to non-bank and foreign entities (policy permitting) to enhance financial inclusion (e.g. stablecoin issuers).
- Enable 24/7 access to CeBM to support beneficiary banks in servicing customers.

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The speed of cross-border payments is not limited to technological or regulatory challenges but also economic incentives and competition – the fewer financial services providers that have access to CeBM, the more costly and slow the services in the market.⁹⁸ Public-private cooperation with agencies like FATF and the Office of Foreign Assets Control (OFAC) will be paramount to mitigating illicit activity and supporting regions where cross-border payments move at a slower pace.

Persistent industry challenge

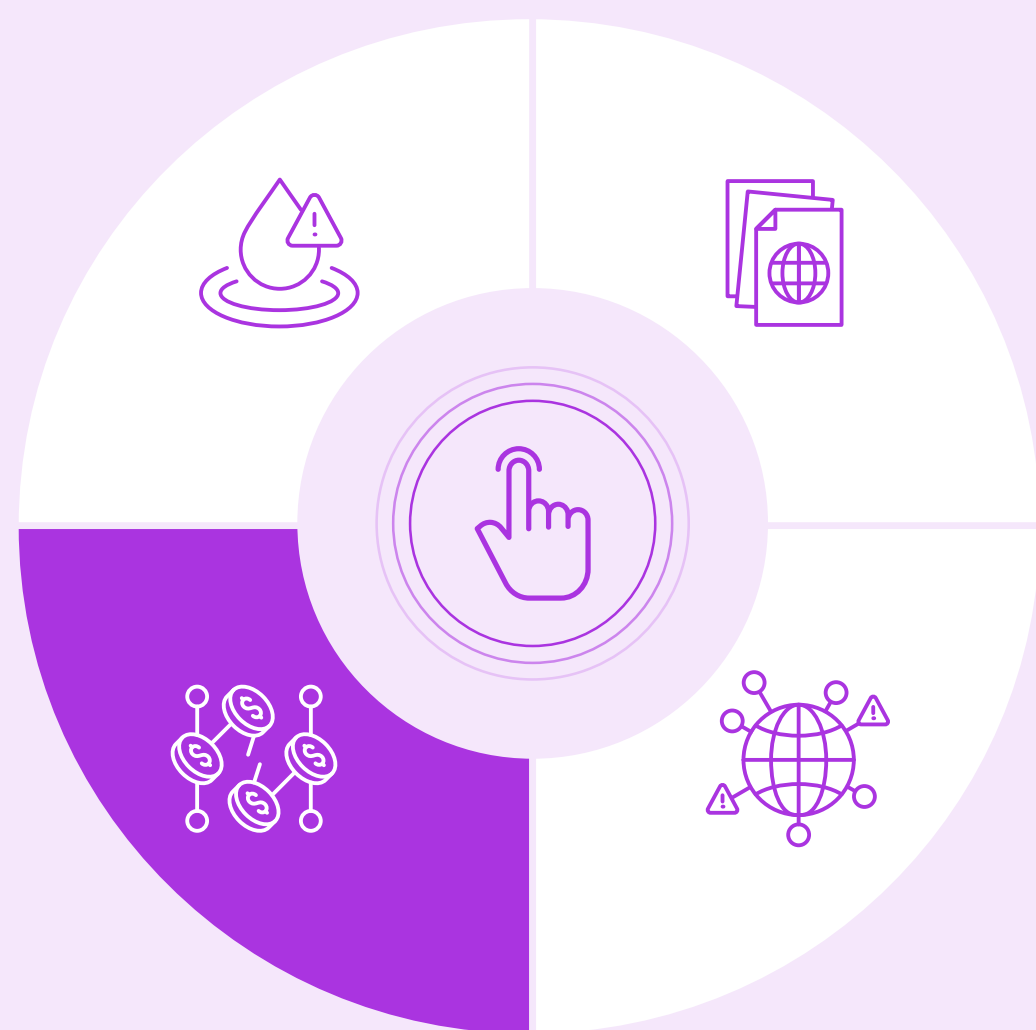
De-risking and its impacts on the cross-border payments market is widely recognized as a source of inefficiency, particularly impacting high-risk regions. Expanding access is a policy decision that central banks must consider the benefits and risks of.



Lack of secure technical interoperability

A flurry of new systems could lead to a disconnection between DLT and conventional systems, resulting in increased risk and liquidity fragmentation.

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Interoperability in payments

Limited technical interoperability has been attributed to legacy systems built on jurisdiction-specific standards, causing discrepancies between data standards and communication formats. The BIS defines payment system interoperability as the seamless interaction of proprietary acceptance and processing platforms, aiming to promote competition, reduce fixed costs and enhance user convenience.⁹⁹ ISO 20022, a universal financial message scheme format, seeks to standardize communications among FIs. A 2023 World Economic Forum report emphasizes the need to ensure the interoperability of CBDC systems with conventional payment infrastructures.¹⁰⁰ A recent Swift report acknowledges the benefits of tokenization but warns of potential asset fragmentation across networks, prompting the exploration of technical interoperability by connecting public and private blockchains and non-blockchain networks. Two approaches are being pursued: Swift's CBDC Connector and Chainlink's Cross-Chain Interoperability Protocol, which demonstrated the ability of Swift's connectivity and messaging to access tokenized instruments.¹⁰¹ Both Swift and Chainlink are messaging systems rather than settlement systems.

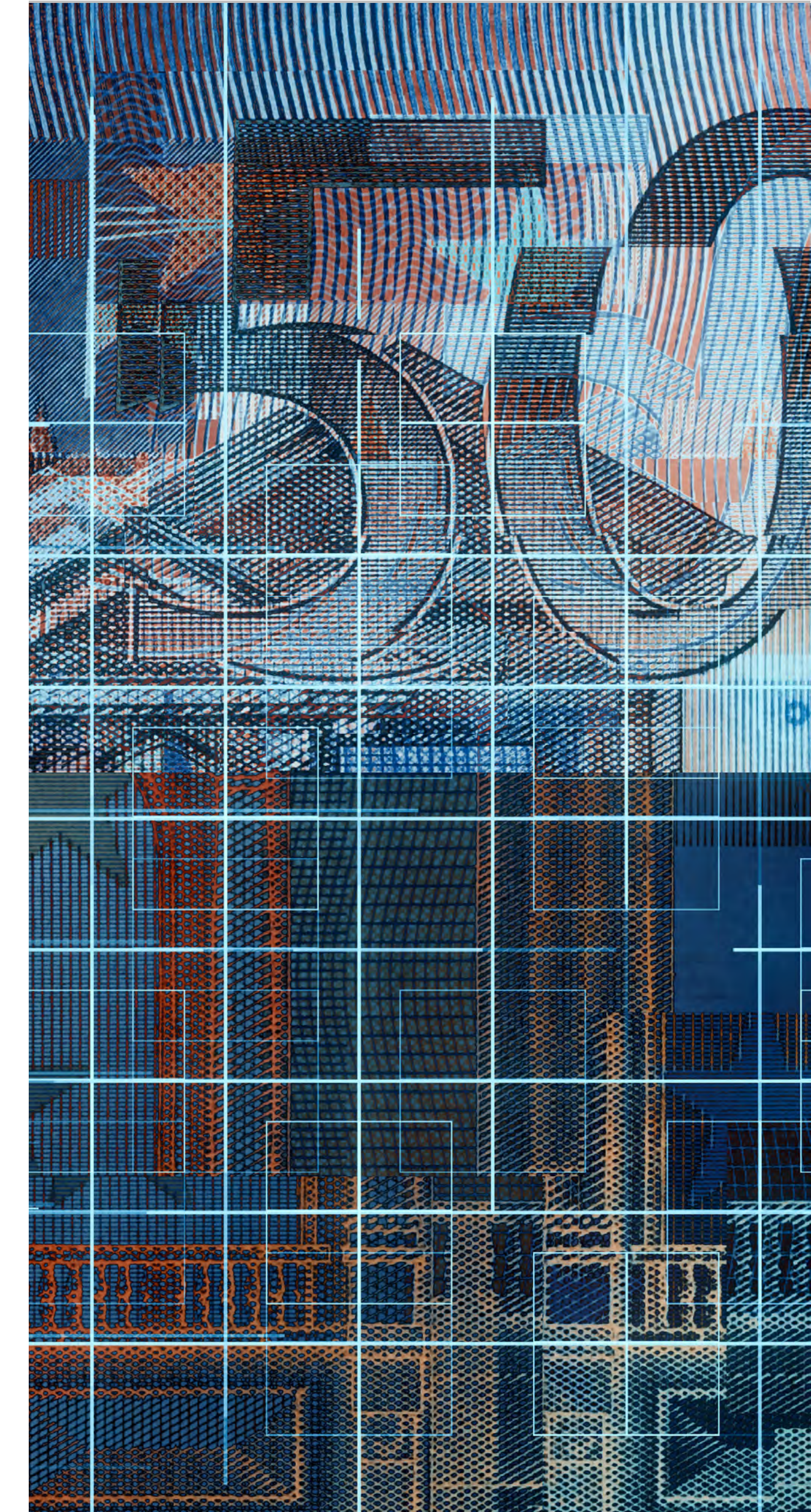
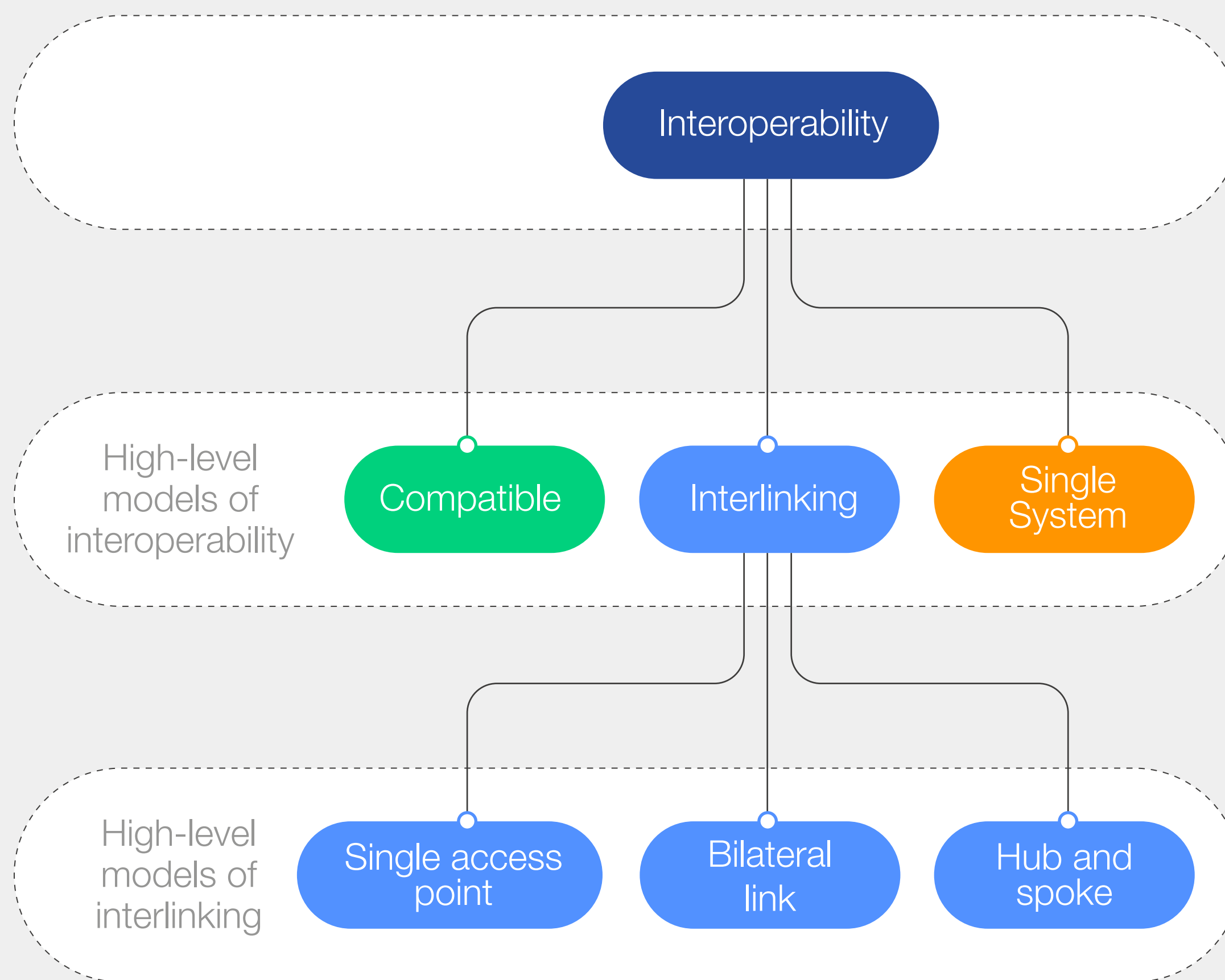


FIGURE 16

High-level models of interoperability and interlinking of CBDC systems



Source: BIS, *Options for access to and interoperability of CBDCs for cross-border payments*, 2022.

CBDC interoperability models

A key anticipated challenge of multiple CBDC networks is interoperability among themselves and between jurisdictions. The BIS outlined several CBDC interoperability models, which inform the future industry options:¹⁰²

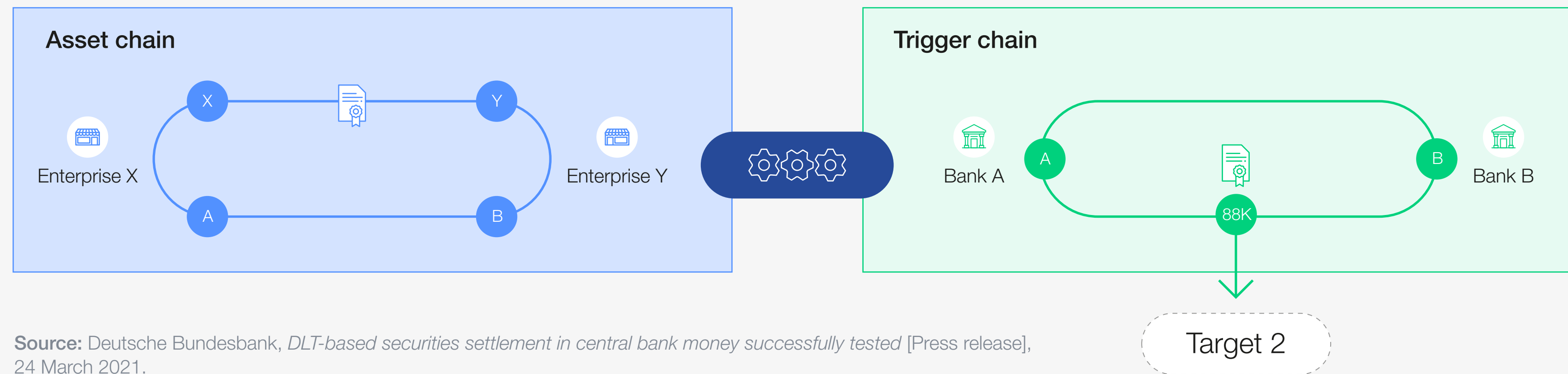
- 1 **Compatibility:** A model whereby individual systems use common interoperability standards. Analogies could be drawn to industry standards like ISO 20022.
- 2 **Interlinking:** The solution could emulate Swift's, which acts as a supranational network with which institutions could integrate. Project Icebreaker is experimenting with this model by interlinking three retail CBDC systems through a hub-and-spoke model.¹⁰³ Swift is experimenting with this interoperability model in a CBDC context with more than 30 FIs and central banks.¹⁰⁴
- 3 **Single system:** An example of a single system is mBridge, which uses a common platform model for cross-border payments and FX among participant financial institutions settled in CBDCs issued by their central banks. Another example is the Regulated Liability Network (RLN) initiative, conceptualizing a common platform for central banks and FIs with settlement in CBDC.¹⁰⁵

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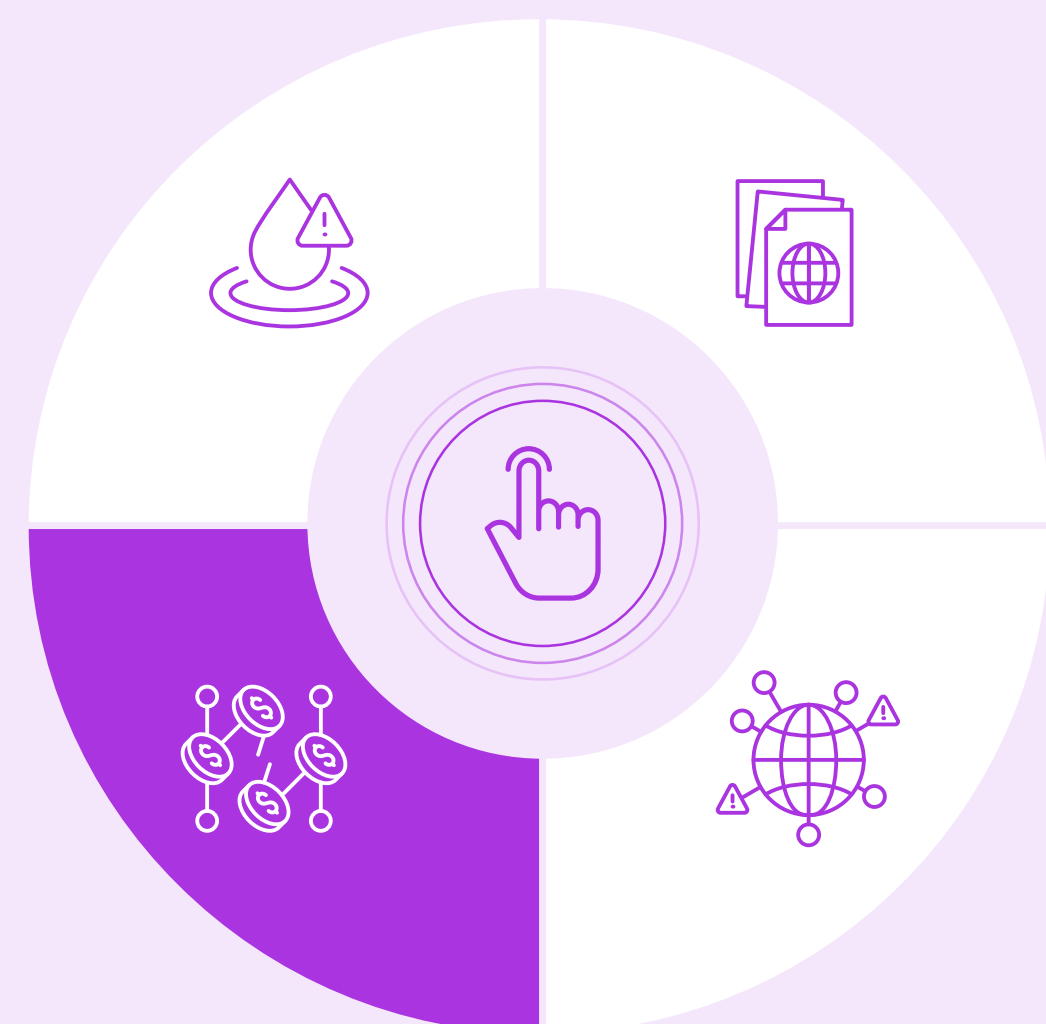
FIGURE 17

Trigger solution



Source: Deutsche Bundesbank, *DLT-based securities settlement in central bank money successfully tested* [Press release], 24 March 2021.

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DLT interoperability

Notably, the ECB launched exploratory work on how wholesale financial transactions recorded on DLT platforms could be settled in CeBM. For this purpose, in 2023, the New Technologies for Wholesale Settlement - Contact Group was created, composed of market participants to support and inform this work. As part of its exploratory work, the Eurosystem will test three solutions for CeBM settlement of tokenized assets: two solutions designed to trigger settlements in TARGET services (RTGS system for the solution supported by the Deutsche

Bundesbank and TARGET Instant Payment System (TIPS) for the solution supported by the Banca d'Italia) and a wCBDC solution offered by the BdF.¹⁰⁶ A gap with today's RTGS systems is a lack of DLT interoperability because of the challenge of reading and writing cryptographic proofs (e.g. proof of funds). In 2017, the BOE tested DLT interoperability with its RTGS system, Clearing House Automated Payments System (CHAPS), and identified that CHAPS could not natively produce cryptographic proofs.¹⁰⁷

1 Deutsche Bundesbank's trigger solution: Deutsche Börse, Deutsche Bundesbank and Germany's Finance Agency have developed and successfully tested a settlement interface for electronic securities, working with other participants. Securities settlement using DLT is performed with a "trigger" solution and a transaction coordinator in Target 2, the Eurozone's RTGS system.¹⁰⁸ The trigger bridges the existing payment solution with DLT applications.¹⁰⁹ This is intended to use the existing RTGS system and build an additional layer to integrate with DLT systems.¹¹⁰

2 Banca d'Italia's TIPS Hash-Link service: The TIPS Hash-Link (TIPS H-L) solution facilitates interoperability between a generic market DLT platform and a payment system using a DLT-agnostic application programming interface (API) approach. Successfully tested by the Banca d'Italia (Bdl) with the TIPS platform, it enables instantaneous DvP transactions 24/7. This protocol can be extended to integrate a market DLT platform with real-time payment systems like TARGET services. This model does not require new development to support new DLTs, and the API gateway allows the Eurosystem to act as the "trusted third party" that securely generates and stores the hashes.¹¹¹

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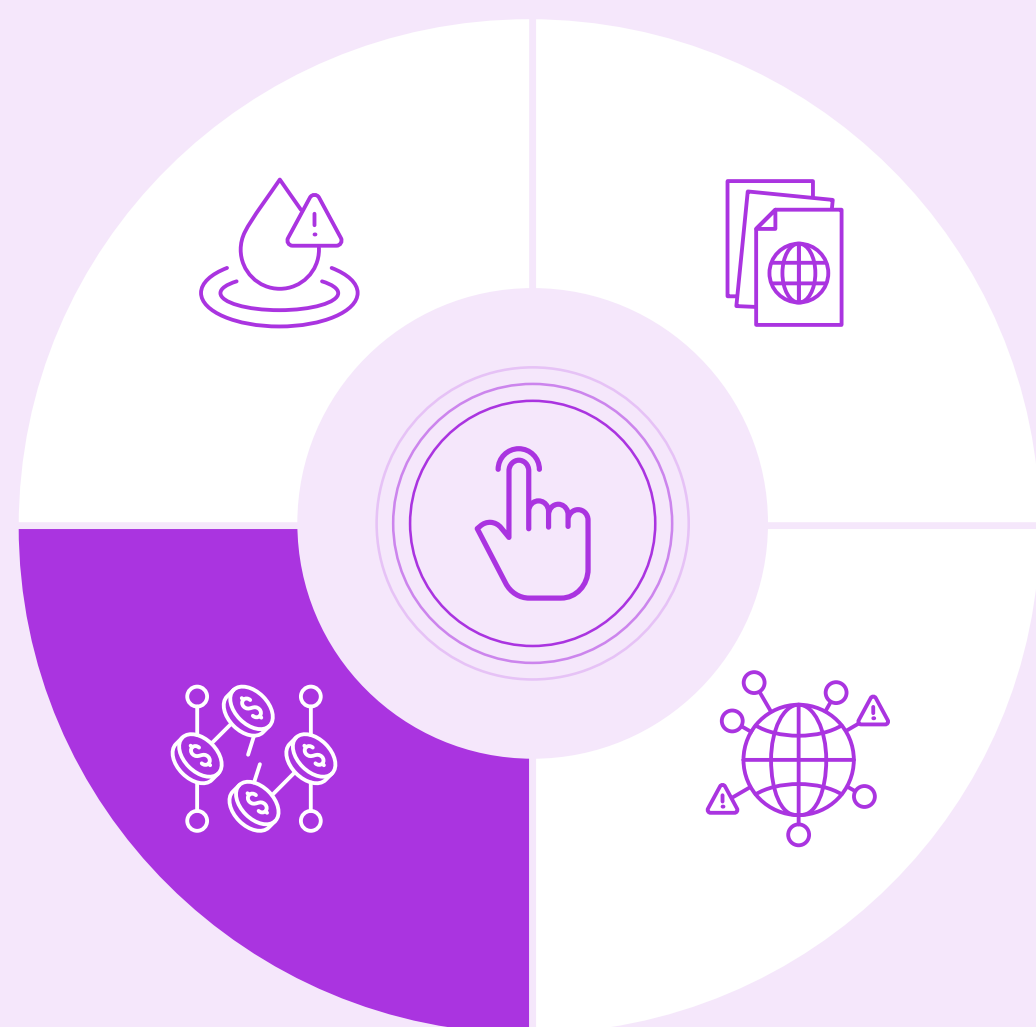
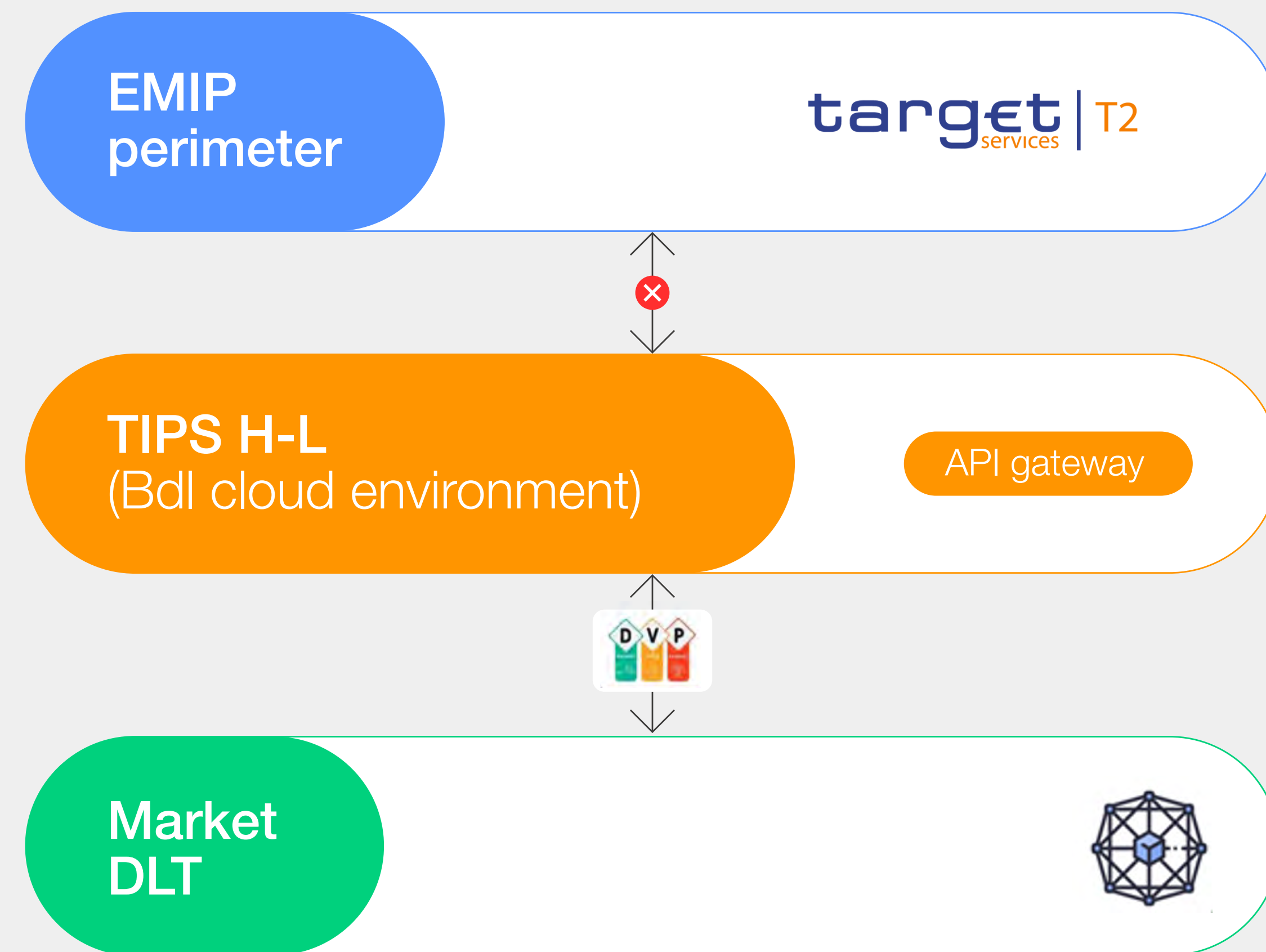


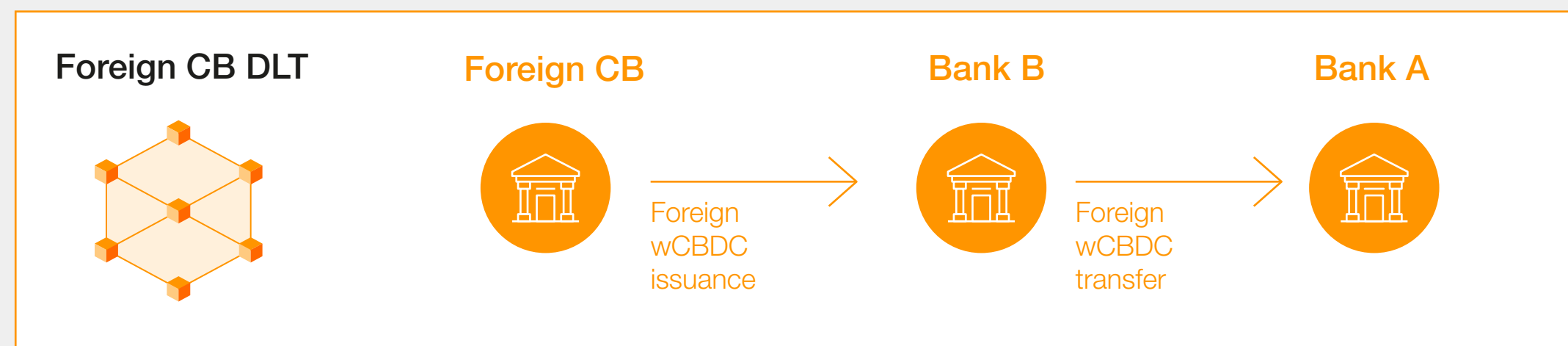
FIGURE 18
TIPS Hash-Link service




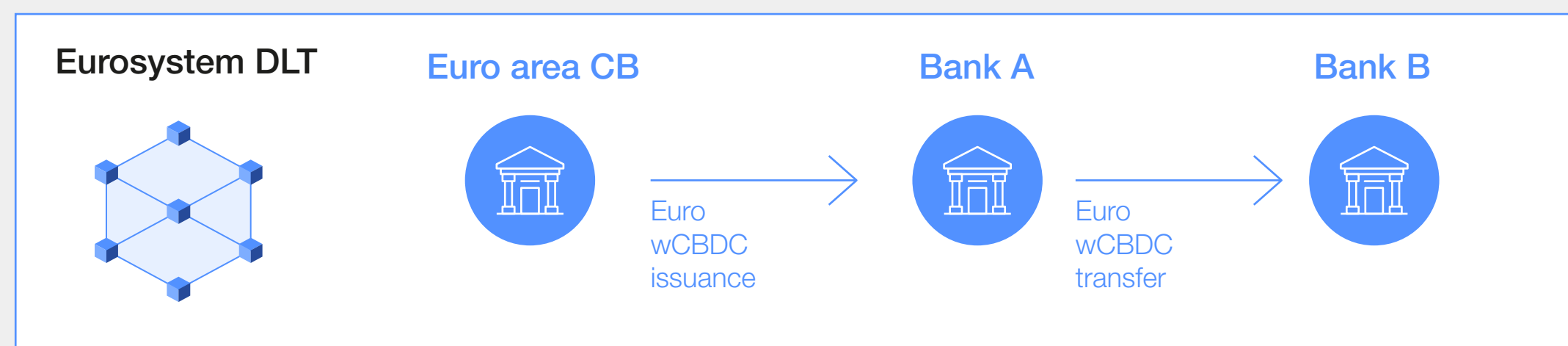
Source: European Central Bank, *TIPS Hash-Link Service Description*, 2023.


FIGURE 19

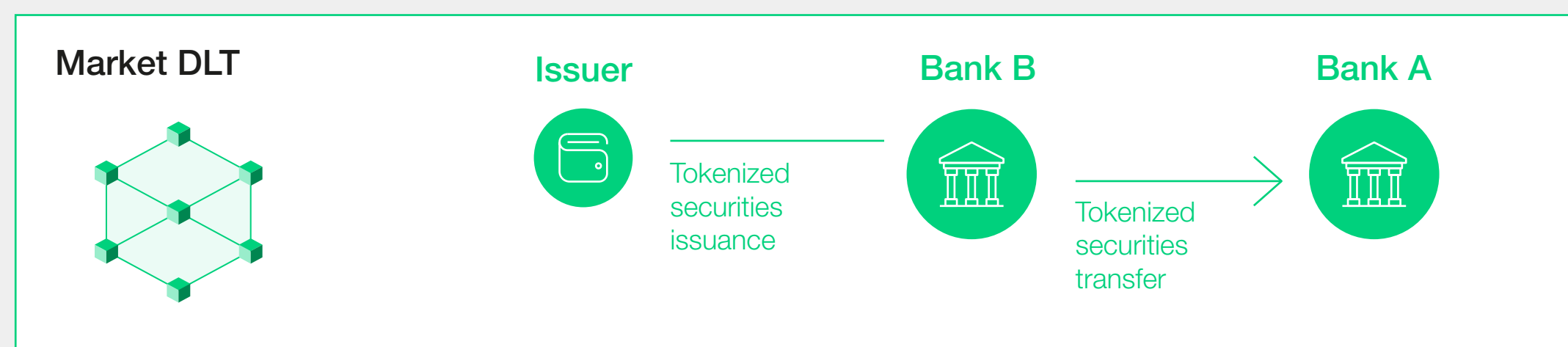
Full interoperability solution with two market DLTs and two national central banks (bank A and B)



Interoperability mechanism 



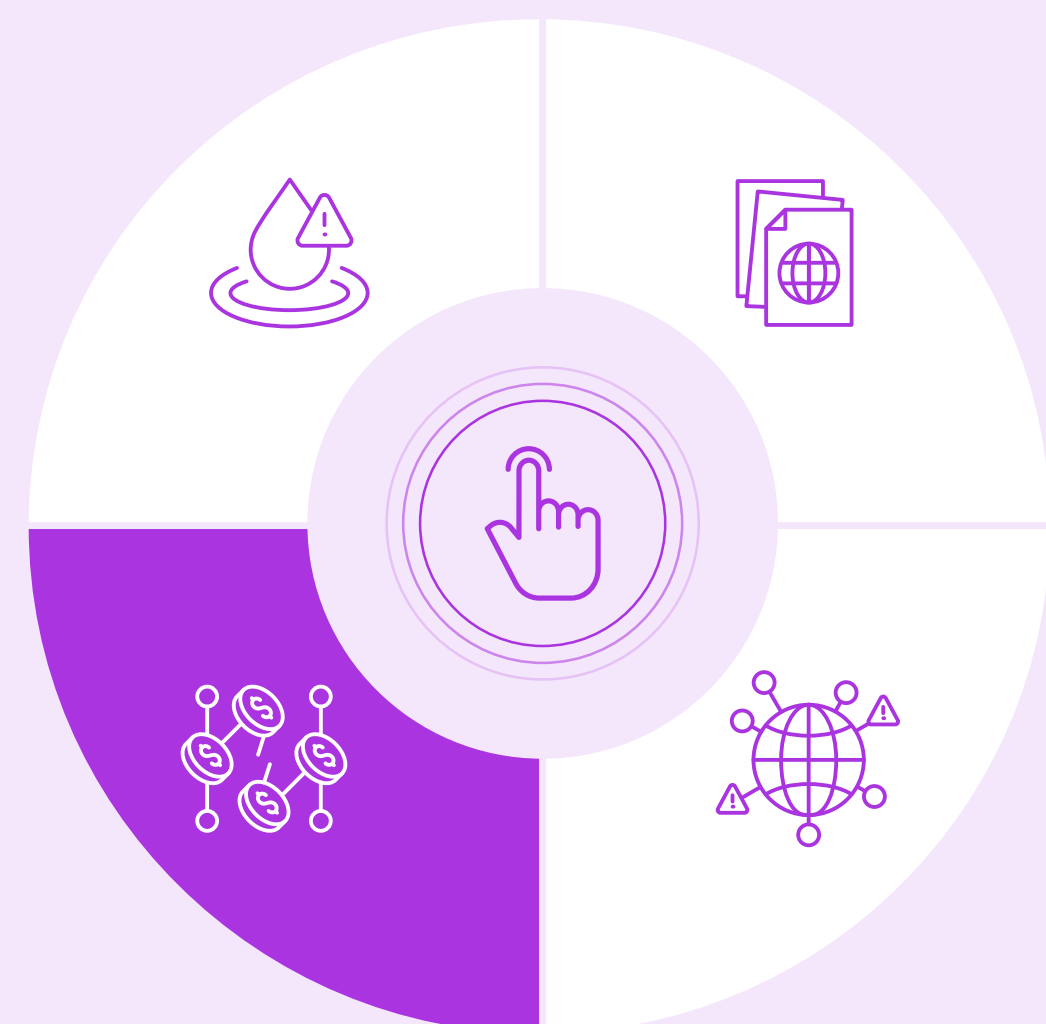
Interoperability mechanism 



Source: BdF, Wholesale Central Bank Digital Currency Experiments with the Banque De France, 2023.

3 Banque de France’s full interoperability solution: The BdF has undertaken an experimentation programme since November 2020. On this basis, the BdF conceptualized an interoperability model, the full DLT interoperability solution, which allows the settlement of tokenized assets with wCBDC on two separate DLTs using the BdF’s blockchain, Distributed Ledger for Securities Settlement System (DL3S). In this model, the Eurosystem, as an issuer of CeBM, would set up its own DLT infrastructure – the Eurosystem DLT – where TARGET participants could use Euro wCBDC for settlement. In this model, the Eurosystem DLT can be connected to other market DLTs owned by market participants or central banks within or outside the EU, on which both cash and securities could circulate to perform both DvPs or PVPs in domestic or cross-border contexts. The interoperability of the Eurosystem DLT with other DLTs allows for the implementation of atomic DvP, where the securities transaction on a market DLT automatically initiates a payment in euro wCBDC on the Eurosystem DLT through smart contracts. A similar mechanism applies in the case of PVP whereby the foreign wCBDC transaction on the DLT of a foreign central bank automatically initiates a payment in euro wCBDC on the Eurosystem DLT through smart contracts.

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7 Persistent industry challenges

It is important to note that these three models could exist in parallel, and ongoing experimentation by Eurozone participants will continue to derive insights related to the performance of each. No conclusions can be made regarding which is most ideal as of the time of writing.



Interoperating with new and existing systems

The emergence of tokenized securities and assets strengthens the case for delivering CeBM to private platforms like market DLTs. Industry efforts aim to realize the potential of DLT by creating integration points to bridge market DLT platforms with central bank payment systems. Provided that each of the example in the previous sections are ongoing efforts and no conclusion has been made regarding interoperability with new and existing systems, this report proposes four areas where continued research is needed for wCBDC systems to address interoperability challenges:

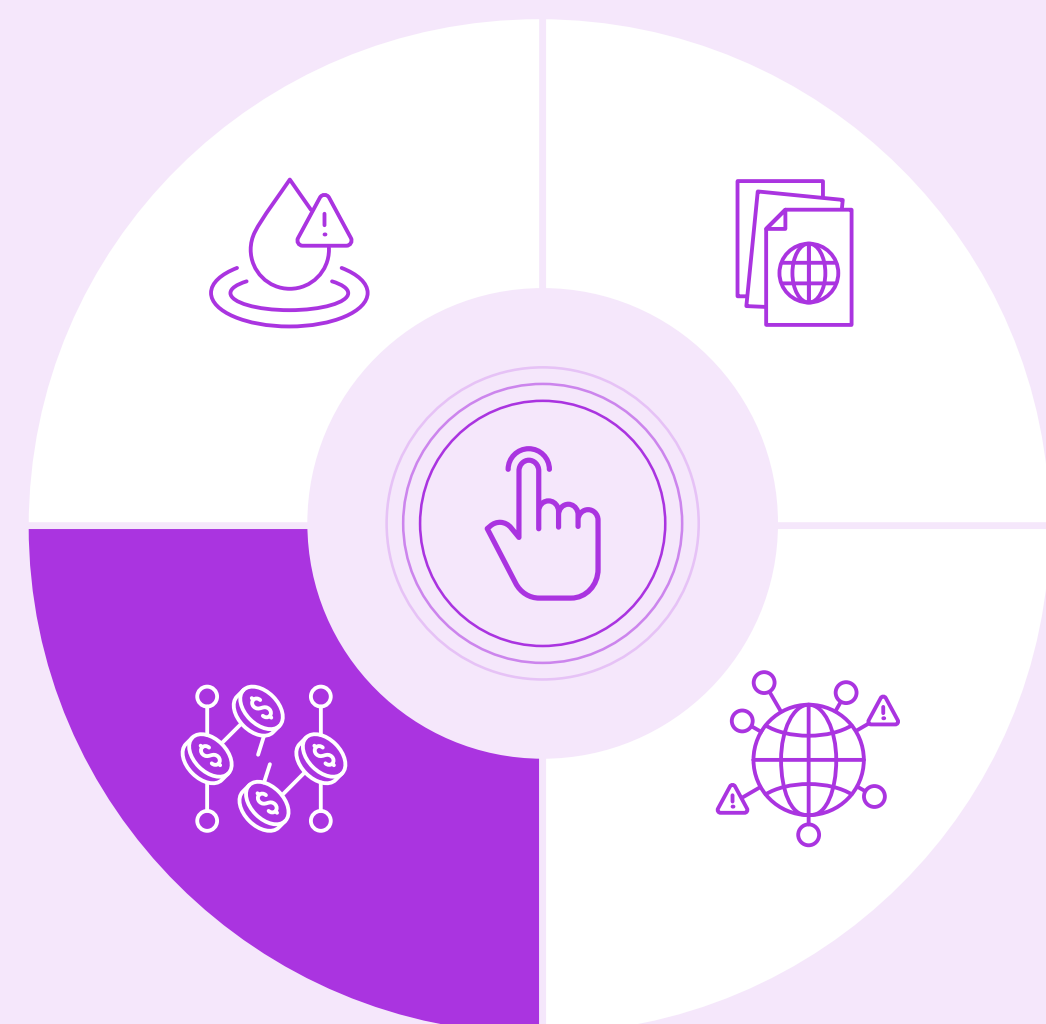
- Expand the number of initiatives exploring new technologies for delivering CeBM to new systems with broad private sector involvement, such as the ECB’s call for expression of interest.¹¹²
- Coordinate with private sector leaders to determine creative models for preventing liquidity fragmentation, such as the call to action promulgated by the DTCC, Clearstream and Euroclear.¹¹³
- Explore the ability of any new systems, like wCBDC, to integrate with core banking systems, including treasury, cash management and DT platforms.
- Catalyse industry discussions on advancing the setting of standards for digital assets, such as with the International Organization for Standardization (ISO).

Project mBridge, Helvetia and Jasper demonstrated the importance of integrating with conventional infrastructure. mBridge allows central and commercial banks to integrate their core systems and manage wCBDC via simple API connections. Project Meridian used a prototype DLT to synchronize settlement in CeBM held in RTGS systems, achieving the automatic orchestration of the exchange of ownership of funds and assets.¹¹⁴

Persistent industry challenge

Critical industry efforts are making headways in creating standards for the payment rails of tomorrow, and any FMI modernization including CBDC systems will likely be limited until there are widely accepted models for integrating CBDC networks, DLT systems and conventional systems.

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8

Trade-offs and considerations



Introducing a wCBDC underscores several important trade-offs and considerations that should be closely examined by policy-makers.

Trade-offs

Bearer instrument vs sight deposit

A bearer instrument is a financial instrument that grants ownership rights to whoever possesses the instrument, which acts as an obligation to pay its holder a fixed amount of another asset upon demand. Bearer instruments are intended to preserve anonymity, much like bearer bonds, which are now largely banned as their ability to be traded freely without traceability was exploited for evading taxes and other crimes. The Bank of Indonesia (BOI) described two key traits of a bearer instrument CBDC:¹¹⁵

- 1 No recorded ownership (no registration)
- 2 Possession entitles the holder to ownership

There is an ongoing debate over whether a wCBDC should be classified as a bearer instrument or follow conventional models, like a sight deposit. A sight deposit refers to funds held in an account at a financial institution, in this case at a central bank, that can be withdrawn by the account holder on demand or “at sight”. Notably, the SNB, as part of Project Helvetia, is exploring a tokenized wCBDC that acts as a sight deposit because this aligns with the relevant legal frameworks specific to Switzerland. While other models exist, these two are examined to distinguish a potential wCBDC bearer instrument from conventional models like a sight deposit.

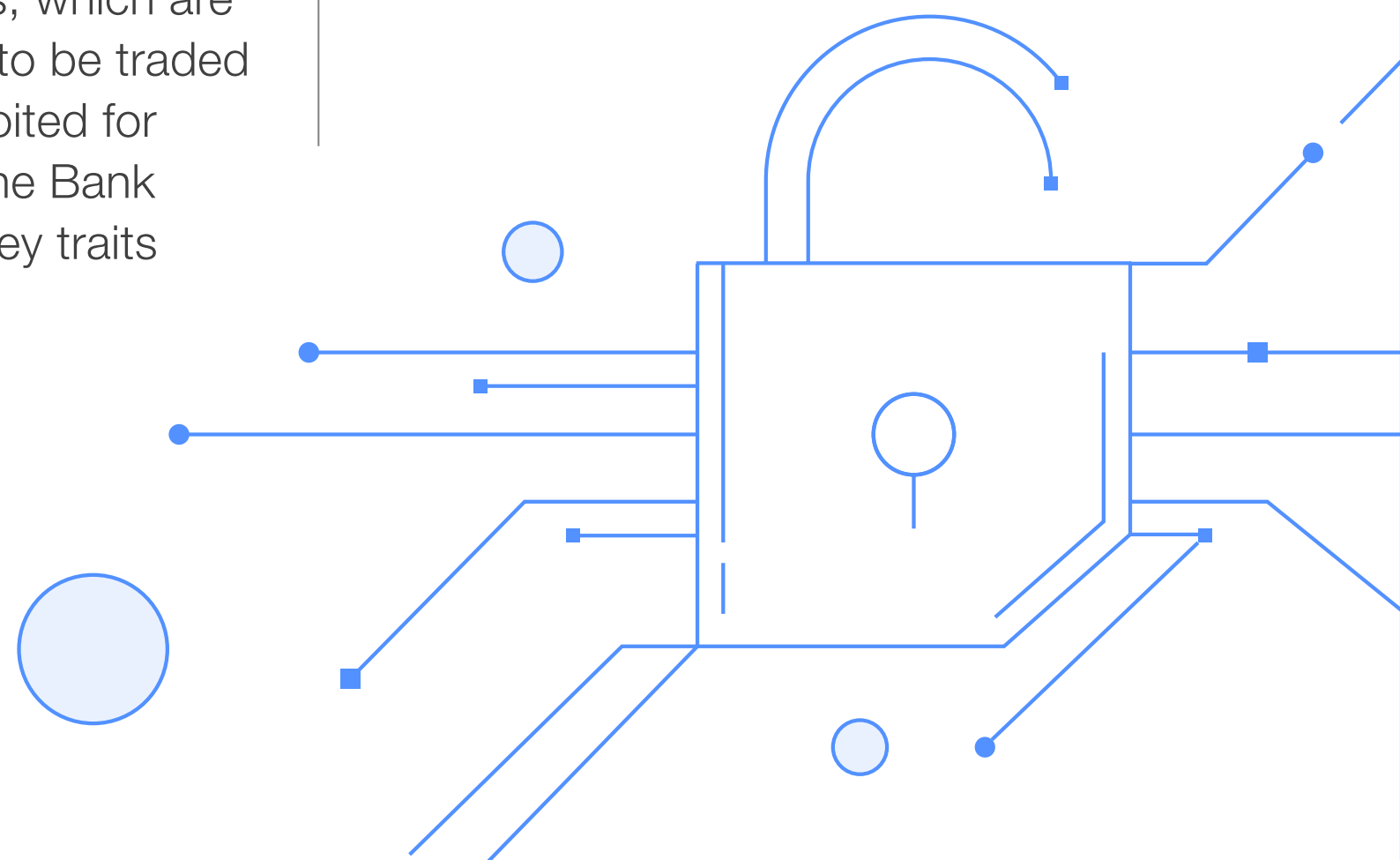




TABLE 4

Bearer instrument vs sight deposit

	 Bearer instrument	 Sight deposit
Definition	A financial instrument that grants ownership rights to whoever possesses the instrument.	Funds held in an account at a central bank that can be withdrawn by the account holder on demand or “at sight”
Advantages	<ul style="list-style-type: none"> – Provides a higher level of anonymity if authorized – Simplifies intermediary chains as no central intermediary may be necessary – Speeds up settlement times as transfers are instantaneous and final 	<ul style="list-style-type: none"> – Facilitates a traceable and transparent record of transactions – Strengthens the role of central bank(s) as settlement agent(s) – Allows for revocability of transactions in case of fraud or misdirection
Limitations	<ul style="list-style-type: none"> – Higher security risks as they are susceptible to theft¹¹⁶ – Difficulty tracing transactions to comply with KYC/AML/CFT rules 	<ul style="list-style-type: none"> – Dependence on centralized infrastructure or intermediaries – Privacy concerns regarding individual data or in cross-border scenarios

Bearer instruments rely on possession for ownership and support anonymity, which lends well to retail CBDC, where cash-like characteristics are paramount. A sight deposit is tied to specific accounts and identities, offering more traceability and security. Some experts also suggest that a tokenized CBDC cannot act as a bearer instrument in the private property law sense if a permissionless data record system is enabled.¹¹⁷ Tokenization can support both a bearer instrument and a sight deposit. For example, Franklin Templeton’s MMF Benji token is not a bearer instrument.

Other experts suggest that a wCBDC should be a bearer instrument because it provides a provably unique asset and provides unambiguous ownership. Accenture proposed that a tokenized CBDC generally has properties akin to a digital bearer instrument.¹¹⁸ However, ultimately, the decision to designate a wCBDC as a bearer instrument or a conventional construct, like a sight deposit, is a legal choice that policy-makers must carefully deliberate and will likely vary depending on whether it is a retail or wholesale application.

Data privacy vs regulatory compliance

Another trade-off relates to preserving privacy and enforcing relevant compliance measures. As observed in high-risk regions, there is a growing concern about the risk of facilitating cross-border payments as the cost to comply with KYC/AML/CFT measures continues to grow. In parallel, there are demands for increased consumer privacy and institutions to reduce the amount of data collected and transmitted, which results in a balance that policy-makers must strike.

Liquidity-efficiency vs speed

There is a trade-off between preventing liquidity fragmentation and the speed of transactions. The decision to prioritize either depends on the transaction context – or trading scenario – where customer preferences determine the best choice. As observed in the assessment of instant settlement, there may not always be a benefit to prioritizing speed, as liquidity demands will likely increase to settle transactions faster. For example, in retail, speed can be more important than liquidity efficiency as retail users rarely have multiple parallel transactions under way and would not benefit from a lapse in time to net or offset. Often, FIs prioritize liquidity efficiency over speed in most wholesale financial use cases because of the large average

transaction size and a beneficial lapse from trade to settlement to offset/net obligations.

Considerations

Accessibility

A prevailing presumption is that wCBDC could allow central banks to widen access to CeBM to FMs and other institutions, like non-bank and foreign participants, given new permissions techniques. While expanding or restricting access is a policy choice, expansion could promote financial inclusion. There are three basic levels of CeBM access: 1) access to reserves, 2) access to reserves with monetary facilities (lending capacity), and 3) access to the system or network as a service provider, such as how the role of access enablers are envisioned in [Project Sela](#). Also, accessibility relates to the duration of holding wCBDC and a choice between intraday and overnight CBDC. Greater access is achievable through conventional systems. Still, the unique characteristics of wCBDC systems could allow for more flexibility.

Distributed ledger technology

Using DLT is a technology choice that policy-makers and private sector parties should make while considering these benefits specific to their jurisdiction’s policies. DLT can offer three perceived benefits:

- **Shared state governance.** DLT provides multiple models for controlling token issuance, access and redemption through permissions that allow authorities to designate certain privileges to known node operators, who can be monitored and audited.¹¹⁹ Further, DLT facilitates a shared state across multiple organizations where multiple organizations retain autonomy and ownership over the underlying infrastructure. In cross-border scenarios with more than one authority (e.g. two or more central banks), DLT could help to facilitate consensus across jurisdictions.
- **Embedded business logic.** DLT could enhance straight-through trade and post-trade processing for DvP and PVP and contribute to financial stability¹²⁰ by natively representing tokens across multiple organizations and embedding business logic into the tokens. Programmable payments could enhance proof of transaction across authorized parties.

8 Trade-offs and considerations

– **Redundant and secure operations.** DLT facilitates data replication across trusted and authorized nodes run by operators (e.g. commercial banks). This could strengthen wCBDC system resiliency by maintaining network data, such as account balances, in multiple locations if a single node is compromised. This redundancy can be especially beneficial for cross-border scenarios where data security rules differ across jurisdictions.

DLT could also introduce additional responsibilities, such as node operations and cyber-resilience needs, to safeguard the network from threat vectors like malicious nodes, as there is no widely accepted cybersecurity framework.¹²¹ This report contends that these attributes and benefits could lend themselves well to cross-border scenarios involving multiple authorities.

Legal settlement

Legal settlement is distinct from the technical evidence of settlement. The latter is typically recorded as ledger entries in financial systems. Legal settlement occurs when agreed-upon obligations are met, often involving contractual commitments. It is crucial to align

the technical aspects of new systems with legal requirements. While smart contracts are discussed as providing legally enforceable settlements, Moody's highlights that they do not fully replace traditional legal contracts yet.¹²² To address this, industry leaders are developing rulebooks that codify procedures to achieve mutual agreement in new systems.

Legislative factors

Currently, 61% of central banks face legal restrictions on currency issuance for retail, primarily confined to banknotes and coins. Wholesale is more straightforward, with 85% of central banks in jurisdictions having laws that support wCBDC issuance to users like banks.¹²³ wCBDC may benefit from precedence whereby the public sector operates public payment systems like FPS and RTGS systems. Changes are under way; a survey of 81 central banks showed that 10% are revising legislation to support CBDCs.¹²⁴

Programmability

This report refers to programmable payments rather than what is defined as programmable money. The ECB has rejected programmable money because it possibly undermines sovereign and publicly available currency.¹²⁵ Programmable payments is a separate but adjacent concept where automatic payments

are made when certain conditions are met. This is not to be conflated with purpose-bound money,¹²⁶ an idea introduced by the Monetary Authority of Singapore. It is a concept that enables money to be directed towards a specific purpose without requiring the money to be programmed.

61%

of central banks face legal restrictions on currency issuance for retail, primarily limited to banknotes and coins.

85%

of central banks in jurisdictions have laws that support wCBDC issuance to entities like banks.

10%

of central banks are revising legislation to support CBDCs.

9

RTGS systems


RTGS systems are being modernized to meet evolving needs and will continue playing a critical role in financial markets.

RTGS systems offer many advantages, such as intraday final settlement and limiting participant risk exposure.¹²⁷ As of 2020, 120 jurisdictions indicated they use at least one RTGS system. RTGS adoption is highest in high-income countries (over 90%).¹²⁸ Some regions, such as the West Africa Monetary Union and the Eurozone, share one system, while most RTGS systems are limited to a country (e.g. Fedwire in the US).

According to the FSB, at least five jurisdictions operate at or near 24/7 operations: India, Mexico, South Africa, Switzerland and Oman.¹²⁹ However, more jurisdictions are enhancing the availability of their RTGS systems. As the primary liquidity storage mechanism in their respective jurisdictions, RTGS systems will continue to play a critical role in financial markets.

Many central banks are modernizing RTGS systems to better serve participants in the following ways:

 Messaging format standardization

 Processing speed enhancement

 Widened and easier accessibility

 24/7 operational capacity







 Interoperability with new systems

 Liquidity management optimization

 Cybersecurity resilience

TABLE 5

RTGS system modernization programmes

Summary of modernization	
<p>United Kingdom</p> 	<p>The BOE is overhauling its RTGS system for a June 2024 launch involving a new core settlement engine. The initiative aims to boost resilience, expand access and enhance interoperability with ISO 20022 standards. The BOE is also exploring the next stage of RTGS enhancements after 2024, including the use of synchronization operators to enable conditional settlement between RTGS and external asset ledgers, and has worked with the BISIH to provide a proof-of-concept through Project Meridian.^{130,131,132}</p>
<p>Eurozone</p> 	<p>In March 2023, the Eurosystem launched an upgraded T2 wholesale payment system, integrating RTGS and central liquidity management tools, processing around 400,000 transactions on the first day.¹³³</p>
<p>Oman</p> 	<p>The Central Bank of Oman upgraded its RTGS system in 2020, enabling 24/7 operations. Integrated with cross-border platforms like AFAQ and Buna, Oman’s financial ecosystem efficiency is enhanced.¹³⁴</p>
<p>Philippines</p> 	<p>In July 2021, the Bangko Sentral ng Pilipinas launched PhilPaSSPlus, an upgraded RTGS system, doubling capacity, expanding access channels and using transactional data for improved decision-making, aligning with digital transformation goals.¹³⁵</p>
<p>Buna Arab Region</p> 	<p>Buna, launched in 2020 by the Arab Monetary Fund, is a regional cross-border payment platform for Arab banks, promoting efficiency, transparency and financial development with six supported currencies.</p>
<p>United States</p> 	<p>Fedwire is the RTGS system for the US and is undergoing planned modernization to support compatibility with ISO 20022 standards beginning in 2025. In mid-2023, the Federal Reserve began rolling out FedNow, which is a retail and commercial-focused instant payment system.^{136,137}</p>

10

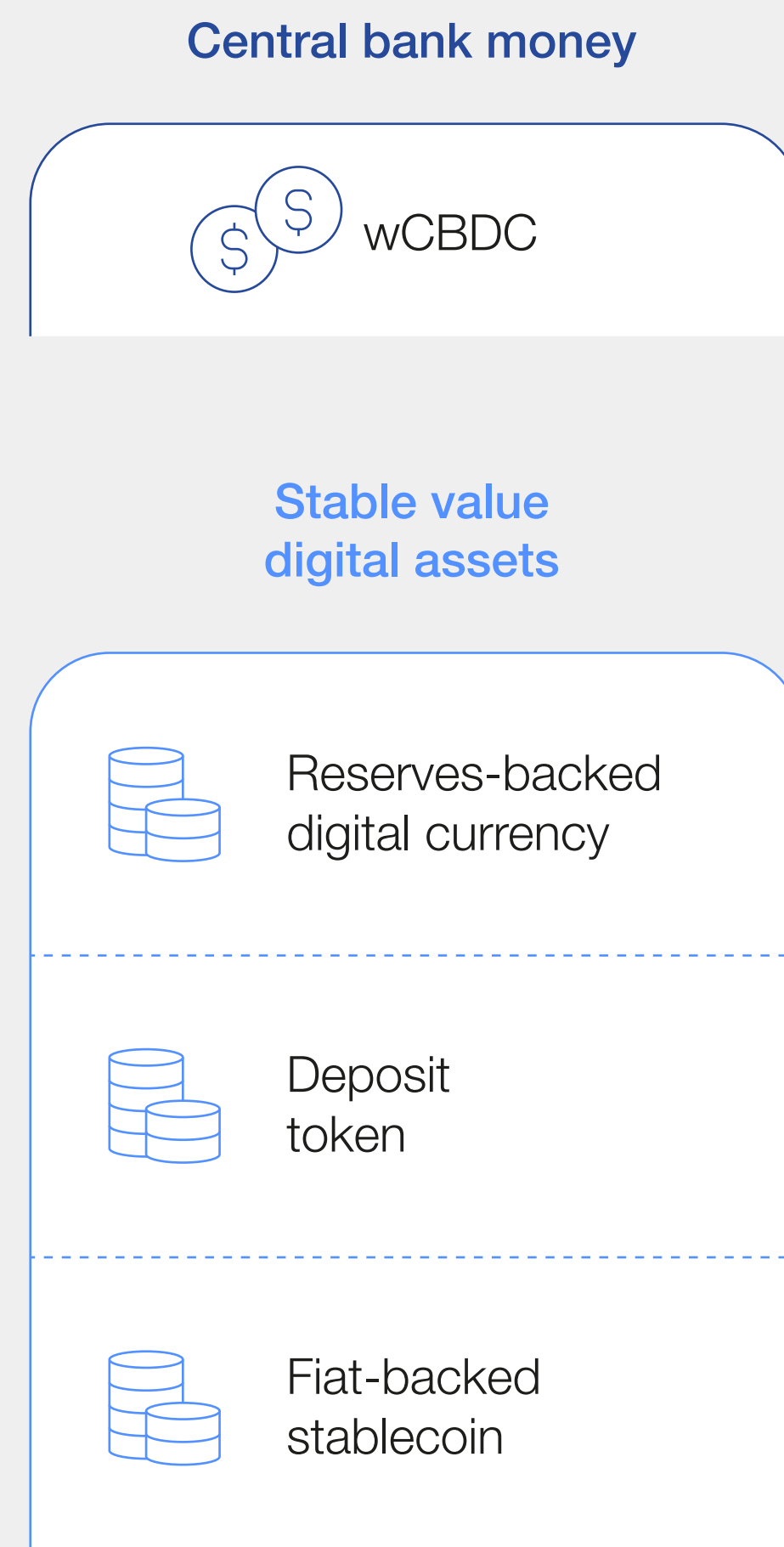
Alternative payment instruments



Reserves-backed digital currencies, deposit tokens and fiat-backed stablecoins are emerging as adjacent payment instruments alongside wCBDC.

It is necessary to classify the new payment instruments arising alongside wCBDC. “Stable value digital assets” is an umbrella term to categorize emerging payment instruments that seek to maintain stable value with fiat currency. While these may seem fungible in practice, they each carry unique characteristics.

FIGURE 20
Digital forms of money



Reserves-backed digital currency

RBDC, sometimes mistakenly called “synthetic CBDCs”, involves a third-party operator (a commercial bank or a non-bank FI) that operates a joint account held at a central bank that co-mingles funds, which are then tokenized for use by participants.¹³⁸ The following characteristics distinguish RBDC from wCBDC:

- **Non-CeBM:** RBDC is not CeBM and thus carries risks, as users would not hold a claim against the central bank. RBDCs are a form of narrow bank money that lacks key features of CeBM, such as public policy orientation and liquidity. For further information on the BIS’ standpoint on RBDCs, see the BIS’s [Central bank digital currencies: foundational principles and core features](#) report.
- **Reserve access requirement:** In general, operators require direct access to CeBM to back RBDCs on a one-to-one basis. Theoretically, the reserves could also be held by a third party with access to reserve accounts at the central bank. Access to a central bank account is typically limited to certain FIs. Thus, the RBDC operator would need access to a central bank joint account to issue RBDC if the settlement account fully balances the RBDCs.

There is precedence for expanded access as non-bank FIs have been granted access to central bank reserves in jurisdictions like the UK. For example, Wise was granted access to CHAPS in 2018.¹³⁹

- **Third-party operator:** A regulated third-party operator, typically equipped with a rulebook and risk management controls, operates the platform on behalf of the participants.¹⁴⁰
- **Joint account model:** A core enabler is a joint account at a central bank to segregate customer funds so there is a clear claim on each customer’s proportion of the funds. This joint account is a pre-funded account that co-mingles all participants’ funds and usually has a trust ownership structure that includes all participants. This name of the account structure varies by jurisdiction (e.g. in the UK, it is called an omnibus account, in the US, it is a joint account, and in the Eurozone, it is called a technical account).
- **Settlement risk:** RBDCs are not a direct claim on central banks, and therefore, participants would be using private money to settle in a narrow-banking-like setting, thus requiring legal clarity.



- **Bankruptcy-remote:** RBDC is protected against the operator’s and participants’ default. With the joint account model, the reserves account is fully funded, and each participant only has a claim over their share, as evidenced by the ledger balance.
 - **In case of a single participant’s bankruptcy,** a rulebook tailored to the jurisdiction’s regulations dictates the wind-down procedures to safeguard other customer funds (e.g. removing bankrupt participants from the allow-list for making payments).
 - **In case of operator default,** the private keys that designate operatorship can be transferred to an authorized party to wind down the assets or continue operations.
- **Counterparty risk:** As a third party operates the RBDC platform, counterparty risk remains unless there is an arrangement where the reserve assets are held in a bankruptcy-remote way.¹⁴¹
- **Likely interest-bearing:** Because RBDC uses a joint account at the central bank, the balances will accrue interest and be owned by participants.

In December 2023, Finality announced that in collaboration with Lloyds Banking Group,

Banco Santander, and UBS, the inaugural set of live payments for the first phase of its RBDC solution were transacted using an omnibus account at the BOE.¹⁴² In 2021, the BOE announced that they would permit an omnibus account structure to access central bank reserves, a requirement for this payment instrument (segregation of customer funds).¹⁴³ This structure will allow Finality “to pool funds within a single account ... to utilize those funds to settle payment-related transactions”, thus enabling 24/7 access. Finality does not issue RBDC but operates the platform. Beyond the BOE, other central banks must weigh the costs and benefits of allowing a joint account structure.¹⁴⁴

Deposit tokens

DTs are digital money; a licensed depository institution issues tokens based on bank deposits. Importantly, DTs differ from tokenized deposits because:

- DTs are native tokens that are deposits and claims on the issuing banks. In a recent speech at the Office of the Comptroller of the Currency symposium on the tokenization of real-world assets and liabilities in February 2024, Hyun Shin explained that deposit tokens are akin to bank-issued stablecoins.^{145,146}

10 Alternative payment instruments systems

- Tokenized deposits are tokenized forms of traditional deposits backed by loans and available natively (i.e. on-chain).¹⁴⁷

In 2022, the Federal Reserve Bank of New York noted that DTs are a “fruitful avenue to pursue” for a few reasons: they avoid locking up liquidity unnecessarily because of their fractionally backed nature, the payment rails exist today to support customer adoption, and DTs would presumably be insured under deposit insurance regimes.¹⁴⁸ The Swiss Banking Association proposed three models for DTs and analysed each, as seen in Figure 21.

A standardized token is not ideal because it requires a currency-standard set of criteria and requirements for any commercial bank to issue, raising questions about the backing model and the need to segregate reserves. The coloured token model raised economic concerns because of the potential for a bank run or liquidity event where token holders flock to a bank with a better credit rating. A joint token model allows a jointly-owned entity of two or more banks to issue a token. According to the analysis, this is the most promising because it offers choice in the backing model, offers lower costs

related to settlement, can accrue interest and makes segregating reserves easier than the segregated variant.¹⁴⁹ DTs can provide many options to drive mutual acceptance among banks.

JP Morgan and Oliver Wyman outlined three deployment models for DTs.¹⁵⁰ The primary consideration for the deployment model of choice is the use cases and customers the issuing entity seeks to engage. In a single bank ledger model, the network effects would be limited as the users are solely the bank’s customers. In a shared ledger, the users may expand to include other banks and their customers. In a universal ledger concept, there would be global access.



TABLE 6

Deposit token deployment models

	Single bank ledger	Shared ledger	Universal ledger
Description	Intra-bank value transfer	Inter-bank settlement and clearing	Connected regional clearing networks creating global connectivity
Primary users	Bank clients	Commercial banks and corporates	Global with possible restrictions imposed by the issuer
Examples	JPM Coin System	Partior	JPM SGD deposit token ¹

Note: 1. SGD deposit tokens issued by JPMorgan in connection with MAS Project Guardian pilot transaction. SGD deposit tokens are not a generally available live product offering.

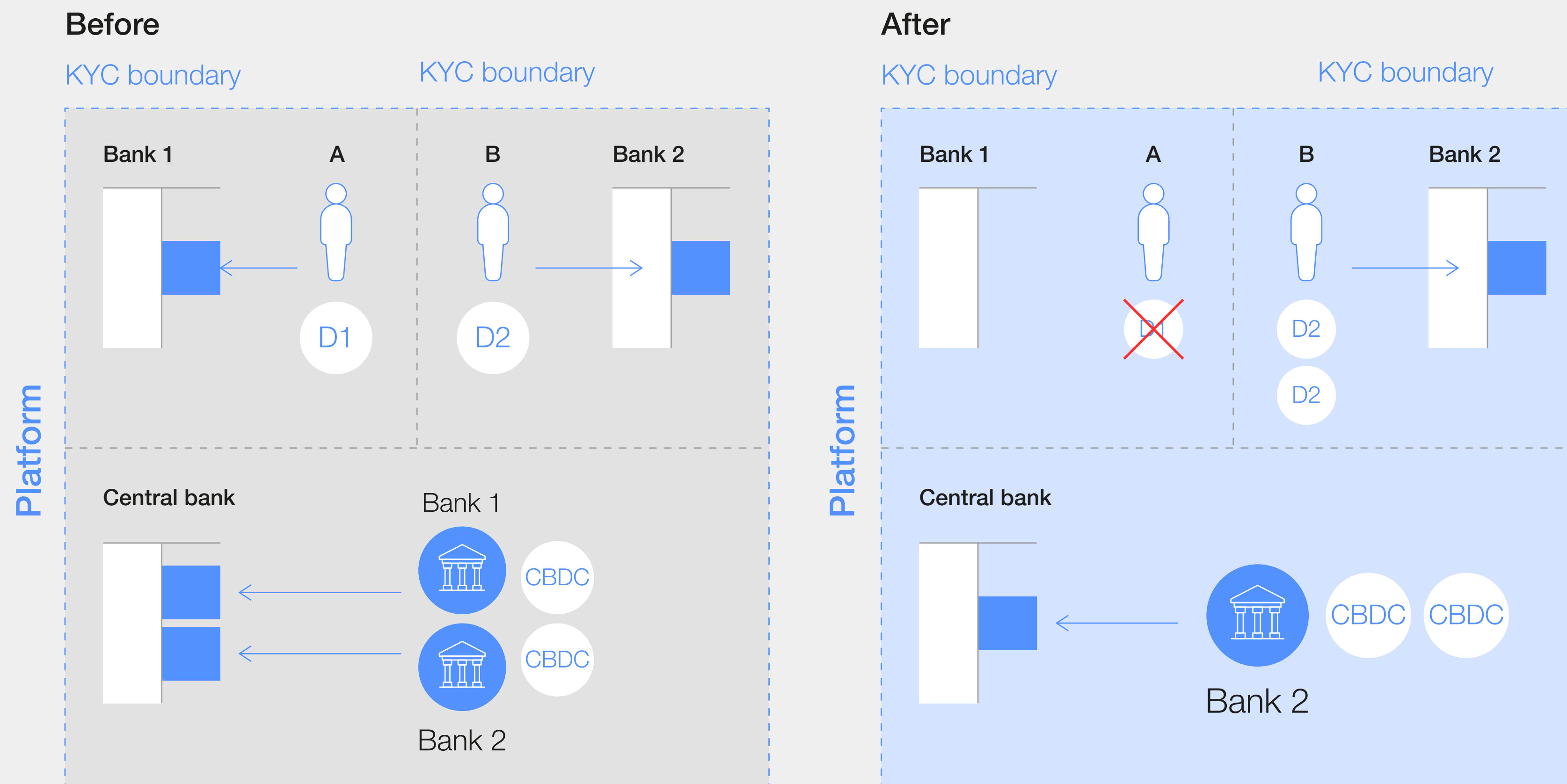
Source: JP Morgan and Oliver Wyman, *Deposit Tokens: A foundation for stable digital money*, 2022.

DTs maintain the current banking system by tokenizing conventional customer deposits (M1) that rely on M0 money settlement (RTGS balances or wCBDC) for interbank payments. This fundamental reliance on M0 money facilitates simpler fungibility between DTs and preserves the singleness of money.¹⁵¹ According to the BIS, such tokens are not digital bearer instruments as the circulation payments of DTs mimic the movement of money in today's banking system or within the issuing bank's KYC boundary.¹⁵²

While DTs reflect a compliant payment instrument for commercial and retail applications, including business-to-business (B2B), their wholesale applicability is limited. If linked with RTGS systems or wCBDC, DTs could also be used for settlement between customers of different banks (inter-bank), as an M0 settlement infrastructure exists. Primarily, these limitations include the counterparty or credit risk of the issuing institution and its reliance on M0 for settlement finality, which creates redundancies in the context of interbank payments. However, as the Regulated Liability Network demonstrated, this tokenized private money could introduce efficiencies when deploying alongside wCBDC. A multi-token future for multiple levels – wholesale and commercial/retail – could be enabled.

FIGURE 23

KYC boundary for deposit tokens



Source: Garratt, Rodney and Hyun Song Shin, *Stablecoins versus tokenised deposits: implications for the singleness of money*, BIS, 2023.

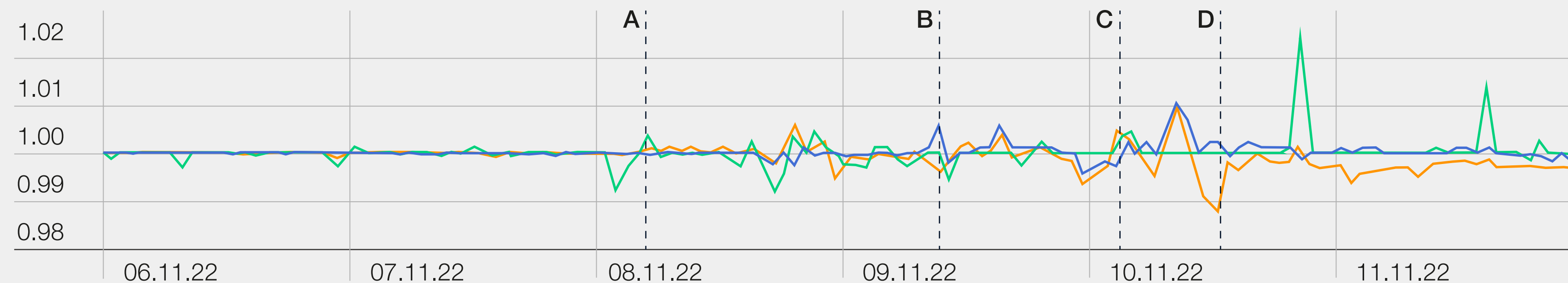
Fiat-backed stablecoins

FBSs are digital tokens backed by liquid assets, such as cash and cash equivalents. During events like the FTX and Silicon Valley Bank collapse, these stablecoins experienced price fluctuations or arbitrage gaps, as they were traded as transferable liabilities by multiple private issuers. It is worth noting that during the 2008 global financial crisis, many highly regulated and supervised MMFs similarly deviated from par (\$1). The BIS noted that this trading method categorizes stablecoins as financial assets with market prices, leading to exchange rate fluctuations, which could impact the singleness of money.¹⁵³

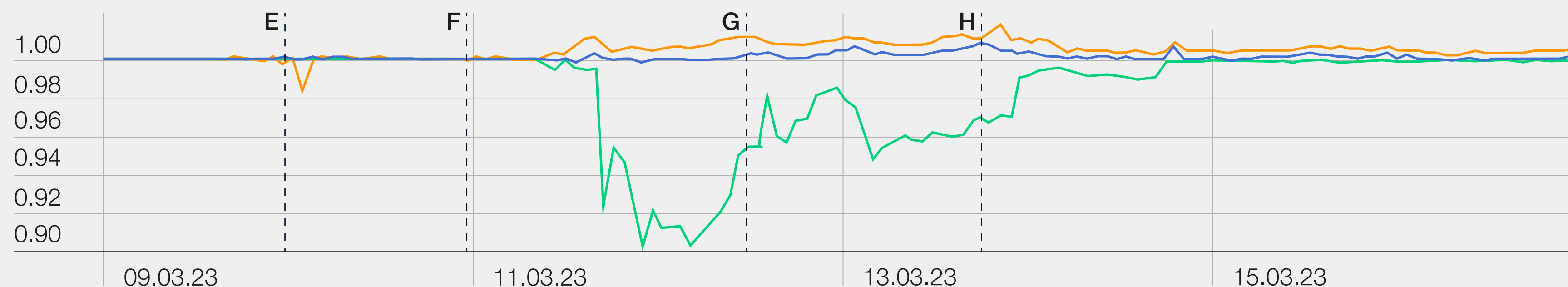
FIGURE 24

FTX and Silicon Valley Bank collapses coincide with volatility in stablecoin prices

FTX collapse



Silicon Valley Bank collapse



● BUSD ● USDC ● USDT

A: FTX strikes an acquisition deal with Binance for its non-US business. **B:** Binance backs out of the deal. **C:** FTX Chief Executive Officer Sam Bankman-Fried apologizes on Twitter. **D:** Bahamas securities regulator freezes FTX assets. **E:** Silicon Valley Bank announces that it will raise additional capital by selling stock. **F:** SVB Financial seeks a buyer. A few hours later, a California regulator shuts Silicon Valley Bank and appoints the Federal Deposit Insurance Corporation (FDIC) as receiver to take control of its parent company. **G:** Employees of Silicon Valley Bank offered 45 days of employment at 1.5 times their salary by the FDIC. **H:** “Depositors will have access to all of their money starting Monday, March 13”, the US Treasury, Federal Reserve and FDIC say in a statement, adding that no losses associated with the resolution of Silicon Valley Bank will be borne by the taxpayer.

Source: Garratt, Rodney and Hyun Song Shin, *Stablecoins versus tokenised deposits: implications for the singleness of money*, BIS, 2023.

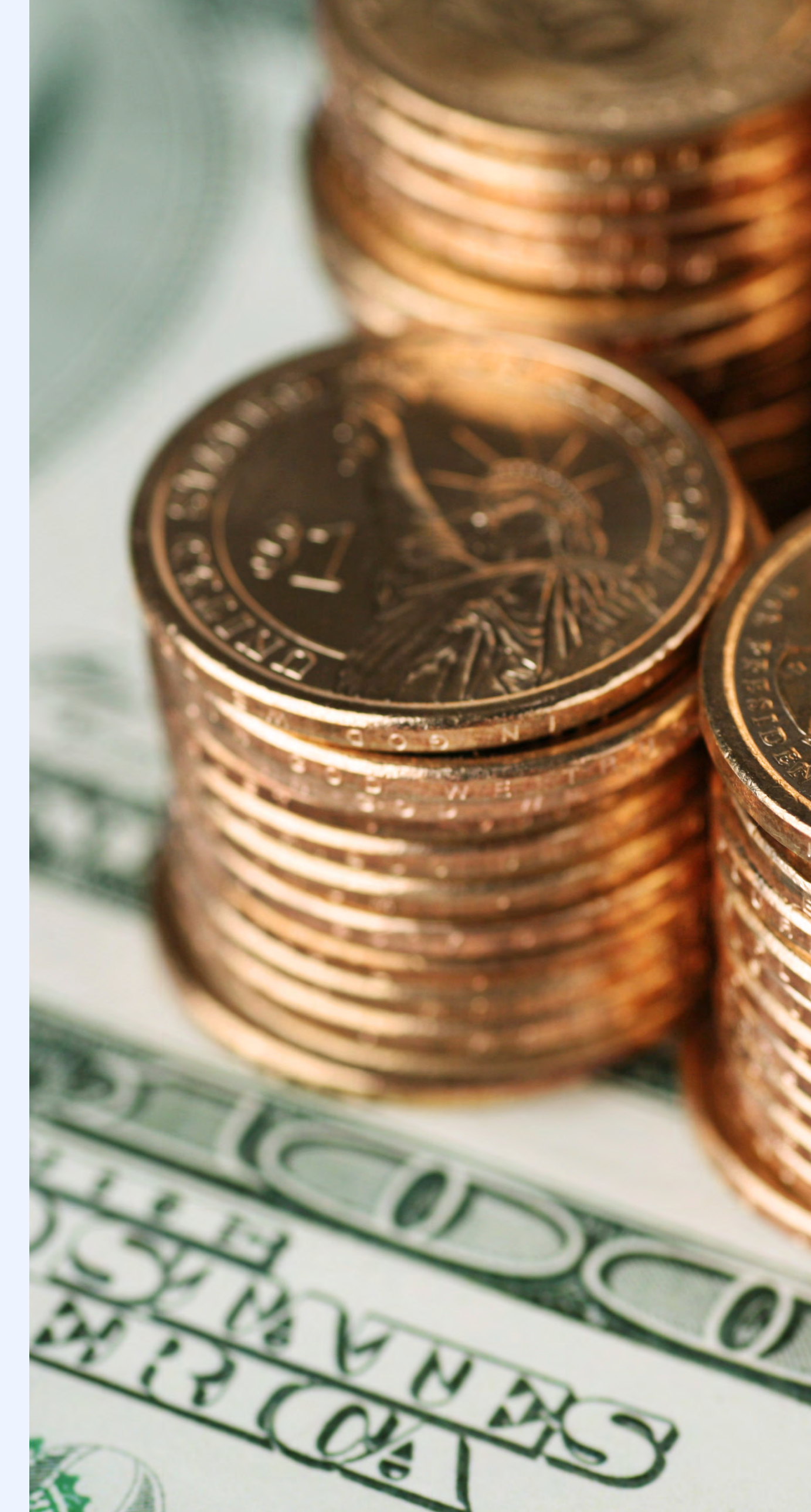
The challenge arises from dual trading on primary and secondary markets. Primary markets involve initial issuance and redemption with the issuer, while secondary markets include centralized and decentralized exchanges where stablecoins are traded for various assets. Table 7 exhibits deviations from par for FBSs across primary and secondary markets. Deviations from parity can occur in secondary markets when trading stablecoins for fiat currency, other stablecoins or crypto assets. However, deviations from par in primary markets do not occur.

TABLE 7

Price distribution of US dollar coin (USDC) in primary and secondary markets

Market	Average daily volume (\$ millions)	Daily volume weighted average price of USDC in USD					
		Min	1%	Mean	50%	99%	Max
Primary	\$645.5	\$1	\$1	\$1	\$1	\$1	\$1
Secondary	\$32.5	\$0.9452	\$0.9991	\$0.9999	\$1.0000	\$1.0007	\$1.0109
Combined	\$678.0	\$0.9841	\$0.9999	\$1.0000	\$1.0000	\$1.0000	\$1.0004
Combined (weekdays only)		\$0.9988	\$1.0000	\$1.0000	\$1.0000	\$1.0000	\$1.0002

Source: Liao, Gordon, "Payment versus trading stablecoins", *Centre for Economic Policy Research*, 25 March 2023, <https://cepr.org/voxeu/columns/payment-versus-trading-stablecoins>.

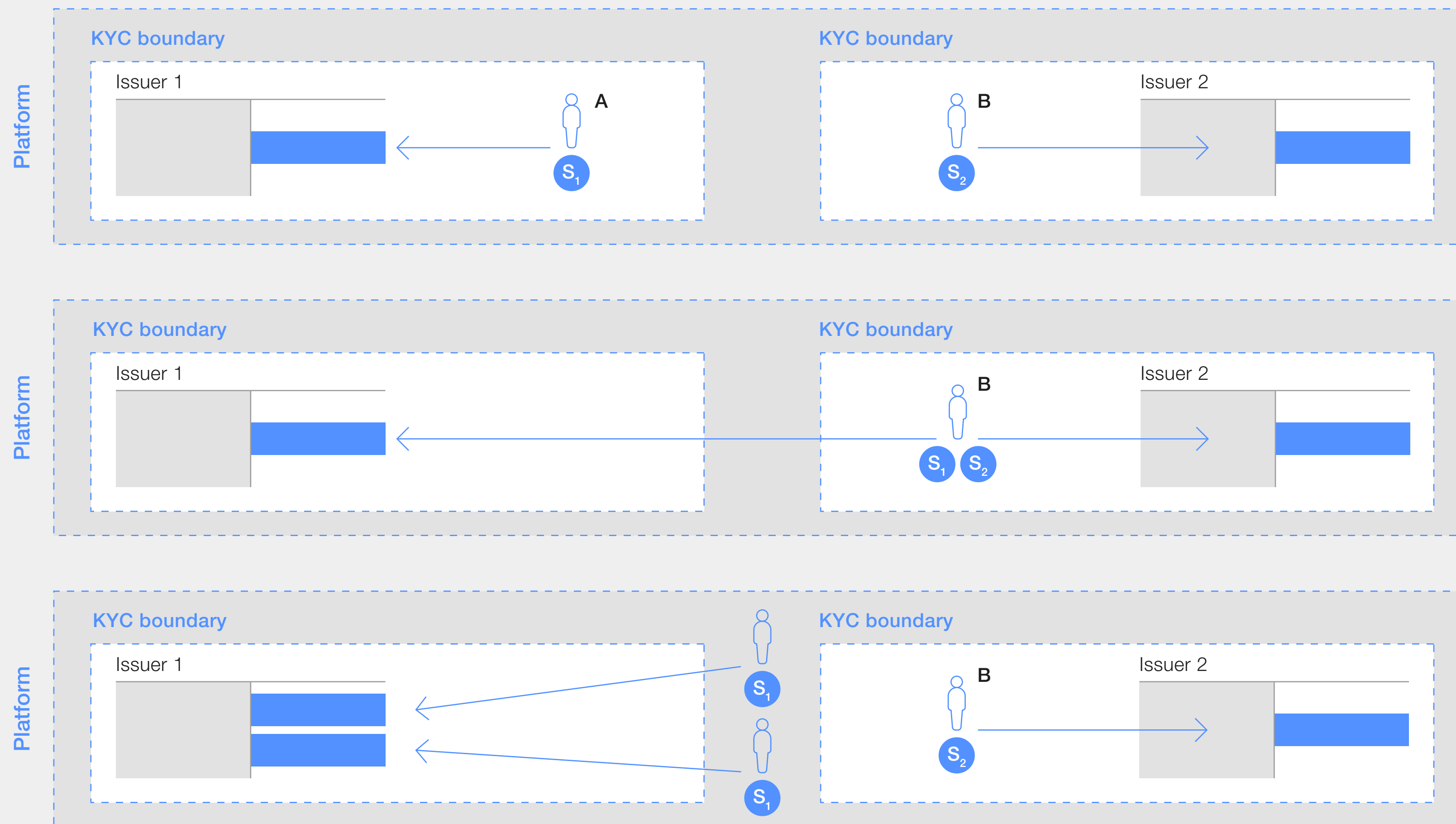


Primary markets experience no price disruption. Issuers maintain a collateralized model 2-7 times more liquid than most global systemically important banks (GSIB). Although the degree of collateralization may outsize GSIB balance sheets, a challenge that stablecoin issuers encounter is the ability to prove performance during stress testing – for example, handling redemptions at scale without deviating from par. Issuers are also competing over which stablecoin has more liquidity in the backing model. As digital bearer instruments, stablecoins pose compliance challenges because verification only happens during issuance and redemption (see Figure 25). However, many transactions have at least one identifiable wallet because of a direct linkage to a centralized exchange.

FBSs carry characteristics lending themselves well to commercial, retail, and B2B and B2C use cases rather than wholesale use cases wherein CeBM is preferred.

FIGURE 25

Digital bearer instrument model of private tokenized money (i.e. stablecoins)



Source: Garratt, Rodney and Hyun Song Shin, *Stablecoins versus tokenised deposits: implications for the singleness of money*, BIS, 2023.

11

Multi-token and multi-system future

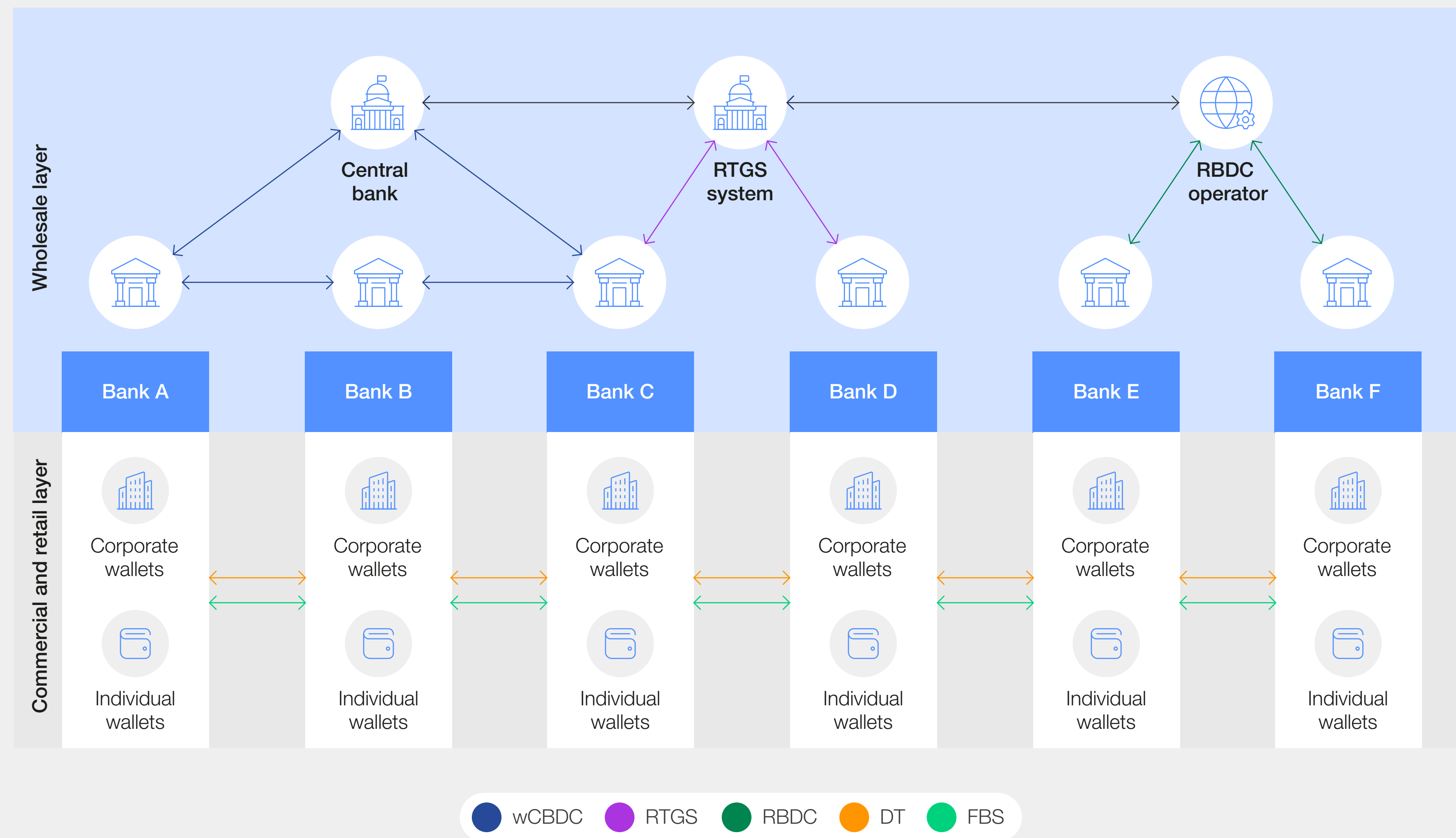
wCBDC systems can act as a M0 settlement layer and can co-exist with parallel payment instruments.

The foundation for a digital payments future

This report finds that the digitization of certain assets and cash is growing, driven by efficiencies sought by institutions and their customers. The development of tokenized monies like DTs and FBSs may realize value by delivering speed and convenience for users. Novel payment instruments like RBDC platforms are also changing institutional payments. However, there is a need for an M0 payment instrument that is compatible and interoperable with these new systems. wCBDC systems deployed by multiple jurisdictions could act as virtually credit risk-free payment instruments to facilitate continued innovations in emerging payment instruments. The confluence of these various instruments across wholesale, commercial and retail layers will result in diverse options for customers and citizens globally.

FIGURE 26

Simplified diagram of a multi-token and multi-system future



Conclusion

Public and private sector leaders should evaluate wCBDC specific to their jurisdictional context and decide whether the effort to implement such a system is warranted.

The immediate areas where wCBDC can derive differentiated value are realizing a global settlement window to harmonize disparate settlement times, mutualizing data sharing to mitigate operational risk and settlement failures, expanding PvP arrangements to support a greater diversity of currencies and regions, and delivering CeBM to settle tokenized securities transactions. This unlocks opportunities to re-imagine models for conducting cross-border, multi-party and multi-asset use cases, like FX or securities transactions.

To achieve these ambitions, it is necessary to co-exist with legacy infrastructure, including today's primary liquidity storage mechanisms (RTGS systems), which are undergoing important modernization efforts themselves. Likewise, wCBDC will likely coexist in parallel with digital payment instruments like RBDCs, DTs and FBS.

Introducing a wCBDC requires examining its careful trade-offs and considerations, as these choices could impact the ability to capture and realize value for stakeholders. Competing views remain for wCBDC's designation as a bearer instrument or a sight deposit, privacy and regulatory compliance must still be balanced to deliver equitable outcomes, and stakeholders will continue to demand tailored solutions that offer variability for liquidity efficiency across trading scenarios.

Still, there are several areas where persistent challenges will require deep private-public sector collaboration and experimentation to overcome. These include optimizing liquidity management, ensuring compliance-by-design to automate supervisory functions, determining who can access CeBM and exploring how new participants could introduce efficiencies, and interoperating with new and existing systems.

Next steps

Policy-makers, FMIs and private-sector leaders would benefit from tailoring the insights in this report to their jurisdictional and institutional contexts. This report offers key findings to facilitate further exploration of wCBDC and hopes to serve as a foundational step towards a more efficient, responsible and secure future for financial markets.



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