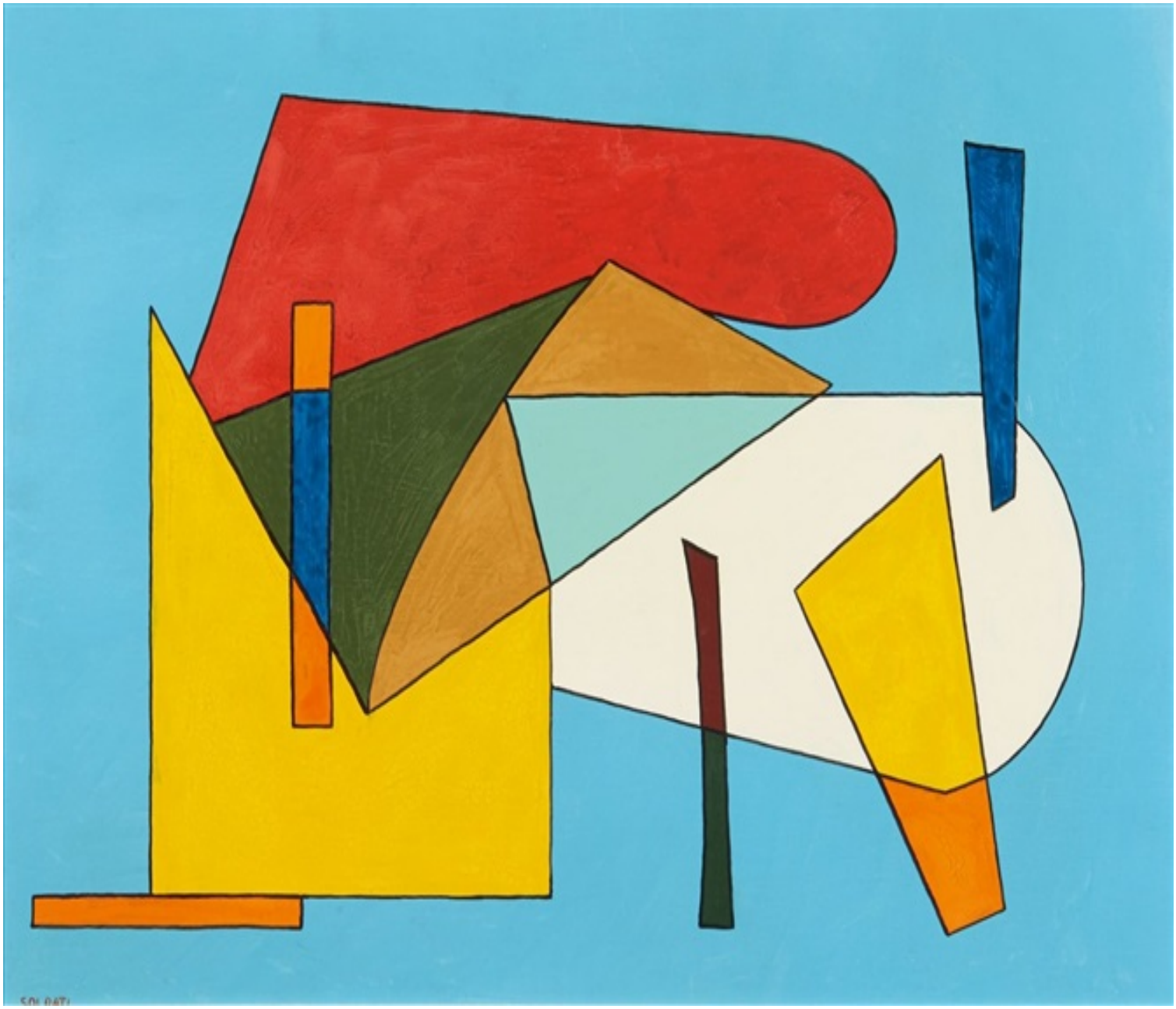
Issue N. 28 - 2025

ARGO

New Frontiers in Practical Risk Management



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Articles submission guidelines
Argo welcomes the submission of articles on topical subjects related to the risk management. The articles can be indicatively, but not exhaustively, related to models and methodologies for market, credit, liquidity risk management, valuation of derivatives, asset management, trading strategies, statistical analysis of market data and technology in the financial industry. All articles should contain references to previous literature. The primary criteria for publishing a paper are its quality and importance to the field of finance, without undue regard to its technical difficulty. Argo is a single blind refereed magazine: articles are sent with author details to the Scientific Committee for peer review. The first editorial decision is rendered at the latest within 60 days after receipt of the submission. The author(s) may be requested to revise the article. The editors decide to reject or accept the submitted article. Submissions should be sent to the technical team (**info@iasonltd.eu**). LaTeX or Word are the preferred format, but PDFs are accepted if submitted with LaTeX code or a Word file of the text. There is no maximum limit, but recommended length is about 4,000 words. If needed, for editing considerations, the technical team may ask the author(s) to cut the article.

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Dear Readers,

Welcome to the Spring 2025 edition of our Argo series.

This edition presents a diverse collection of articles that shed light on emerging challenges and opportunities within the financial sector. These contributions delve into the evolving intersections of technology, financial innovation, and sustainable governance—three pillars redefining global economic systems.

*We begin with "**Atomic Settlement: Enhancing Market Efficiency and Reducing Risk Through Settlement Cycle Compression**" by C. Papetti and V. Ciminelli. This insightful contribution explores the crucial role of efficient post-trade settlement processes in fostering resilient financial markets. Highlighting recent developments in the US and Canada with the transition to a T+1 settlement cycle, the article examines the potential benefits of adopting a simultaneous settlement framework powered by Distributed Ledger Technologies (DLTs) and smart contracts. The authors provide a thorough analysis of how Atomic Settlement mechanisms could significantly reduce systemic risks, streamline operational processes, and enhance market efficiency across global financial ecosystems.*

*Continuing in the realm of technological innovation, "**CBDC for Financial Inclusion**", offers an in-depth analysis of one of the key challenges of our time: promoting financial inclusion through innovation. The article assesses the potential impact of Central Bank Digital Currencies (CBDCs) on bridging financial gaps, particularly in underserved regions. By providing a comprehensive overview of CBDC characteristics, current financial inclusion gaps, and potential applications, it highlights how thoughtful design choices—such as accessibility, offline capabilities, and low-cost infrastructure—could drive broader participation in the financial system. This analysis is particularly timely as central banks worldwide weigh the opportunities and risks of introducing digital currencies.*

*Our issue concludes with a timely and insightful contribution in the area of Environmental, Social, and Governance Risks, titled "**EBA Final Guidelines on the Management of ESG Risks**" by M. Carminati, A. Proietti, and T. Travenzoli. This article offers a thorough analysis of the European Banking Authority's latest guidelines, which set minimum standards for the identification, measurement, management, and monitoring of ESG risks within financial institutions. It reviews how these guidelines require the integration of ESG risks—such as climate change, biodiversity loss, and governance deficiencies—into business strategies, risk frameworks, and internal capital adequacy assessments. Emphasizing forward-looking*

assessment methodologies and the importance of robust data governance, the authors outline the regulatory timelines, key challenges around ESG data standardization, and the pivotal role of stress testing and transition plans in enhancing financial stability and fostering a sustainable economy.

We hope this edition inspires and informs you, providing valuable insights into the ever-evolving world of finance and technology. We encourage you to engage with these topics and share your perspectives.

Thank you for joining us on this journey of exploration and discovery. Wishing you an insightful and fulfilling read.

Antonio Castagna
Luca Olivo
Giulia Perfetti

Just in Time

iason Notes

AI: Regulation, Rise and Challenges

Starting from the first release of Chat GPT, the interest surrounding AI applications has spread across various industries thanks to the potential of these technologies to enhance productivity, increase efficiency, and drive economic growth.

While the AI market and applications have shown rapid growth that is expected to continue in the next years, concerns about its implications for i.e., human rights, financial stability, and data protection have grown in parallel.

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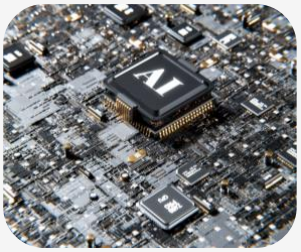
Date April 2025

AI Act: AI System Definition and Prohibited AI Practices



With the establishment of the AI Act, the European Union has set an important milestone as the first cross-jurisdictional regulatory framework focusing on AI. The AI Act entered into force in August 2024 with a regulatory roadmap that outlines the application of several rules, gradually coming into effect until August 2026

In February 2025, the rules on prohibited AI practices and AI literacy requirements will start to apply.

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Date March 2025

MiCAR Supervisory Activities as Part of EBA Priorities 2025-2027

The growing intersection of Financial Markets and Technology has increasingly captured investors' attention, particularly towards innovative financial products such as crypto-assets As crypto-assets become even more central, their high volatility and recent market turmoil, including several bankruptcies in recent years, have underscored the urgency for regulators to introduce comprehensive regulatory frameworks In this context, the European Union, as part of its strategy outlined in the 'Digital Finance Package,' has aimed to establish a harmonized crypto-asset regulatory framework across all member states The full enforcement of MiCAR on 31/12/2024 represented a significant milestone as the first cross-jurisdictional regulatory and supervisory framework for crypto-assets.

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Date March 2025

EU Platform on Sustainable Finance Report

The European regulatory framework has experienced significant updates in favor of sustainability, including key legislative acts such as the EU Taxonomy, the CSRD, and the CSDDD. Given the European economic context, primarily composed of SMEs, an excessive reporting burden has been identified for these businesses. In this context, the EU Platform on Sustainable Finance has prepared a report with several recommendations to simplify the current structure of the EU Taxonomy. The report suggests four main actions.

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Date February 2025

Economic Scenario Generators: RWESG and RNESG

The application of Economic Scenario Generators (ESGs) in life insurance is focused primarily on understanding how interest rate fluctuations interact with policyholder behavior, particularly as these changes impact both asset performance and liability payouts. In life insurance, financial results at both the product and enterprise levels are influenced by the returns on invested premiums and the timing and magnitude of liabilities, such as mortality, morbidity, policy surrenders (which are often tied to crediting strategies), and annuity payouts. Due to the intricate interplay of these factors over long time periods, an ESG is essential for gaining insights into a wide range of possible outcomes.

read more

Date March 2025

EIOPA Dashboard Risk: Market Risk focus

This Insurance Risk Dashboard, based on Solvency II data and published by the European Insurance and Occupational Pensions Authority (EIOPA), summarises the main risks and vulnerabilities in the European insurance sector through a set of risk indicators from the second quarter of 2024 and end-2023. On October 31, 2024, the Insurance Risk Dashboard has been published. What the dashboard exposes is that, while risks in the European insurance sector are “stable and overall, at medium levels”, there are “pockets of vulnerabilities” which originate from specific areas such as market volatility and real estate prices.

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Date February 2025

Hedging of Counterparty Credit Risk Exposures

On November 2024, BCBS purposed Technical Amendments to the credit risk and CCR standards, introducing a floor on the Unprotected Portion of counterparty credit risk exposures, preventing banks from fully offsetting their risk using CDS and guarantees to ensure more conservative capital requirements. ISDA (International Swaps and Derivatives Association) and IIF (Institute of International Finance) challenge these revisions, arguing that they overstate residual risk, disincentivize effective hedging strategies, and impose excessive capital requirements.

read more

Date Aprile 2025

BCBS: Guidelines for Counterparty Credit Risk management

This presentation aims to provide an overview of the Guidelines for counterparty credit risk management issued by the Basel Committee on Banking Supervision (BCBS) in December 2024. This is the finalized version after a draft was issued for public consultation and comment in April.The BCBS guidelines include key practices critical to resolve long-standing industry weaknesses in CCR management, in particular about due diligence and monitoring, exposure measurement, governance organization, infrastructure and data management and closeout and watchlist practices.

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Date January 2025

EBA IRRBB Heatmap Implementation

The European Banking Authority (EBA) published a report on IRRBB Heatmap Implementation to deliver on the short/medium term objectives of its action plan. It contains observations and recommendations for Institutions and Supervisors, including some tools for Supervisors to support them in the assessment of Interest Rate Risk arising from the Banking Book (IRRBB) on several dimensions. The report is not setting any new requirement, but it provides several descriptive statistics, guidance and good practices, without suggesting new limits or thresholds. The recommendations and tools are aimed to be a practical resource to foster a shared understanding of the assessment of IRRBB risks.

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Date March 2025

ECB: SREP 2024 and SSM Priorities 2025-2027

The 2024 Supervisory Review and Evaluation Process (SREP) for banks under ECB supervision confirms the sector's resilience, with strong capital and liquidity positions despite economic uncertainties. Profitability remained strong, driven by rising net interest income (NII), while asset quality showed stability, though concerns persist in commercial real estate (CRE) and SME sectors. Governance weaknesses, particularly in risk data aggregation and risk reporting (RDARR), remain a supervisory priority. Amid growing cyber and IT risks, banks are expected to strengthen operational resilience under the Digital Operational Resilience Act (DORA).

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Date February 2025

iason Weekly Insights

Regulatory/Supervisory Pills

Among iason's various publications we also find the iason Pills.

With these daily Pills, iason aims to offer a summary on information, mostly, of the main regulatory and supervisory news in the banking and finance sector on both Pillar I and Pillar II risks of the Basel framework. The main purpose of these publications is to give the reader an effective, timely and brief overview of the main topics of the moment.

The authors of the Iason Pills are Dario Esposito and Cecchin Matteo.

read more

Market View

Among iason's weekly insight you can also find the iason Market View, a weekly update on financial market by Sergio Grasso.

The author, with almost three decades of investment experience, presents an accurate analysis of market fluctuations of the week, giving a critical view of observed phenomenos and suggesting interesting correlations with the main world events.

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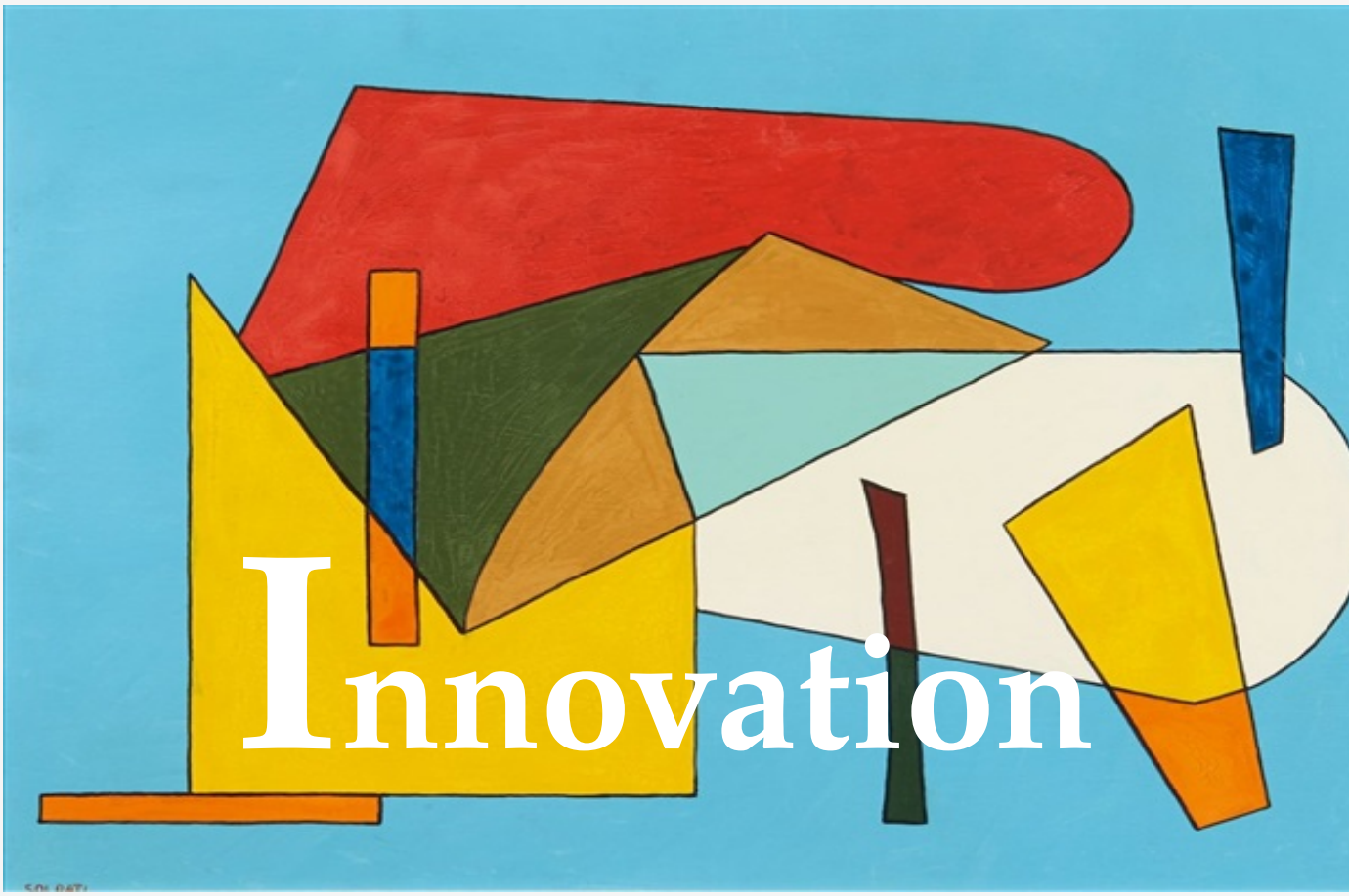

Atomic Settlement: Potential Implications of DLT-based Compressed Settlement Cycles

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This document was prepared in collaboration with Nicola Mazzoni, who at the time was working for Iason Consulting.

Atomic Settlement: Potential Implications of DLT-based Compressed Settlement Cycles

Martina Arcodia Valerio Ciminelli Nicola Mazzoni
Caterina Papetti

The financial sector is undergoing a transition toward shorter settlement cycles, led by the U.S. adoption of a T+1 settlement cycle and other economies, such as the EU and UK, scheduling their transactions accordingly. Within this context, Atomic Settlement, enabled by Distributed Ledger Technology (DLT), makes it possible to further reduce settlement timing and enables the simultaneous settlement of transactions. While the introduction of these technologies could enhance market efficiency and mitigate counterparty risk, they also pose challenges that may require a restructuring of market infrastructure and the business models of financial players. This paper aims to explore the opportunities presented by a DLT-based Atomic Settlement cycle, while also analyzing the potential challenges to financial markets.

Efficient and timely post-trade settlement processes play a key role in reducing systemic risks and fostering resilient financial markets. Shortening settlement cycles leads to lower counterparty risk, greater liquidity, and fewer transaction failures. Considering this, in May 2024, the US and Canada adopted a T+1 post-trade cycle, shifting from the classic T+2 framework, with several benefits in terms of reducing failure rates and margin requirements. Following the results of these countries, others, such as the UK, Switzerland, and the EU, started planning to move to a shorter and more aligned settlement cycle in the coming years. Furthermore, with the evolution of financial innovation, the feasibility of adopting a simultaneous settlement cycle has been made possible by leveraging DLT and smart contracts, with the potential to further reduce counterparty risk, minimize the need for intermediaries, and significantly lower operational costs and capital requirements. Atomic settlement represents the market application of a simultaneous settlement mechanism where the exchange of assets between parties occurs simultaneously and irrevocably, eliminating settlement risk. However, as outlined by Lee, Martin, and Muller [19] distinguishing between instant and atomic settlement remains crucial, as they address different aspects of settlement efficiency and risk management. Specifically, the instant settlement does not incorporate atomic features and refers to a transaction process in which trades are settled immediately after execution. However, it does not guarantee atomicity-meaning that both parties may not receive their assets at the same moment. While simultaneous atomic cycles could enhance efficiency and mitigate risks, a non-atomic instant settlement mechanism could severely impact market integrity, requiring even greater oversight by central intermediaries. The analysis will first focus on explaining the current evolution of settlement cycles and the benefits a shorter cycle could bring to economic systems, particularly exploring the US's shortened cycle and the EU's next steps. The second part will provide a brief overview of how DLTs and related environments work. Finally, the research will highlight the characteristics of Atomic Settlement and analyze the potential impacts on the financial market infrastructure of the adoption of an Atomic Settlement Cycle that relies on DLTs.

The Evolution of Settlement Cycles

Settlement plays a crucial role in the current financial market infrastructure. In financial transactions, counterparties fulfill their contractual obligations through the exchange of securities and funds, which is executed via settlement operations. In financial markets, trading and settlement typically occur at different times. The period between the trade date ("T") and the settlement date is known as the settlement cycle. Settlement plays a crucial role in financial transactions by ensuring an efficient, accurate, and secure exchange of assets and funds. This process serves two key functions:

- **Reduction of Counterparty Risk:** it ensures that both investors and institutions receive what was agreed upon, reducing the risk of failed deliveries or counterparty default.
- **Financial System Stability:** a well-functioning settlement system helps reduce credit and counterparty risks, helping prevent systemic crises and preserving market trust.

Several parties are involved in the settlement process, including:

- **Transaction Counterparties:** investors, financial institutions, and traders;
- **Financial Intermediaries:** brokers, custodian banks, and clearinghouses that facilitate settlement;
- **Central Securities Depositories (CSDs):** institutions responsible for safekeeping and settlement of financial instruments.

Settlement systems have evolved significantly over time to adapt to the increasing complexity and pace of financial markets. The shift towards digital systems has enabled a reduction in both settlement times and operational costs. Additionally, mechanisms like netting[1] have optimized liquidity management by minimizing the number of required transactions. The introduction of clearinghouses has been pivotal in automating the settlement process, improving security, and mitigating settlement risks. A quicker settlement cycle allows market participants to reallocate capital and securities more efficiently, improving overall market liquidity. In a T+n settlement model (where "n" refers to the number of business days until settlement), investors cannot reinvest or access funds until the transaction is finally finalized. Reducing this cycle helps financial institutions optimize their operations and improve market efficiency. In recent years, many financial markets have increasingly shortened the settlement cycle. In May 2024, the U.S. shifted from a T+2 to a T+1 settlement cycle, while European regulators and market participants are considering a similar transition to align with global best practices. Looking ahead, emerging technologies like blockchain and distributed ledger technology (DLT) can deeply modify the current financial market infrastructure affecting the future of the settlement cycles. These technologies could make settlement faster, more transparent, and more secure, minimizing errors and reducing the risk of fraud. Over time, they could redefine how financial transactions are settled, leading to the adoption of real-time settlement solutions.

The U.S. Model: from T+2 to T+1

In 2024, the U.S. officially moved to a T+1 settlement cycle, meaning transactions are settled one business day after the trade date. Historically, the settlement period was T+5, meaning transactions were completed five business days after execution. This extended timeframe was necessary because investors had to physically deliver stock certificates, requiring sufficient time for processing and payment transfers. Over time, advances in technology and risk mitigation efforts have progressively shortened this timeframe. The Securities and Exchange Commission (SEC) first reduced the settlement cycle to T+3 in the 1990s and then to T+2 in 2017. In May 2024, after extensive consultations and technological upgrades, the U.S., alongside countries like Canada and Mexico, transitioned to a T+1 settlement cycle. The timeline of this transition is as follows:

- **February 2022:** the SEC began a review of the settlement cycle and gathered feedback from the financial sector.
- **February 2023:** the SEC officially announced its decision to shorten the settlement cycle from T+2 to T+1, setting May 28 2024, as the implementation date.
- **May 2023:** major financial institutions began operational testing to prepare for the new standard.
- **December 2023-April 2024:** simulations and tests were conducted to ensure the resilience of the new system.
- **May 2024:** the T+1 settlement cycle officially takes effect for most U.S. markets transactions.

This shift marks a significant milestone, driven by technological evolution and increasing trade volumes. Under T+1, if an investor sells shares on a Wednesday, the transaction will settle the following Thursday, assuming it's a business day. This means the securities will be officially transferred to the buyer's account and funds to the seller's account one business day after execution. The adoption of T+1 has required market participants to accelerate operational timelines:

- **Order Submission:** participants must submit transaction details (buy/sell parties, quantities, etc.) by 7:00 PM (Eastern Time) on the trade date (T+0).
- **Clearing Discrepancy Resolution:** any discrepancies must be resolved by the end of the same trading day (T+0).
- **Transaction Confirmation:** transactions must be confirmed by the end of the trading day (T+0), with a suggested industry deadline of 9:00 PM (Eastern Time).

The main goals and benefits of this shorter settlement cycle include:

- **Mitigation of Counterparty and Market Risk:** the faster settlement minimizes exposure to insolvency risks between parties.
- **Improved Liquidity and Market Efficiency:** a faster settlement allows investors to reinvest capital more quickly.
- **Adaptation to Technological Advancements:** the reduction in settlement time has been made possible by improvements in digital infrastructure.
- **Increased Transparency, Speed, and Security:** a faster cycle increases predictability and reduces operational inefficiencies.

Despite the benefits, transitioning to T+1 has also introduced several challenges:

- **Post-Trade Infrastructure Adjustment:** financial institutions needed to update their systems to handle the new cycle.
- **Increased Operational Efficiency Requirements:** the reduced settlement time demands greater precision in clearing and settlement processes.
- **Impact on International Participants:** foreign investors, operating across different time zones, must adjust to tighter timeframes to complete transactions.

The following are the main performance indicators observed in the first days of operation of the T+1 settlement cycle, with reference to the affirmation rates, fail rates, and the impact on the clearing fund. The analysis highlights the variations compared to the previous T+2 system and the related implications for market efficiency and stability [9].

[1] Netting is a process used in the financial sector that, through a compensation system, allows for the reduction in the number and value of transactions to be settled between two or more counterparties. Instead of conducting multiple separate payments or exchanges, the parties agree on a "net balance" to be settled, which represents the total amount one party owes to the other after offsetting all reciprocal amounts or securities. Netting can involve two counterparties, referred to as bilateral netting, or more than two counterparties, referred to as multilateral netting.

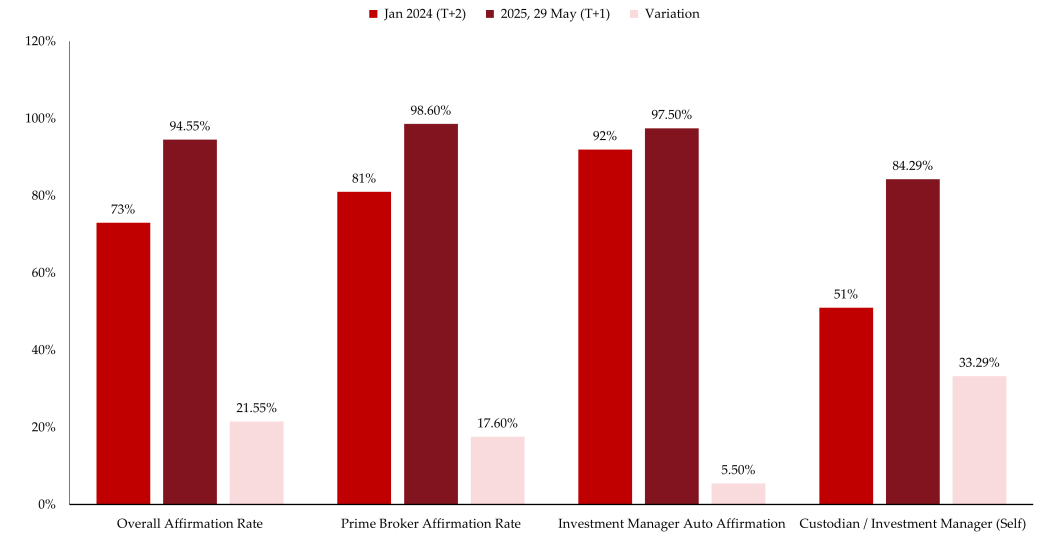


FIGURE 1: Affirmation Rate Improvement

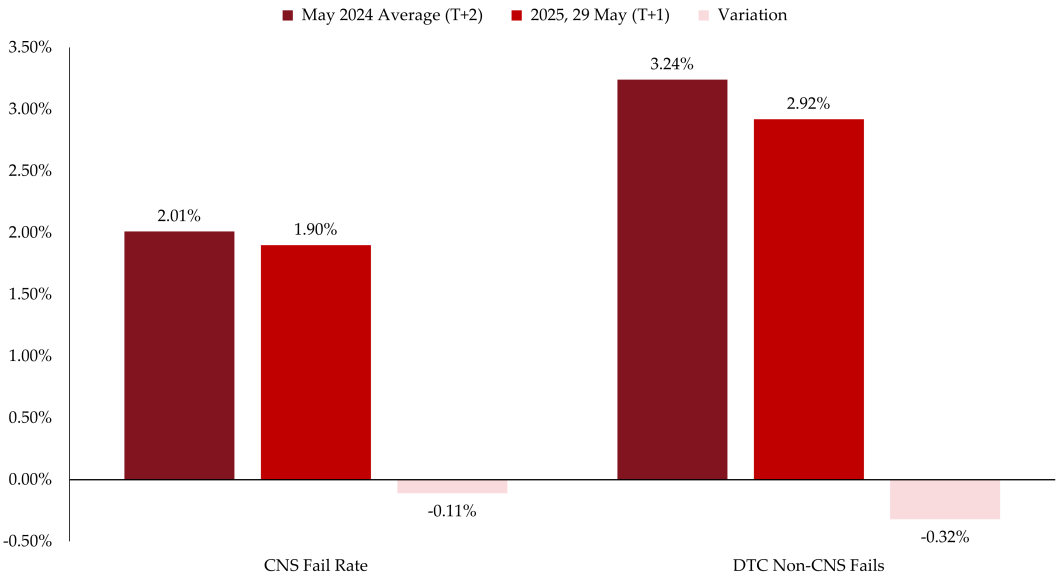


FIGURE 2: Fail Rate Reduction

- **Affirmation Rates (ref. Figure 1):** the data shows that the transition to T+1 has significantly improved affirmation rates across various market segments. The overall affirmation rate has increased from 73% (January 2024) to 94.55% (May 29, 2024), with particularly notable increases in the custodian/investment manager segment (+33.29 percentage points) and in prime brokers (+17.6 percentage points).
- **Fail Rates (ref. Figure 2):** with the shift to T+1, the transaction fail rate has decreased, with the CNS Fail Rate dropping from 2.01% to 1.90%, and the DTC Non-CNS Fails reduced from 3.24% to 2.92%. This indicates greater efficiency in the settlement process, reducing the risk of incomplete transactions.
- **Clearing Fund Impacts (ref. Figure 3):** the transition to T+1 has led to a significant reduction in the margin requirements for clearing, with the NSCC Clearing Fund decreasing by 29% (-3.7$ billion) from the past quarterly average of 12.8 $ billion, and by 25% (-3.1$ billion) from the past month average value of 12.2$ billion. This increase in efficiency helps improve the overall liquidity of the market.

Overall, in the initial months following implementation, several early trends have emerged:

- **Reduction in Default Risk:** the shorter exposure period effectively reduced the risk of default in transactions.
- **Improved Liquidity Management:** market participants have reported faster transaction settlements and more efficient capital use.
- **Initial Adjustment Costs:** many institutions have faced significant costs to update their systems, although the long-term benefits are expected to out-

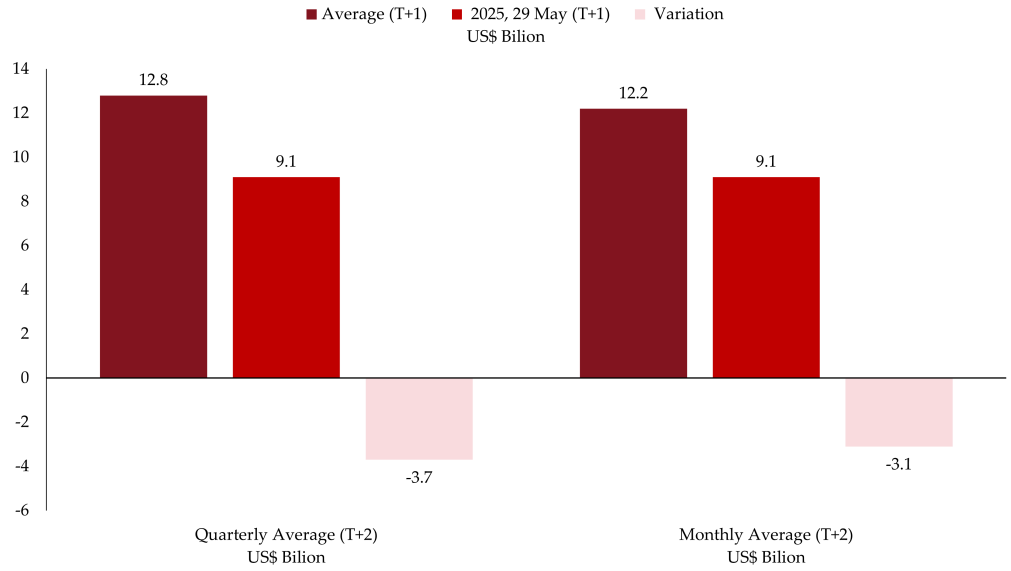


FIGURE 3: Margins Reduction

weigh these costs.

- **Operational Challenges for International Investors:** foreign investors, especially in Europe, have faced difficulties due to the discrepancy between the U.S. T+1 cycle and the T+2 cycle in Europe. This has increased trading costs and reduced returns [21].

The success of T+1 implementation has sparked discussions about further reducing settlement times to T+0 settlement. With emerging technologies such as blockchain and asset tokenization, the financial market may move toward a nearly simultaneous settlement cycle in the near future. The full impact of the T+1 transition will continue to be assessed as financial institutions adapt to the new system, and more data will be collected on its effects on global markets.

European Settlement Model

In the past, the settlement cycle of securities transactions in the European Union was highly fragmented across different countries, making cross-border transactions costly and inefficient. This highlighted the need to harmonize securities settlement cycles to improve efficiency and mitigate financial market risks. To address this challenge, over the past years, the European settlement cycles have already undergone significant evolution:

- **October 2014:** the European settlement cycle moved from T+3 to T+2, a change that improved market efficiency and reduced counterparty risk. This shift was driven by the adoption of the CSDR (Central Securities Depositories Regulation)[2], which established a standardized settlement cycle across European member states, eliminating differences between countries. One of the key objectives of this move was to reduce systemic risk, achieved by creating a uniform system for securities depositories throughout the European Union. However, the adoption of the CSDR also posed some challenges. Businesses had to adapt to new technological and operational systems, which impacted costs and implementation timelines. Additionally, the need to comply with a uniform regulation required coordinated efforts across different jurisdictions, with some market participants initially struggling to adapt. Despite these challenges, the overall results have been positive, with greater stability and efficiency [18].

- **June 2015:** following the adoption of the CSDR and the shift to T+2, the European Union subsequently implemented the TARGET2-Securities (T2S) system. T2S is a pan-European platform for settling securities transactions across the euro area in a centralized and standardized way. T2S marked a significant step toward integrating and harmonizing European markets by reducing settlement costs, improving transparency, and minimizing operational and systemic risks. Before the introduction of T2S, the settlement of securities transactions was fragmented through various national central securities depositories (CSDs), with operational differences and high costs for cross-border transactions. The platform made it possible to settle securities transactions more quickly and efficiently, laying the foundation for the future harmonization of the settlement cycle. The primary objective of T2S has been to centralize and standardize the settlement of securities transactions across the euro area, reducing operational complexity and lowering settlement costs for both domestic and cross-border transactions. Settlement occurs according to the Delivery versus Payment (DvP) principle, where the delivery of securities and payment happen simultaneously, reducing counterparty risk. Figure 4 summarizes how the platform operates.

After the US shift to a T+1 environment, Europe started to evaluate the feasibility of a compressed settlement cycle. As a result, analyses are underway to evaluate the Key reports published by the European T+1 Task Force in October 2024 and by ESMA in November 2024.

[2]The CSDR is an EU regulation that establishes a regulatory framework for Central Securities Depositories (CSDs), aimed at improving the security and efficiency of securities settlement operations. It was officially adopted by the European Parliament and the Council of the European Union on July 23, 2014, and became immediately binding across all EU member states. The CSDR introduced measures to harmonize settlement cycles, reduce operational risks, and enhance transparency, making cross-border transactions safer and contributing to the stability of the European financial system.

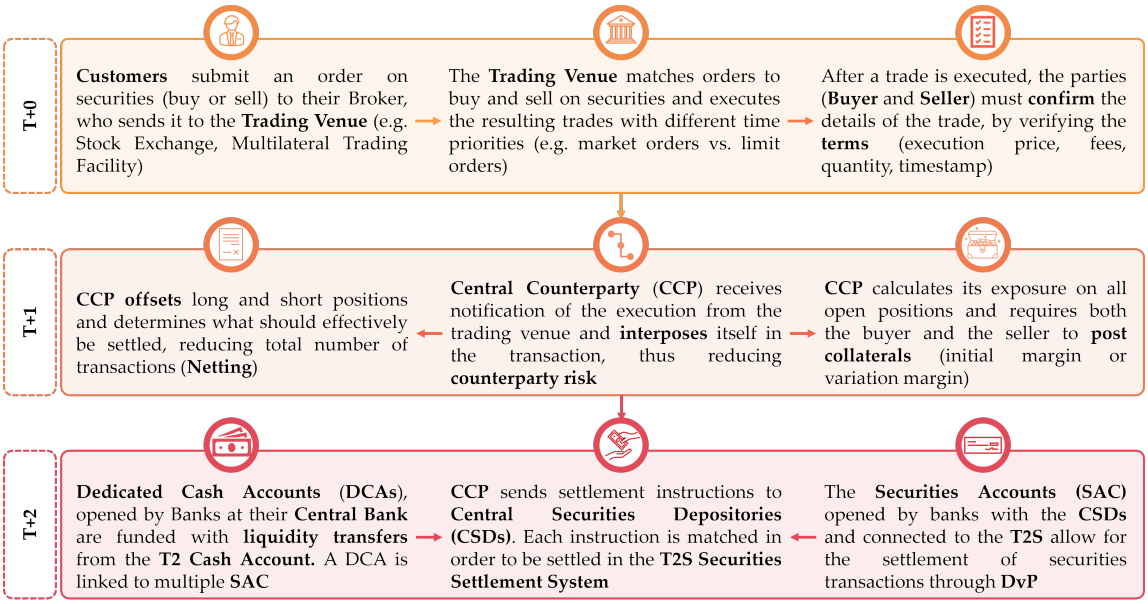


FIGURE 4: Target-2-Securities: How Does it Work[2]

- **European T+1 Task Force Report:**[2] the report published in October 2023 by the European T+1 Task Force[14] laid the groundwork for transitioning to a T+1 settlement cycle in European financial markets. This document provided a detailed analysis of the regulatory, technical, and operational changes necessary to ensure a smooth and secure transition, outlining the key objectives and recommendations to align European practices with international standards. Central to this effort is coordination among stakeholders to enhance market efficiency, minimize risks associated with an uncoordinated transition, and align European practices with global standards. Key preliminary activities for accelerating settlement include: updating regulations, revisiting market standards, improving pre-settlement processes to optimize resources and standardize settlement instructions, identifying potential post-trade inefficiencies, and implementing necessary adjustments to facilitate the adoption of T+1. The report highlights the need for a structured transition period, estimated to be between 24 and 36 months, reflecting the complexity of the project. Furthermore, it provides an essential contribution to discussions led by the European Securities and Markets Authority (ESMA) for future implementation stages.
- **ESMA Report:**[15] in November 2024, ESMA published a report emphasizing the need for thorough market preparation to implement a shift in the European settlement cycle. The report stressed that such a significant change could not occur without effective coordination among all stakeholders. Therefore, ESMA recommends a well-planned transition period, during which in-depth testing will be conducted to ensure that settlement infrastructures can operate seamlessly. Other important points discussed in the report include:
  - **Technological Adaptation:** post-trading infrastructures, including central securities depositories and settlement platforms, must invest in upgrading their systems to support the shorter settlement cycle. These technological updates are crucial to prevent delays and inefficiencies that could compromise market stability.
  - **Regulatory Alignment at the European Level:** since different member states have adopted varying practices and regulations, ESMA insists on reviewing existing regulations to ensure consistency and harmonization across EU financial markets. Without proper regulatory coordination, the risk of fragmentation could increase, creating new operational hurdles.
  - **FX Transaction Management (ref. Figure 5):** moving to T+1 would compress the time for currency conversion, which could create challenges in managing liquidity and determining settlement timings. ESMA suggests reviewing current procedures to ensure the FX market can adapt without negatively impacting financial stability.
  - **Post-Implementation Monitoring:** once the T+1 settlement cycle is introduced, a monitoring system will be necessary to evaluate the actual effects of the transition and identify and address any issues without causing instability.

European Commission Proposal

Based on these analyses and recommendations, On February 12, 2025, the Commission published a proposal[8] to reduce the settlement cycle to T+1 by October 11, 2027. Key challenges identified include:

- **Infrastructure Adaptation:** market participants will need to update their technological systems to support the accelerated settlement process.
- **Operational Risk Management:** the reduced settlement time may increase the likelihood of settlement errors, requiring more effective solutions to mitigate risks.
- **Harmonization Across Member States:** ensuring a coordinated transition is crucial to prevent fragmentation and regulatory misalignment.

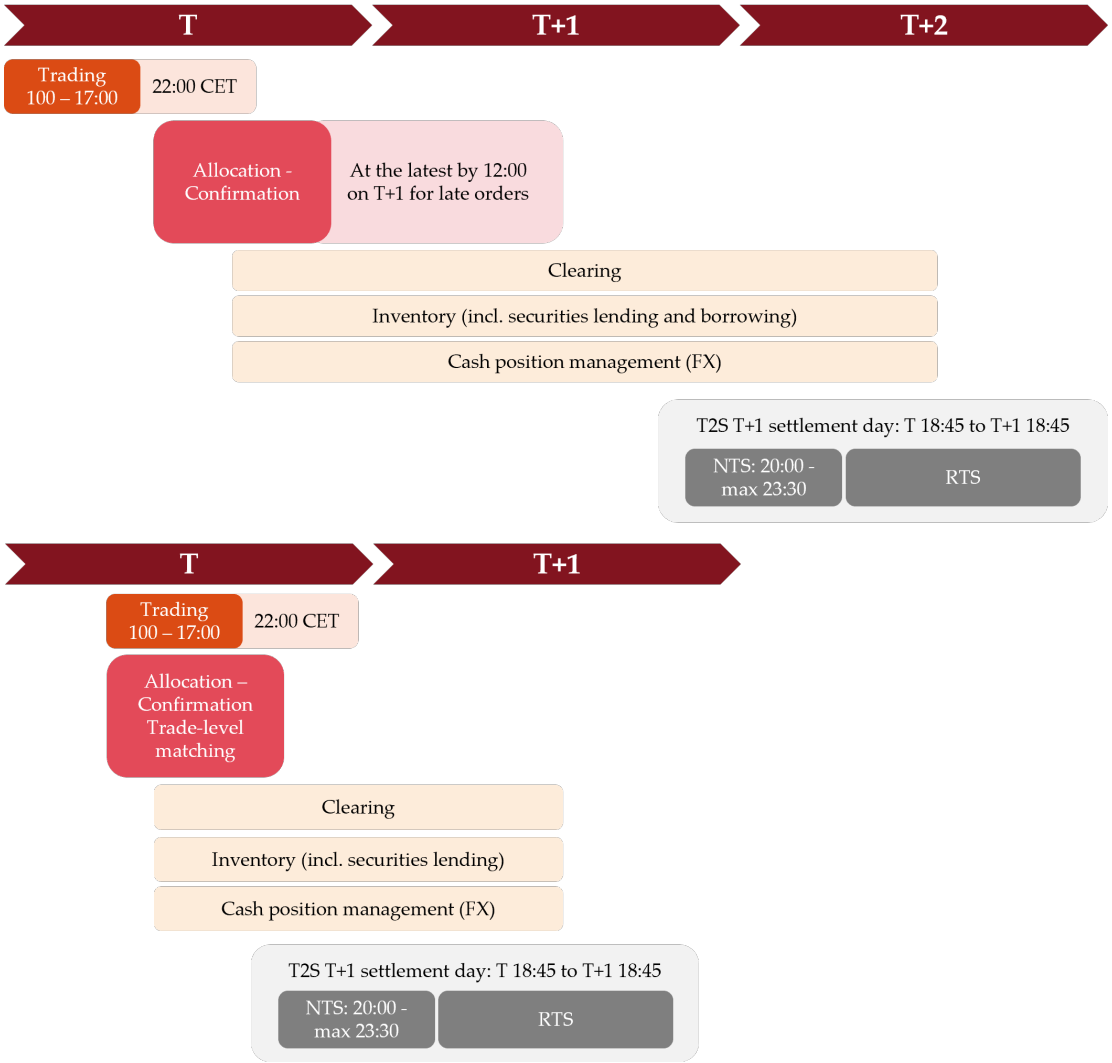


FIGURE 5: Potential Evolution Form T+2 to T+1[15]

The proposed amendment to EU Regulation No. 909/2014 (CSDR) aims to shorten the settlement cycle for securities transactions to just one business day (T+1), enhancing the efficiency of settlement services and strengthening the competitiveness of European financial markets. Both the European Commission's analysis and ESMA's report highlight the long-term benefits of this transition, including increased automation, reduced risk exposure, lower margin requirements, and the elimination of costs associated with misalignment across jurisdictions. Over time, these advantages are expected to exceed the initial investment needed for implementation. While T+1 settlement is already technically and legally feasible within the EU, the complexity of its financial markets - due to the diversity of participants and systems - makes a coordinated approach at the EU level essential. A harmonized transition will prevent market fragmentation and provide legal certainty for financial operators. Under the principle of subsidiarity established by Article 5 of the Treaty on the European Union, EU action is essential to facilitate a smooth and timely transition, helping the EU remain competitive as global markets shift to faster settlement cycles. The adoption of T+1 in the EU would offer benefits similar to those already observed in the US, including:

- **Greater Capital Efficiency:** shortening the settlement period would enable financial institutions to utilize available funds more quickly, optimizing cash flows.
- **Lower Counterparty Risk:** with less time between trade and settlement, the risk of default is reduced, enhancing market stability.
- **Increased International Competitiveness:** aligning with the U.S. and other advanced markets would be crucial for attracting global investment and ensuring European markets remain competitive.
- **Reduced Margin Requirements:** the shorter settlement cycle will reduce the need for margin maintenance with central counterparties (CCPs), positively impacting operational costs and market competitiveness.
- **Fewer Settlement Failures:** the adoption of T+1 will encourage more automation and standardization, reducing settlement errors and related penalties.

The next steps for the transition to T+1 in the EU are as follows:

- **2025-2026:** discussion of the proposal in Parliament and Council;
- **2026:** approval of the regulation;
- **2026-2027:** transition period and operational adjustments;
- **Ocotber 2027:** official implementation of T+1.

The transition to T+1 is an important step for the EU, aiming to enhance efficiency, liquidity, and global competitiveness. However, its implementation will require careful coordination between regulators, financial infrastructures, and market participants, along with significant technological investments. The success of this transition will depend on the EU's ability to overcome operational challenges and ensure appropriate regulatory adaptation.

T+0 and Beyond: the India Case and the Future of Settlement Cycles

India is emerging as one of the most dynamic and innovative financial markets globally, driven by a strong commitment to modernizing its trading and settlement infrastructure. After successfully implementing the T+1 settlement cycle in 2023, the country introduced a voluntary T+0 option, further solidifying its position at the forefront of market efficiency. A key factor enabling India's adoption of T+0 is its robust digital infrastructure. The Unified Payments Interface (UPI), which revolutionized instant payments in the country, has demonstrated the feasibility of real-time financial operations, creating a favorable environment for accelerating settlement cycles in capital markets. Additionally, India is home to two of the world's largest and most sophisticated central securities depositories-the National Securities Depository Limited (NSDL) and the Central Depository Services Limited (CDSL)-which play a crucial role in ensuring transaction efficiency and security. With T+0, trades are executed and settled on the same day, eliminating the settlement risk associated with longer cycles. This shift not only mitigates counterparty risk but also enhances overall market liquidity. Moreover, adopting T+0 could increase the attractiveness of India's stock market for global investors by providing faster and more efficient access to capital, enabling more dynamic investment strategies. The success of this initiative could position India as a global benchmark for simultaneous settlement, paving the way for even more advanced models like atomic settlement. In this scenario, trade execution and settlement occur simultaneously, reducing settlement failures and further improving market efficiency. If widely adopted, T+0 and atomic cycles could influence other emerging economies and developed markets to reconsider their settlement cycles to remain competitive in an increasingly fast-paced and digital financial landscape.

Digital Ledger Technologies

As financial transactions continue to evolve, traditional settlement mechanisms often face delays, counterparty risks, and inefficiencies. Atomic settlement is a DLT-based process that ensures the simultaneous exchange of assets without intermediaries and relies heavily on the principles of DLT to function securely and efficiently. Understanding the functioning of Distributed Ledger Technologies (DLTs) is therefore essential for grasping the impact that introducing a DLT structure fostering an atomic settlement cycle could have on the current financial market infrastructure. DLT is a decentralized system that enables the secure and transparent recording, sharing, and synchronization of data across multiple participants. Unlike traditional centralized databases, where a single entity controls the data, DLT ensures that information is distributed in identical copies between the nodes that comprise the network, enhancing security, transparency, and resilience. One key feature of DLTs is that ledger information is continuously and simultaneously updated across all network nodes with every transaction. DLT serves as the foundation for various applications, including blockchain technology, cryptocurrencies, and decentralized finance (DeFi). DLT exhibits several key characteristics that differentiate it from conventional centralized systems:

- **Decentralization:** unlike traditional ledgers maintained by a central authority, DLT distributes data across multiple nodes and each participant in the network maintains a copy of the ledger, reducing the risk of a single point of failure.
- **Transparency and Immutability:** every participant can see each transaction recorded on a DLT and every node, once data is validated, contains the same immutable information.
- **Consensus Mechanism:** DLT operates through Consensus Mechanisms, ensuring that all participants agree on the state of the ledger. For example, some common consensus algorithms include Proof of Work (PoW), Proof of Stake (PoS), and Byzantine Fault Tolerance (BFT).
- **Cryptography:** DLT uses cryptographic techniques to secure transactions and prevent unauthorized modifications. Digital signatures and encryption ensure data integrity and authenticity.

How the Ledger Works

A distributed ledger is a digital record of transactions maintained across multiple nodes in a decentralized network. Unlike traditional centralized ledgers, where a single entity has control, DLT ensures that all participants have access to an identical copy of the ledger, reducing the risk of fraud and data manipulation. Initially, a user initiates a transaction, which is broadcast to the network and verified by multiple nodes. Once verified, the transaction is added to the ledger through a consensus mechanism. Finally, the updated ledger is synchronized across all participating nodes. This decentralized approach enhances security and transparency, as no single entity can alter the ledger without network-wide agreement. Different types of distributed ledgers exist, each with unique structures and functionalities. In Blockchain (e.g. Bitcoin, Ethereum, Hyperledger) transactions are grouped into blocks, which are cryptographically linked in a sequential chain. Each block contains a reference to the previous block, ensuring immutability. In Directed Acyclic Graphs (DAGs) (IOTA, Hedera Hashgraph) transactions are structured in a graph rather than blocks. Instead of miners, users confirm previous transactions, reducing energy consumption. Hybrid Ledgers combine elements of blockchain and DAG to optimize scalability, security, and speed. They are used for enterprise applications requiring both transparency and privacy.

Consensus Mechanism

A key aspect of any distributed ledger (DLT) is how participants agree on transaction validity. Without a central authority to verify and approve transactions, decentralized networks rely on consensus mechanisms to maintain integrity and security. These mechanisms ensure all ledger copies stay synchronized and only legitimate transactions are recorded. A major challenge in decentralized environments is coordinating participants to agree on updates. This issue relates to the Byzantine Generals Problem, where some nodes may act maliciously or provide incorrect information, risking network inconsistency or attacks like double-spending. To prevent such issues, DLTs use specific consensus algorithms that help the network determine

which updates should be applied. Several notable mechanisms include:

- **Proof of Work (PoW)**: used by Bitcoin, PoW relies on a "Mining Process that requires the network components to solve high-level computational problems to validate the information and update the ledgers" [7]. These complex cryptographic puzzles, known as hash functions, demand significant computational power, making the process highly energy-intensive. The first miner to solve the puzzle broadcasts the solution to the network, and if many nodes verify its correctness, the new block is added to the blockchain. This mechanism ensures security by making it computationally impractical for malicious actors to alter past transactions, as they would need to do again the work for all subsequent blocks faster than the rest of the network combined.
- **Proof of Stake (PoS)**: unlike PoW, PoS selects validators based on the amount of cryptocurrency they stake. The more tokens a participant locks up, the higher their chances of being chosen to validate transactions, e.g. Ethereum, after transitioning from Proof of Work (PoW) to Proof of Stake (PoS), uses a system in which validators must deposit 32 ETH to participate in transaction validation and network security.
- **Delegated Proof of Stake (DPoS)**: DPoS is an evolution of PoS, that allows network participants to vote for a limited number of trusted validators who then handle transaction confirmations.
- **Proof of Authority (PoA)**: PoA mechanism defines predefined trusted public entities that act as validators. This configuration permits a faster and less costly environment in exchange for a reduction of the degree of decentralization of the network.
- **Proof of Capacity (PoC)**: this mechanism is based on the storage power of the network participants. The validators must store a pool of hash solutions in a memory space and every time a new block of the chain is created, they must search for the solutions inside their storage. The bigger the memory space they have at their disposal, the bigger the probability is of having the solution of the hash in the downloaded pool of solutions.
- **Proof of Burn (PoB)**: this mechanism bases its trusted validation process on the requirement of "burning" tokens to become a network validator. This configuration requires that validators destroy a certain number of tokens, removed from the network circulation, to participate in the "mining" of new nodes.
- **Byzantine Fault Tolerance (PBFT)**: "Byzantine Fault Tolerance Models" (BFT-Models) refer to a multitude of architectures that aim to solve the Byzantine Generals'problem ensuring that the consensus within a network is reached even if a third of the participants act malevolently. The most notable are:
  - **Practical Byzantine Fault Tolerance (PBFT)**: PBFT environments are based on a voting round system where at least two-thirds of the network must agree on the validity of a transaction.
  - **Delegated Byzantine Fault Tolerance (DBFT)**: in the DBFT environment, network participants choose a delegation of participants that has to carry the burden of reaching the consensus for the network"[6].

DLT Architectures

Distributed Ledger Technology (DLT) can be categorized into permissionless and permissioned architectures based on how participants access and interact with the network. Each model offers distinct advantages and trade-offs in terms of decentralization, security, efficiency, and governance:

- **Permissionless Architecture**: a public ledger, where everyone can join the network, validate transactions, and maintain a copy of the ledger without requiring approval from a central authority. The most famous permissionless architecture is Blockchain, and another is Ethereum, a decentralized smart contract platform with a transition to PoS for better scalability.
- **Permissioned Architecture**: a restricted network where access and participation are controlled by a

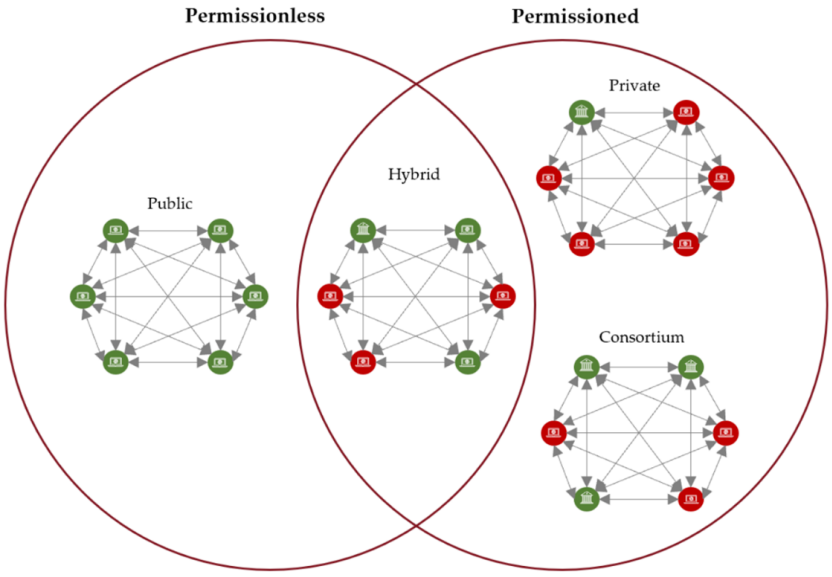


FIGURE 6: DLT Architectures[7]

governing entity. Unlike public blockchains, only authorized participants can validate transactions, maintain the ledger, or execute smart contracts. Permissioned DLTs are also divided into:

- **Permissioned Private**: where "the transaction validator role is in the hand of the Central Authority" [7].
- **Permissioned Consortium**: where validators are a small group of participants.

Smart Contracts

Smart contracts are "computer protocols with predetermined conditions that ensure the automatic execution of an agreement, with no need for a central authority, where the conditions are met"[7]. These contracts eliminate the need for intermediaries by directly executing transactions once the conditions embedded in their code are met. They rely on cryptographic security, ensuring transparency, immutability, and trust among participants. Structurally, a smart contract consists of a unique contract address, state variables that store data related to execution, functions that define operational rules, event logs for tracking contract activities, and permissions that determine which entities can interact with it. Smart contracts can be broadly classified into various categories based on their function, two important types are [17]:

- **Security Smart Contracts**: smart contracts designed to automate and enforce security-related tasks, such as asset transfers, access control, and encryption, ensuring safe transactions and interactions on blockchain networks.
- **Settlement Smart Contracts**: smart contracts used to automate the finalization of financial transactions, ensuring that all conditions are met for the transfer of assets or payment, often used in trading or insurance settlements.

Security Smart Contracts[17] (ref. Figure 7) are crucial for issuing, managing, and transferring digital representations of financial instruments like stocks and bonds. They enable the digitization of financial assets, facilitating their trading and management on blockchain platforms. Key functions include the issuance of digital securities, ownership tracking, automation of corporate actions, and regulatory compliance. For instance, a company issuing tokenized shares through a smart contract can ensure that only authorized investors can trade them, adhering to regulations. Typically, a security smart contract includes issuer details, a link to an ISIN for traditional databases, transaction transfer functions, and an indicator of collateralization eligibility, ensuring compliance with regulations while offering an efficient method for digital asset management.
Settlement smart contracts[17] (ref. Figure 8) streamline asset transfers and payments by enforcing predefined rules, particularly in instant payments and financial clearing, removing the need for intermediaries like banks and clearinghouses. A key feature is atomic settlement, where the simultaneous exchange of securities and payments mitigates counterparty risk. These contracts operate through a unique address for receiving and sending cash amounts and tokens. This structure minimizes human error and ensures fast, efficient transactions. The execution of an atomic settlement involves two key transactions. First, the contract is called with sender instructions, which specify details such as the euro and securities sender addresses, the amounts involved, and a timestamp that determines when the transaction should be completed.
If both sides fulfill their commitments within the specified timeframe, the contract executes the exchange, transferring the assets to the respective parties. If the required amounts are not received by the deadline, the contract automatically invalidates the transaction, returning any assets sent and notifying central banks to take necessary actions, such as penalizing the party responsible for the failure.
Such atomic transactions are widely used in permissionless blockchains through swap contracts or decentralized exchanges (DEXs), a platform that allows users to trade assets directly from their wallets without intermediaries. By ensuring that both legs of a transaction occur simultaneously, these contracts enhance security and efficiency in financial settlements while minimizing counterparty risk.

Oracles

Oracles play a crucial role in DeFi and especially for Smart Contract because they allow them to access real-world data, permitting them to connect the network to outside data and verify if determined conditions that occur outside the DLTs and are necessary for the execution of actions are met. For instance, in Decentralized Assurance "their function is to permit the smart contracts' algorithms to determine if a claim should be paid or not"[6]. There are several types of oracles, each serving different purposes:

- **Inbound Oracles**: fetch real-world data and bring it onto the blockchain. Examples include price feeds for cryptocurrencies and commodities.
- **Outbound Oracles**: send blockchain-generated data to external systems, such as triggering payments or notifications.
- **Software Oracles**: obtain data from online sources like APIs, databases, and websites.
- **Hardware Oracles**: interact with physical devices, such as IoT sensors, to transmit real-world information to smart contracts.
- **Human Oracles**: rely on individuals or groups to verify and submit data to the blockchain.
- **Centralized Oracles**: operated by a single entity, providing data from a specific source.
- **Decentralized Oracles**: aggregate data from multiple sources to enhance reliability and prevent manipulation, unlike centralized oracles.

Oracles typically work by [22]:

1. **Collecting data** from external sources (e.g., APIs, websites, IoT devices).
2. **Validating and verifying** the data for accuracy.
3. **Formatting the data** to be compatible with blockchain protocols.
4. **Submitting the data** to smart contracts on the blockchain.

This process enables smart contracts to execute based on real-world events and conditions, greatly expanding their functionality and applicability.

Tokens

Tokens are digital assets exchanged among participants in a distributed ledger technology (DLT) network. They can represent any form of value or claim, from real estate property to intellectual property rights, by embedding specific conditions within smart contracts that govern their creation, issuance, and management. Unlike traditional assets, tokens are programmable, allowing them to be tailored to

Security SC
Contract Address: 0x4da138a2 **Owner Address**: 0xac45f07b **ISIN**: xxxxx **Supply**: 1m **Current balances**: (…) **Corporate actions**: (…)

FIGURE 7: Security Smart Contract

Settlement SC
Contract Address: 0x1d34a6a3 **Owner Address**: 0x2c451e9f **Mode**: DvP **Code**: Check instructions Check if security arrived Check if hash arrived If both: send to respective receiver If not both: Send back to original owner If time expired: Send back to original owner

FIGURE 8: Settlement Smart Contracts

distinct economic, regulatory, and governance purposes. Their classification depends on their underlying function, regulatory compliance, and economic characteristics. Additionally, tokens can be structured into two different layers that determine their characteristics: the Core Layer, which defines the fundamental logic and governing rules of the token within the platform, and the Service Layer which determines key attributes like ownership rights, issuance value, and other defining characteristics.
There exist a lot of possible types of tokens, some examples follow:

- **Utility Tokens**: provide access to specific services, products, or functionalities within a given ecosystem.
- **Security Tokens**: represent financial instruments such as equity, debt, or derivatives that are subject to regulatory frameworks.
- **Payment Tokens**: function as a medium of exchange and store of value, similar to traditional currencies.
- **Stablecoins**: a subset of payment tokens, are pegged to an underlying asset, typically a fiat currency, to maintain a stable value and facilitate seamless transactions without volatility concerns.
- **Governance Tokens**: enable holders to participate in decision-making processes within decentralized systems.
- **Non-Fungible Tokens (NFTs)**: represent unique digital assets that are indivisible and non-interchangeable. They are commonly used for digital art, gaming assets, intellectual property rights, and identity verification. Unlike fungible tokens, NFTs contain metadata that distinguishes each asset, ensuring its authenticity and provenance.

[3]For a more detailed analysis of the topic see [7].

DeFi

Decentralized Finance (DeFi)[3] is a financial ecosystem built on DLTs that aims to eliminate intermediaries such as banks and financial institutions. It enables permissionless access to financial services, including lending, borrowing, trading, and yield farming, using smart contracts to automate transactions. A DeFi environment is structured into three core layers:

- **Settlement Layer**: the foundational layer based on Decentralized Ledger Technology (DLT), which ensures the execution and updating of financial transactions across the network. Ethereum, Solana, Polygon, and Cardano are popular blockchains in this space.
- **DLT Application Layer**: "this layer defines the protocols and the services that are offered within the network, including also the native crypto asset that is exchanged within the environment"[6].
- **Interface Layer**: the top layer represents the user interface, through which users interact with the DeFi environment.

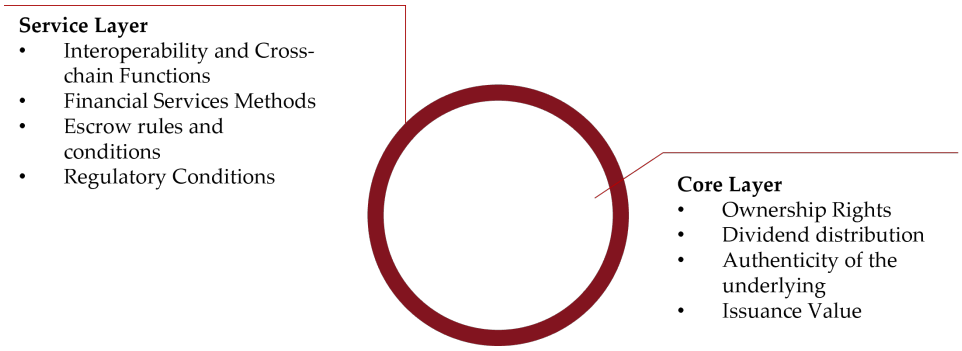


FIGURE 9: Token Anatomy[7]

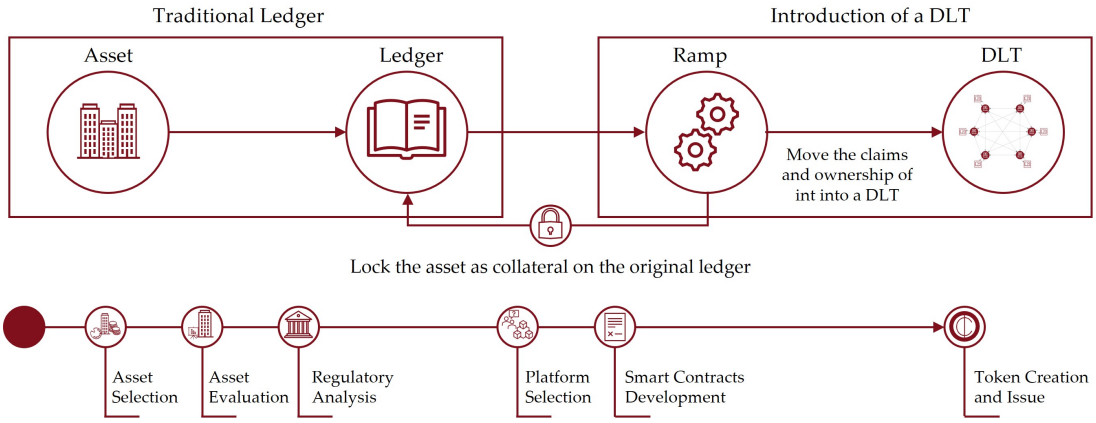


FIGURE 10: Asset Tokenization[6]

Atomic Settlement

DLTs and DeFi environments aim to enhance the financial system by reducing centralization and making transactions more efficient, leveraging the automation guaranteed by smart contracts, and controlling failures and fraud through consensus mechanisms. DLT-based environments could play a pivotal role in fostering the compression of the settlement cycles beyond the T+n standard through atomic settlement processes which could guarantee near-simultaneous transaction settlement. Atomic settlement refers to a type of transaction in which all phases are executed simultaneously or not executed at all. The term "atomic" refers to the indivisibility of the components. Real-time settlement is, by nature, difficult to implement in traditional financial infrastructures where rights transfer accounts and payment accounts are separate, requiring reliance on a technological architecture like DLTs that can enable atomic settlement. In contrast to traditional payment and securities settlement systems, which are generally based on centralized infrastructures where market participants connect to a central database, in DLT systems a database is shared across a network distributed in identical copies among the nodes and its data are accessible to the network's members, who can also actively participate in its operation.

For a centralized settlement system to be gradually decentralized into an atomic settlement system, it is necessary to proceed with the tokenization of Real World Assets (RWAs). Tokenization can be defined as the process that allows the recording of real-world assets from traditional ledgers to DLTs. The technical process that enables the transfer from the traditional ledger to the digital ledger requires a "ramp" that locks assets in their platform of origin as collateral for the tokens, which are then issued on the programmable platform. The real-world asset, or claim, continues to exist off-chain, but its rights are transferred on-chain through token issuance. This process usually involves six main phases, briefly summarized in the Figure 10:

1. Asset Selection;
2. Asset Evaluation;
3. Regulatory Analysis;
4. Platform Selection;
5. Smart Contracts Development;
6. Token Creation and Issue[4].

In the specific case of atomic settlement systems, the assets to be tokenized will be cash (payment leg) and securities (delivery leg), making the token vs. token (TvT) transfer possible. However, DLTs could also be used to foster hybrid solutions where only one leg is tokenized and settled on-chain, with securities settled by transferring account-based securities in exchange for cash tokens (AvT transfer) or transferring security tokens in exchange for cash in accounts (TvA transfer)"[4].

Atomic Settlement Architectures

This paragraph delves into the three main settlement architectures that DLTs can foster: Single-Ledger Settlement, Cross-Chain Settlement, and hybrid Asset vs. Token (AvT) Settlement. Single-Ledger Settlement is used within a single blockchain environment while cross-chain settlement practices facilitate exchanges between different environments.

[4]For a more comprehensive explanation see[7].

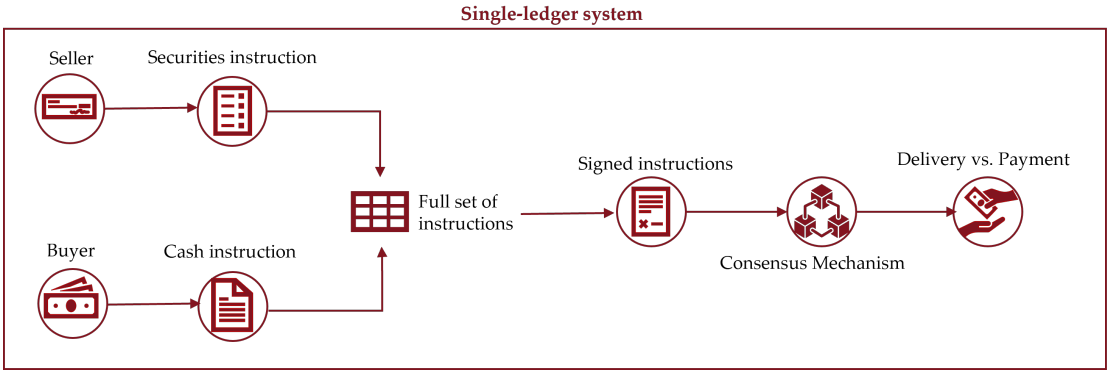


FIGURE 11: Single Ledger Atomic Settlement

Meanwhile, hybrid architectures exploit bridges and oracles to link the standard systems and verify the off-chain status of the account, ensuring the settlement of the tokenized leg on-chain.

Single Ledger Atomic Settlement

This type of transfer can be executed on a single ledger or across two separate ledgers. If the security tokens and cash tokens exist on the same ledger, an atomic settlement smart contract can be used to coordinate the clearing and settlement process. When a single blockchain network is used, atomic settlement is executed through the network's consensus algorithm (see "Digital Ledger Technologies") according to the following simplified process (ref. Figure 11):

- Both counterparties have access to the same DLT platform. The counterparty originally holding the securities creates the instruction for the securities leg, while the counterparty holding the currency creates the instruction for the cash leg. At this preliminary stage, neither of the instructions has been digitally signed yet.
- The securities counterparty sends its part of the instruction, without a signature, to the cash counterparty, which verifies the contents of the securities instruction and combines it with its cash instruction, thereby creating a complete set of instructions composed of information on the Sender and Receiver, the asset involved in the transaction, the amount of the asset and the cash in exchange, and the digital signature of the cash counterparty.
- The securities counterparty, at this stage, verifies the complete instruction and signs its part. Once signed by both counterparties, the complete instruction is submitted to the blockchain's consensus mechanism.
- Following the consensus mechanism algorithm of the specific blockchain used, the complete set of duly signed instructions is verified, and the result is written on the distributed ledger.
- If the transaction is validated, the cash token and the security tokens are instantly and simultaneously transferred to their respective recipients, achieving DvP (Delivery versus Payment). If the transaction is not validated, the tokens remain with their original owners.

Transaction failure in a single ledger approach could occur at any step of the process described above. For example, if the cash counterparty finds that the securities counterparty's instruction contains errors, it will not proceed with combining it with its own instructions. As a result, the process is suspended, the instruction is not confirmed by the consensus mechanism, and no update is recorded on the ledger. Consequently, the cash and securities will remain with the original holders and can be immediately used in other transactions.

Cross-Ledger Systems

If the two tokens are instead registered on two different ledgers, the settlement must occur via cross-chain payments, requiring interaction between distinct blockchain systems. This process is enabled by smart contract protocols such as Hashed Time-Locked Contracts (HTLC)[5], which ensures synchronization without the need for a centralized intermediary, using hash lock and time lock features, specifically:

- **Hashlock**: a condition requiring the presentation of a secret value (called the preimage) to unlock the payment.
- **Timelock**: a time limit, expressed in blocks or real-time, within which the payment must be completed. If the payment is not executed within this time, it is canceled, and the funds are returned to the sending party.

As well outlined by the ECB and the Bank of Japan (2018)[12], a DvP settlement using HTLC can occur in the following way (ref. Figure 12):

- **The seller** generates a cryptographic key (X) and the corresponding hash function (Y = H(X)). The seller uses this hash to lock the security tokens on its ledger with a specified time limit (e.g., four hours). The seller then creates an instruction with two states:
  1. To send the securities to the buyer using the hash (Y) if the buyer provides X that satisfies the hash function or;
  2. If the time limit expires, return the securities to the seller.

  The seller, finally, signs and submits the signed instruction to the securities consensus mechanism. Following the implemented consensus mechanism of the platform, the submitted securities instruction is verified and confirmed, and results are written on the ledger in the securities DLT platform.

[5]HTLC refers to a type of smart contract used in blockchain applications to mitigate counterparty risk by creating a time-based escrow that utilizes a cryptographic passphrase. HTLC transactions use multiple signatures consisting of a private and public key to verify and validate transactions.

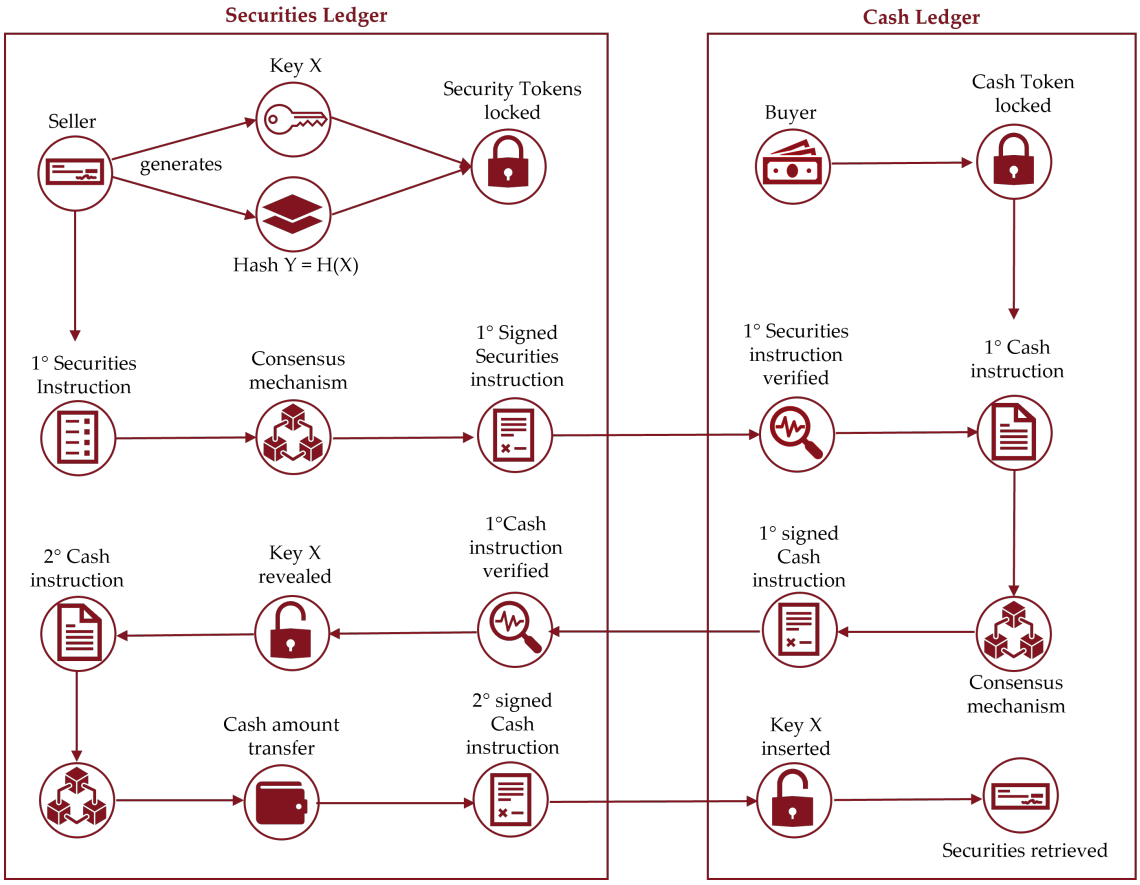


FIGURE 12: Cross-ledger systems

- **The buyer** verifies the content of the committed securities instruction and if confirms it, locks the cash token on their ledger with a shorter time limit (e.g., two hours). The buyer creates a conditional instruction to either send the cash token to the seller using the hash (Y) or return it to the buyer after two hours. The conditional instruction is signed and submitted to the buyer's consensus mechanism. Following the implemented consensus mechanism of the platform, the submitted securities instruction is verified and confirmed, and results are written on the ledger in the cash DLT platform.
- **The seller** verifies the cash instruction of the buyer and eventually reveals the secret (X) into a second cash instruction signed and submitted to the consensus algorithm of the cash DLT platform. The consensus mechanism verifies the content of the second cash instruction and, in the event of a positive outcome from the check, proceeds to write the result on the distributed ledger. Upon the occurrence of this condition, the cash amount is transferred from the buyer's account to the seller's account.
- **The buyer** can then use the secret (X) received in the second cash instruction and proceed to create a second securities instruction by inserting the secret value of (X). Once signed, the instruction is submitted and checked by the platform's consensus algorithm, which verifies its content and proceeds to write the results on the ledger to unlock and retrieve the security tokens.

Compared to single-ledger systems, a settlement failure in HTLC systems could potentially result in counterparty risk exposure for one of the two parties involved in the transaction. In HTLC systems, the risk is particularly linked to the functioning of the time lock, as it is true that if, after the completion of the first set of instructions (securities and cash), the securities counterparty does not submit the second cash instruction within the predefined locking time, the cash and securities are returned to their respective original holders. However, it is equally true that in the case where the securities counterparty has already received the cash leg while the other counterparty has not submitted the second instruction within the predefined locking time, the securities counterparty will also be refunded the securities leg, leaving the cash counterparty exposed to principal risk.

Hybrid Solutions

In addition to Token vs. Token (TvT) systems, which have a greater impact but are more complex to implement, industry practices highlight the use of 'hybrid' systems. These architectures rely on the tokenization of only one of the transaction's legs (ref. Figure 13):

- **AvT:**[4] in this configuration, the settlement involves a delivery leg in a traditional account-based securities system and a tokenized payment leg on a DLT. In an Asset vs. Token (AvT) environment, after the affirmation process, the securities are transferred through the traditional financial system-either directly to the counterparty's account or via a custodian or CSD. Once the securities transfer is confirmed, this information is communicated via a bridge or oracle to the DLT environment. A smart contract then checks if tokenized money is available in the buyer's on-chain

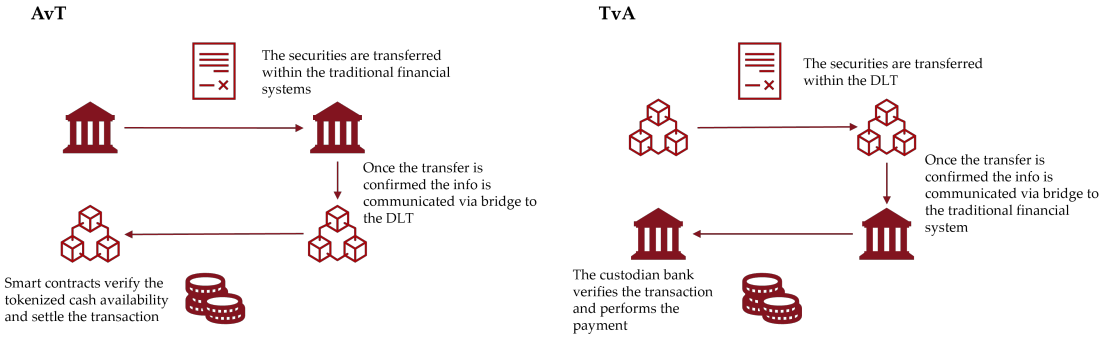


FIGURE 13: AvT and TvA Solutions

wallet. If sufficient funds are available, the smart contract transfers the tokenized cash to the seller's on-chain wallet, finalizing the settlement.

- **TvA:**[4] in this configuration, the settlement involves a delivery leg on a DLT-based system (tokenized securities) and a payment leg in a traditional account-based cash system. In a Token vs. Account (TvA) environment, after the affirmation process, the security tokens are transferred on-chain from the seller's wallet to the buyer's wallet, according to the smart contract rules. Once the token transfer is executed on-chain, an oracle or bridge notifies the traditional financial system. A custodian or bank then verifies the transaction and processes the corresponding cash transfer in the off-chain banking system.

Despite the fact that these configurations could exploit bridges and oracles to coordinate the execution of both legs in order to achieve a near-atomic settlement, it is also possible to implement a configuration that follows the traditional settlement cycle. In such a setup, the two legs, the delivery of securities and the payment of cash are settled in separate phases, aligning with standard T+n settlement cycles rather than executing simultaneously. In this configuration bridges and oracles ensure the consistency of the reconciliation process between the on-chain and the off-chain leg. A hybrid solution could be easier to adopt in the initial stages by traditional financial systems, with less impact on both IT architectures and business models. Integrating bridges and oracles to provide a link within DLT environments could ensure smooth settlement flows and mitigate operational risks. An example of a hybrid infrastructure is given by the Bond-i, the first DLT-based tokenized bond, issued by the World Bank and arranged by the Commonwealth Bank of Australia (CBA). The Bond-i can be purchased and traded as a tokenized security on the chain, while the cash settlement occurs separately via fiat money in a traditional bank account.

Market Applications

Within the growing popularity of DLTs and DeFi environments, examples of the application of atomic settlement architectures have spread more widely. In particular, the following highlighted solutions carried out by consolidated financial institutions need to be cited:

- **JP Morgan's Kynexis:** previously known as Onyx, Kynexis is the private permissioned blockchain-based platform developed by JP Morgan that provides a scalable, and efficient infrastructure for digital payments, asset tokenization, and financial transactions. The platform relies on blockchain-based accounts where deposit tokens are stored and used to perform exchanges that allow assets, that were once recorded in separate ledgers, to be integrated into a single ledger, fostering atomic settlement of various assets and ensuring automated maturity with high precision. With transactions occurring on a single ledger, users have access to a consolidated and transparent record, enhancing clarity and efficiency in the settlement process.
- **SIX Digital Exchange (SDX):** SDX, powered by SIX Swiss Exchange, is a fully regulated blockchain-based asset exchange and central depository, adhering to FINMA requirements and strict legal and compliance standards. The SDX platform leverages blockchain technology to enhance transparency, speed, and automation in financial markets, offering several different services that comprehend digital asset issuance, trading, settlement, and custody. Leveraging the DLT structure, SDX ensures a near-simultaneous transaction settlement through atomic settlement procedures, in particular, the trading venue verifies with the DLT-based Central Securities Depository whether the participants have sufficient tokenized assets or tokenized cash available for the transaction before confirming it.
- **Euroclear D-FMI:** D-FMI is a DLT-based platform, developed by Euroclear, that supports the issuance, distribution, and primary market settlement of fully dematerialized international securities through its D-SI (Digital Securities issuance) service. The platform is fully interconnected with Euroclear's legacy platform, which permits tokenizing cash from legacy accounts into D-FMI's tokens. The primary market settlement will follow a fully atomic settlement environment, where instructions are entered, matched, and positioned in the D-FMI based on participants' securities and cash tokens. The bridges between D-FMI wallets and legacy ones permit the movement of securities into Euroclear accounts for secondary market trading.
- **Eurosystem DLT-based wholesale central bank money settlement:** the EU[10], with the goal of fostering an integrated European market for digital assets, conducted between May and November 2024 (the DLT pilot regime started on March 2023) a series of exploratory tests to assess the feasibility of the development of a DLT platform for wholesale transaction settlement processing over 200 transactions for a total value of 1.59 billion euros. During the trial, three different solutions were also tested to facilitate interaction between TARGET Services and DLT platforms. In February 2025[11], the ECB stated its intention to extend the initiative to settle

transactions recorded on DLT in central bank money through a two-track approach that consists:

  - **Platform Development:** the Eurosystem will, at the earliest feasible time, develop a DLT-based platform to settle transactions in central bank money while guaranteeing interoperability within the TARGET system. (A roadmap is still not disclosed yet and will be announced at the proper time).
  - **International Operations:** the Eurosystem will also explore a more integrated, long-term solution for settling DLT-based transactions in central bank money that will extend also to international operations (e.g. FX settlement).

- **The 2nd phase of the Stella Project of ECB and Bank of Japan:** the joint project of the ECB and BoJ examined the ways in which Delivery vs Payment settlement can be conceptually designed and technically achieved in a DLT environment, based on prototypes from three DLT platforms: Corda, Elements, and Hyperledger Fabric.
  - **Atomic Settlement on Corda:** project Stella tested the use of Corda for delivery versus payment (DvP) on a single DLT. In the test, the Corda network consisted of four nodes: two dedicated to cash and two dedicated to securities. The test used a "soft-locking" mechanism to prevent nodes from simultaneously using the same input states, with the possibility of unlocking them if the transaction remained pending for too long. Assets were self-issued by the cash and securities nodes, respectively for the buyer and the seller. The DvP transaction was executed in a single flow and finalized atomically, meaning that each update to the ledger was recorded simultaneously, preventing one participant from spending their balance without the others being able to do so.
  - **Atomic Settlement on Elements:** the test conducted on the Elements platform focused on executing Delivery versus Payment (DvP) transactions on a single distributed ledger. The Elements platform provided specific functionalities, such as the ability to issue multiple assets with encrypted identifiers and amounts, while maintaining auditability. The network used in the test consisted of multiple nodes that managed both cash and securities and relied on cryptographic mechanisms to ensure transaction security. On the Elements platform, transactions were executed using the Unspent Transaction Outputs (UTXO) model, which ensures that assets cannot be spent more than once. Consensus was reached through the verification of transactions by participating nodes, ensuring simultaneous and irreversible recording of transactions on the ledger, thus preventing double-spending risks.
  - **Atomic Settlement on Fabric:** in the Fabric network setup used in the Stella project, an order and two organizations have been used each managing a peer that acted as an endorser and a Certificate Authority. Atomic settlement on the Fabric platform was ensured through the use of the platform's endorsement policy. This policy included an "AND" condition, whereby the transaction was recorded on the ledger only if the results of the seller and buyer were identical. Delivery versus Payment (DvP) transactions were executed using chain code, which recorded each action in the platform's ledger. Each counterparties' balance was stored as a series of deltas in the state database to avoid using a single key representing the total balance.

Opportunities and Challenges of the Adoption of an Atomic Settlement Cycle

Atomic settlement based on DLT systems has the potential to profoundly innovate financial market infrastructures by allowing market participants to near-simultaneously settle securities transactions, thus reducing counterparty risk and increasing market efficiency. However, like other use cases of DLT technology, atomic settlement brings with it several challenges, primarily related to cybersecurity and the regulatory framework. The development of a financial system that exploits a DLT exchange environment that fosters the settlement through atomicity could create several enhancement opportunities:

- **Increased Efficiency and Speed:** DLT facilitates near real-time transaction processing, significantly increasing the speed of settlement. Traditional settlement cycles in financial markets can take up to several days (e.g., T+2 or T+3), while DLT-based systems can enable simultaneous settlement. This is particularly advantageous for financial institutions, for which delayed settlements can result in capital being tied up and liquidity constrained. Moreover, the absence of the role played by intermediaries results in a substantial reduction in transaction-related costs, as highlighted by Pinna and Ruttenberg[20], the crediting and debiting of investors' securities accounts could be performed with the same cost- and time-efficiency as that with which internalized settlement is currently carried out in the accounts of custodian banks. However, since it takes place in the distributed ledger, the segregation of securities in individual investors' accounts is carried out at no additional cost.
- **Principal Risk Reduction:** the use of DLT systems for securities transaction settlement could significantly mitigate the principal risk typically associated with traditional systems. In securities settlement, principal risk represents the risk that one party transfers securities or cash but does not receive the corresponding payment or asset in return, resulting in a significant loss. This risk can arise in any securities transaction, including those between financial institutions, banks, or between intermediaries and their clients. The atomic settlement, by ensuring a Delivery versus Payment (DvP) transaction, guarantees that the settlement of one obligation occurs if and only if the settlement of the linked obligation also takes place. This theoretically ensures a substantial reduction in the principal risk to which transaction participants are exposed. However, in single-ledger systems, the risk reduction is potentially total, as the securities leg and the cash leg are executed only in the final step of the process, and in case of failure to fulfill the obligation, the assets return to their original holders. In cross-ledger systems, the risk could arise if a counterparty fails to retrieve the securities before the expiration of the locking time, and the securities would be returned to the original holder who has already received the cash.

- **Cost Reduction:** a decentralized settlement system, by eliminating the need for intermediaries, can significantly reduce transaction costs associated with fees owed to Central Clearing Counterparties or settlement agents. According to a 2015 estimate, the use of DLT systems in the clearing and settlement market brings potential annual operational savings of up to approximately 20 billion dollars globally. Some of these efficiencies should have already been realized by market participants to date.
- **Increased Transparency:** as described in detail in Chapter 2, DLT provides a transparent and immutable record of all transactions on the ledger. Once a transaction is validated and added to the ledger, it cannot be altered or deleted. This ensures that the settlement process is transparent, reducing the potential for fraud and errors. The use of cryptographic algorithms in DLT ensures that only authorized participants can access transaction data, while the system remains transparent to all stakeholders. For further insights on the increased trust among market participants, see the paper by Catalini and Gans[5].
- **No need for cutoff windows:** in traditional securities settlement systems, cutoff windows represent specific periods during which transactions must be completed to be included in the scheduled settlement cycle. Currently, most securities are settled under a rolling cycle where trades are executed on day T and settled at a later date (typically one to three days later). DLT potentially enables the simultaneous transfer of assets between counterparties reducing the need for time-based coordination or windows. Unlike traditional settlement systems that require end-of-day or specific-time settlement windows to batch process transactions, DLT ensures that settlement occurs instantly, reducing settlement delays and by doing so reducing the time window in which one party may default after receiving its side of the transaction but before delivering its obligation. Furthermore, by eliminating cutoff windows, Atomic Settlement through DLT allows international financial markets to operate 24/7. At least on a regional level, traditional settlement systems already allow for instant transfers, as in the case of TARGET Instant Payment Settlement (TIPS) launched in 2018 by the Eurosystem to allow instant retail payments between banks across the EU to be settled in central bank money in real-time available 24 hours a day, 7 days a week, and 365 days a year.

Despite the opportunities for improvement and the potential benefits for the financial markets the development of an atomic settlement environment could create, the established procedures of financial markets and the necessary enhancement of technical infrastructures underlying a set of potential challenges that must be faced:

- **Technical Challenges:** the development of settlement systems based on blockchain technology requires the establishment of robust and reliable technological infrastructures. As well documented by Alshahrani et al.[1], current blockchain networks demonstrate inefficiencies in scalability, leading to problematic transaction per second (TPS) levels. For instance, Bitcoin and Ethereum can process between 7 and 20 transactions per second, with significant energy consumption. Considering the high volume of transactions processed daily by traditional financial infrastructures, the scalability and energy efficiency of blockchain technology represent a considerable challenge for market participants. To address this limitation, some blockchains, such as Ethereum, have already launched projects aimed at significantly increasing the number of transactions executed per second.
- **Security Risk:** although the decentralized nature of the chain makes DLTs less exposed to single points of failure, **Proof of Work (PoW)** and **Proof of Stake (PoS)** mechanisms are potentially vulnerable to cyber-attacks. A 2024 paper published by the Basel Committee on Banking Supervision has essentially confirmed that permissionless systems might be vulnerable to so-called "51% attacks"[3] in which a coordinated effort is put forward to control greater than 50% of the validation nodes or 50% of the staked native token and thus select which, and how, blocks are added to the blockchain. Furthermore, there is evidence of several smaller proof of work (PoW) blockchains that have experienced 51% attacks, but to date, no proof of stake (PoS) blockchain network has experienced a 51% attack.
- **Regulatory Challenges:** DLT-based atomic settlement introduces new regulatory and legal challenges. The existing regulatory frameworks in most jurisdictions are designed for traditional financial markets and intermediaries. As DLT eliminates the need for intermediaries, regulators face challenges in determining how to oversee and regulate decentralized networks. However, the Regulator has launched a series of regulatory initiatives aimed at creating a solid legal framework for assets traded on the blockchain [16].
- **Liquidity Constraints:** while atomic settlement mitigates principal risk, it may lead to liquidity constraints for market participants. In traditional systems, institutions have a time window (e.g., T+2) to settle transactions, allowing them to manage their liquidity needs more flexibly. Atomic settlement requires institutions to have sufficient liquidity or collateral at all times, which can be burdensome. As settlements are processed in real-time, atomic settlement systems would require banks to keep significant idle balances of money and assets. In a 2023 paper, FNA proposes a possible 'hybrid' solution to limit the liquidity absorption of atomic settlement, based on introducing an intermediate liquidity-saving service between the trading and settlement layers that clears transactions before they reach the settlement system. This service would slightly reduce the immediacy of some transactions but would still compress settlement times in wholesale markets by several orders of magnitude.

Implications of an Atomic Settlement Cycle on the Financial Market Infrastructure

The compression of the settlement cycles has always represented a fundamental shift in the core processes of financial markets with studies and market evidence showing that "efficient and timely processes reduce systemic risks and create resilient financial markets. Reduction of counterparty risk, increase in liquidity, and decrease in failure rates can all be achieved with shorter settlement cycles"[2]. In May 2024, the US moved from a T+2 settlement environment

to a T+1 settlement for all securities eligible for settlement in the Depository Trust and Clearing Corporation (DTCC); this marked a milestone in the discussion on the benefits that a shorter settlement cycle could bring into financial markets. Following the US example, other nations (e.g. UK, and Swiss) started to outline their strategy to implement a similar shift in the settlement process. In February 2025, the European Commission proposed to shorten the settlement period for EU transactions from T+2 to T+1 within October 2027. The reasons why regulators promote a reduction of the settlement cycle are various and comprehended, as outlined in Chapter "The Evolution of Settlement Cycles".

- **Greater Capital Efficiency;**
- **Reduction of Counterparty and Market Risk;**
- **Reduction of Principal Risk;**
- **Increasing Liquidity;**
- **Fewer Settlement Failures.**

However, the reduction of settlement cycles affects the process and procedures of all the market participants requiring also infrastructure investment to fulfill the new timely obligations. As the reduction of settlement cycles accelerates and the widespread adoption of innovative financial frameworks the potential integration of DLTs and atomic settlement processes could offer an efficient way to enhance settlement and reduce operational complexities related to stringent timelines. While atomic settlement could be crucial in enhancing post-trade processes, its widespread adoption as a new standard could lead to impactful changes across the financial industry. In particular, the development of an atomic settlement cycle will require the redesign of business processes and strategies, with significant investments in enhancing IT architectures, pushing some market participants to rethink their roles and responsibilities within the financial market.

Potential Impacts on Market Participants

Moving to an atomic settlement cycle, supported by technologies such as DLTs, will significantly affect the current structure of financial market infrastructure[**?**], which relies on a centralized, well-established framework for its function. In particular, the effects on CCPs, CSDs, and banks will be twofold, impacting the foundations of traditional business models and requiring significant investment in IT infrastructure and interoperability. Below, we explore the implications for each of these key market participants:

- **Central Clearing Counterparties (CCPs):** CCPs play a central role in the actual financial market infrastructure acting as the connection between trading counterparties fostering credit risk reduction and stability of the financial markets. CCPs fulfill several functions that aim to ensure the functioning of the current financial markets such as:
  - **Counterparty Risk Reduction:** CCPs interpose between trading counterparties to mitigate the whole credit risk of trades.
  - **Position Netting:** CCPs provide to offset multiple transactions to reduce the number of actual settlements. **Margin Management:** CCPs collect and manage the collateral amounts of market participants necessary to avoid potential losses even in volatile market conditions. This implies the day-by-day valuation of the collateral adjustments that ensure that market participants can cover their obligations.

  The introduction of DLT infrastructures necessary to support an atomic settlement cycle will deeply modify the roles that CCPs play, in particular:
  - **Smart Contracts and Netting:** smart contracts could automatically embed the conditions of transactions netting if needed, reducing the importance of a central function that fulfills it.
  - **Reducing Margin Requirements:** in a DLT environment atomic settlement occurs only if both counterparties dispose of assets at the time of the trade, under penalty of transaction failure, reducing the importance of margin management in financial transactions.
  - **Reducing Principal and Counterparty Risk:** since atomic settlement requires pre-funded assets to be locked before execution, the risk of counterparty default and failed settlement is significantly reduced. This diminishes the role of CCPs as risk intermediaries, making their involvement less critical in certain transactions.

  The evolution of a financial market and the settlement cycle to an atomic-environment will potentially change the whole role of CCPs. Rather than fulfilling risk management and settlement functions, CCPs could evolve into governance entities acting as the designer and guarantor of smart contracts and network rules and conditions. In this new framework, CCPs could serve as network validators, ensuring compliance, standardization, and security within a decentralized financial infrastructure.
- **Central Securities Depository (CSD):** CSDs represent another key player in the current financial market infrastructure, providing the custody of dematerialized securities, their book-recording, and facilitating the transfer ensuring transaction settlement. They fulfill several important functions that guarantee the proper functioning of the financial system, in particular:
  - **Custody:** since the advent of dematerialized securities CSDs fulfill the role of securities custody centralizers. They keep the official book records of securities ownership mitigating the risk of erroneous recording, unauthorized transfers, and fraud.
  - **Settlement Services:** after a trade is performed, CSDs facilitate the transfer of securities and the payment transaction, ensuring that both sides of the trade fulfill their obligations. This implies that CSD ensures that the delivery of securities occurs only when the payment of the deal is performed, guaranteeing also the conclusion of the transaction.
  - **Corporate Actions Management:** CSDs manage corporate actions related to securities. These include dividend payments, overseeing stock split and reverse stock split, rights issues, and bond coupon payments.

  The transition to a DLT-based financial environment that supports an atomic-settlement cycle will deeply modify the business model of CSDs, in particular:
  - **Record Keeping and Custody:** in a DLT-based environment, as analyzed in Chapter 2, once a transaction is executed and validated, the record becomes immutable and is instantly

updated across all nodes in the network. The DLTs exploit also consensus mechanisms to validate transactions before they are recorded ensuring the network against fraud.

  - **Settlement Activities:** in an atomic settlement environment, the legs of transactions are exchanged simultaneously and only if both the securities and the payment amount are available in the parties' wallets. The checks and locks of the necessary resources to perform the transaction are carried out by smart contracts which also ensure the automatic and simultaneous execution of both legs. These procedures will lower the necessity to have a central party to ensure that the settlement steps are fulfilled.
  - **Corporate Actions Management:** as for settlement procedures, even the management of CA could be performed automatically by smart contracts. These contracts would be programmed with the specific rules and rights governing corporate actions for the securities involved (e.g. the automatic payment of a bond coupon).

The role of CSDs in a DLT-based financial infrastructure could undergo a significant transformation. In particular, CSDs could develop and manage the DLTs on which transactions are executed and settled, acting as guarantors of the ledger's integrity and overseeing the proper execution of transactions. An example of this potential shift has already been demonstrated with the deployment of Euroclear's D-FMI.

- **Banks:** the shift from a T+n settlement environment to an atomic settlement cycle will deeply impact banks' business models, requiring the redesign of the infrastructure of lines of service and the restructuring of market strategies. In particular:
  - **Liquidity Management:** the actual settlement processes require transactions to be settled within n days (usually 1 or 2) after the trade is performed. The delay between execution and settlement to commit capital and securities in other operations, for instance, repos or O/N lending activities avoids capital from being idle. The main characteristic of atomic settlement is that in order to settle the transactions both capital and securities should be available and locked in each party's wallets to ensure a simultaneous transfer. The shift to atomic settlement means that capital and securities would no longer be as flexible for other operational uses. Banks would need to balance the need to provide liquidity for settlement with the costs of holding idle capital. In particular, under a positive rate regime, idle capital due to settlement requirements has a high cost, making it necessary to consider the cost opportunities for each operation that a bank would carry out with potential changes in how financial institutions deploy their capital. In addition, atomic settlement processes will have a huge impact on offsetting practices. Offsetting is a process where financial institutions net out multiple transactions, reducing both the amount of requirement capital needed and the number of transactions. For instance, in traditional settlement processes, netting allows firms to consolidate multiple trades, meaning they only settle the net difference instead of individual transactions, which helps save on liquidity. To lower the impact on banks' operations and ease the transition to a full atomic cycle, two solutions based on DLT could be developed:
    - **Transaction Fragmentation (ref. Figure 14):** after a transaction is performed smart contracts could be developed to reduce the transactions into smaller pieces each one settling through atomicity at a predetermined time but within the trade date. Consider for instance that in t, X and Y performed a share acquisition of 100.000 Euro:
      - In a full atomic environment smart contracts will check the resource's availability, lock them, and simultaneously transfer them between the wallets of two counterparties.
      - In a fragmented atomic environment, smart contracts will divide, for instance, the transaction into four smaller ones and will settle them through defined hours within the trade date. This will require the resource availability only at a determined hour within the day lowering the liquidity management challenge.
  - **Batched Atomic Settlement: (ref. Figure 15)** all trades conducted on a given trade date with a certain counterparty are aggregated by a smart contract, which automatically applies netting to offset positions. At the end of the trade date, smart contracts verify the liquidity requirements, ensuring that both parties have the necessary assets or funds locking the assets in each wallet. If the condition of availability is fulfilled then the settlement occurs simultaneously and atomically. This process will ensure an end-of-the-day atomic settlement ensuring the reduction of capital requirements to a standard atomic settlement environment.

Both of these solutions will be a strong middle way to improve financial innovation in banking and settlement procedures guaranteeing the atomicity of settlement but lowering the impact of near-real-time procedures will have on banks' business models. The eventual process of moving toward an atomic cycle could be smooth by developing hybrid solutions like the one above. Nevertheless, the introduction of a DLT-based market infrastructure environment will require important investments also in the IT architectures with the redesign of the flow chain between front office systems and their interactions within the back office structure with legacy systems that must be updated to ensure that they are capable of processing atomic settlements effectively. Also, banks and other market players should deploy solutions to enable interoperability within DLTs and other market platforms and develop effective bridge solutions and middleware that ensure structure and platform linkage and interoperability.

- **Custody and Depository Services:** banks, in particular depository banks, offer different lines of securities services related to the post-trade market cycle which include:

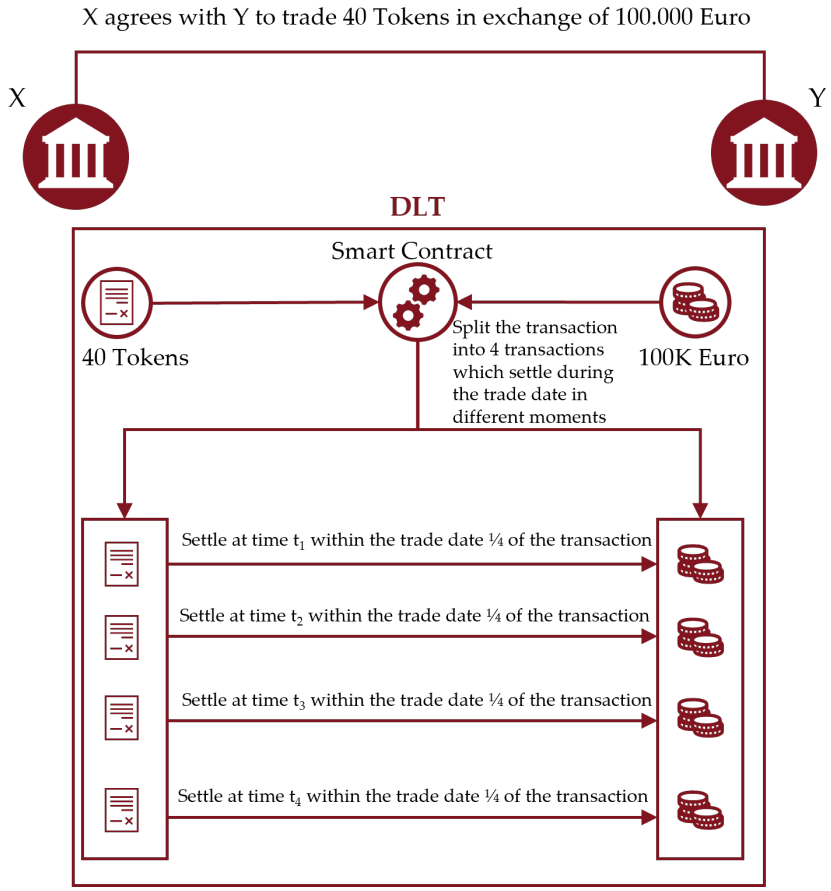


FIGURE 14: Transaction Fragmentation

- **Custody:** hold the safekeeping and the book records of their client's securities and cash accounts, ensuring ownership integrity and fraud avoidance.
- **Settlement:** interface with CSD on behalf of their clients to facilitate and ensure the correctness of transactions guaranteeing that securities are delivered, and cash payments are settled.
- **Collateral Management:** assist in the calculation of the margin requirements ensuring that clients provide the necessary collateral for derivatives trading or secured lending in order to avoid margin calls.
- **Corporate Actions Management:** manage the proper execution of CAs ensuring, for instance, the bonds' coupon payment and dividend distribution.

Reliance on DLTs to support the atomic settlement cycle will change how these services are carried out. As seen with CSDs, smart contracts could ensure the automatic and rigorous execution of each settlement operation and CA management, while the atomicity process will lower collateral management requirements. Asset custody on the other hand will be properly handled by the intrinsic features of DLTs. Considering so, banks could improve their services by implementing internal DLTs to handle and streamline custody and depository services. In a scenario where CSDs implement central DLT to manage the settlement-cycle activities, banks should build their DLTs to interface with it. This will require huge investments in the restructuring of IT architectures and collaboration among multiple actors in the markets to ensure interoperability and cross-chain settlement in a multi-platform environment. Despite that, banks through these new processes could foster the integrity of the process, lower operational risk, and cut costs in the long run.

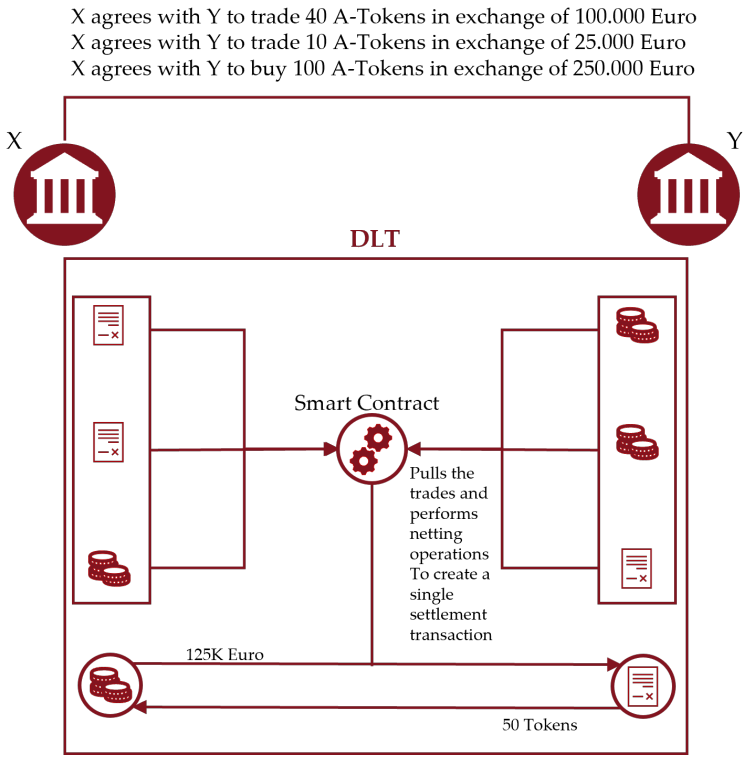


FIGURE 15: Batched Atomic Settlement

Conclusions

The transition to a T+1 settlement in the US has become an important milestone for the structure of the current financial market infrastructure. In fact, following the American example, other countries, including also the UE, have developed a roadmap to move toward a more compressed life cycle and others are analyzing the steps to develop their schedule. A shorter settlement lifecycle could bring several benefits to the financial system lowering the overall credit and counterparty risk, reducing the trade failures, and reducing the margin requirements ensuring a more stable financial market. The spreading popularity of DLTs and their potential impacts on the market infrastructure and the will to foster a shorter settlement cycle have highlighted the feasibility of moving forward with a near-simultaneous settlement cycle. The benefits of the atomic settlement are numerous and include:

- **Increased Efficiency**;
- **Principal Risk Reduction**;
- **Cost Reduction**;
- **Increased Transparency**.

Nevertheless, the invasive technological and methodological shift required to sustain the transition to a DLT-based atomic settlement cycle hides significant challenges for all the market players. In particular, a so drastic change will modify the roles and business models of the main intermediaries involved in the market requiring also huge capital investments in the restructuring and renewing of IT architecture and operations flow. Banks in particular could see their business strategy overturned with unavoidable impacts on their returns. The approach that has to be taken into consideration for a smooth potential transaction to an atomic settlement cycle will indeed require careful analysis that must inevitably gauge hybrid solutions that could help in both reducing the business and IT investment impacts, such as:

- Models that enable a less stringent liquidity requirement within the trade date;
- Models that rely on settlement batches and offsetting with the occurrence at the end of the trade date;
- Hybrid version of the two.

Other than that, in order to achieve positive outcomes in a transaction to a DLT-based market infrastructure that supports an atomic cycle is indeed required a collaborative approach among each market player to fulfill the necessary interoperability and linkage between platforms and architectures. To summarize, the compression of settlement cycles has proven clear benefits for financial markets. However, transitioning to a fully atomic environment introduces significant challenges for market participants. This shift necessitates careful consideration of the approach that should be followed to ensure a smooth and minimally impactful transition, balancing the advantages of instantaneous settlement with the well-established operational and business processes of financial institutions. Hybrid solutions, interoperability frameworks, and strategic IT investments will be crucial to mitigating impacts while maximizing efficiency and risk reduction.

References

[1] **Alshahrani, H., Islam, N. and Sulaiman, A.** *Sustainability in blockchain: a systematic literature review on scalability and power consumption issues.* Energies n.16, February 2023.

[2] **Arcodia, M., Ciminelli, V., Mazzoni, N. and Papetti, C.** *Accelerating Settlement: Potential Impacts of T+1 on European Settlement Cycle.* Just In Time, December 2024.

[3] **Atsumi, Y. et al.** *Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies.* BCBS, Working Paper n.44, August 2024.

[4] **Bech, M., Hancock, J., Rice, T. and Wadsworth, A.** *On the Future of Settlement Securities.* BIS Quarterly Review, March 2020.

[5] **Catalini, C. and Gans, J.** *Some simple economics of the blockchain.* NBER Working Paper Series, December 2016.

[6] **Ciminelli, V., Figuriello, J. and Mazzoni, N.** *Ensuring the Future: The Potential Evolution of the Insurance Market.* Argo n.27, December 2024.

[7] **Ciminelli, V., Mazzoni, N. and Morisani, G.** *Asset Tokenization: Potential Applications.* Argo n.25, April 2024.

[8] **Citi Securities Services.** *Beyond T+1: What's Next? The Continued Impact of Shortened Settlement Cycles.* Citi, 2024.

[9] **DTCC.** *Comments on Industry's T+1 Progress.* DTCC, 2024.

[10] **European Central Bank.** *Exploratory work on new technologies for wholesale central bank money settlement.* ECB Press Release, March 2024.

[11] **European Central Bank.** *Eurosystem expands initiative to settle DLT-based transactions in central bank money.* ECB Press Release, February 2025.

[12] **European Central Bank and Bank of Japan.** *Securities Settlement Systems: delivery-versus-payment in a distributed ledger environment.* STELLA - a joint research project of the European Central Bank and the Bank of Japan, March 2018.

[13] **European Commission.** *Proposal for a Regulation of the European Parliament and of the Council amending Regulation (EU) No 909/2014 as regards a shorter settlement cycle in the Union.* February 2025.

[14] **European T+1 Industry Task Force.** *High-Level Roadmap For Adoption Of T+1 In EU Securities Markets.* October 2024.

[15] **European Securities and Markets Authority.** *ESMA assessment of the shortening of the settlement cycle in the European Union.* November 2024.

[16] **Figuriello, J., Mazzoni, N. and Ranieri, M.** *MiCAR Supervisory Activities as part of EBA Priorities 2025-2027.* Just In Time, March 2025.

[17] **Hackel, J., Haunold, W., Hermanky, H. and Taudes, A.** *Distributed ledger technologies for securities settlement - the case for running T2S on DLT.* Monetary Policy & the Economy, Oesterreichische Nationalbank (Austrian Central Bank), January 2021.

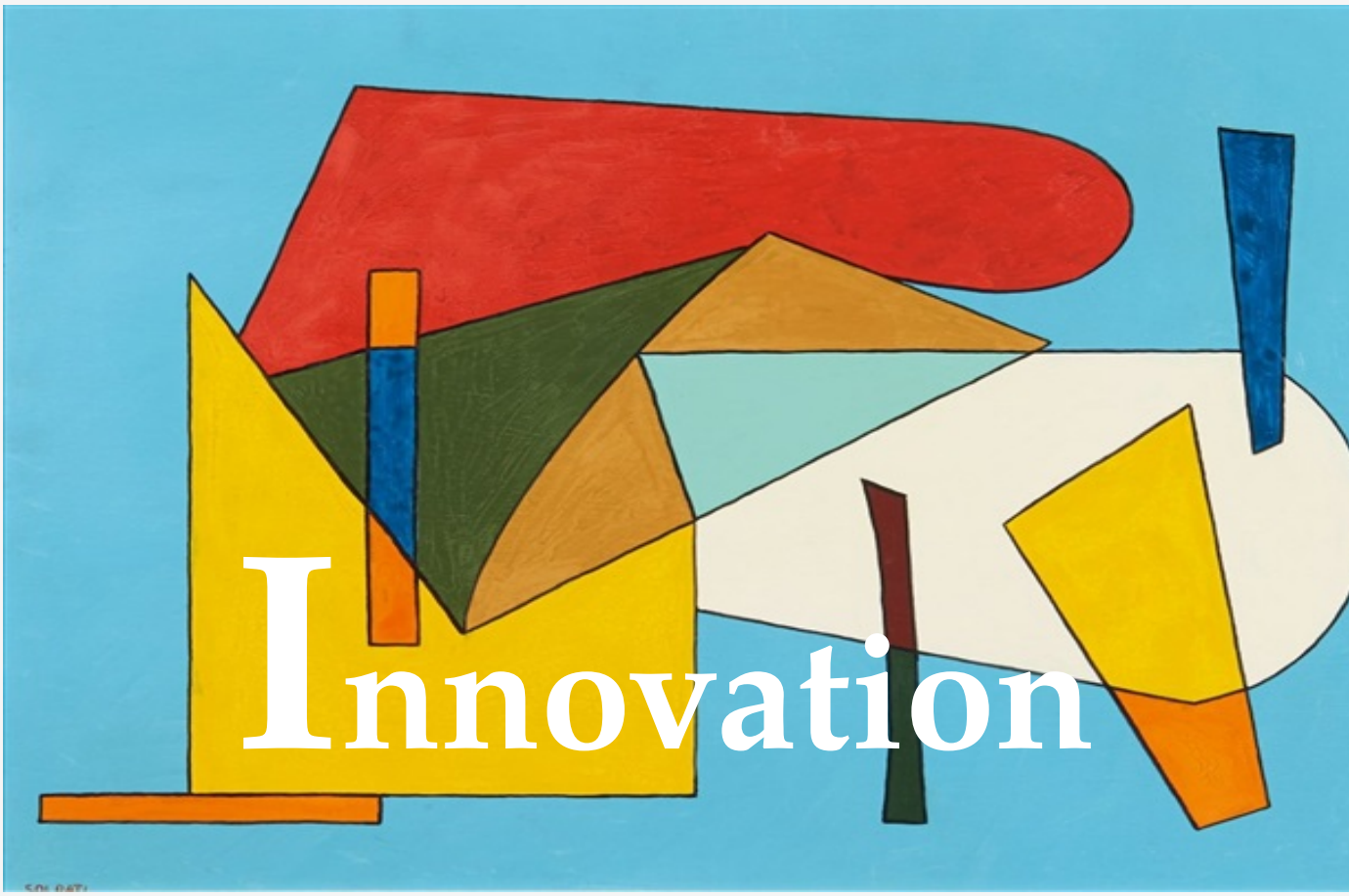
[18] **ICMA European Repo Council's Operations Group.** *The impact of T+2 settlement on the European repo market.* September 2014.

[19] **Lee, M., Martin, A. and Muller, B.** *What Is Atomic Settlement?* Federal Reserve Bank of New York Liberty Street Economics, November 2022.

[20] **Pinna, A. and Ruttenberg, W.** *Distributed ledger technologies in securities post-trading, revolution or evolution?* ECB Occasional Paper Series, April 2016.

[21] **Van Egghen, R.** *European fund performance significantly lags behind US peers after T+1.* Financial Times, August 2024.

[22] **Velar.** *The Role of Oracles in DeFi: Bridging the Gap Between On-Chain and Off-Chain Data.* Velar, October 2024.



CBDC For Financial Inclusion

Evidences from Sand Dollar and e-Naira

CBDC For Financial Inclusion

Evidences from Sand Dollar and e-Naira

Nicola Mazzoni*

The integration of technological innovation and sustainable development represents one of the main challenges for every actor within the global economic system. In particular, to build more efficient and resilient economic systems, the issue of financial inclusion has always played a key role, as emphasized in the United Nations (UN) 2030 Agenda, which highlights the importance of promoting economic systems that ensure universal access to basic financial infrastructure and services for all economic participants. This objective has been integrated into the United Nations (UN) 17 Sustainable Development Goals (SDGs). This study aims to analyze the potential effects that the issuance of a Central Bank Digital Currency (CBDC) could have in enhancing financial inclusion within an economic system. The first part of the research will introduce the key characteristics of CBDCs, highlighting the potential implications that issuing this innovative form of central bank money could have on an economic system. The second part will analyze the current state of financial inclusion worldwide and the main actions that could be taken to improve it within the economic system. Finally, the last part of the analysis will explore and assess the effects that the introduction of a CBDC could have in enhancing financial inclusion, examining both the theoretical implications and the observed impact of the Sand Dollar and e-Naira on financial inclusion in The Bahamas and Nigeria, respectively.

Financial innovation and digital advancements are leading to profound transformations in financial market infrastructure. While these changes are often associated with increased efficiency in payments and banking services, their potential impact on financial inclusion is equally significant, as they have the potential to bridge economic gaps by providing accessible, affordable, and secure financial services to unbanked and underbanked populations. This paper aims to analyze how Central Bank Digital Currencies (CBDCs) can foster financial inclusion by addressing barriers to financial access and promoting broader economic participation. Focusing on the effects of the first two issued CBDCs-the Sand Dollar in The Bahamas and the e-Naira in Nigeria-the study explores how digital financial tools can mitigate financial exclusion and expand economic opportunities. The analysis is structured into three main sections. The first section introduces the foundations of CBDCs, delving into their key features and architectural configurations. The second section examines the current state of financial inclusion worldwide, relying on the latest studies and data from the World Bank. The final section evaluates the real-world impact of the Sand Dollar and the e-Naira, assessing their design, adoption, and effectiveness in enhancing financial accessibility.

Central Bank Digital Currencies

The rapid development of digital innovation and the increasing use of new technologies within economic and financial systems have led to radical changes, both in terms of the products offered and the infrastructures on which they rely. In this context, the rise of digital payments and new native digital currencies (e.g., cryptocurrencies) has also prompted central banks to reconsider their internal models for managing and distributing money to avoid a diminished role as the focal point of the economic system. This scenario has led to growing interest in the study and development of Central Bank Digital Currencies (CBDCs). CBDCs are nothing more than Central Bank money[2] issued in digital form. They are issued at par with cash, fully representing their digital counterpart, which can be used for all the purposes for which physical cash is typically employed. This introductory chapter aims to outline the key characteristics that define CBDCs and the main implications and benefits they may bring to the economic system.

CBDC Environment

In literature, three types of models are typically distinguished for how a Central Bank can structure the "deployment of a CBDC":

- **Direct Model:** in this model, the Central Bank is responsible for all functions related to the management of CBDC. It records the issued CBDCs in its accounting books as liabilities and directly handles transaction settlement. Additionally, it performs tasks typically carried out by the private sector, such as user management (e.g., relationship management and onboarding activities).
- **Indirect Model:** this model delegates the management of CBDC-related activities, such as issuance and transaction processing, to the private sector, such as banks. The Central Bank's role is to guarantee the exchange parity between CBDCs and physical banknotes while also maintaining control over the total supply of CBDCs within the system.

*At the time of the writing of this article, the authors were working for Iason Consulting.

[2]Central Bank money is the money directly issued by a Central Bank and guaranteed by public authority and regulators. This has not to be confused with commercial money, which is the money detained in bank accounts and guaranteed only by the financial stability of the intermediary.

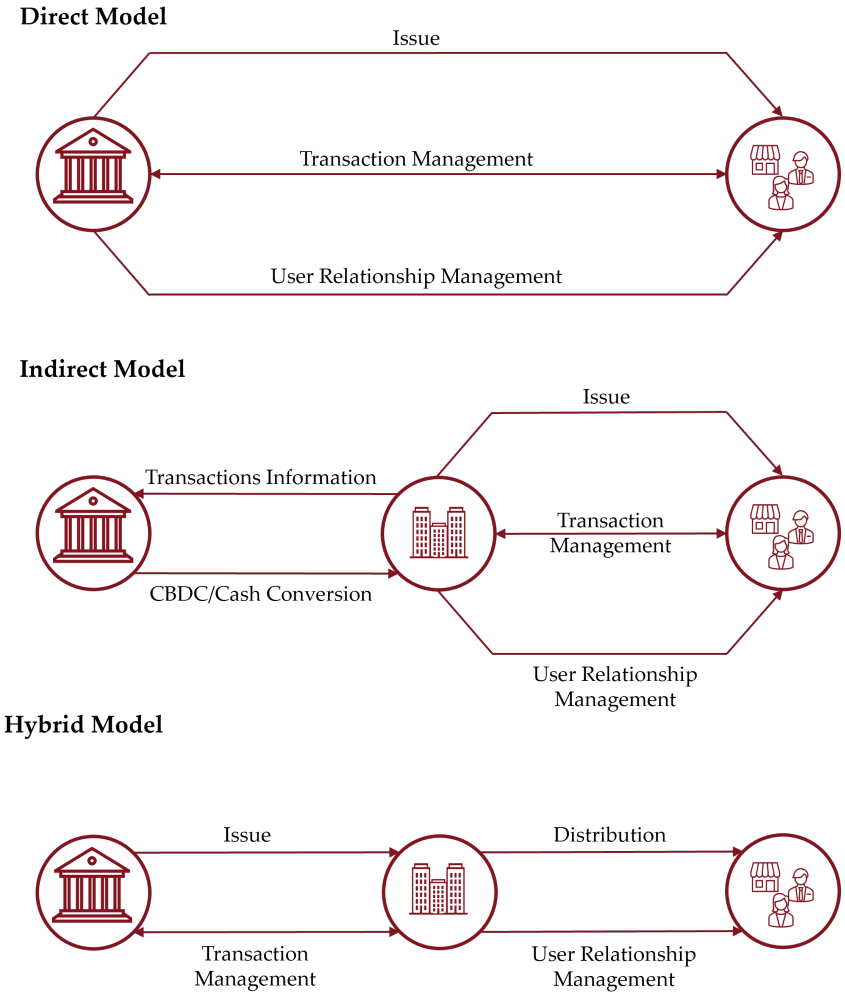


FIGURE 16: Distribution Models [9]

- **Hybrid Model:** compared to the previous two models, this approach divides responsibilities between the Central Bank and the private sector. The Central Bank handles CBDC issuance and transaction management, while the private sector is responsible for distributing CBDC within the economic system and managing user relationships.

The definition of the deployment model represents a key decision to determine the evolution of the CBDC as well as reflecting the strategic choices of the Central Bank, which, also based on this, will define the architectural model on which to build the CBDC environment. An architectural model defines the IT structure on which the whole CBDC model will be built, which can be identified in two possible architectural choices:

- **Centralized Model:** in this configuration, the CBDC is based on a traditional Ledger governed by a central entity, an electronic register that collects and manages financial transactions or data.
- **Distributed Ledger Technology (DLT) Model:** in this model, the CBDC will rely on a DLT, which is "a database distributed in identical copies among the nodes that compose the environment. The peculiarity of DLTs is that the ledgers among the nodes chain are simultaneously updated through a consensus mechanism. The node's network is in charge of the maintenance of the ledgers implying the continuous update of the information stored in the registries."[10] DLTs, depending on the governance and management of the system, can be divided into:
  - **Private Permissioned:** in which the network is managed by a single central authority that validates transactions and decides the participants in the network.
  - **Consortium Permissioned:** in which the network is managed by a limited number of trusted administrators.

Considering the characteristics of the main types of DLT, it is easy to find that, due to the type of instrument that CBDCs represent for Central Banks, the application of a decentralized network, such as a permissionless DLT, seems unlikely, both because of the lack of control over the network and the issues related to speed and scalability of transactions typically associated with this type of network. In contrast, the application of a permissioned network aligns with the objectives of Central Bank. In particular, the application of a private network would find its use in all the possible distribution configurations previously outlined, as it would tend to replicate the application of a traditional centralized model. However, the consortium model would be easily applicable in an indirect model, where the network of private operators acting as the main actors of the system (such as banks) could operate as the network managers.

Considering the technical features of CBDCs, the configuration through which transactions are verified, and how users can access and exchange rights related to digital currency covers a crucial role. In this context, two different

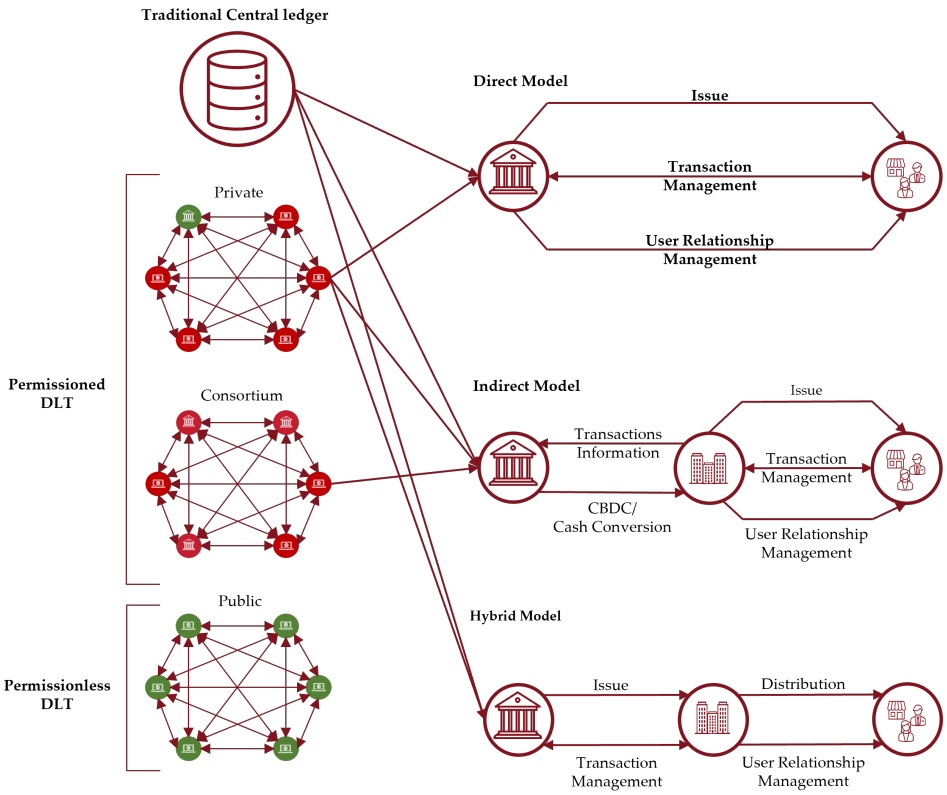


FIGURE 17: Architectural Models [9]

	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5
Sign up	In person	Remote	Remote	Remote	Remote
Authentication	ID and phone number	ID and phone number	ID and phone number	E-mail and phone number	E-mail and foreign phone number
Connected account	Yes	Yes	No	No	No
Balance limit	None	500.000	20.000	10.000	1.000
Transaction limit	None	50.000	5.000	2.000	500
Daily limit	None	100.000	10.000	5.000	1.000
Annual limit	None	500.000	100.000	50.000	10.000

TABLE 1: e-CNY Digital Wallets[9]

	Personal Wallet Liv.1	Personal Wallet Liv.2	Commercial Wallet
Sign Up	ID	ID and KYC controls	Corporate Documentations (e.g. Financial Statements) and KYC controls
Detention Limit	500 BSD	8.000 BSD	1.000.000 BSD
Daily Transactions Limit	1.500 BSD	10.000 BSD	Variable

TABLE 2: Sand Dollar Wallets

types can be distinguished:

- **CBDC Account-Based:** in this configuration, access to the CBDC mirrors the approach of bank accounts, meaning each user has their identity linked to a specific account through which CBDC operations are performed. The application of this typology brings:
  - A reduction in the level of privacy for users, as the user's identity is linked to the account.
  - No effects in terms of innovation and financial inclusion.

  However, an Account-Based CBDC will facilitate AML/CFT controls with a reduction in the architecture development costs, as this architecture is based on systems already widely used in traditional banking models. Additionally, with an Account-Based system, the Central Bank could "more adequately control the stock of digital currency in circulation...contributing to preserving monetary sovereignty"[2].
- **CBDC Token-Based:** the Token-Based approach, on the other hand, relies on cryptographic algorithms that allow the exchange of tokens only if private keys/codes are known. This model has many analogies with the Blockchain model and offers significant advantages in terms of both privacy and financial inclusion. However, the high level of privacy can lead to negative effects on KYC and AML activities and could also encourage an increase in fraud.

When issuing CBDC, a Central Bank must also consider which type of users it wants to distribute its digital currency to, thus distinguishing between:

- **Wholesale CBDC:** this type of CBDC is designed to be distributed only to financial institutions and aims to facilitate interbank transactions and the settlement of payments between various institutional players.
- **Retail CBDC:** this type of CBDC is designed to be distributed to the public, including private individuals and businesses. Retail CBDCs are issued with the goal of complementing cash within the economic system.

Implications of CBDCs on the Economic System

Since the early hypotheses regarding the possible creation of a Central Bank Digital Currency, studies, and analyses have sought to capture and hypothesize the possible effects that a CBDC could have on:

- **The Banking System**;
- **The Monetary Policy**.

Implications for Bank Industry

The main focus of studies on the potential effects of CBDC issuance on the banking system primarily revolves around two key topics:

- **Bank Run:** the introduction of a Central Bank Digital Currency that can be held directly in digital wallets could lead to a change in the preferences of individuals against bank deposits. This shift in preferences would be primarily due to the lower credit risk embedded in Central Bank currency compared to commercial money guaranteed by a private credit institution. In particular, the risk of a bank run would still be present even in models where digital wallets are managed by private institutions, as these, in order to maintain the characteristics of a Central Bank currency for the CBDC, would need to represent a segregated asset compared to the bank's own assets. In addition to the above, when issuing a CBDC, it must also be taken into account that the potential remuneration of this could further incentivize depositors to move away from the private system, thereby increasing the liquidity risk for the banking system.
- **Funding Cost and Credit Crunch:** shifts in preferences could also lead to a negative effect on the banks' funding activity, as, due to a lower deposit rate, they would have to use more expensive instruments (such as debt issuance) to support their fund-raising activities. The increase in funding costs would lead to a consequent increase in the cost of credit access, thereby generating a decrease in demand and a credit crunch effect on the economic system.

In order to reduce the potential negative effects that CBDC could have on bank industry, some solutions have been proposed:

- **Detention Limits**: the introduction of detention limits could help in mitigating run from bank deposits. For example:
  - **e-CNY:** the PBOC (People's Bank of China) introduced a system of holding limits for the e-CNY based on the identity verification levels of users, with a maximum limit of 1.000 CNY if the wallet holder's authentication is done remotely by providing only email and wallet details; and a maximum limit of 500.000 CNY if authentication is done in person by providing an ID and phone number (ref. Table 1).
  - **Digital Euro:** the ECB has confirmed, with the conclusion of the exploratory phase, that the Digital Euro will have holding limits, not yet defined for individuals; while businesses will always be required to maintain a zero balance of digital euros in their wallets. Therefore, every transaction made will trigger the waterfall mechanism (or reverse waterfall) that will deposit the Digital Euros received, converting them into euros, directly into the business's bank account.
  - **Sand Dollar (Bahamas):** the Sand Dollar has different detention limits depending on whether the user is a private person or a company (ref. Table 2).
- **Remuneration Limits (ref. Figure 18):** one of the main models theorized to guarantee a CBDC that offers remuneration, but at the same time does not become more attractive than bank deposits, was hypothesized by U. Bindesil[3]. This model foresees the introduction of two scenarios for the remuneration of the CBDC depending on the Deposit Facility Rate[3]. The model requires that, up to a certain amount of CBDC held, the remuneration of the CBDC will range between a maximum of 0% and the Deposit Facility Rate -1%, while beyond the holding threshold, the remuneration of the CBDC becomes punitive, settling at the minimum between zero and the Deposit Facility Rate minus 1%. According to the model, this configuration should ensure that, in a

[3] O/N interest rate that the ECB sets on the bank reserves deposited with it.

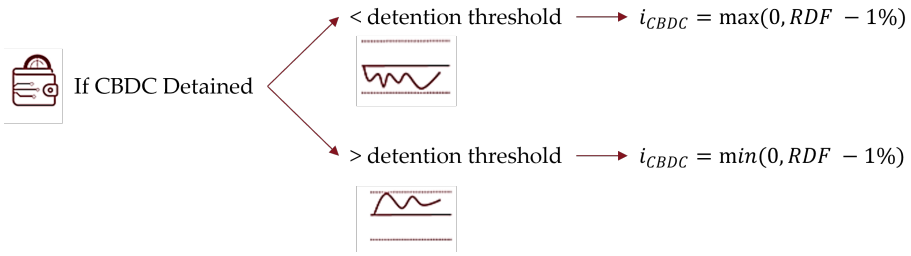


FIGURE 18: U.Bindseil Two-Tier Model

high-interest-rate environment, the remuneration of the CBDC is lower than that of bank deposits, while in a low-interest-rate environment, the remuneration rate offered on the CBDC should be zero or negative. In both scenarios, therefore, holding a CBDC should still be less attractive than bank deposits. In practice, in order to avoid competition between the digital currency issued and bank deposits, many central banks are considering or have designed their CBDCs with zero remuneration. Among these, can be mentioned: the Digital Renminbi, the Sand Dollar, the Digital Euro, and the e-Naira.

Implications for Monetary Policy

Three main implications are usually considered when analyzing the effects that the introduction of a CBDC can have on Monetary Policy:

- **Effects on Money Velocity:** "the introduction of a CBDC into the economic system could lead to a shift into the detention preferences of households and businesses that could prefer to fund digital wallets with CBDCs instead of detaining cash in their pockets or bank deposits. The implications of the possible shift in preferences could lead to severe causes affecting money velocity. The digital nature of CBDC could easily affect the monetary exchanges in the economic system as digital payments do not have the same physical barriers that characterize cash exchanges and also the settlement and the accounting of monetary units on the digital wallet will occur with a lower lag than the necessary time to deposit cash into bank accounts. Considering the Velocity of Money as:

$$V_t = T_n / M. \tag{1}$$

It is easy to figure that the increase of exchanges T_n driven by the digital nature of the CBDC could lead to an increase of the Velocity of Money, this could break the relationship between money and inflation affecting the monetary targeting of the Central Bank. In fact, looking at the relation between Monetary Mass and the GDP of a country defined by the equation:

$$M_t x V_t = P_t x Q_t; \tag{2}$$

$$P_t = (M_t x V_t) / Q_t, \tag{3}$$

where:

  - M_t: Money Mass[4];
  - V_t: Velocity of Money;
  - P_t: Average Price Level;
  - Q_t: Production.

  We can state that the average price level increases with increasing in the total money volume ($M_t x V_t$). So considering the Money Mass as a variable under the control of the Central Bank, is it clear that the possible quick growth of the transactions that a digital, unconstrained, central bank currency could carry should bring a steepen in the inflation levels"[9].

- **Open Market Operations:** among the potential effects that the introduction of CBDC may have on the banking system, the possible reduction of bank deposits due to a change in user preferences can be highlighted. A reduction in the level of bank deposits would lead to a chain reduction in the deposits held by banks at the Central Bank, impacting open market operations and the Central Bank's economic policy strategies. Again, the adoption of configurations that impose limits on CBDC holdings could mitigate these potential negative effects.

- **Seigniorage Income:** seigniorage income consists of the income generated by a central institution through the difference between the nominal value of the currency and the cost of printing and issuing it into the economic system. CBDCs can, on one hand, reduce the costs of printing money, but on the other hand, they may introduce new costs related to their issuance and maintenance, with potential negative effects on the seigniorage earnings of a state.

Potential Benefit Associated with the Issuance of a CBDC

The introduction of a CBDC does not only entail potential implications that require careful design and regulatory considerations by the Central Bank to mitigate the potential effects on the economic system but also brings benefits with significant positive impacts on both the economic and social systems. The introduction of the infrastructure supporting the issuance and management of a CBDC can indeed be a pivotal engine to increase the technological development of the economic system, with positive effects on both technological and financial innovation. The application of a technologically neutral framework based on a hybrid or indirect model can foster the development of innovative solutions by the private sector. Specifically, it could encourage the deployment of diverse innovative solutions to meet market needs, with beneficial effects on market competition. Financial innovation linked to the introduction of CBDCs could also promote improvements in cross-border transactions (e.g., the development of the mBridge project[4], which aims to implement a system for the exchange and interoperability of CBDCs). Another significant positive effect on society that could be generated by the introduction of a CBDC is the increase in financial inclusion, a CBDC that relies on digital wallets, could reduce the entry barriers

[4]The total average nominal amount of money in circulation in the economy.

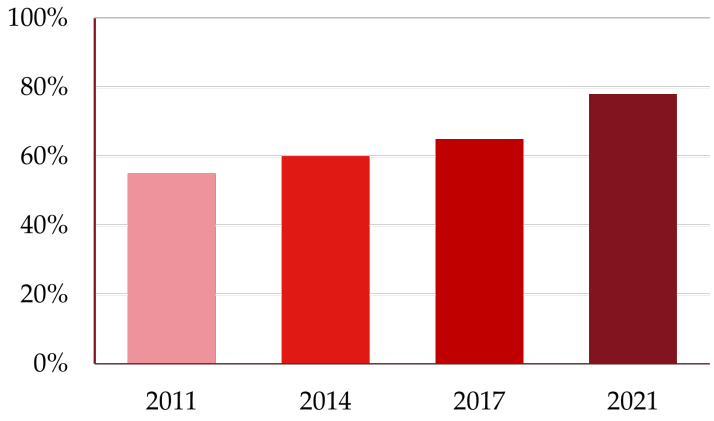


FIGURE 19: Worldwide Increase in Bank and Bank-Like Accounts

	2011	2014	2017	2021
Low Income	11%	18%	30%	38%
Medium Income	33%	44%	52%	60%
High Income	84%	89%	92%	96%

TABLE 3: Bank Account and Bank-Like Account Owners Growth divided by Economy

to the financial system for populations facing challenges in accessing the traditional banking system.
These challenges may include, for example, the costs associated with maintaining a bank account and the difficulty in providing the necessary documentation to open a banking account. The development of digital wallets could thus facilitate access to accounts that provide digital deposit and payment services without relying on the traditional banking system. This would help reach historically "unbanked" populations (in 2021, approximately 1.4 billion adults lacked access to a bank account). This principle relies also on the development of in-house solutions that offer essential services for CBDCs, such as providing digital wallets and payment services. These solutions have been deployed or are being considered by various central banks, such as the e-CNY app developed by the PBOC or the Digital Euro app hypnotized during the ECB's analysis of the Digital Euro.

Financial Inclusion

Financial inclusion refers to individuals within an economic system's ability to easily access essential financial services, enabling them to participate in the economy in a simple, effective, and sustainable manner. These services include:

- **Bank Accounts;**
- **Insurance Services;**
- **Payment Services.**

The importance of financial inclusion as one of the pillars that enable the sustainable development of a healthy economic and social system has also been recognized within the UN 2030 Agenda, which affirmed within the UN 17 SDGs (Sustainable Development Goals)[5] the importance of promoting economic systems that allow access to basic financial infrastructures and services for all actors in an economic system, as financial inclusion represents a key element for reducing poverty and supporting sustainable global economic growth.

Status of Financial Inclusion

A key indicator used to represent the state of financial inclusion in an economic system is based on evaluating the level of access to a bank account by economic system participants. Having access to a bank account enables the use of a wide range of essential financial services, such as electronic payments, money transfers, and easier access to the credit market. Therefore, an economic system in which all participants have access to this type of service is more efficient and resilient compared to an economic system lacking access to such services. According to the latest research conducted by the World Bank in 2021[6], 76% of individuals worldwide had a bank account (or an account providing similar services, such as a mobile payment service). Over the past 10 years, data showed exponential growth, with an increase from 51% in 2011 to 76% in 2021, representing an almost 50% rise (ref. Figure 19).
With a more detailed analysis of the data, it can be observed that in "low-income" countries, the growth rate of individuals with an account experienced a significantly higher increase during the 2011-2021 period compared to the same period in "middle-income" and "high-income" countries, reaching 236% (ref. Table 3, Figure 20).
During the 2011-2021 period, the following changes occurred:

- **Low Income:** increased from 11% to 38%, with a total growth of 236%;
- **Middle Income:** increased from 33% to 60%, with a total growth of 81%;
- **High Income:** increased from 84% to 96%, with a total growth of 13%.

[5] https://sdgs.un.org/goals

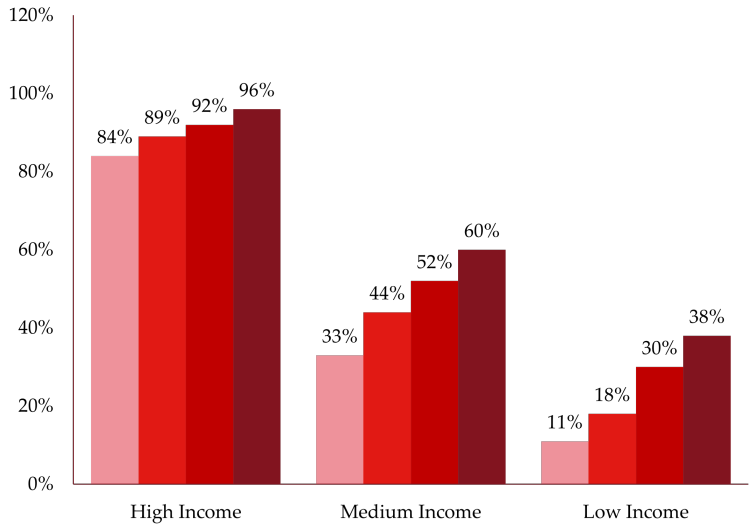


FIGURE 20: Bank Account and Bank-Like Account Owners Growth divided by Economy

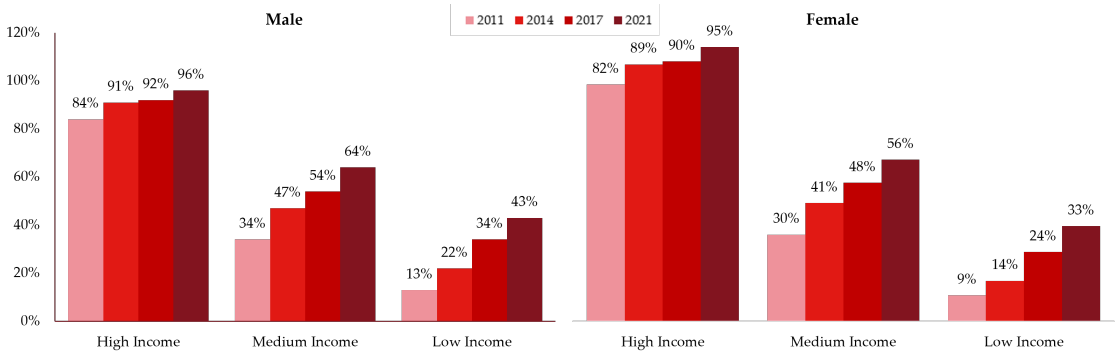


FIGURE 21: Gender Gap

Focusing on the gender gap within different economies, we can observe the following (ref. Figure 21):

- **Low Income:** as of 2021, the average rate of individuals with access to a bank account (or similar service) shows a 10% difference between men and women, a gap that has narrowed over the last three years (in 2017, the gap was 12%). The growth rate of individuals with access to an account has shown significant increases for both genders, with a +219% growth for men and +265% for women during the analysis period.
- **Middle Income:** as of 2021, the average rate of individuals with access to a bank account (or similar service) shows an 8% difference between men and women, which has remained relatively stable over the last three years. The growth rate of individuals with access to an account has increased for both genders, with a +77% growth for men and +87% for women during the analysis period.
- **High Income:** as of 2021, the average rate of individuals with access to a bank account (or similar service) shows only a 1% difference between men and women, which has decreased by about 2% over the last three years. This suggests that in higher-income economies, the gender gap in financial inclusion is virtually nonexistent. The growth rate of individuals with access to an account has increased for both genders, with a +11% growth for men and +16% for women during the analysis period.

Considering aggregate data about analyzed economies, 78% of men have access to a bank account (or similar service), compared to 74% of women, highlighting a general financial inclusion gender gap of 4%. Moreover, for the purpose of this analysis, it is important to note that in developing economies, bank account ownership tends to be lower in rural areas compared to urban areas. However, data on this comparison remains fragmented, making it difficult to establish a clear and comprehensive assessment. In particular, as highlighted by the World Bank in the report "Financial Inclusion, Digital Payments, and Resilience in the Age of COVID-19"[6], defining what constitutes an urban or rural area is challenging due to the heterogeneity of countries worldwide. As the report states: "What might be considered rural in Bangladesh or India, for example, might be considered urban in less populous economies."[6] However, using the proxy definitions of urban vs. rural determined by the Gallup World Poll survey, the World Bank's data reveals that, in the selected developing economies (Bangladesh, India, and Malaysia), there is no significant difference in account ownership between individuals living in urban and rural areas. Nevertheless, when analyzing the entire sample, the data shows an average 10% gap in bank account ownership between urban and rural inhabitants. Among the most notable cases, Laos stands out, where the difference between urban and rural areas reaches 39%. Similar disparities are also observed in Zambia and Cambodia. Overall, as seen in Figure 22, living in a rural area tends to be a barrier to financial inclusion across the sample analyzed (ref. Figure 22).

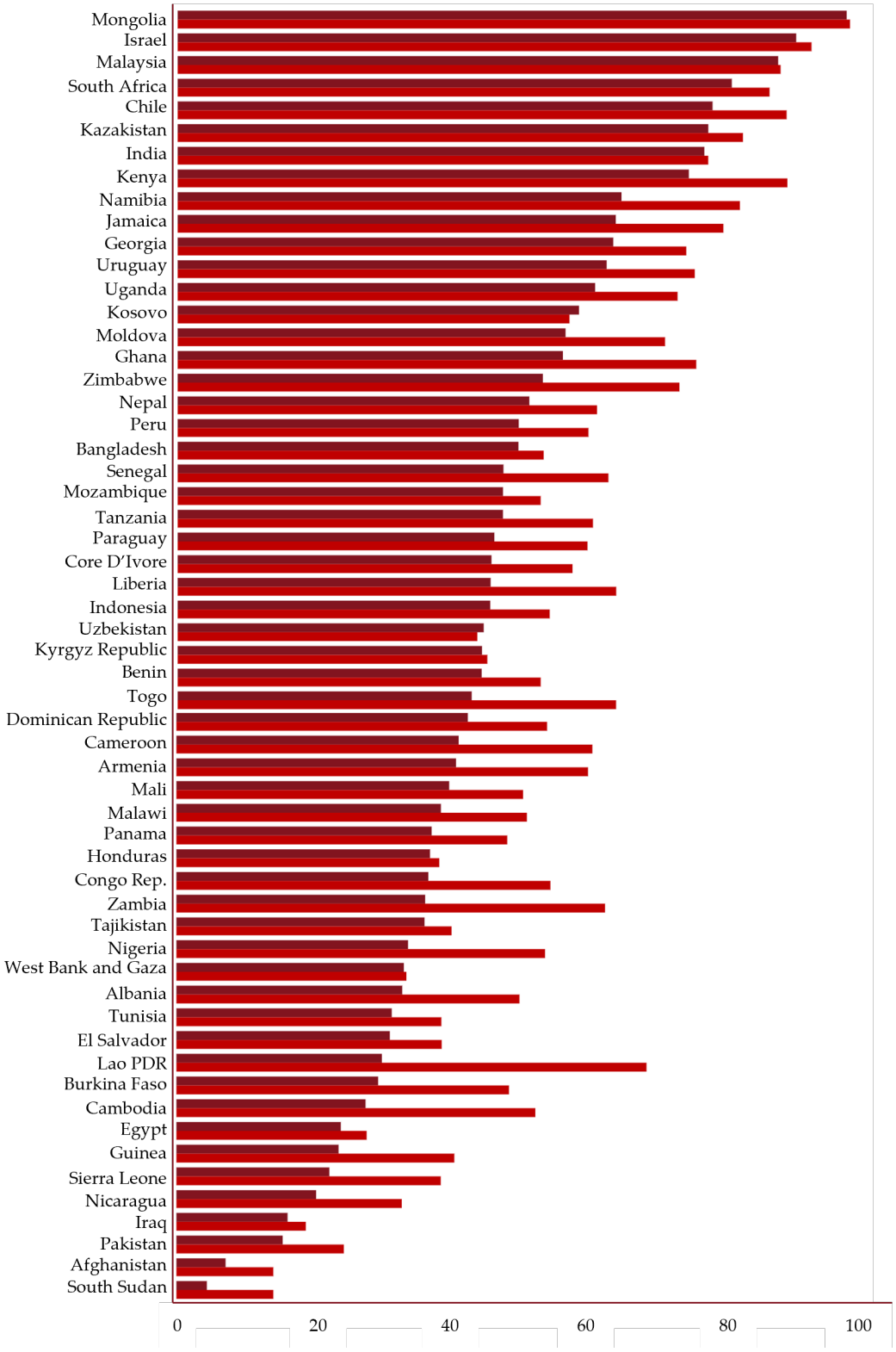


FIGURE 22: Urban-Rural Gap

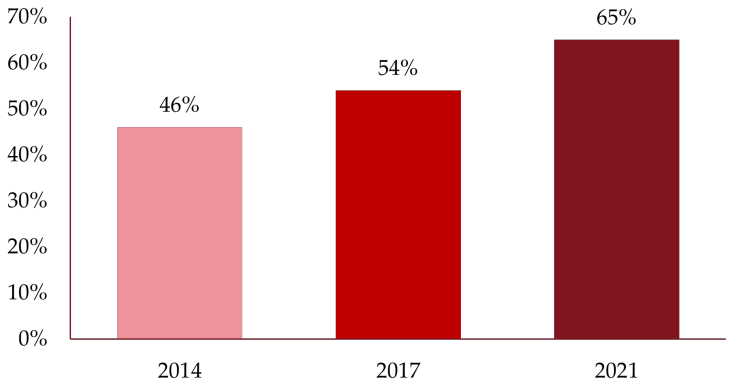


FIGURE 23: Mobile Payment Growth

Between 2014 and 2021, the number of individuals who made and/or received payments via mobile saw a substantial increase of +41%, reaching a total of 64% of adults worldwide in 2021 (equivalent to 84% of bank and bank-like account holders). The total increase in mobile payment usage by account holders was +27% from 2014 to 2021 (ref. Figure 23).
As reported by the World Bank[6], in high-income economies, 95% of adults in 2021 used a mobile service to make or receive payments, compared to 57% in developing economies. However, this latter figure should be viewed positively, as from 2011 to 2021, the growth in mobile payment users in developing economies registered an increase of +22%.

Potential Solutions to Increase Financial Inclusion

As previously stated, the ability to access essential financial services plays a key role in determining the sustainability and resilience of an economic system. In this context, the ability to access a bank account or receive money quickly is a key feature in enabling a population to cope with potential difficulties, even within relatively short timeframes. Furthermore, access to a bank account (or similar) can simplify access to the credit system, which in turn plays a fundamental role in any sustainable economic system. Currently, the global unbanked population stands at 1.4 billion individuals, including 740 million adult women, who still represent the majority among the unbanked adults. With about 52% of people excluded from the banking system belonging to seven countries:

- **India 17%**;
- **China 9%**;
- **Pakistan 8%**;
- **Indonesia 7%**;
- **Nigeria 5%**;
- **Egypt 4%**;
- **Bangladesh 4%**.

The main causes of financial exclusion include:

- **Monetary difficulties**, which would be aggravated by the costs of financial services and maintaining a bank account.
- **Distance from financial institutions**, especially in large rural areas, can be one of the major deterrents to entering the traditional banking system.
- **Having a household member with an account**, this point, especially regarding the gender gap, is more frequently indicated by women.

Key points to increase financial inclusion include the following:

- The implementation of effective policies that could reduce bureaucratic requirements for opening bank accounts (e.g., introducing alternative forms of identification).
- Introducing inclusive policies aimed at improving access to financial services for vulnerable populations, such as conditional transfers and/or subsidies.
- Foster the use of innovative technologies that can integrate into the current economic-financial system (Mobile Banking, Payment Apps, Digital Wallets, Blockchain, etc.).

These issues are closely related to the development of CBDCs. Specifically, as outlined in the first chapter, CBDCs could provide access to a digital payment system to a wide range of individuals, and the development of applications by Central Banks that enable the use of digital wallets and at least the minimum services related to the CBDC could effectively support this hypothesis. Additionally, the deployment of various types of wallets based on the granularity of the provided identification data, as implemented by the PBOC, would reduce the bureaucratic costs associated with opening a bank account and address issues related to obtaining official identification documents in some underdeveloped areas of the world. Furthermore, an economic system that guarantees a universally accepted digital payment tool, issued by the Central Bank itself, reduces the physical barriers posed by distance to traditional financial operators. To access such services, all that would be needed is the CBDC app. In the continuation of the analysis, we will focus specifically on the concrete effects that CBDCs could have on financial inclusion.

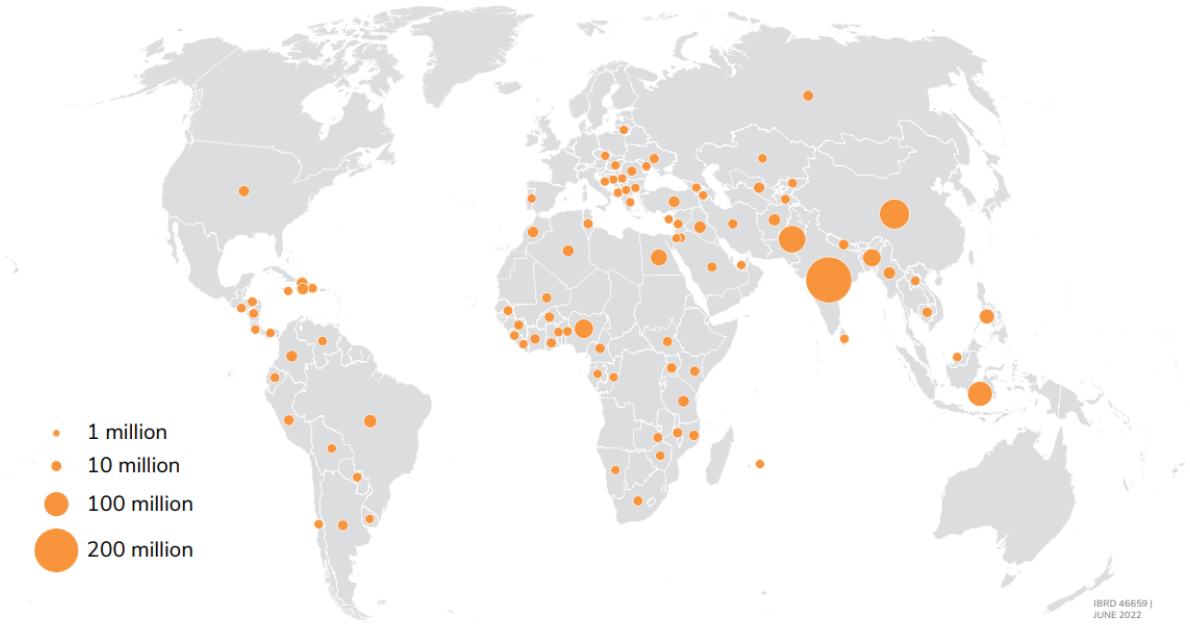


FIGURE 24: Unbanked Adults across the Wolrd[6]

CBDC For Financial Inclusion

The integration of technological advancements in financial systems can promote greater financial inclusion. Specifically, the introduction of a CBDC, supported by an adequate environment (e.g., digital wallets, apps developed by the Central Bank, reduced bureaucracy compared to the traditional financial system...), could play a key role in enabling individuals excluded from the traditional financial system to access various financial services. Literature[11] supports the potential increase in financial inclusion due to the issuance of a CBDC:

- The introduction of CBDC can act as a catalyst for the digitalization of the entire financial value chain. In particular, by offering businesses access to wholesale CBDCs, the Central Bank can encourage their integration into the digital financial system. This transition can generate benefits not only for financial inclusion within the economy, but also for greater transparency across various business processes, ultimately leading to a more efficient and resilient economic system.
- A CBDC can facilitate the use of financial services for all individuals within the economic system. A universally accepted digital currency, supported by an adequate technological infrastructure (e.g., apps, digital wallets...), can expand the number of users who can access financial services, such as wallet peer-to-peer transfers, without relying on cash or the traditional financial system.
- In systems that adopt a "technology-neutral" approach and an indirect or hybrid distribution model, the development of a CBDC can drive the development of various technological solutions leading to greater efficiency in the financial system, with positive spillover effects on financial access for participants in the economy.
- The availability of different types of digital wallets with varying levels of required identification information (and different levels of access to CBDC-related services) can allow individuals typically excluded from the traditional financial system due to a lack of credit history or valid identification documents to access financial services linked to CBDCs.
- The introduction of CBDC can also lead to a reduction, through digital wallets, in transaction and account maintenance costs, which often act as barriers to opening bank accounts in economies with higher poverty rates.
- The development of offline functionality can enable the continuous use of CBDCs even in regions with limited internet access. This prevents financial exclusion in countries with lower network coverage.

While theory suggests that CBDCs could have a positive impact on financial inclusion, it is essential to evaluate the actual outcomes of CBDCs already deployed. In the following sections, we will analyze the real-world impact of the Sand Dollar and e-Naira on financial inclusion in the Bahamas and Nigeria.

Sand Dollar

The Sand Dollar is the CBDC issued by the Central Bank of The Bahamas, launched in October 2020 (following a pilot conducted in 2019 in the Exuma district). It was the first CBDC to be developed and issued on a national scale. The main goal that inspire CBoB to analyze and develop a CBDC was to increase access to financial services among the population of The Bahamas. In fact, financial service access has often been a challenge within the archipelago. In 2018, 18% of the adult population in the Bahamas was unbanked, mainly due to the following factors:

- The geographical structure of The Bahamas (an archipelago of approximately 700 islands) entails high commuting costs for individuals wanting to open a bank account, as some smaller islands lack bank branches[14].
- The de-risking process undertaken by large international banks led to a significant reduction in the

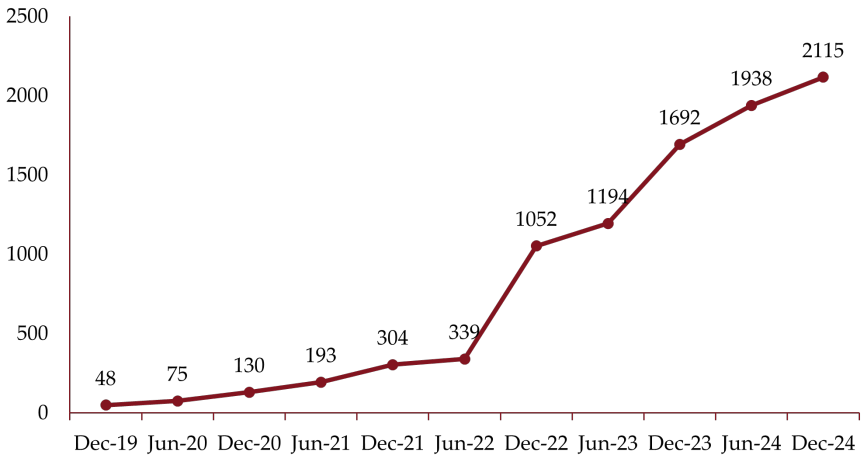


FIGURE 25: Total Amount of Sand Dollar, Data in Thousands of Bahamas Dollars

number of bank branches operating within the country.

- The cost associated with opening a bank account has often been a barrier for the population of the archipelago.

Thus, in order to increase financial inclusion within the country and modernize the payment system, the Central Bank of The Bahamas with the deployment of the Sand Dollar established the following goals:

- Enhancing the efficiency of the payment system in The Bahamas through safer transactions and faster settlements;
- Providing non-discriminatory access to payment systems, regardless of age, immigration status, or residency;
- Achieving greater financial inclusion, economic convenience, and expanded access to financial services across all of The Bahamas;
- Strengthening national defenses against money laundering.

In this context, considering the widespread adoption of mobile devices (96% of the adult population), the introduction of a fully digitalized Central Bank currency, supported by an environment that enables secure and controlled financial transactions, could reduce barriers to entry and increase the use of financial services among the population of the archipelago.

Features

The Sand Dollar is a CBDC that does not accrue interest and is issued at par with the Bahamian dollar, and Since the Bahamian dollar is pegged 1:1 to the US dollar, the Sand Dollar is also effectively pegged 1:1 to the US dollar. The Sand Dollar operates on an indirect two-tier model, in which:

- The Central Bank of The Bahamas issues the Sand Dollar and distributes it to authorized financial institutions (banks, payment service providers);
- Authorized intermediaries provide CBDCs, digital wallets, and facilitate transactions for individuals and businesses.

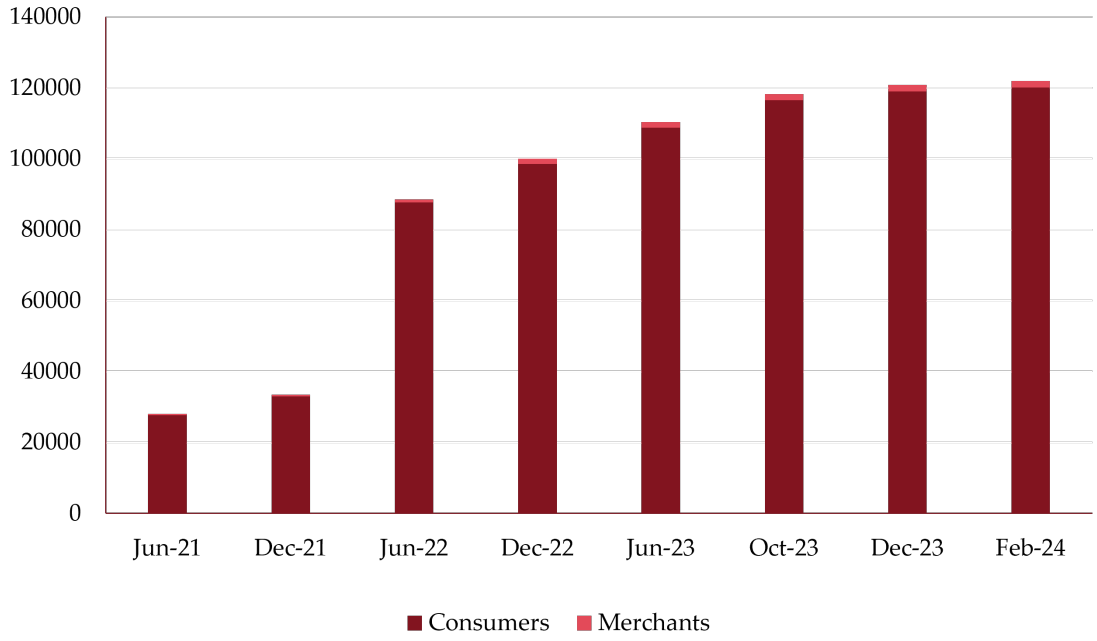
Sand Dollars can be deposited in a digital wallet provided by authorized financial institutions. CBoB has set different types of wallets, categorized based on the level of information required, deposit limits, and monthly transaction limits:

- **Tier 1:**
  - **Deposit limit:** 500 Sand Dollars;
  - **Monthly transaction limit:** 1.500 Sand Dollars;
  - **KYC requirements:** No specific KYC requirements.
- **Tier 2 (Premium Wallet):**
  - **Deposit limit:** 8.000 Sand Dollars;
  - **Monthly transaction limit:** 1.000.000 Sand Dollars;
  - **KYC requirements:** Valid government-issued ID from The Bahamas.
- **Tier 3 (Merchant Wallet):**
  - **Deposit limit:** 1.000.000 Sand Dollars;
  - **No transaction limits**;
  - **KYC requirements:** Bank account connection and valid business license.

To ensure interoperability between devices and providers, CBoB has developed an app (Sand Dollar App) to support exchanges and transactions with the Sand Dollar. Additionally, the Sand Dollar also supports offline transactions, in fact, by leveraging technologies such as Bluetooth and NFC, individuals, in the absence of a network connection, can connect their devices and exchange Sand Dollars. In this scenario, transaction validation is carried out directly by the individuals involved in the transaction on their devices. Once the network is restored, the digital wallets are updated, reflecting the changes that occurred offline.

Financial Inclusion Results

Since the introduction of the Sand Dollar in 2019, the total amount of Sand Dollars in circulation has steadily increased, from 48.000 Sand Dollars in December 2019 to over 2 million in February 2024. It is interesting to note that since June 2022, there has been an increase of over 500% (ref. Figure 25).
Similarly, the total number of Sand Dollar wallets has seen a constant increase over time, reaching a total of 121.901



	Jun-21	Dec-21	Jun-22	Dec-22	Jun-23	Oct-23	Dec-23	Feb-24
Consumers	27.671	32.905	87.682	98.551	108.707	116.493	118.991	120.101
Merchants	372	565	813	1.429	1.622	1.732	1.797	1.800
Total	28.043	33.470	88.495	99.980	110.329	118.225	120.788	121.901

TABLE 4: Active Sand Dollar Wallets

at the beginning of 2024, of these, 120.101 are consumer wallets (Tier 1 and Tier 2 wallets) and 1.800 are merchant wallets (Tier 3 wallets), with a total increase of 300% since 2019 (ref. Table 4). Considering the total adult population (approximately 320.000 individuals), we can highlight that 38% of the adult population has potentially opened a Sand Dollar wallet.

Despite the encouraging figures, it is important to highlight that the current amount of Sand Dollar in circulation corresponds to only 0.5% of the total money supply within the archipelago. This indicates that the adoption and use of the CBDC remain marginal among the population compared to the Central Bank of Bahamas' objectives of increasing financial inclusion. However, the CBoB is continuously carrying out various initiatives to further integrate the use of the Sand Dollar into the daily habits of the population, specifically:

- **Integration of the Sand Dollar with the Automated Clearing House (ACH):** in 2022, the CBoB completed the integration of the CBDC with the automated clearing system of commercial banks. This allowed Tier 2 wallet holders to transfer funds directly from bank accounts to Sand Dollar wallets via online banking platforms. Additionally, since 2023, the reverse functionality has been introduced, enabling users to transfer funds from wallets back to bank accounts.
- **Partnership Strategies with Commercial Banks:** by 2025, the Central Bank of Bahamas aims to strengthen its dialogue with commercial banks to simplify the issuance and adoption processes of the Sand Dollar. The goal is to enhance Sand Dollar adoption among commercial bank customers.

During his speech at last year's CBDC Conference, S. Porter (Central Bank of Bahamas) outlined the future financial inclusion objectives for the Sand Dollar. "In terms of financial inclusion, we expect that in the near future, the Sand Dollar will be an ubiquitous form of digital money that does not require traditional banking services. This will help us to reach the under-served communities, where we see unbanked and under-banked individuals, and we can include them in basic financial services"[13].

E-Naira

In October 2021, the Central Bank of Nigeria (CBN) officially launched its own CBDC, the e-Naira, making Nigeria the second country, after the Bahamas, to officially issue a nationwide CBDC. The primary goals of the CBN in issuing the e-Naira are:

- **Increasing Financial Inclusion:** Nigeria has a high percentage of unbanked individuals, equal to 26% of the total adult population. However, 93% of these individuals have access to a smartphone[1]. Based on these considerations, the CBN decided to implement its CBDC to provide financial services to those with a smartphone but without a bank account. Initially, access to an e-Naira wallet was only possible for individuals with a bank account. However, since August 2022, it has become possible to activate a wallet directly from a smartphone without requiring a bank account.
- **Strengthening the Online Payment System:** following the COVID-19 pandemic, there has been continuous and rapid growth in the use of e-payments, re-

flecting a significant shift in consumer habits worldwide. This trend is also evident in the Nigerian economy, where, after 2020, online transactions increased by 113%, leading to a decline in cash usage. In this evolving payment landscape, CBN implemented the e-Naira with the dual objective of preserving the role of central bank money and strengthening the country's electronic payment system.

- **Enhancing Transparency:** like many African countries, Nigeria has a significant share of unregistered transactions. By developing a CBDC as a payment method, the CBN aims to make transaction tracking more transparent and efficient, thereby reducing the impact of the "informal economy" within the country. The increase in cashless transactions could also help mitigate inflation, which now is near 25% (at the end of 2024 exceeded 30%) and has remained in double digits for over a decade. According to Ozili[12], reducing cash usage as a payment method could decrease the accumulation of banknotes outside the banking system, leading to direct positive effects on inflation reduction. Additionally, limiting the use of cash for untraceable speculative activities could further contribute to lowering inflation.

Features

The e-Naira is a non-interest-bearing CBDC, exchanged at parity with the Naira, and operates under a two-tier indirect model, where:

- The Central Bank of Nigeria (CBN) is responsible for the issuance and settlement of e-Naira transactions, leveraging a private, permissioned DLT system. Additionally, CBN monitors the total stock of e-Naira in circulation and oversees all transactions to ensure regulatory compliance and security.
- Financial institutions handle the distribution of e-Naira to individuals and the management of digital wallets.

CBN has introduced different types of wallets, categorized based on user type and the level of personal information required during wallet creation. Each wallet tier has specific limits on holdings and transaction values:

- **Wallet Tier 0**:
  - **Target Users**: retail individuals, including those without a bank account;
  - **Requirements**: only a mobile phone number (no personal identification required);
  - **Transaction Limit**: 20.000 Naira per day;
  - **Holding Limit**: 120.000 Naira.
- **Wallet Tier 1**:
  - **Target Users**: retail individuals, including those without a bank account;
  - **Requirements**:
    - Mobile phone number;
    - Photo ID;
    - Basic personal information (name, date of birth, etc.);
  - **Transaction Limit**: 50.000 Naira per day;
  - **Holding Limit**: 300.000 Naira.
- **Wallet Tier 2**:
  - **Target Users**: retail individuals with a bank account;
  - **Requirements**:
    - Bank Verification Number (BVN);
    - Photo ID;
    - Basic personal information verified against the bank database;
  - **Transaction Limit**: 200.000 Naira per day;
  - **Holding Limit**: 500.000 Naira.
- **Wallet Tier 3**:
  - **Target Users**: retail individuals with a bank account;
  - **Requirements**:
    - Bank Verification Number (BVN);
    - All information required under Nigerian AML/KYC regulations;
  - **Transaction Limit**: 1.000.000 Naira per day;
  - **Holding Limit**: 5.000.000 Naira.
- **Wallet Merchant**:
  - **Target Users**: businesses;
  - **Requirements**:
    - Existing bank account;
    - Tax Identification Number (TIN);
    - BVN of the CEO/Managing Director;
    - Email address;
    - Valid business registration certificate;
  - **Transaction & Holding Limits**: no restrictions.

To facilitate interoperability across devices and service providers, the CBN developed the e-Naira Speed Wallet app, to support seamless transactions using the e-Naira. Since 2022, the e-Naira also supports offline transactions, developed in collaboration with telecommunications companies (Telcos). This functionality operates through a USSD-based service, accessible via the code *997#, allowing users to transact without an internet connection or smartphone. The USSD system was chosen over alternative peer-to-peer authentication methods to expand e-Naira accessibility among rural populations, where banking penetration is low and digital literacy is limited.

Financial Inclusion Results

Despite the efforts made by the Central Bank of Nigeria to promote the spread of e-Naira, the adoption of the CBDC within the country is currently slow. Since its release, the e-Naira has faced slow adoption by individuals, with the number of wallets opened at the end of 2021 standing at only 860.000 (out of an adult population of about 130 million people). Although data published by the International Monetary Fund[8] shows that the total number of e-Naira wallets is now around 13 million (a significant increase since its launch), it should be noted that approximately 98% of these are currently inactive. Furthermore, since its launch, e-Naira transactions have accounted for an average of about 0.0018% of the country's M3 money supply. Despite the results from these early years showing slow adoption of the CBDC within the country, and therefore a limited effect on increasing financial inclusion of the population, this could partly be due to the gradual release of e-Naira features by the CBN. As already explained, in the initial period after its release, e-Naira wallets were available only to individuals who already had a bank account, while the functionality for conducting offline transactions was only made available in 2022. Additionally, it should also be considered that, as

shown by network dynamics, the increase in the use of the CBDC and the expansion of its adoption by businesses and merchants as a payment method may generate a gradual increase in the spread of the CBDC and a shift in individuals' preferences.

Conclusions

As reported, financial inclusion has proven to be one of the main drivers in central banks' decisions regarding the implementation of CBDCs already deployed in the market. The literature and theory[5] have shown that the issuance of CBDC within an economic system can lead to positive impacts on financial inclusion within that system. In particular, the issuance of CBDC can lead to a generalized increase in financial inclusion within an economic system through:

- The introduction of different types of wallets that require different levels of information to be opened. The possibility of not necessarily needing a bank account and not having to undergo complex identification processes (as with the e-Naira) can allow even unbanked individuals to access a service similar to deposits.
- The implementation of a CBDC that allows offline transactions also ensures service continuity and availability of funds even if the issuing country does not guarantee full internet coverage across the entire territory. This way, even individuals living in areas with limited network access could still benefit from basic financial services such as deposits and transfers.
- The implementation of a national app could ensure a "minimum" level of service, as well as interoperability between all the solutions present in the system. Furthermore, through this, governments could be facilitated in making money transfers and subsidies to the less affluent segments of the population.
- The development of a "technologically neutral" context could also lead system operators to implement both innovative solutions and new types of products that meet the needs of different customer segments.

However, as shown by the data related to Sand Dollar and e-Naira, the introduction of a CBDC, in practice, does not have clear and immediate effects on the development of financial inclusion within an economic system. In this regard, the historical series available is still not very relevant, and the real effects will need to be studied in detail over the next few years. It should, however, be undelighted that, despite the speed at which financial inclusion has increased often not meeting the expectations of the issuing central banks, the results still show a slight trend towards improving the situation within the system in which these are introduced. It should also be specified that, although there has been a recent increase in online transactions in favor of a reduction in the use of cash, the change in individuals' habits, especially when these are "imposed" or "suggested" by a regulator, requires timeframes that are not always measurable in the short term. Aware of that, some central banks, to foster their CBDC programs and facilitate a post-release broad adoption, have chosen to adopt strategies to include all the relevant stakeholders through collaborative and involvement practices in the development and design of the CBDC. For instance:

- **Digital Euro:** the European Central Bank[7] is proactively promoting several initiatives to fulfill the expectations of all internal and external stakeholders. In particular, to understand the needs of stakeholders, the ECB has scheduled several touchpoints to shape a Digital Euro that fulfills market needs, in particular:
  - **Financial Market Participants:** technical sessions where, for instance, the CBDC effects on banks' deposits are analyzed in order to calibrate the detention limits.
  - **Merchants:** the ECB promoted and attended different category conferences and round tables to both introduce the Digital Euro project and gather insights from merchants.
  - **General Users:** for instance, user research analyses have been conducted to gather insights about detention limits and user segmentation.
- **E-CNY**: The PBOC[9] since 2020 prompted an intensive stakeholder engagement strategy, in particular:
  - **Pilots:** several pilots involving different cities and regions have been developed by the PBoC since 2020 (e.g., Shenzhen, Suzhou, Xiong'an, Chengdu) to gather important insights related to user payment habits and future feature development.
  - **Payment Systems Integration:** other than traditional financial intermediaries such as banks, the PBoC is involved in the e-CNY design process with several important FinTech corporations and payment service providers, such as Alipay and WeChat Pay, with the goal of deploying an integrated environment for the usage of e-CNY.
  - **National and International Events:** leveraging relevant events, such as the 2022 Beijing Winter Olympics, the PBoC, in collaboration with merchants and payment service providers, permitted the usage of e-CNY by athletes, tourists, and residents-even without a Chinese bank account-to gather important data about the usage of the CBDC.

Therefore, to provide an overall judgment on the effect that the issuance of a CBDC may have on increasing the financial inclusion of a country, we will need to wait for both the increase in issuing countries of CBDCs and for the supporting data to cover longer periods of time.

References

[1] **A2F.** *Access to Financial Services in Nigeria*. December 2023.

[2] **Barucci, E.** *Euro Digitale.* Egea, May 2023.

[3] **Bindseil, U.** *Tiered CBDC and the financial system.* ECB Working Paper Series n. 2351, January 2020.

[4] **BIS Innovation Hub.** *Project mBridge: Connecting economies through CBDC.* Bank for International Settlements, October 2022.

[5] **Brandon, J.T.** *Central Bank Digital Currency and Financial Inclusion.* IMF Working Paper 23/69, March 2023.

[6] **Demirguc-Kunt, A., Klapper, L., Singer, D. and Ansar, S.** *Financial Inclusion, Digital Payments, and Resilience in the Age of COVID-19.* July 2022.

[7] **European Central Bank.** *Progress on the preparation phase of a digital euro-Second progress Report, Progress on the preparation phase of a digital euro.* 2024.

[8] **International Money Fund.** *2024 Article IV Consultation-Press Release; Staff Report; Staff Statement; and Statement by the Executive Director for Nigeria.* May 2024.

[9] **Mazzoni, N., Mori, G. et al.** *Exploring the Digital Renminbi: Insights into China's CBDC.* Argo n. 26, July 2024.

[10] **Mazzoni, N., Ciminelli, V. and Morisani, G.** *Asset Tokenization: Potential Applications.* Argo n. 25, April 2024.

[11] **Ozili, P.K.** *Can central bank digital currency increase financial inclusion? Arguments for and against.* MPRA Paper 110786, University Library of Munich, Germany, November 2021.

[12] **Ozili, P.K.** *Using eNaira CBDC to solve economic problems in Nigeria.* MPRA, May 2023.

[13] **Porter, S.** *CBDC Conference, Istanbul.* September 2023.

[14] **Rolle, J.** *How the Tiny Bahamas Beat Global Giants in the E-Currency Race.* May 2021.

Sitography

[15] **Central Bank of Nigeria.** *Website*.

[16] **Central Bank of The Bahamas.** *Website*.

[17] **eNaira.** *Website*.

[18] **International Monetary Fund (IMF).** *Website*.

[19] **Sand Dollar.** *Website*.

[20] **United Nations Sustainable Development Goals (SDGs).** *Website*.

[21] **World Bank.** *Website*.

EBA Final Guidelines on the Management of ESG Risks

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EBA Final Guidelines on the Management of ESG Risks

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*The **EBA Guidelines on the Management of Environmental, Social and Governance (ESG)**[3] risks establish minimum standards for the **identification, measurement, management**, and **monitoring** of ESG risks within financial institutions. These risks, including climate change, biodiversity loss, and governance deficiencies, impact traditional financial risks and require forward-looking assessment methodologies. Institutions must **integrate ESG risks into business strategies, risk appetite frameworks, and the ICAAP**, conducting periodic materiality assessments based on qualitative and quantitative data. The guidelines mandate robust data governance and the adoption of assessment methodologies based on exposure, sector, and scenario analysis, considering short-, medium-, and long-term time horizons.*

***Climate stress testing and scenario analysis** are essential tools for enhancing resilience, requiring the **development of transition plans** aligned with ESG regulatory objectives. These plans must include strategic targets, risk indicators, and sectoral policies. Large institutions must comply by 2026, while small and non-complex institutions (SNCI) have until 2027.*

*Challenges in ESG data standardization necessitate more advanced methodologies and greater regulatory coordination. A first step toward the **data standardization** is represented by the adoption of **European Sustainability Reporting Standards (ESRS)** or **voluntary reporting standard** for non-listed Small and Medium-size Enterprises (SMEs). The collection of information disclosed by counterparties in accordance with such standards enables institutions to leverage robust and homogeneous **data** for the **adoption of advanced methodologies**. The implementation of these guidelines strengthens risk management, improves financial stability, and supports the transition to a sustainable economy, mitigating reputational and regulatory risks while fostering a proactive ESG risk culture.*

Climate change, biodiversity loss, social issues, and other environmental, social, and governance (ESG) factors represent and will continue to represent significant challenges for the economy. Events such as the occurrence of **acute** and **chronic physical risk** events and the **transition** toward a **sustainable economy** are driving profound **economic transformations** that, in turn, impact the **financial sector**. This is due to its critical role both in supporting the transition to a climate-neutral and sustainable economy, as envisaged by the *Paris Agreement*, *the United Nations 2030 Agenda for Sustainable Development*[15], and the *European Green Deal*[8], and in managing financial risks associated with this transition and/or arising from other ESG factors.

Environmental risks will have an increasingly significant impact due to the possible combinations of **transition risks** and **physical risks**, as well as their strong **interconnections** with **all traditional financial risk categories**. Furthermore, the counterparties with which institutions interact may also be subject to negative consequences arising from **social factors**, such as human rights violations, demographic changes, digitalization, health or labor conditions, as well as **governance factors**, including deficiencies in executive leadership, corruption, or bribery practices. These factors, in turn, can generate financial risks that institutions must assess and manage. The **practices adopted** by financial intermediaries for understanding, identifying, and measuring these risks, characterized by their forward-looking nature, distinct impacts across different time horizons, and limited availability of relevant historical data, **vary significantly across institutions**.

Supervisory colleges' monitoring activities and supervisory authorities' experience indicate that **ESG risk management** remains in its **early stages**, with significant room for development. For most EU institutions, established practices for managing ESG risks other than climate-related ones are still emerging. Despite progress in recent years, significant shortcomings have been observed in the integration of ESG risks into corporate strategies and risk management frameworks. These **deficiencies** could pose substantial **challenges** to the **soundness and stability of institutions** as the EU advances in its transition toward a more sustainable economy and as the materialization of ESG risks intensifies.

To ensure the resilience of an institution's business model and risk profile over the short, medium, and long term, including a time horizon of at least 10 years, these **guidelines** issued by the EBA set **minimum standards** and **reference methodologies** for the **identification, measurement, management**, and **monitoring** of **ESG risks** for institutions.

In particular, institutions are required to regularly assess the **materiality of ESG risks** to which they are exposed through robust data management processes and a combination of methodological approaches, including exposure-based, portfolio-based, sector-based, portfolio alignment, and scenario-based methodologies.

Institutions are also required to **incorporate these risks** into operational **processes** such as risk appetite framework, internal controls, and ICAAP. Furthermore, in accordance with *Article 76(2) of Directive 2013/36/EU*[10], institutions must develop **specific plans**, using a risk-based approach, to address risks arising from the **transition** and **adaptation** of the economy to the regulatory ESG objectives of the jurisdictions in which they operate. To this end, institutions must evaluate and **integrate ESG risk** considerations into their **strategic plans, policies**, and **risk management processes** through a transition planning framework that accounts for short, medium, and long-term time horizons.

Guidelines

The guidelines issued by the EBA[3] specify, in accordance with *Articles 87a(1) and 74 of Directive 2013/36/EU*[10], the risk management processes and governance frameworks for the identification, measurement, management, and monitoring of ESG risks over the short, medium, and long term that institutions should implement as an integral part of their broader risk management framework. In particular, they address:

- **Minimum standards** and **reference methodologies** for the **identification, measurement, management** and **monitoring** of environmental, social and governance (ESG) risks;
- **Qualitative** and **quantitative criteria** for the **assessment** of the **impact** of ESG risks on the risk profile and solvency of institutions in the short, medium and long term;
- The **content of plans** in accordance with *Article 76(2) of Directive 2013/36/EU*[10] which shall include specific timelines and intermediate quantifiable targets and milestones, in order to monitor and address the financial risks stemming from ESG factors, including those arising from the process of adjustment and transition trends towards the relevant Member States and Union regulatory objectives in relation to ESG factors.

Furthermore, these guidelines serve as a supplement and clarification to the EBA Guidelines on Internal Governance[4] and the EBA Guidelines on Loan Origination and Monitoring[5] concerning the management of ESG risks. The EBA expects these guidelines to be adopted by institutions other than small and non-complex institutions from 11 January 2026, whereas for small and non-complex Institutions, the adoption is expected from 11 January 2027.

Reference Methodology for the Identification and Measurement of ESG Risks

The guidelines identify the reference methodologies for the following areas:

- Materiality assessment;
- Identification and measurement of ESG risks;
- Data processes;
- Main features of reference methodologies for the identification and measurement of ESG risks.

Materiality Assessment

In defining the reference methodology for the identification and measurement of ESG risks, the EBA establishes that institutions shall conduct a **regular assessment of the impact** of such risks **on all categories of traditional financial risk** to which they are exposed, including the following: credit risk, market risk, liquidity risk, operational risk (including legal risk), reputational risk, business model risk, and concentration risk.
Institutions are required to conduct this assessment at least annually, or for small and non-complex institutions (SNCIs) every two years, unless exceptional circumstances necessitate a more frequent update. In particular, the assessment must be reviewed in the presence of significant changes in the operating environment, such as the adoption of new relevant public policies or substantial modifications to the business model, portfolio composition, or the institution's operations.

The materiality analysis of ESG risks should be carried out using a **risk-based approach** that integrates both quantitative and qualitative information. This approach should consider the financial impacts of ESG risks **across different time horizons**, including the short and medium term, as well as a long-term period of at least 10 years. Such a framework ensures a proportionate and institution-specific assessment that duly accounts for the nature, scale, and complexity of financial activities, portfolio exposures, and service offerings.
In the assessment process, institutions should adopt a sufficiently comprehensive framework for analyzing environmental factors. In particular, when examining the drivers of physical and transition risk, they must take into account at least the following elements:

1. For **transition risks**:
   - The **main economic sectors** that the financed assets support or in which the institution's counterparty has its principal activities;
   - Ongoing and potential **future** material **changes** in **public policies, technologies** and **market preferences** (e.g. new environmental regulations or tax incentives, development of innovative low-carbon technologies, shifts in consumer or investor demand);
   - With respect to **climate-related risks**:
     - Exposures toward **sector** that **contribute** highly to **climate change** with particular consideration given to exposures towards fossil fuel sector entities;
     - The **degree of alignment or misalignment of portfolios** with the relevant **regulatory objectives** of the jurisdictions where they operate - for SNCIs and other non-large institutions at least on the basis of a high-level qualitative assessment.
2. For **physical risks**:
   - The **geographical areas** in which key **assets** of counterparties (e.g. production sites) and, in particular for real estate exposures, **physical collateral** is located;
   - The **vulnerability** level to **environmental hazards** (e.g. temperature-related, wind-related, water-related, solid mass-related hazards) associated with different **climate scenarios** and **transition pathways** or, for SNCIs and other non-large institutions, associated with at least one adverse scenario.

Institutions should substantiate and document as part of their ICAAP their materiality assessments of ESG risks, including methodologies and thresholds used, inputs and factors considered and main results and conclusions reached, including non-materiality conclusions.

Identification and Measurement of ESG Risks and Data Process

As part of the minimum standards for the identification and measurement of ESG risks, institutions should adopt a **forward-looking approach** that considers the impacts of these risks over the short, medium, and long term. In particular, the assessment of the potential impact of ESG risk drivers and their transmission channels on traditional risks and financial risk metrics should be conducted with a level of granularity and accuracy of data points, quantification

tools, methods and indicators, proportionate to their materiality assessment, as well as to the size and complexity of the institution. This level should generally be higher for short- and medium-term horizons, while the long-term horizon should be considered at least on a qualitative basis.
With regard to **environmental risks**, the internal procedures and methodologies adopted should enable institutions to:

- **Quantify climate-related risks** by estimating the probabilities of materialization and the magnitude of financial impacts stemming from climate factors.
- Properly understand the **financial risks** that may result **from other types of environmental risks**, such as those stemming from the degradation of nature, including biodiversity loss and the loss of ecosystem services, or the misalignment of activities with actions aimed at protecting, restoring, and/or reducing negative impacts on nature.
- **Establish key risk indicators (KRIs)** covering at least short- and medium-term time horizons and a scope of exposures and portfolios determined in line with the results of the materiality assessment.

With regard to **social and governance risks**, institutions should, at a **minimum**, conduct a **qualitative assessment** of their impact on operations and financial risks, progressively developing more advanced approaches in line with regulatory and scientific developments, data availability, and methodological advancements.
Finally, in assessing the **interconnections between different categories of ESG risks**, internal procedures should initially provide for a separate measurement of each risk, taking into account its specific characteristics, before considering potential interdependencies and interconnections in the measurement of these risks.

Data Processes

Institutions should have internally implemented **robust and up-to-date information management systems** at the institution-wide level to identify, collect, structure, and analyze the data necessary to support the assessment, management, and monitoring of ESG risks within the overall data governance framework and IT infrastructure.
The internal procedures implemented should **collect data at both the client and activity level**, leveraging both internal and external sources, with a degree of granularity appropriate to enable institutions to assess, manage, and monitor both current and forward-looking ESG risks to which they may be exposed through their counterparties.
Among the different sources of data, a particularly significant role is played by the information disclosed by counterparties in accordance with **European Sustainability Reporting Standards** or **voluntary reporting standard** for non-listed Small and Medium-size Enterprises (SMEs).
Where institutions rely on **third-party providers** for access to ESG data, they should ensure an adequate understanding of the sources, data, and methodologies employed by the data providers, including any limitations. If the **quality or availability of data is insufficient** to meet risk management needs, institutions should adopt and document **corrective actions**, such as the use of estimates or proxies based on sectoral and/or regional characteristics, incorporating adjustments to account for counterparty-specific factors.
For **large corporate counterparties** (*Article 3(4) of Directive 2013/34/EU*[9]), institutions should collect the following data, where applicable:

1. For **environmental risks**:
    - Geographical location of key assets (e.g. production sites) and exposure to environmental hazards (e.g. temperature-related, wind-related, water-related, solid mass-related hazards) at the level of granularity needed for appropriate physical risk analysis, and availability of insurance.
    - Current and, if available, targeted greenhouse gas (GHG) scope 1, 2 and 3 emissions in absolute value and, where relevant, in intensity value.
    - Dependency on fossil fuels, either in terms of economic factor inputs or revenue base.
    - Energy and water demand and/or consumption, either in terms of economic factor inputs or revenue base.
    - Level of energy efficiency for real estate exposures and the debt servicing capacity of the counterparty.
    - The current and anticipated financial effects of environmental risks and opportunities on the counterparty's financial position, financial performance and cash flows.
    - Transition-related strategic plans, including transition plan for climate change mitigation disclosed in accordance with *Article 19a or Article 29a of Directive (EU) 2022/2464*[11], when available.
2. For **social and governance risks**:
    - Alignment with the OECD Guidelines for Multinational Enterprises, *"UN Guiding Principles on Business and Human Rights and International Labour Organisation Declaration on Fundamental Principles and Rights at Work"*[14].
    - Negative material impacts on own workers, workers in the value chain, affected communities and consumers/end-users including information on due diligence efforts or processes to avoid and remediate such impacts.

For exposures to **counterparties other than large enterprises**, institutions should:

- **Determine the data points needed** for the identification, measurement and management of ESG risks;
- Where needed to address **data gaps**, use **expert judgment, qualitative data, portfolio-level assessments and proxies**.

Main Features of Reference Methodologies for the Identification and Measurement of ESG Risks

Internal methodologies for risk assessment used by institutions should incorporate a combination of exposure-based, sector-based, portfolio-based, and scenario-based approaches. In particular, to achieve a comprehensive analysis of ESG risks across all relevant time horizons, institutions should:

- Utilize **exposure-based** methods to obtain a **short-term** view of the impact of ESG risks on counterparties' risk profiles and profitability;
- Adopt **sector-based, portfolio-based**, and **scenario-based methods** to support **medium-term planning**, the definition of **risk limits**, and **risk appetite**;
- Apply **scenario-based methodologies** to assess their sensitivity to ESG risks across **different time horizons**.

Exposure-Based Methods

To assess the exposure of counterparties' activities and key assets to ESG factors, particularly environmental factors and the effects of climate change, as well as the adequacy of the mitigation measures adopted, institutions should incorporate these factors - placing particular emphasis on environmental ones - into their **internal risk classification procedures**. In line with the provisions set out in paragraphs 126[6] and 146[7] of the *EBA Guidelines on Loan Origination and Monitoring*[5], these factors should be considered in the assessment of a borrower's default risk and, where relevant, integrated into risk indicators, internal credit scoring or rating models, and collateral evaluation.
When assessing environmental risks at the exposure level, institutions' internal procedures should include a **set of risk factors and criteria** capable of capturing both **physical and transition risk drivers**. For **large institutions**, these should, where applicable, include at least the following aspects:

- The degree of vulnerability to environmental hazards, taking into account the geographical location of the key assets of counterparties and guarantors, or of the physical collateral backing the exposures, considering both on-balance sheet and off-balance sheet exposures.
- The degree of vulnerability to transition risks, taking into account relevant technological developments, the impact of applicable or forthcoming environmental regulations affecting the sector of activity of the counterparty, the current and if any targeted GHG emissions in absolute and, where relevant, intensity value of the counterparty, the impact of evolving market preferences, and the level of energy efficiency in the case of residential or commercial real estate exposures together with the debt service capacity of counterparties.
- The exposure of the counterparty's business model and/or supply chain to critical disruptions due to environmental factors such as the impact of biodiversity loss, water stress or pollution.
- The exposure of the counterparty to reputational and litigation risks taking into account completed, pending or imminent litigation cases related to environmental issues.
- The (planned) maturity or term structure of the exposure or asset.
- Risk-mitigating factors, such as private or public insurance coverage, for example based on applicable national catastrophe schemes or similar frameworks, and the capacity of the counterparty to ensure resilience to transition and physical risks including through forward-looking transition planning.

For the assessment of **social and governance risks** at the exposure level, institutions should implement **due diligence** processes aimed at evaluating the financial impacts arising from these factors and the vulnerability of counterparties' business models to such risks. In particular, institutions should consider:

- The counterparties' adherence to social and governance standards;
- The counterparty's exposure to legal risks arising from social or governance-related matters;
- The applicable regulatory framework in the jurisdiction in which the counterparty operates.

Sector-Based, Portfolio-Based and Portfolio Alignment Methods

In accordance with paragraphs 127 and 149[8] of the *EBA Guidelines on Loan Origination and Monitoring*[5], sector-based and portfolio-based methodologies, including graphical representation techniques such as heat maps highlighting ESG risks across individual economic sectors or sub-sectors, should **enable the mapping of portfolios** in relation to **ESG risk factors** and the identification of potential concentrations in one or more ESG risk profiles.
For the assessment of **non-climate-related ESG factors**, large institutions should develop:

- Methods to identify sectors that are highly dependent on, or have a significant impact on, ecosystem services, and tools to measure the financial impact of nature degradation and actions aimed at protecting, restoring and/or reducing negative impacts on nature.
- Approaches to measuring the positive or adverse impacts of their portfolios on the achievement of the UN Sustainable Development Goals[16] and evaluating potential related financial risks.

With regard to **climate risks**, institutions should adopt at least one **portfolio alignment methodology** that allows for the sectoral assessment of the degree of alignment between an institution's portfolios and climate pathways or benchmark scenarios. Where appropriate, this assessment should include counterparty-level analysis by comparing a given counterparty's greenhouse gas (GHG) emissions intensity against an appropriate sectoral benchmark.
The **selection of scenarios** for assessing climate-related ESG factors should be based on **up-to-date scientific evidence** relevant to the economic sectors and geographical areas of the exposures and sourced from authoritative institutions such as national, EU or international organizations such as national environmental agencies, Joint Research Center of the EU Commission, the International Energy, Network for Greening the Financial System, International Panel on Climate Change. Sectoral decarbonization pathways should be consistent with the EU's environmental objectives, including achieving climate neutrality by 2050 and reducing greenhouse gas emissions by 55% by 2030 compared to 1990 levels, or any applicable national targets.
Institutions should determine the scope and level of sophistication of portfolio alignment assessments based on the characteristics of their portfolios, the outcome of the

[6]Par. 126: Institutions should assess the borrower's exposure to ESG factors, in particular environmental factors and the impact on climate change, and the appropriateness of the mitigating strategies, as set out by the borrower. This analysis should be performed on a borrower basis; however, when relevant, institutions may also consider performing this analysis on a portfolio basis.

[7]Par. 146: Institutions should assess the borrower's exposure to ESG factors, in particular environmental factors and the impact on climate change, and the appropriateness of the mitigating strategies, as set out by the borrower.

[8]Par. 127-149: In order to identify borrowers that are exposed, directly or indirectly, to increased risk associated with ESG factors, institutions should consider using heat maps that highlight, for example, climate-related and environmental risks of individual economic (sub-)sectors in a chart or on a scaling system. For loans or borrowers associated with a higher ESG risk, a more intensive analysis of the actual business model of the borrower is required, including a review of current and projected greenhouse gas emissions, the market environment, supervisory ESG requirements for the companies under consideration and the likely impacts of ESG regulation on the borrower's financial position.

materiality assessment, and the size and complexity of the institution.
Finally, institutions are required to justify and document the methodologies adopted, including scenario selection, base year definition, sectoral scope, and, in the case of SNCIs or smaller institutions, the identification of a representative sample of exposures. Any significant changes to the methodologies over time should be duly documented. The information derived from climate portfolio alignment methodologies should be used to:

- Assess and monitor **transition risks** arising from the **misalignment** of counterparties and/or portfolios with regulatory objectives and climate pathways established at the EU, Member State, or third-country level, as well as the associated financial risks.
- **Support decision-making** regarding the definition and implementation of risk appetite, corporate strategy, and transition planning, including through the prioritization of engagement with specific counterparties.

Scenario-Based Methods

In addition to exposure-based, sector-based, portfolio-based, and portfolio alignment methods, institutions' internal procedures should provide for the use of scenario-based analyses to test their **resilience to ESG risks**, starting with **climate risks**, across **different scenarios**.

Report on Data Availability and Feasibility of Common Methodology for ESG Exposures

For the methodologies outlined, the EBA in its recent document 'Report on data availability and feasibility of common methodology for ESG exposures'[7] highlighted that, despite progress in integrating ESG risks into risk management frameworks, **significant challenges** remain, particularly in **standardizing methodologies** for **identifying** and **qualifying exposures** to **ESG risks**. The report emphasizes that the **availability**, **quality**, and **granularity** of **ESG data** continue to be **major obstacles**, along with their **limited comparability** and **transparency**. While regulatory initiatives such as the *Corporate Sustainability Reporting Directive* (CSRD) and the *European Sustainability Reporting Standards* (ESRS) have improved the ESG data landscape, **gaps persist, particularly** for **retail SMEs** and **household** exposures. In contrast, **non-financial corporates** (NFCs) benefit from **structured ESG reporting frameworks**, enabling the adoption of more advanced risk assessment methodologies.
The **application of ESG risk assessment methodologies varies significantly** across institutions, leading to **inconsistencies** in materiality assessments and difficulties in data comparability. Currently, the **most advanced ESG risk measurement practices** are observed in **NFCs**, where institutions typically rely on information collected from counterparties or external providers, which feed into internal scores, stress testing, or scenario analysis. However, using such scores as a potential basis for a standardized methodology presents significant challenges due to the **complexity and variability of ESG scores**, stemming from different approaches, heterogeneous data sources, and differences among rating providers. Additionally, **retail SMEs** face **further challenges** due to **high data collection costs** and the **lack of mandatory disclosure requirements**. The EBA considers that the **fundamental elements** are **not yet sufficiently developed** to form a solid foundation **for** the establishment of a **standardized** and **robust methodology** for identifying and qualifying ESG risks at this stage, particularly concerning their impact on credit risk. However, the situation varies significantly depending on the type of exposure and the risks considered. In this context, the introduction of a standardized methodology for identifying and qualifying exposures appears to be **more feasible for climate transition risk in non-financial corporates (NFCs) and, to a lesser extent, for climate-related transition and physical risks associated with household mortgage exposures**. Accordingly, a **sequential approach would be preferable**, starting with **climate risks for exposure classes where practices are more advanced, such as large corporates, and then gradually extending this methodology to other exposure classes and ESG risk dimensions**.
Furthermore, while **supervisory stress testing and scenario analysis** are **gaining importance** in ESG risk assessment, they **remain largely exploratory and require further methodological refinements** before they can serve as the basis for a standardized ESG risk classification.
The EBA emphasizes the importance of maintaining a prudential, risk-based, and evidence-driven approach, allowing ESG risks to be recognized in an integrated manner while preserving the integrity and purpose of the prudential framework.

Minimum Standards and Reference Methodology for the Management and Monitoring of ESG Risks

This paragraph establishes the essential criteria and reference methodologies for the effective management and proper monitoring of ESG risks.

Principles of ESG Risk Management

In recent years, **deficiencies** have been identified in the inclusion of **ESG risks** within **corporate strategies** and **risk management frameworks**. These types of risks, considering their impact and synergies with the bank's traditional risks, could pose a threat to the security and stability of institutions. It is essential for institutions to integrate ESG risks into their Risk Appetite Framework (RAF) and consider the role of these risks as potential drivers of all categories of financial risks (credit risk, market risk, operational risk, liquidity risk, reputational risk, business model risk, and concentration risk).
Institutions should, therefore, **incorporate ESG risks into their risk management frameworks**, ensuring consistency with corporate strategy and the overall risk strategy they intend to adopt. In their risk mapping activities, banks must consider these types of risks, defining their risk capacity, risk appetite, and risk tolerance thresholds. Additionally, institutions should incorporate ESG risks into their internal control processes and ICAAP.
Regarding **ICAAP**, banks should assess capital adequacy by considering the impact of **ESG risks** (particularly environmental risks, including climate-related risks, which will become even more evident in the future through various combinations of transition and physical risks) on all other traditional risk categories.
Once identified, institutions should develop risk management and mitigation tools, adopting a solid and forward-looking approach that considers the short, medium, and long term (up to a 10-year horizon). Institutions should utilize a set of functional **tools to mitigate and manage ESG risk**, such as:

- **Dialogue with counterparties and advisory services**: establishing relationships with counterparties to better understand their geographic area of operation, sectoral legislation, risk profile, resilience to ESG risks, and transition processes.
- **Adjusting financial terms**: including contractually agreed safeguard measures, modifying conditions

and pricing based on ESG criteria.

- **Considering ESG risks when developing sectoral policies**: setting sectoral or global risk limits, applying deleveraging strategies.
- **Portfolio diversification based on ESG criteria**: promoting transition processes and reallocating financing toward exposures more resilient to ESG risks and with sustainable transition plans.

To this end, institutions could **define Key Risk Indicators (KRIs) and early warning thresholds to monitor ESG risk exposure**. Institutions should also implement granular and frequent monitoring of counterparties, exposures, and portfolios identified as materially exposed to ESG risks.

Strategies and Business Models

When defining and implementing their corporate strategy and risk profile, institutions must consider ESG risks. A **forward-looking approach** should consider several aspects, including:

- Understanding and assessing the **operating environment**: analyzing exposure to structural changes in the economy and financial system while considering the impact of ESG factors on business strategies.
- Evaluating how ESG risks, particularly environmental risks (transition and physical risks), may negatively affect **business model feasibility** and **corporate strategy sustainability** in the medium to long term.
- Assessing how ESG risks could compromise the institution's ability to achieve its **strategic objectives** while remaining within its risk appetite. To support decision-making, banks should implement forward-looking risk assessment methods, including:
  - Periodic scenario analysis of environmental risk, considering potential future business environments;
  - Climate or environmental stress tests to assess resilience in the face of adverse shocks;
  - Heat maps visualizing ESG risks in different economies or sub-sectors and portfolio alignment methodologies evaluating sectoral alignment with climate-related pathways and reference scenarios.

Risk Appetite

Institutions should **integrate ESG risks** into their risk appetite framework, specifying the level and type of ESG risk they are willing to assume within their portfolio. This risk appetite should align with their business model while considering the principle of proportionality.
Risk assessments should factor in ESG risks concerning financial products, client segments, collateralized loans, and risk mitigation tools. Within the risk appetite framework, banks should define their **ESG-related KRIs**, including thresholds, potential limits, or exclusions. Once defined, these KRIs must be continuously monitored and analyzed.
Large institutions should monitor at least the following **indicators**:

- **Exposure amounts and income share** (interest, fees, commissions) from business relationships with counterparties operating in **sectors that significantly contribute to climate change**.
- **Portfolio alignment metrics**, showing the extent to which exposures align with climate-related regulatory objectives, such as achieving net-zero greenhouse gas emissions by 2050.
- **Financed greenhouse gas emissions**.
- **Progress** in implementing **key financing strategies** to **ensure resilience to ESG risks** and preparedness for the transition to a sustainable economy.
- **Breakdown of real estate-backed portfolios by energy efficiency levels of collateral**.
- **Ratio of environmentally sustainable exposures** financing activities contributing to climate change mitigation.
- **Ratio of financing for low-carbon energy supply technologies vs. fossil fuel-based energy supply technologies**.
- **Measures of concentration risk related to physical risks** (e.g., exposures in high-risk flood zones, water stress areas, wildfire-prone regions).
- **Reputational risk measures** related to ESG factors and any ESG-related litigation.
- **Parameters regarding exposures to counterparties with material dependencies or negative impacts on biodiversity**.

Internal Culture, Capabilities, and Controls

To develop an effective ESG risk assessment and monitoring system, institutions should ensure that boards are adequately trained to understand ESG implications and challenges. A strong risk culture must be promoted throughout the institution.
ESG risks must be embedded in internal control frameworks through the **three lines of defense**:

- **First Line** of Defense: responsible for conducting **ESG risk assessments**;
- **Second Line** of Defense:
  - **Risk management function**: independently assesses and monitors ESG risk, ensuring compliance with risk limits;
  - **Compliance function**: oversees how the first line ensures adherence to ESG legal requirements and internal policies, advising management on necessary measures.
- **Third Line** of Defense (Internal Audit Function - IAF): provides **independent review and assurance** of ESG risk control frameworks and systems.

Internal Capital Adequacy and Liquidity Adequacy Assessment Process (ICAAP & ILAAP)

As previously mentioned, institutions should integrate ESG risks into **ICAAP** to determine the appropriate internal capital buffer for ESG-related risks. Special **attention** should be given to **exposures** and **portfolios** deemed **more vulnerable** to ESG risks, requiring additional capital buffers.
Capital planning should be forward-looking, considering adverse scenarios, including specific environmental risk elements that could significantly drain capital reserves. **ESG-related capital needs** should be calculated using **stress testing** and **scenario analysis**.
Additionally, institutions should incorporate material environmental risks and their impacts on liquidity into their **ILAAP** across appropriate time horizons. ICAAP and ILAAP frameworks should define risk appetite, thresholds, and limits for material ESG and environmental risks and their effects on solvency and liquidity.

Policies and Procedures for Financial Risk Categories

ESG risks can act as drivers for traditional financial risks. Proper management is essential to mitigate the current and potential future impact of ESG risks on the following:

- **Credit Risk**. ESG risks should be integrated into credit risk assessment frameworks.
- **Market Risk**. Institutions should evaluate how ESG risks impact the value of financial instruments, potential losses, and portfolio volatility.
- **Liquidity and Funding Risk**: ESG risks could affect net cash outflows, asset valuations, and funding stability, requiring adjustments in liquidity buffers.
- **Operational and Reputational Risks**. Institutions must consider ESG risk impact on operational losses, reputational damage, and greenwashing-related risks. By implementing strong identification, prevention, and management processes, institutions can mitigate risks associated with greenwashing, reputational damage, and regulatory scrutiny.
- **Concentration Risk**. Banks should assess sectoral/geographic exposure concentrations prone to ESG risks, including carbon emissions, geographic vulnerabilities, and ESG-related controversies.

Plans in Accordance with Article 76(2) of Directive 2013/36/EU

Plans developed in accordance with *Article 76(2) of Directive 2013/36/EU*[10] should provide an overview of the **strategic actions and risk management tools** adopted by institutions to ensure their resilience to ESG risks and their preparedness for the transition to a sustainable economy.
The plans developed by institutions should address the **forward-looking** aspects of ESG risk management while maintaining consistency with other applicable requirements, such as those related to due diligence, sustainability reporting, and the strategic actions necessary to align business models with the transition to a sustainable economy.
At the group-wide level, institutions should ensure that their plans and objectives are proportionate to their nature, size, and operational complexity, as well as to the materiality of ESG risks, and that they are aligned with risk and funding strategies, risk appetite, ICAAP, and the overall risk management framework.

Governance

This paragraph provides guidelines on governance and transition planning related to ESG risks, defining roles and responsibilities, internal processes, data management, scenario analysis, metrics, and key contents of the plans. Additionally, it establishes criteria for monitoring, reviewing, and periodically updating the plans, ensuring an integrated and strategic approach to sustainability management.

Roles and Responsibilities

Institutions should clearly identify **roles** and assign **responsibilities** for the **development, validation, implementation**, and **monitoring** of the plans. Institutions should take into account the influence that the transition planning process should exert on other processes, such as the overall corporate strategy and risk appetite.
The body responsible for approving these plans should oversee their implementation, provide ongoing updates on relevant developments and progress made against the institution's objectives, and, where necessary, take corrective actions in the event of significant deviations from the predefined targets.
For the proper **integration of ESG risks within the three lines of defense**, institutions should ensure that:

- The **first line of defense** possesses the necessary **expertise** and **experience** to assess the extent to which **counterparties' transition strategies** - including their transition plans, where available-enhance their resilience to ESG risks and align with the institution's objectives and risk appetite.
- The **risk management function** ensures that the **risk limits** set out in the risk appetite statement, within the overall risk management framework, are **consistent** with all aspects of the **institution's plan**, including sectoral policies.
- The **internal audit function (IAF) reviews** the **institution's plan** as part of the risk management framework and assesses its compliance with legal and regulatory requirements, as well as its alignment with the institution's strategy and risk appetite in relation to ESG risks.

Internal Processes and Capacity

Institutions, within the process of formulating, implementing, and reviewing plans, should systematically consider information and feedback from all levels of the organization. To this end, it is essential to ensure the **involvement** of, at a minimum, the **heads of functions responsible for strategic planning, risk management, sustainability reporting, legal services, and compliance**.
To ensure the effective implementation of the transition planning process, institutions should also have adequate capacities, competencies, and resources to support the development of plans, the periodic assessment of their soundness, the monitoring of their implementation, and the timely adoption of any necessary corrective actions.

Data Management

Institutions must implement **robust governance processes** for the **collection, validation**, and **aggregation** of the **data** necessary to support transition planning and monitor the implementation of the plans.

Transition Planning

The Transition Planning section outlines the framework for analyzing and managing ESG risks, with a particular focus on transition and physical risks, through the use of scenarios and strategic pathways. It defines the criteria for scenario selection, the establishment of time horizons and interim milestones, the assessment of risk materiality, the adoption of metrics for monitoring and measuring impacts, and the key components of transition plans. Finally, it describes the process for monitoring, reviewing, and updating the plans to ensure alignment with the institution's strategic objectives.

Scenarios and Pathways

Institutions should analyze their **sensitivity to ESG risks**, particularly transition and physical environmental risks, by leveraging various scenarios and assessing how these may impact their transition planning efforts.
The selection of scenarios should be proportionate to the institution's size and complexity and aligned with its business model and exposures. In particular, **small and non-complex institutions**, as well as other non-large institutions, may rely on a **simplified set of key parameters and assumptions**,

including risks, time horizons considered, and regional breakdowns of impacts. **Large institutions** must benchmark their plans against a **scenario compatible with the 1.5 global warming limit**, in line with the Paris Agreement, and the objective of achieving **climate neutrality by 2050**.
In selecting scenarios, institutions must follow at least the following steps:

- Assess the potential implications of EU, Member States and, where relevant, third countries' objectives for transition pathways, at least for selected sectors determined on the basis of the materiality assessment. In this process, institutions should take into account the likely pathways originated from the European Green Deal[8], the EU Climate Law[12], and the latest reports and measures prescribed by the European Scientific Advisory Board on Climate Change.
- Consider science-based and up-to-date scenarios originating from national, EU or international organizations.
- Take into account voluntary or regulatory-mandated objectives or commitments of the institution with respect to climate change mitigation and adaptation.

Institutions must ensure that the scenarios and pathways used in their plans are consistent across the organization and aligned with the time horizons considered, such as in the process of defining corporate strategies and setting short-, medium-, and long-term objectives.
Institutions must document the scenario selection process, including the rationale for any modifications or differences in their application.

Time Horizons and Milestones

As part of their plans, institutions should consider a set of differentiated **time horizons**, including the short, medium, and long term, with the latter defined as a period of no less than ten years. To ensure effective monitoring of progress towards the established targets, institutions should **define interim milestones at regular intervals**, ensuring full alignment with the objectives set for each time horizon.
To this end, institutions should adopt an integrated approach that enables the translation of long-term objectives, such as commitments to climate neutrality and the reduction of net greenhouse gas (GHG) emissions, into medium-term strategies. This may be achieved, for instance, through the implementation of sector-specific policies or the establishment of growth targets for specific business lines. Similarly, short-term financial metrics and operational objectives (e.g., profitability indicators, cost of risk, KPIs, KRIs, risk limits, pricing frameworks) must be structured to ensure consistency and alignment with medium- and long-term objectives, thereby supporting a harmonized and sustainable strategic approach over time.

Materiality Assessment Basis

The **transition planning** process aims to **manage materially relevant ESG risks**, with particular focus on transition and physical environmental risks, which may have significant implications for the economy's adaptation to applicable regulatory and legislative objectives concerning ESG factors.

Metrics

In line with their corporate strategies and risk appetite, institutions must adopt a **comprehensive set of metrics**, including forward-looking metrics, to define objectives, guide decision-making, and monitor the implementation of their plans.

To this end, the measurement and monitoring process must include:

- The assessment, calculation, and use of metrics designed to estimate the **financial implications of transition planning on the institution's business model** and risk profile across different time horizons (short, medium, and long term).
- The measurement of the **impact of transition planning on financial performance, revenue streams, profitability, and portfolio risk exposure**.

In accordance with the principle of proportionality, non-complex firms and other smaller institutions may adopt a more limited set of indicators for defining objectives and using metrics, leveraging qualitative targets where appropriate.
While institutions are required to adopt at least a combination of climate risk-related metrics, they must **progressively integrate indicators that enable a broader assessment of their exposure to and management of environmental risks not directly linked to climate change**. Such risks include, for instance, those arising from ecosystem degradation and biodiversity loss, as well as their potential correlation with climate risks. Furthermore, institutions must consider integrating metrics to monitor social and governance risks to ensure a holistic approach to ESG risk management.

Key Contents of the Plans

Institutions must document and periodically review the methodologies, assumptions, criteria, and objectives used in the preparation of their plans to ensure their soundness and adequacy in relation to the institution's risk profile and corporate strategy. As part of the planning process, institutions must clearly **specify the scope of the risks considered**, ensuring that each section of the plan addresses at least environmental risks.
Large institutions must include at least the following elements in their plans:

1. **Strategic objectives and roadmap of the plans**:
   i. The **definition** of the overarching **strategic objective** for managing ESG risks across different time horizons (short, medium, and long term), in alignment with the overall corporate strategy and risk appetite.
   ii. The comprehensive set of **long-term objectives** and **interim milestones** aimed at ensuring the resilience of the business model to ESG risks, guaranteeing consistency between the corporate structure and the revenue sources linked to the achievement of such milestones.
   iii. The **key assumptions**, inputs, and relevant contextual information for defining the institution's objectives and targets, including the selection of reference scenarios and the conclusions drawn from ESG risk materiality assessments, portfolio alignment analyses, and other scenario analyses.
2. **Targets and metrics**:
   i. The **quantitative objectives** defined to address ESG risks, including measures aimed at facilitating the transition towards a sustainable economy.
   ii. The **scope of application** of objectives and monitoring metrics, covering portfolios, sectors, asset classes, business lines, and, where applicable, economic activities, ensuring that the coverage is adequate in relation to the nature, size, and

complexity of the institution's activities and the assessment of ESG risk materiality.

iii. The **time horizons** to which the objectives and metrics apply, with a clear distinction between short, medium, and long term.

3. **Governance**:

i. The **roles and responsibilities** assigned for the formulation, validation, implementation, monitoring, and updating of the plan, as well as the escalation processes to be activated in case of deviations from the predefined objectives.

ii. The **actions and resources allocated** to ensure the acquisition of adequate skills, knowledge, and expertise for the effective implementation of the plan, including training initiatives on ESG risks and the development of a strong corporate culture in this area.

iii. The **remuneration policies and practices** aimed at promoting a prudent and sound management of ESG risks, in alignment with the institution's objectives and risk profile.

iv. The **data and systems** employed to support transition planning.

4. **Implementation strategy**:

i. The description of **actions undertaken or planned** in the short, medium, and long term to achieve the plan's objectives, including mechanisms for integrating these objectives into decision-making processes and the risk management framework.

ii. The **adaptation of policies and procedures** related to financial risk categories, as well as the revision of lending and investment conditions in key sectors and economic activities.

iii. The **modifications** introduced in the **product and service offering**, including pricing policies, to support the plan's implementation.

iv. The **investments and portfolio allocation strategies** aimed at ensuring alignment with the corporate strategy and risk appetite concerning ESG risks.

5. **Engagement strategy**:

i. The **counterparties' engagement policies**, including information on the frequency, scope, and objectives of engagement, as well as the types of actions planned and the applicable escalation criteria and processes.

ii. The **processes, methodologies and metrics** used to **collect** and **assess information** on **counterparties' exposure to ESG risks** and their alignment with the institution's objectives and risk appetite.

Small and non-complex institutions (SNCI) and other smaller institutions must include in their plans at least the aspects covered in the following points: 1(i)-(ii), 2(i)-(ii), 3(i), 4(i)-(ii) and 5(i)-(ii).

Monitoring, Review, and Update of the Plans

Institutions must ensure **continuous and systematic monitoring of the implementation of their plans**, in proportion to the nature, size, and operational complexity of the entity. This process must provide an integrated organizational perspective, enabling a timely and effective assessment of the institution's ability to achieve its predefined objectives.
The monitoring framework must allow the management body to oversee both the **evolution of ESG risk monitoring metrics** and the **progress made toward the milestones** set in the plan. Furthermore, in cases where objectives are not met, the institution must provide a clear and detailed justification, supported by an analysis of the potential impact on different financial risk categories, with reference to various time horizons.
Institutions must regularly **review** and, where necessary, **update** their **plans**, and in any case, whenever there is a modification to the corporate strategy. The review process must incorporate the most up-to-date information, including: new ESG risk materiality assessments; changes in portfolios and counterparties' activities; newly available scenarios, sector benchmarks, and updated transition pathways; and the impacts arising from regulatory changes or the introduction of new legal requirements.

Consultation Paper on Guidelines on ESG Scenario Analysis

In January 2025, the European Banking Authority (EBA) published *Guidelines on ESG Risk Management*[2], taking into account the principle of proportionality. These guidelines integrate the *Guidelines on Institutions' Stress Testing (EBA/ GL/ 2018/ 04)*[6] and assist institutions using the Internal Ratings-Based (IRB) approach in incorporating ESG risks-particularly physical and transition risks stemming from climate change-into their credit risk stress testing. These **stress tests** should be conducted periodically to **assess** the **effect of specific conditions on institutions' capital requirements for credit risk**.
The guidelines emphasize the role of **scenario analysis** (see Table 5) in enhancing institutions' resilience against **environmental risks**, starting with climate-related risks. Scenario analysis is a critical tool that helps institutions anticipate and prepare to manage ESG risks while also identifying opportunities arising from the challenges posed by climate change.
In this analytical process, institutions move **from basic qualitative "what-if" approaches to more sophisticated models** that require continuous monitoring of data and methodologies. The ultimate goal is to assess and understand the potential implications of a range of plausible future states on institutions' strategies and risk exposure. A distinction must be made based on the intended **purpose** of the scenario analysis:

- **Testing financial resilience**: evaluating the institution's resilience to severe short- and medium-term shocks and assessing capital and liquidity adequacy (ICAAP and ILAAP).
- **Assessing long-term business model resilience**: determining whether the institution's business model remains viable and its strategy sustainable over the long term.
- **Evaluating portfolio vulnerability**: assessing the extent to which portfolios are exposed to transition and physical risks.
- **Integrating ESG risks into corporate culture**: embedding ESG considerations into the institution's risk management culture.

Use of Climate Scenario Analysis (CSA) to Test Bank's Resilience	
Climate Stress Testing (CST)	**Climate Resilience Analysis (CRA)**
Test bank's financial resilience • Limited to a rather short-term horizon (less than 5 years) • Under Reasonable Uncertainty – hypotheses not forecasts • Using a baseline & adverse but plausible scenarios • Through a static or dynamic balance sheet approach, including the changes from the transition plan • Considering indirect effects and seeking consistency between counterparty and macro level	**Challenge bank's business model resilience** • Encompassing a long-term horizon (at least 10 years) • Under Deep Uncertainty – hypotheses not forecast • Using a central scenario & a set of district scenarios • Through a dynamic (balance sheet) approach • Leveraging sectoral trajectories and counterparty transition plans
➢ **To measure financial impacts** ➢ **To check capital & liquidity adequacy**	➢ **To assess compatibility with global warming of 1.5°C** ➢ **To check robustness of the business model**

TABLE 5: A Schematic Illustration of the Use of Climate Scenario Analysis to Test Bank Resilience[2]

Scenarios should be regularly reviewed, and the analyses conducted should be validated and properly documented. Institutions should prioritize analyzing material ESG risks, starting with the most significant ones. To achieve this, institutions should map ESG risks and their transmission channels concerning their sectoral and geographical portfolio exposure.

Climate Stress Test

The effectiveness of a Climate Stress Test (CST) depends on a detailed understanding of climate-related risks and their direct and indirect impact on an institution's financial performance, capital base, and liquidity position.
However, ESG risks have specific characteristics that make their full integration into institutions' risk management systems challenging. These challenges include extended time horizons, new risk transmission channels that are not yet supported by historical data, and fundamental uncertainties regarding global economic shifts.
When developing climate scenarios, institutions should **consider a set of interconnected factors** to ensure relevance:

- Socioeconomic context;
- Technological advancements;
- Climate policies;
- Energy systems;
- Consumer preferences;
- Sectoral pathways toward net-zero emissions;
- Emission levels and climate impact.

Institutions should **use credible scenarios based on the latest scientific knowledge**, developed by international or regional organizations, and refine them to align with their scope, granularity, and analysis objectives (see Figure 26).
In CSTs, institutions should incorporate:

- A **baseline scenario** (the reference scenario);
- A **set of adverse scenarios** that are severe (tail risk) yet plausible (reasonably likely).

The baseline scenario should reflect adopted or soon-to-be-adopted policies during the analysis period. Institutions should also analyze how their counterparties, particularly the largest or most concentrated ones, are indirectly exposed to climate-related risks.
Based on materiality assessments, institutions should adopt proactive measures, including **risk mitigation strategies** such as:

- Insurance coverage;
- Adaptation plans by counterparties;
- Local or governmental adaptation measures (without relying excessively on government actions or overly optimistic financial support schemes).

Scenario analysis should serve as a guiding framework for institutions operating under uncertainty and over an extended time horizon.
The Task Force on Climate-related Financial Disclosures (TCFD)[13] recommends the use of climate scenario analysis to help institutions explore the potential range of climate-related outcomes, assess their business impacts in a structured manner, and proactively address or even anticipate these risks.
Besides being a key tool, scenario analysis fosters a culture of continuous adaptation and change, essential for planning an institution's transition strategy.
Conducting scenario analysis requires several **preliminary steps**:

- **Understanding the business environment**: institutions should conduct an in-depth analysis of their operational landscape and how it may evolve.
- **Using internationally recognized scenarios**: institutions should reference scenarios developed by the International Energy Agency (IEA) and the Network for Greening the Financial System (NGFS), ensuring they are adverse yet plausible.
- **Incorporating Basel Committee guidance**: the Basel Committee on Banking Supervision (BCBS) has contributed to climate scenario analysis, publishing a discussion paper in April 2024[1].

Scenario analysis is a critical decision-making tool, but caution is required given the uncertainties in the operating environment. Beyond defining scenarios, institutions must **identify transmission channels through which ESG events translate into concrete financial impacts** (see Table 6).

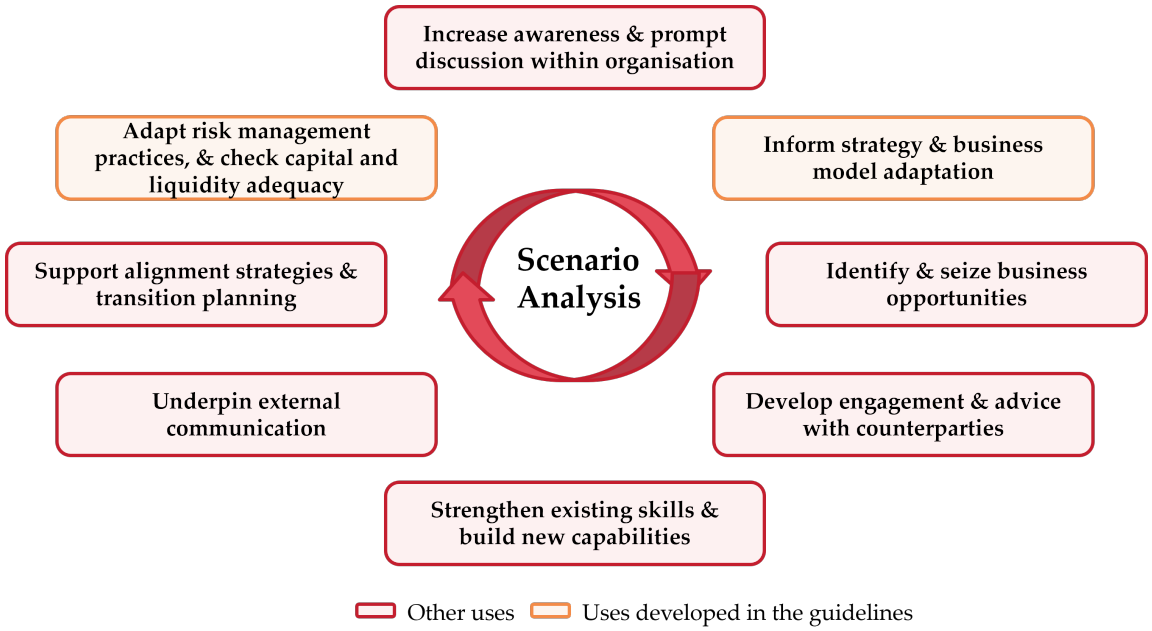

FIGURE 26: Uses of Scenario Analysis in the Banking Sector[2]

Climate Risk Drives		Sources of variability
Climate Transition Risk	**Climate Physical Risk**	
Microeconomic Channels • Unprofitable or overly indebted corporate due to lack or partial transition • (Near) stranded assets • Legally liable corporate • Higher running costs for households	**Microeconomic Channels** • Lower corporate profitability due to disruptions or growing physical stress • Household's income & health affected by shocks or gradual deterioration of physical conditions • Property damage • Increasing adaptation costs	**Geographic/ Sectoral heterogeneity** • Exact location • Vulnerabilities and dependencies **Amplifiers/ Mitigants** • Risk driver's interactions • Banks reactions • Availability and pricing of insurance • Adaptative capacity of counterparties • Availability of hedging solutions
Macroeconomic Channels • Change in energy mix, price and use • Significant shift in prices • Productivity changes • Labor market frictions • Changes in consumer and market preferences • International trade, government revenues,…	**Macroeconomic Channels** • Knock-on effects to economies • Significant shift in prices • Reduced workforce productivity • Supply chain disruption & resource scarcity • Migrations and displacements…	
Business model risk / Credit risk / Market risk / Liquidity risk / Operational risk		

TABLE 6: Summary of Climate-related Risk Transmission Channels[2]

Climate Resilience Analysis

A new proposed tool to support institutions is the Climate Resilience Analysis (CRA). This tool serves as a **forward-looking assessment of the potential impacts of distinct long-term (10+ years) climate scenarios** including both transition and physical risks on an institution's business model feasibility and resilience. In particular, the Climate Resilience Analysis (CRA) include the following:

- Uses **"what-if" analysis** (due to limited quantitative data availability);
- Evaluates **risk-adjusted profitability** for each business unit;
- Supports institutions in defining a **strategy** that aligns with their risk appetite and transition plan objectives over the next decade;
- Progressively increasing **capital buffers** to enhance resilience to environmental risks;
- Regularly **updating risk inventories** to include newly identified climate risks;
- Conducting **targeted portfolio analyses** for segments

identified as vulnerable.

Given the increasing relevance of ESG factors, regulators are intensifying efforts to integrate ESG risks into prudential supervision.
While it is essential to advance scenario analysis and ESG risk management practices, institutions must be given sufficient time to implement the necessary changes effectively.
By developing comprehensive risk management tools and methodologies, institutions can **address a wide range of emerging risks**, including:

- Epidemics;
- Human migrations;
- Ecosystem collapse;
- Species extinction;
- Terrorism and wars;
- Political instability.

These risks are often interlinked with or exacerbated by climate-related factors.
The key output of a CRA is a qualitative assessment of an institution's business model feasibility and strategic sustainability across different tested scenarios.
By implementing CRA, institutions can ensure long-term business viability, proactively adapt to evolving environmental conditions, and maximize their likelihood of achieving transition objectives.

Conclusions

The EBA guidelines on ESG risk management represent a fundamental step in **encouraging institutions to integrate environmental, social and governance factors into their risk management framework and business models**. The objective is to ensure the resilience and sustainability of the banking sector in the medium to long term in response to the challenges posed by climate change, the energy transition, and other ESG factors.
The **adoption of advanced methodological approaches**, the **definition of monitoring metrics**, and the **promotion of an ESG risk culture** within institutions are key elements for an effective and forward-looking risk management strategy. Institutions must also consider the relationship between these risks and the main categories of financial risk, assessing how ESG risks can act as drivers for all other risk categories within the bank. Additionally, the introduction of **scenario analysis** and **climate stress testing** will help institutions assess their exposure to ESG risks under adverse conditions and develop appropriate mitigation strategies.
To adequately assess ESG risks, banks must first **collect the necessary data** and among the different sources of data, a particularly significant role is played by the **information disclosed by counterparties** in accordance with **European Sustainability Reporting Standards** or **voluntary reporting standard** for non-listed Small and Medium-size Enterprises (SMEs). The collection of information disclosed by counterparties in accordance with such standards enables institutions to leverage **robust and homogeneous data** for the adoption of **advanced methodologies**.
Compliance with the guidelines and the gradual integration of ESG risks into corporate decision-making processes will contribute not only to financial stability but also to the transition towards a more sustainable and resilient economy, in line with European and international objectives. Moreover, institutions have a key role in supporting the transition to a sustainable economy.
Finally, adherence to these guidelines will help reduce compliance risk and reputational risk for institutions.

References

[1] **Basel Committee on Banking Supervision.** *Discussion Paper - The role of climate scenario analysis in strengthening the management and supervision of climate- related financial risks*, April 2024.

[2] **European Banking Authority.** *Consultation Paper - Draft Guidelines on ESG Scenario Analysis*, January 2025.

[3] **European Banking Authority.** *Final Report - Guidelines on the management of environmental, social and governance (ESG) risks*, January 2025.

[4] **European Banking Authority.** *Final Report on Guidelines on internal governance under directive 2013/36/EU*, July 2021.

[5] **European Banking Authority.** *Final Report - Guidelines on loan origination and monitoring*, May 2020.

[6] **European Banking Authority.** *Final Report - Guidelines on institutions' stress testing*, July 2018.

[7] **European Banking Authority.** *Report on Data Availability and Feasibility of Common Methodology for ESG Exposures*, February 2025.

[8] **European Commission.** *The European Green Deal*, December 2019.

[9] **European Parliament and the Council.** *Directive 2013/34/EU of the European Parliament and of the Council of 26 June 2013 on the annual financial statements, consolidated financial statements and related reports of certain types of undertakings, amending Directive 2006/43/EC of the European Parliament and of the Council and repealing Council Directives 78/660/EEC and 83/349/EEC*, June 2013.

[10] **European Parliament and the Council.** *Directive 2013/36/EU of the European Parliament and of the Council of 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC*, June 2013.

[11] **European Parliament and the Council.** *Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting*, December 2022.

[12] **European Parliament and the Council.** *Directive (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for chieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ("European Climate Law")*, July 2021.

[13] **Task Force on Climate-related Financial Disclosures.** *Task Force on Climate-related Financial Disclosures - Overview*, December 2022.

[14] **United Nations.** *Implementing the United Nations "Protect, Respect and Remedy" Framework*, April 2011.

[15] **United Nations.** *The Paris Agreement - United Nations - Framework Convention on Climate Change*, December 2015.

[16] **United Nations.** *Trasformation our world: The 2030 Agenda for Sustainable Development*, October 2021.

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