ICMA
International Capital Market Association

Smart contracts and DLT-based fixed income markets: What's next?

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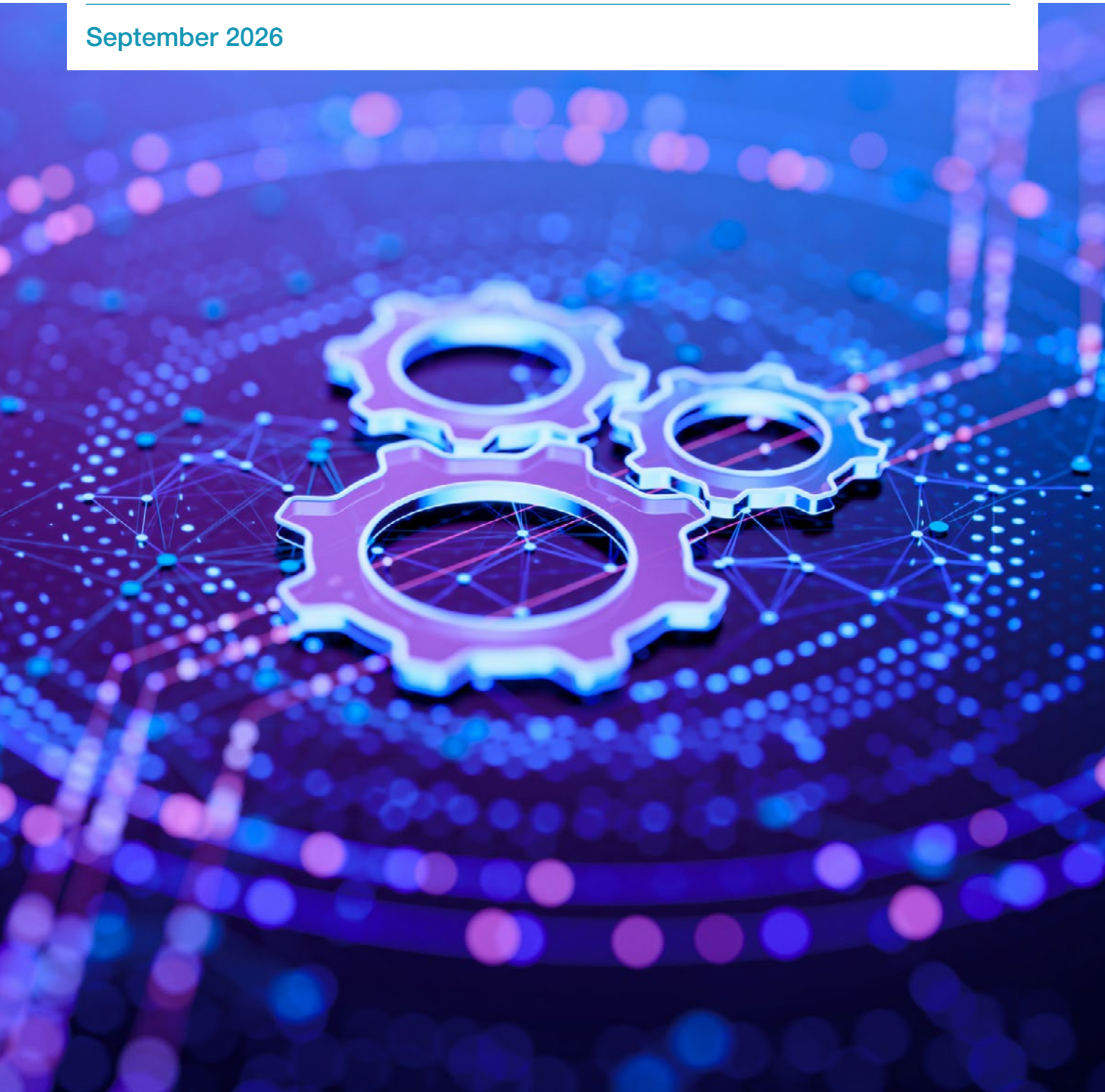

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1. Introduction

Although the concept dates back to the 1990s, smart contracts only became a defining feature of finance with the rise of the crypto-asset and decentralised finance ("DeFi") space and have since crossed into traditional finance. Banks, issuers and market infrastructures are aiming to apply the same programmability that powers DeFi markets to regulated financial markets, in pursuit of faster, safer and more efficient processes across issuance, trading, servicing and settlement. This migration makes the question of their relevance to regulated fixed income markets timely.

Smart contracts are at the core of the value proposition of DLT-based capital markets. They are the mechanism through which the promises of tokenisation (including enhanced access to capital and funding, streamlined and automated operations and servicing, faster or atomic settlement, improved transparency and auditability, greater collateral mobility, and reduced operational risks and costs) can be delivered in practice. However, as market participants each deploy their own implementations, the market risks recreating the very fragmentation that tokenisation is meant to overcome.

The question this paper seeks to examine is the state of play of smart contracts in fixed income markets and what comes next. Where should harmonisation efforts be directed: at smart contracts themselves, at the broader legal, infrastructure and data standards that surround them, or at both, and in what order?[1] The choices made now, while the market is still nascent, will help determine whether DLT-based fixed income markets can scale into deep, liquid and interoperable markets.

In this spirit, the paper is intended to demystify smart contracts, take stock of applications in DLT-based fixed income markets, and explore the need for greater standardisation to help scale the market. To guide that discussion, the paper poses four sets of key questions to the reader, highlighted in boxes throughout.

1 In this paper, "standardisation" refers to the adoption of common technical standards (eg, for token contracts or data), while "harmonisation" refers to the broader alignment of market practices, rules and frameworks. Standardisation at the smart contract level is one contributor to market harmonisation.

2. Background

ICMA's focus on smart contracts builds on the Bond Data Taxonomy ("BDT"), which provides a standardised, machine-readable language for key bond information typically contained in a bond term sheet. The Monetary Authority of Singapore's ("MAS") Project Guardian, following the initial release of the Guardian Fixed Income Framework ("GFIF"),[2, 3] embeds the BDT and outlines, among other aspects, different proposals to integrate the BDT into smart contracts.[4]

As a follow-up to this work, and to explore the use of smart contracts to automate corporate actions and their broader value proposition, two workshops were held jointly with members of the ICMA DLT Bonds Working Group and ICMA Bond Data Taxonomy Working Group, on 25 November 2025 and 12 February 2026 (the "Smart Contract Workshops"). In them, participants discussed definitions and divergences, took stock of existing industry initiatives and regulatory guidance related to smart contracts, considered ongoing post-trade harmonisation initiatives, identified current pain points in the lifecycle of a bond that could be addressed by smart contracts, and addressed the potential role of standards and focus areas going forward.

This paper is based on input received from ICMA members through the workshops, bilateral conversations and research. It is intended to foster a wider discussion on the role that smart contracts could play in DLT-based bond markets, and on the work being done to address the risks that fragmentation poses to this nascent segment and the wider DLT-based market.

2 *ICMA welcomes the release of the Monetary Authority of Singapore's Guardian Fixed Income Framework (GFIF)*, published on 4 November 2024.
3 Singapore, Monetary Authority of Singapore, Project Guardian, *Guardian Fixed Income Framework* version 1.1, published in November 2025.
4 ICMA Bond Data Taxonomy Working Group webpage.

3. Defining smart contracts

The term "smart contract" is thought to have been coined by computer scientist Nick Szabo in 1994 to describe "computerised" transaction protocols that execute the terms of a contract automatically, well before blockchain technology existed.[5] The concept was implemented at scale with the launch of programmable blockchains (eg, Ethereum),[6] and was first deployed in the crypto-asset and DeFi ecosystem. That demonstrated the defining feature of the technology as first realised, which is token programmability. Business logic (who may hold an asset, when payments occur, what happens on a given event, etc.) can be embedded directly into the asset and composed with other on-chain services, executing once set conditions are met.

Like many technologies that have advanced rapidly, smart contracts suffer from a definition problem, with parties from varying jurisdictions and markets defining them differently. In the private realm, this struggle becomes even more pronounced, with companies providing varying characterisations to closely align with their own business cases. To provide a baseline definition for this paper and foster a common understanding, these are some of the definitions of smart contracts given by authorities and official sector bodies:

- United Kingdom ("UK"), **Bank of England:** *"A smart contract is a self-executing, automated digital agreement with terms directly written into code, stored in a blockchain"*;[7]
- European Commission, European Union ("EU") **Blockchain Observatory and Forum:** *"A smart contract is an agreement between parties that is written in the form of a computer program. Such "self-executing" programs can be stored in a blockchain and programmed to run when certain conditions are met"*;[8]
- United States of America, **Commodity Futures Trading Commission** ("US CFTC"): *"Fundamentally, a "smart contract" is a set of coded computer functions" that "May incorporate the elements of a binding contract (eg, offer, acceptance, and consideration), or may simply execute certain terms of a contract" and which "Allows self-executing computer code to take actions at specified times and/or based on reference to the occurrence or non-occurrence of an action or event (eg, delivery of an asset, weather conditions, or change in a reference rate)"*;[9] and
- Hong Kong ("HK"), **HK Monetary Authority** ("HKMA"): *"Smart contracts can be defined as automated transactions based on pre-defined events"*.[10]

Based on this set of definitions from leading financial jurisdictions, smart contracts can be understood as **programs stored on a distributed ledger that execute automatically when predefined conditions are met. They may incorporate terms agreed between parties, for example those arising from a financial transaction, but they are not necessarily legal contracts, or components of legal contracts, in their own right.** This distinction is fundamental; the code may perform obligations set out in legal documentation (such as bond terms and conditions or DLT platform service agreements),[11] embed some or all of those obligations, or execute functions with no contractual character. The extent to which the code may also carry legal effect will remain a matter for the applicable legal framework.

It should also be clarified that **deployment on DLT/blockchain is a defining feature of smart contracts** as encountered in implementations presented in this paper. It is the distributed ledger that provides the environment in which the code is stored and executes identically for all parties without reliance on a central operator.[12] Automation of a

5 Nick Szabo, *Smart Contracts*, published in 1994.
6 Ethereum Learn Hub landing page, accessed on 18 September 2026..
7 United Kingdom, Bank of England, *DLT Innovation Challenge 2025: Final Report*, published on 12 May 2026
8 European Union, EU Blockchain Observatory and Forum, *What is a smart contract?*
9 United States, Commodity Futures Trading Commission, LabCFTC, *A Primer on Smart Contracts*, published on 27 November 2018.
10 Hong Kong, Hong Kong Monetary Authority, *White paper 2.0 on Distributed Ledger Technology*, published on 25 October 2017.
11 These terms and conditions are to be read in addition to the legal documentation itself, which prevails in case of discrepancies.
12 It is important to highlight, as further described in Section 6, that some DLT/blockchain networks are operated by a central operator or consortium. There, smart contracts function more like shared workflow automation among known parties. Their execution may be automated once deployed, but governance, permissions and upgrades may still depend on the relevant operator or consortium.

conventional, centrally operated system, no matter its level of sophistication, does not amount to a smart contract in this sense; this characterisation helps distinguish smart contracts from conventional software solutions that automate fixed income processes.

1. Key questions:
Do market participants need a single, common definition of smart contracts for DLT-based debt securities? Do you agree that deployment on DLT is the defining feature differentiating smart contracts from other solutions automating fixed income issuance, trading, atomic or non-atomic settlement and distribution processes? What set of specific criteria do you see as required for a smart contract to be recognised as such?

4. Smart contract initiatives, implementations and use cases

Smart contracts have developed along with the industry itself: from the limited scripting that was possible in the earliest blockchains,[13] to general-purpose programmability, to token standards and composable protocols in DeFi and, in recent years, to developments supporting integration with traditional finance.

In a capital markets context, these building blocks look to underpin digital bond issuances, intraday repo and collateral mobility at the institutional level. Smart contracts are the mechanism through which DLT-based debt securities can deliver automated lifecycle servicing, programmable settlement and straight-through processing across the lifecycle of the security; the challenge for the markets is to harness this potential within a regulated environment in a coordinated manner.

Within capital markets, smart contracts have also moved beyond concept into practice. To illustrate this, we highlight existing smart contract implementations and initiatives: (i) DZ BANK's Smart Bond Contract ("SBC"), an open protocol digitising the full lifecycle of a DLT-based security; (ii) CMTA Token Framework ("CMTAT"), which standardises the smart contract layer; (iii) ACTUS, which provides a standardised framework for financial contracts, including cash-flow generation and contractual event logic; and (iv) the MIT-SODA interoperability standards, addressing the transfer of smart contract-based assets across DLT systems.

These initiatives span both industry-led implementations and standards, in the case of the SBC and CMTAT, and academic and research-led standardisation efforts, in the case of ACTUS and the MIT-SODA interoperability standards. Each of these is examined in more detail in the subsections below. Among them, DZ BANK's SBC stands out as a prime example and, to date, the industry's most complete use case implementing the full lifecycle of a DLT-based debt security in a legally binding live pilot transaction, as further detailed below. After these, the section turns to the institutional DLT networks on which smart contract applications are deployed (Section 4.5), live industry use cases already operating at scale (Section 4.6), and repo and collateral as areas of particular potential (Section 4.7).

13 FinTech Magazine, *From white paper to gold rush: a history of the blockchain*, published on 11 August 2025.

4.1. DZ BANK Smart Bond Contract (SBC)[14, 15]

Background	The SBC was presented in a 2025 white paper by DZ BANK. In March 2026, DZ BANK (as issuer) and KfW (as investor) completed a pilot transaction using SBC, providing a smart contract-based implementation of a complete lifecycle of a tokenised security issued under German law on a public blockchain. The pilot represents a prime example of a fully smart contract-operated DLT-based bond lifecycle including smart contract-based Delivery-versus-Payment using the ERC-7573 standard proposal.[16] Notably, its digital issuance terms were created and stored directly in the smart contract in accordance with ICMA's BDT. The ERC-8100 proposal enables a standardised approach to store the underlying ICMA BDT-XML data directly on-chain managed by a smart contract, serving as a single source of truth.[17]
Description	Open, modular and platform-agnostic functional protocol through which the full lifecycle of a DLT-based security is digitally and functionally mapped in a smart contract, which itself serves as a digital intermediary without the need for a central orchestrating agent. The protocol was designed under German law and can be applied internationally.
Purpose	To replace historical processes that are perceived to involve friction and risk with a functional protocol standard, contributing to the early establishment of accepted and transparent digital standards, preventing the rise of new technical risks stemming from fragmentation.
Target Users	Debt capital markets participants, including issuers seeking automated issuances of DLT-based bonds; and investors and dealers transacting in them.

4.2. CMTA token framework[18]

Background	Developed by the Capital Markets and Technology Association (CMTA, Switzerland), it was first published in 2022. Covers equity, debt and structured products, with audited open-source implementations for several DLTs. Adopted by digital asset infrastructure providers and used by financial institutions, it was included in the Guardian Fixed Income Framework with reference to a BDT integration proposal.
Description	Open standard for the smart contract layer, defining the functions that a security token should implement for the tokenisation of securities under Swiss law, with a DLT-agnostic framework.
Purpose	Initially developed under Swiss law, to harmonise the smart contracts used for the creation of tokens representing securities, reducing the need for users to spend time and energy understanding the code and assessing the smart contract's robustness and appropriateness and, consequently, driving down costs. CMTAT has since proven suitable for tokenisation in numerous jurisdictions.
Target Users	Capital markets issuers and their advisers, who deploy the standard contracts to issue tokenised securities; banks and tokenisation platforms, which embed the CMTAT to offer compliant issuance services; and custodians and other infrastructure providers, which integrate it to hold and administer the resulting tokens.

14 DZ BANK, *Smart Bond Contract (SBC) – Towards a functional Redesign of a digital Security's Lifecycle*, published on 28 May 2025.
15 DZ BANK, *Premiere: DZ BANK and KfW fully map the lifecycle of a crypto security on a public blockchain*, published on 25 March 2026.
16 ERC-7573: Conditional-upon-Transfer-Decryption for DvP, created on 5 December 2023.
17 ERC-8100: Representable Contract State, last edited on 15 December 2025.
18 Capital Markets and Technology Association, *CMTA Token (CMTAT)*, latest version published on 26 June 2026.

4.3. ACTUS[19]

Background	Initiated in response to financial crises and maintained by the ACTUS Financial Research Foundation (United States). Jurisdiction-neutral and applicable to most asset classes, it is increasingly referenced in fixed income applications built on DLT (including within DeFi protocols) as a source of standardised cash flow logic.
Description	Open-source data and algorithmic standard providing a standardised, machine-readable way to represent the logic and, notably, cash flows behind financial contracts in smart contracts.
Purpose	To ensure that the contract events defined in a financial contract can be computed from a standardised algorithm.
Target Users	Banks and financial institutions, which use it to automate transaction processing and risk analytics; and, especially, regulators and analytics providers, which use it for standardised, contract-level oversight.

4.4. MIT-SODA interoperability standards[20]

Background	Created in response to blockchain fragmentation in financial services. Included here as an example of interoperability-focused standardisation that aims to complement smart contract-level initiatives, assisting in identifying and addressing gaps and harmonising industry efforts.
Description	Standardisation effort led by MIT Connection Science and SODA, now organised under the Interoperability Standards Organization for Digital Assets (I-SODA), aiming to publish neutral standards that can be followed by any entity that aims to tokenise regulated assets.
Purpose	To enable regulated assets to flow between different digital ecosystems, regardless of where they reside or which network is used to create the token.
Target Users	Primarily network-level. DLT network developers and interoperability providers building network connections to allow the transfer of tokenised securities across networks. Of relevance for the future capital markets ecosystem, where a DLT-based debt security could be issued on one network but held, financed or settled on another.

All four initiatives address slightly different layers and have diverse approaches. Among them:

(i) the SBC maps the entire lifecycle of a security in a single protocol with no central platform operator;

(ii) the CMTAT operates at the level of the deployed contract code itself;

(iii) ACTUS standardises the logic of the financial contract executed by the smart contract; and

(iv) the MIT-SODA interoperability standards aim to address the flow of assets between networks.

Read together, they suggest that “smart contract implementation” does not consist of a single workstream. Instead, there are several workstreams looking at different levels. These initiatives are also noticeably complementary rather than competing. That diversity, however, also highlights the fragmentation risk that is inherent in a nascent segment, and raises the question of whether there is a greater need for harmonisation within the industry.

19 Algorithmic Contract Types Unified Standards landing page.
20 SODA and MIT Connection Science, Interoperability Standards for Digital Assets, published in January 2026.

4.5. Institutional DLT networks

The most recognisable and established venues remain general-purpose public Layer 1 and Layer 2 blockchains (such as Ethereum, Polygon and Solana), on which many DLT-based debt securities have been issued to date, including crypto securities under Germany's eWpG (such as the SBC pilot transaction).[21] These networks are permissionless at the base layer, with permissioning typically applied at the token or application level.

Smart contracts can be deployed on different types of infrastructure, from general-purpose blockchains (mentioned above) to purpose-built private institutional networks. Alongside industry-led implementations and standards-focused initiatives, another category of effort has emerged: shared multi-institution DLT networks intended to provide the common infrastructure on which smart contract applications can be deployed and interoperate. We have selected five examples to illustrate this trend below.

- **Canton Network:** Launched by Digital Asset in May 2023 following the development of capital markets applications built in its Daml smart contract language, the Canton Network is a public permissioned "network of networks" built for institutional finance, in which participants operate separate interoperable ledgers connected through a "Global Synchronizer". Both Broadridge's DLR (described below) and Project Promissa (described in Section 5) run on the Canton protocol, and the network is governed by the Canton Foundation, whose members include a wide range of companies in both the DeFi and traditional finance ecosystems.[22, 23, 24, 25, 26]
- **Regulated Layer One ("RL1"):** Launched in September 2025 by SWIAT, a German fintech company specialising in the development of blockchain software and a tokenisation platform for an open, decentralised financial market infrastructure, together with ten European financial institutions.[27] It went live in July 2026.[28] RL1 is designed as an open, neutral, compliance-optimised and non-profit network built for institutional workflows in the regulated financial markets.[29] It was established as a European Cooperative Society (SCE) in Luxembourg with a governance structure ensuring that every member institution has an equal voice as a deliberate choice to overcome existing market fragmentation due to different DLT networks.
- **Global Layer One ("GL1"):** An initiative first set out in a white paper by MAS in June 2024 which explores a public permissioned shared layer infrastructure developed by regulated financial institutions for the financial services industry. On it, participants could host inherently interoperable digital assets from various jurisdictions, governed by common industry standards and open-source protocols. A group of participating global financial institutions (J.P. Morgan, MUFG Bank, Société Générale FORGE, HSBC and Standard Chartered)[30] and policymakers (the MAS, Banque de France and the Bank of England)[31] has led work on developing GL1. The initiative has also evolved with the development of toolkits to foster an ecosystem of compatible market infrastructures where service providers operate under industry norms to achieve regulatory compliance objectives, with the release in November 2025 of the GL1 Market Infrastructure (MI) Toolkit and the GL1 Programmable Compliance (PC) Toolkit.[32, 33]
- **Swift blockchain-based ledger:** Announced in September 2025 and made available for initial use in July 2026, Swift blockchain-based ledger extends an existing messaging and standards infrastructure into a DLT environment. Designed with input from a group of more than 30 financial institutions and built along with Consensys, it is a permissioned shared ledger where transactions between participants are recorded, sequenced and validated, and rules are enforced, via smart contracts. Its first use case is on the cash leg: the ledger acts as an orchestration layer

21 DZ BANK and KfW, *Pilot Report on Smart Bond Contract*, published in March 2026.
22 Canton Network webpage, accessed on 25 August 2026.
23 Canton Network Encyclopaedic Guide, *about webpage*, accessed on 25 August 2026.
24 Digital Asset, *Customer Story: Broadridge*, published on 21 June 2024.
25 Bank for International Settlements, *Project Promissa, Tokenisation of promissory notes*, Final Report, published in April 2025.
26 Canton Foundation webpage, accessed on 25 August 2026.
27 KFW, *"Regulated Layer One" initiative to start with 10 European financial institutions at launch*, published on 29 September 2025.
28 Regulated Layer One, European blockchain initiative 'Regulated Layer One' goes live, published on 28 July 2026.
29 Regulated Layer One webpage, accessed on 25 August 2026.
30 As of 25 August 2026.
31 As of 25 August 2026.
32 Singapore, Monetary Authority of Singapore, *Global Layer 1 (GL1) White paper*, published on 27 June 2024.
33 Global Layer 1 webpage, accessed on 25 August 2026.

for bank-issued tokenised deposits held on participants' own ledgers, enabling banks to move funds across borders outside conventional operating hours, with final settlement completed through existing systems. Seventeen banks across six continents are preparing to pilot live transactions. It was created to be interoperable both with existing and emerging networks.[34, 35]

- **Swift Digital Assets Standards Platform:** Announced at Sibos in September 2025 as a proof-of-concept, the digital assets standards platform is an initiative focused on tokenised debt securities. It seeks to unify business and technical standards for the creation and lifecycle management of tokenised securities across different settlement systems, including public blockchains, private DLT networks and traditional market infrastructures. The platform follows a modular approach, with asset definitions based on instrument taxonomy built on ICMA's BDT, standardised role definitions and implementations of core lifecycle functions such as issuance, transfer, interest payments and redemption, which can be reused across DLT networks.[36, 37]

Alongside private purpose-built and shared DLT networks, another important category of infrastructure is that of central securities depositories ("CSDs"). As tokenisation reshapes the issuance and lifecycle management process for financial assets, several CSDs are extending their services to DLT-based securities, as the Clearstream D7 and Euroclear D-FMI (defined below) examples in Section 4.6 illustrate, combining DLT-based automation with the governance and settlement finality associated with a regulated CSD environment. The regulatory perimeter within which CSDs operate shapes how far those services can extend to DLT-based settlement assets, as further explored in Section 4.6.

Though different in their jurisdiction and governance structures, these networks share a common point: the premise that smart contracts can only live up to their potential when deployed on common, credibly neutral base infrastructure. Initiatives of this kind at the network connection level are therefore foundations for contract and data-level standards.

4.6. Live Industry use cases

Beyond the initiatives and networks described above, smart contracts are already operating as part of live, production-scale DLT-based capital markets systems. Six, non-exhaustive examples highlighted below illustrate this:[38]

- **HSBC Orion** is a DLT platform for issuing, holding and settling digitally native bonds.[39] It has supported over US$5 billion of digitally native bond issuance across sovereign, supranational, financial institution and corporate issuers, including by the Central Moneymarkets Unit for the issuance of the HKMA's digitally native green bonds and the Hong Kong Mortgage Corporation's inaugural public digital bond issuance.[40, 41] Of note, it is also the first platform to have received Bank of England regulatory approval for operation in the Digital Securities Sandbox and was appointed platform provider for HM Treasury's Digital Gilt Instrument ("DIGIT") pilot.[42, 43]
- **Broadridge's Distributed Ledger Repo (DLR)** platform deploys smart contracts to automate end-to-end repo lifecycle processing.[44] The underlying securities remain immobilised in custody accounts while ownership is transferred via smart contracts on the shared ledger across different forms of repo.[45] The platform reported average daily processed volumes of US$357 billion for the month of June 2026, making it one of the largest institutional applications of smart contracts in any market.[46]

34 Swift, *Swift to add blockchain-based ledger to its infrastructure stack in groundbreaking move to accelerate and scale benefits of digital finance across more than 200 countries and territories worldwide*, published on 29 September 2025..
35 Swift, *Swift's blockchain ledger ready for use as 17 banks set to pioneer tokenised cross-border payments on trusted global infrastructure*, published on 9 July 2026
36 ICMA, *Webinar: Scaling tokenised assets — Swift's Digital Asset Standards Platform and the Bond Data Taxonomy*, published on 10 September 2026.
37 Ledger Insights, *Sibos: Swift's digital asset standards could prove bigger than its blockchain launch*, published on 3 October 2025.
38 See further information on ICMA's tracker of new FinTech applications.
39 HSBC, *HSBC Delivers World's First Multi-Currency Digital Bond Offering*, published on 16 February 2024.
40 Hong Kong, Hong Kong Monetary Authority, HKSAR Government's Third Digital Green Bonds Offering, published on 11 November 2025.
41 Hong Kong, Hong Kong Monetary Authority, *HKMC's HK$12 billion inaugural public digital bond issuance*, published on 11 June 2026.
42 HSBC, *HSBC Orion awarded DIGIT platform mandate*, published on 12 February 2026.
43 HSBC, *HSBC is first company to get Bank of England regulatory approval to go live in the Digital Securities Sandbox*, published on 15 July 2026.
44 Broadridge, Distributed Ledger Repo (DLR), accessed on 25 August 2026.
45 Digital Asset, *Customer Story: Broadridge*, published on 21 June 2024.
46 Broadridge, *Broadridge's Distributed Ledger Repo Processes $7.5 Trillion in June*, published on 7 July 2026.

- **J.P. Morgan's Digital Financing**, a blockchain-based application built on its Kinexys Digital Assets platform, applies smart contracts to intraday repo; settlement and maturity timing are programmed into the trade agreement, and at the agreed time cash (tokenised deposits) and the entitlement to the collateral are transferred, allowing trades to be executed and settled automatically.[47]
- **Clearstream D7** is a digital post-trade platform supporting the issuance, holding and lifecycle management of DLT-based securities. It enables issuers to create and administer native digital securities within a regulated CSD environment, leveraging Daml smart contracts, and has been used for a growing number of live issuances under both German and Luxembourg legal frameworks.[48, 49]
- **Euroclear's Digital Financial Market Infrastructure ("D-FMI")** supports the issuance, transfer and primary DvP settlement of digitally native debt securities on DLT using smart contracts to automate core issuance and settlement functions. Rather than replacing market infrastructure functions, it combines DLT-based automation with the governance, legal certainty and settlement finality of a CSD. Through interoperability with Euroclear's traditional infrastructure, D-FMI preserves access to established investor networks.[50]
- **HQLA^X** operates a DLT-based digital collateral registry, allowing participants to transfer ownership of securities between collateral pools without moving the underlying securities between custodians. HQLA^X announced that its platform is being migrated to the Canton Network, subject to regulatory approval.[51, 52]

These implementations also highlight a bottleneck that runs through every smart contract use case: settlement, particularly the cash leg. Atomic delivery-versus-payment settlements are only as efficient as the forms of settlement asset available, and live systems currently solve this in different ways, including: (i) settlement tokens native to the platform (HSBC Orion); (ii) fiat currency payments and tokenised deposits (Broadridge DLR);[53] (iii) tokenised deposits (Kinexys);[54] and (iv) central bank money via Deutsche Bundesbank's trigger solution (the SBC pilot transaction).[55]

The availability of digital cash (whether tokenised deposits, regulated stablecoins or wholesale central bank digital currency) is as important to the future of DLT-based debt securities as the smart contracts themselves. The addendum to the GFIF published in November 2025 addresses this issue directly. Delivered by the Project Guardian Fixed Income Workstream led by ICMA, it includes a Delivery versus Payment (DvP) settlement guide for DLT-based debt securities which provides practical information on the use of settlement assets, including wholesale CBDC, tokenised deposits and regulated stablecoins.[56]

Scaling of DLT-based fixed income markets also depends on legal certainty as to settlement finality, particularly where DLT-based and legacy post-trade operate alongside each other. Where a CSD operates a DLT-based settlement rail alongside its existing infrastructure, participants need certainty as to whether both form part of the same designated settlement arrangement, and how finality protections apply across them. What matters in practice is certainty as to when transfer orders become irrevocable, irrespective of the rail through which a transaction is processed.

The bottleneck is therefore not only a question of which forms of digital cash are technically available, but also of whether the applicable prudential and post-trade frameworks allow them to perform the intended settlement function. Where they do not, participants may need to maintain parallel funding and liquidity arrangements in legacy environments, adding costs and complexity that automation is meant to remove. Resolving this issue therefore requires more than harmonised token standards and smart contract logic. It also requires alignment between the design of digital settlement assets, the infrastructure through which they are transferred, and the frameworks governing their use.

47 J.P. Morgan, *Digital Financing | Kinexys by J.P. Morgan*, accessed on 25 August 2026.
48 Clearstream Digital Issuance webpage, accessed on 8 September 2026.
49 Digital Asset, *Deutsche Börse's D7 post-trade platform and the call for dematerialization*, published on 1 November 2021.
50 Euroclear D-FMI webpage, accessed on 8 September 2026.
51 https://www.hqla-x.com/our-platform.
52 HQLAX, *HQLAX Announces Strategic Investments from Broadridge and Digital Asset to Support its Next Phase of Growth on Canton*, published on 21 April 2026.
53 Broadridge, Distributed Ledger Repo (DLR), accessed on 25 August 2026.
54 J.P. Morgan, JPM Coin, accessed on 25 August 2026..
55 DZ BANK, *Premiere: DZ BANK and KfW fully map the lifecycle of a crypto security on a public blockchain*, published on 25 March 2026.
56 International Capital Market Association, *Project Guardian Fixed Income workstream deliverables led by ICMA published as an addendum to the Guardian Fixed Income Framework*, published on 12 November 2025.

4.7. Use cases for repo and collateral

Among potential use cases, repo and collateral deserve particular attention, as the Broadridge and Kinexys implementations above already indicate. These processes are highly rules-based, operationally intensive and, in part, already automated, making them well suited to further programmability and end-to-end automation. Potential applications include:

- Intraday repo, as supported by the ICMA Global Master Repurchase Agreement ("GMRA") annexes targeting digital assets and bonds.[57] The ICMA GMRA Digital Assets Annex, published in August 2024, provides standardised terms for repo transactions involving digital cash, digital securities and asset-backed digital assets, and addresses the commercial considerations arising from intraday repo, which shorter settlement cycles on digital platforms have made operationally feasible.[58] The Digital Bonds Annex, published in April 2026, extends that framework to transactions involving natively issued digital bonds.[59]
- Collateral eligibility is a natural fit, as eligibility criteria and schedules are already expressed as structured, largely deterministic rules covering a large set of factors. Encoding these into smart contracts could support automated and dynamic collateral allocation, substitution and optimisation against specific schedules, with assets moving only when the established conditions are met. Standardised representations of the transaction itself lend themselves to such implementations. As an example, the FINOS Common Domain Model ("CDM") provides a machine-readable and machine-executable model of repo trades and their lifecycle events, with its possible capabilities extended to repo and bonds by ICMA;[60]
- Trade validation involves confirming economic terms against agreed parameters before a transaction proceeds and could therefore be performed at the point of execution rather than through subsequent reconciliation;
- Collateral valuation and margining rely on agreed prices, haircuts and thresholds. Where these inputs are available to the ledger, smart contracts could calculate margin requirements and initiate the resulting transfers using a common rule set on which both counterparties rely;
- Entitlements and manufactured payments arising from corporate events affecting collateral securities could be derived from the repo terms and relevant asset data recorded on, or made available to, the ledger, rather than determined separately by each party and reconciled afterwards; and
- Regulatory reporting could become a by-product of the transaction lifecycle. Where transaction, collateral and related event data are recorded using standardised, machine-readable representations (including the ICMA BDT for relevant bond data and the FINOS CDMfor transaction and lifecycle events),[61] the information required under applicable reporting regimes could be generated from the same underlying records.

A shared ledger record combined with smart contract logic could also support greater transparency over collateral re-use and the resulting collateral chains, an area of sustained regulatory interest. Where successive transfers and encumbrances are recorded consistently across relevant systems, the re-use of a given security could become more visible and traceable than it is today. Achieving this, however, would depend on reliable links between ledger records, legal ownership positions and any off-ledger movements.

Taken together, these use cases point to the repo and collateral lifecycle as one of the most compelling near-term applications of smart contracts in fixed income markets. Their potential extends across trade validation, eligibility assessment, collateral allocation and substitution, valuation and margining, corporate-event processing, regulatory reporting and the tracking of collateral re-use.

57 ICMA, Global Master Repurchase Agreement (GMRA) webpage, accessed on 18 September 2026.
58 ICMA, *ICMA publishes GMRA Digital Assets Annex*, published on 19 August 2024.
59 ICMA, *ICMA publishes the Digital Bonds Annex, an addition to the GMRA Digital Assets Annex*, published on 30 April 2026.
60 ICMA, FINOS Common Domain Model (CDM) webpage, accessed on 18 September 2026.
61 ICMA, FINOS Common Domain Model (CDM) webpage, accessed on 18 September 2026.

They also connect directly to the official sector developments discussed in Section 5, especially the ECB's work on the harmonisation of collateral management processes through SCoRE. At the same time, these use cases reinforce the paper's broader argument that automation at this scale depends on harmonisation and interoperability beyond the smart contract itself, including (i) standardised, machine-readable representations of transactions, collateral and lifecycle events, (ii) reliable access to market and reference data, (iii) alignment with legal, regulatory and reporting frameworks, and (iv) the ability to transfer assets and information consistently across platforms and venues.

2. Key questions:
Which smart contract layer (ie, token standards, financial logic, full-lifecycle protocols, network infrastructure or cross-network interoperability) would benefit most from standardisation? Are there gaps that the existing initiatives do not cover? In the context of repo and collateral, which use cases beyond those outlined here offer the greatest potential?

5. Official sector perspectives on smart contracts

Smart contracts are of importance to regulators for a number of reasons. On the one hand, they offer a tool for pursuing market improvements, including (i) automation of manual post-trade processes, (ii) reduction of settlement and reconciliation risks, and (iii) improvement of the transparency and auditability of market activity. On the other hand, they raise questions that sit squarely within supervisory mandates, including (i) whether code that performs financial obligations is legally enforceable, (ii) whether it is secure and behaves as intended, (iii) who is accountable when it does not behave as expected, and (iv) what automated execution means for operational resilience, investor protection and financial stability.

Regulatory guidance to date reflects these perspectives and has emerged in different domains, such as:

- legal status (eg, the UK Law Commission's advice concluding that the current legal framework for England and Wales is able to support smart legal contracts);[62]
- definitions and market education (eg, the US CFTC's primer and the HKMA's whitepaper on DLT cited in Section 3);
- **regulator-convened industry frameworks and standards (eg MAS Project Guardian and its Guardian Fixed Income Framework);**
- **post-trade processes that smart contracts could help operationalise (eg the Eurosystem's post-trade harmonisation and market integration agenda); and**
- **code security and assurance (eg the French authorities' smart contract certification proposal).[63]**

Many of these issues are not technological. Instead, they result from the absence of common standards and market practices, divergent national rules and tax treatments, and limited commercial incentives to change existing processes. Smart contracts may help to operationalise some of these aspects but will not by themselves resolve all of the underlying causes.

Regulators play a central role, both in assessing the areas in which smart contracts could assist in bringing down barriers within the capital markets and in setting the minimum standards to which they must adhere. If established and constructed jointly, these efforts could have great effect in diminishing the risks of fragmentation.

It is worth highlighting that attention to the topic is not confined to national authorities. At the supranational level, the Bank for International Settlements' ("BIS") Innovation Hub, the Swiss National Bank and the World Bank concluded Project Promissa in 2025, demonstrating that paper-based promissory notes used to fund multilateral development banks can be redesigned using DLT (Canton protocol), to address operational challenges which make the process time-consuming and cumbersome.[64, 65] Other projects by the BIS Innovation Hub that explored the use of smart contracts or involved programmable settlement, automated execution or smart-contract-like logic include Projects Pine,[66] Agorá,[67] Mariana,[68] and Genesis 2.0.[69] Additionally, the International Organization of Securities Commissions' ("IOSCO") policy recommendations for decentralised finance, published in 2023, cover DeFi arrangements that necessarily deploy smart contracts.[70]

62 United Kingdom, Law Commission, Smart Contracts, published on 25 November 2021.
63 France, Autorité des Marchés Financiers, *The ACPR and the AMF publish the findings from the Working Group on Smart Contract Certification, and launch a Public Consultation*, published on 3 February 2025.
64 Bank for International Settlements, *Project Promissa: blockchain for multilateral development*, published on 23 April 2025.
65 Bank for International Settlements, *Project Promissa, Tokenisation of promissory notes, Final Report*, published in April 2025.
66 Bank for International Settlements, *Project Pine: Central bank open market operations with smart contracts*, published on 14 May 2025.
67 Bank for International Settlements, *Project Agorá: Shared programmable platform for wholesale cross-border payments*, published on 27 May 2026.
68 Bank for International Settlements, *Project Mariana: Cross-border exchange of wholesale CBDCs using automated market-makers*, final report, published on 28 September 2023.
69 Bank for International Settlements, *Project Genesis 2.0: Smart contract-based carbon credits attached to green bonds*, published on 24 October 2022.
70 International Organization of Securities Commissions, *IOSCO Finalises its Policy Recommendations for Decentralized Finance*, published on 19 December 2023.

The above domains in bold are further examined below.

5.1. Regulator-led industry frameworks and official sector participation[71, 72]

In Singapore, the MAS' Project Guardian provides an example of a global initiative convening policymakers and the industry to develop common standards across asset classes for tokenised markets, rather than through direct regulation. The GFIF, published in November 2024 under Project Guardian with contributions from ICMA and other industry participants, introduces an initial set of non-prescriptive standards and industry best practices for tokenised fixed income assets.

Its relevance to smart contracts is significant. First, it embeds the ICMA BDT as a common language for key bond information and outlines proposals for integrating it into smart contracts. It also recognises existing token standards (including the CMTAT), demonstrating how bond market standards can be carried directly into smart contract implementations. As such, it provides a model in which the official sector is facilitating, rather than substituting, market-led harmonisation, the aim being to enhance liquidity and efficiency of financial markets through asset tokenisation.

Official sector support also extends beyond frameworks to direct participation in DLT-based issuances across regions, as illustrated by the HKMA, HM Treasury and European Investment Bank ("EIB") examples referred to in Sections 4.6 and 6.

Within the EU, two further examples are examined below: The Eurosystem's work on post-trade harmonisation, which concerns barriers to infrastructure processes, as well as the French authorities' work on the security and assurance of the smart contract code itself.

5.2. Eurosystem AMI-SeCo[73]

The Eurosystem's Advisory Group on Market Infrastructures for Securities and Collateral ("AMI-SeCo") is an advisory group bringing together representatives of banks active in the EU, central securities depositories, central counterparties and national central banks, tasked with assisting the Eurosystem in the facilitation of the further integration of the financial markets in Europe.[74] Its September 2025 report on remaining barriers to post-trade integration found that many obstacles remain in (i) legal frameworks, (ii) issuer-investor relationship, (iii) buyer-seller relationship, and (iv) transversally, through the chain.[75] The report then states that the use of DLT within a harmonised regulatory landscape could remove many of the identified operational barriers.

It must be noted that the AMI-SeCo does not address smart contracts. Its work concerns the integration and harmonisation of post-trade processes within the EU, and approaches DLT only insofar as it could support that goal. Its connection to this paper is therefore indirect, but still material. The barriers identified are mostly not technological in origin, instead stemming from other root causes, including diverging withholding tax treatment, lack of cross-CSD connectivity due to limited market sizes, and a lack of commercial incentive. However, common process and data definitions of the kind the AMI-SeCo assesses form an important part of the process of automation, whether through smart contracts or otherwise.

A key instrument for this is the Single Collateral Management Rulebook for Europe ("SCoRE")[76], developed by the AMI-SeCo's Collateral Management Harmonisation Task Force to address this fragmentation. The harmonised collateral management processes set out in the rulebook facilitate the (i) movement of securities and collateral by banks and other market participants between EU countries, and (ii) purchase and use as collateral of securities by investors in any EU country. It also aims to (a) increase efficiency, (b) lower costs, (c) facilitate interoperability across financial market infrastructures, (d) lower risk in the management of securities and collateral, (e) level the playing field for market participants across Europe, and (f) expand their reach beyond domestic markets.

71 Singapore, Monetary Authority of Singapore, Project Guardian, published on 12 November 2025.
72 Singapore, Monetary Authority of Singapore, Project Guardian, *Guardian Fixed Income Framework* version 1.1, published in November 2025.
73 European Union, European Central Bank, *Advisory groups on market infrastructures*, accessed on 20 July 2026.
74 European Union, European Central Bank, *Advisory Group on Market Infrastructures for Securities and Collateral Mandate*, published in January 2023.
75 European Union, ECB AMI-SeCo, *Remaining barriers to integration in securities post-trade services – issues and recommendations*, published in September 2025.
76 European Union, ECB AMI-SeCo, *Single Collateral Management Rulebook for Europe (SCoRE)*, accessed on 20 July 2026.

The AMI-SeCo's Corporate Events Compliance Report 2024 Monitoring Exercise Report showed,[77] among other things, that the SCoRE standards themselves are acting as a catalyst for implementation, demonstrating that such official sector efforts, with support from the market, can promote integration more broadly.

For smart contracts, this work is of relevance. Standardised workflows, ISO 20022 messaging,[78] and corporate event processes provide the common process and data definitions necessary for smart contracts to automate these functions across platforms. SCoRE demonstrates that standards can pull the wider market towards harmonisation. As such, it might offer a template for how smart contract standards themselves might be developed.

5.3. AMF and ACPR[79]

In France, the AMF, jointly with the Autorité de contrôle prudentiel et de résolution ("ACPR"), published a report in February 2025 setting out a proposal for smart contract certification,[80] followed up in July 2025 by feedback that assisted in clarifying technical aspects and refining the proposals (the "Certification Proposal").[81] Its relevance is significant, with the report setting out the measures and principles to be taken into account for the establishment of a certification regime, which could assist in establishing baseline standards for the construction of smart contracts. Such a certification regime, however, should also account for the broader regulatory treatment of the entities that deploy smart contracts (eg, the EU's Markets in Crypto-Assets Regulation ("MiCAR") for the Certification Proposal).[82]

Dedicated certification regimes or further legislative changes may not be necessary for the adoption of smart contracts in all jurisdictions, or even within all EU Member States. In some jurisdictions, such as Luxembourg,[83] existing legal frameworks are sufficiently flexible (or have already been adapted) to accommodate their use in capital markets without the need for further amendments or additional supporting regimes.

These considerations may also be relevant to the repo and collateral use cases discussed in Section 4.7, where the status of the protocols that execute these functions could affect whether institutional participants can rely on them within their existing risk and compliance frameworks. Whether this additional layer is necessary in a highly regulated capital markets context remains an open question.

3. Key questions:
What role should regulators play in the harmonisation of smart contracts? Should standards be market-led, with regulatory endorsement (as in Project Guardian and with SCoRE)? Is there a case for formal certification of smart contract code in a capital markets context, where participants are already regulated? Given the settlement bottleneck described in Section 4, where should the priority lie: (i) on the availability of digital settlement assets, (ii) on the regulatory recognition of digital money for settlement purposes under the applicable prudential and post-trade frameworks, or (iii) on legal certainty as to finality where DLT-based and legacy components coexist?

77 European Union, ECB AMI-SeCo, *Corporate Events Compliance Report 2024 Monitoring Exercise*, published in December 2024.
78 Of note, ICMA is currently working on the integration of the BDT into ISO 20022.
79 France, Autorité des Marchés Financiers, *The ACPR and the AMF publish the findings from the Working Group on Smart Contract Certification, and launch a Public Consultation*, published on 3 February 2025.
80 France, Autorité des Marchés Financiers, Forum Fintech ACPR-AMF, *Report of the Working group on Smart Contract Certification*, published in February 2025.
81 France, Autorité des Marchés Financiers, Forum Fintech ACPR-AMF, *Summary of Responses to the Public Consultation of the ACPR-AMF Working Group on Smart Contract Certification – A Proposal for Smart Contract Certification: Overview, Technical Considerations and Regulatory Discussion Points*, published in July 2025.
82 While MiCAR may be relevant to certain entities or crypto-asset services, DLT-based debt securities that qualify as financial instruments remain subject to securities frameworks. The relevance of the Certification Proposal is mostly through its approach to code assessment.
83 Luxembourg, Commission de Surveillance du Secteur Financier, *Innovation Hub*, last updated on 6 March 2025.

6. State of play of smart contracts: Is there a need for harmonisation?

Smart contracts are not an incidental feature of DLT-based debt securities. They are integral to many of the DLT platforms on which these securities are issued, held and traded. By automating processes across the securities lifecycle, smart contracts have the potential to shorten issuance timelines, reduce intermediary steps and lower operational risk and cost. They can therefore enable a digital bond to offer significantly more than simply recording a conventional bond on a different type of database. As such, it is natural that efforts to harmonise said DLT platforms to allow for interoperability to enable seamless trading and the development of a secondary market and, especially, to automate the back-end processes of DLT-based debt securities would take direct aim at smart contracts themselves. It is important to ask, however, whether that is the only approach.

An important distinction must be drawn between public blockchains and private (permissioned) networks, reflecting the access and governance models set out in Section 4.5.[84] On public blockchains (such as the SBC implementation in the pilot transaction between DZ BANK and KfW)[85] smart contracts are open and interoperable and execute without a central operator. Any permitted participant integrates directly with the contract's interface, and harmonised token and contract standards are essential precisely because no single party controls the environment.

On private DLT networks, participation, governance and upgrades are controlled by an operator or consortium; "smart contracts" there function more like shared workflow automation among known parties, and their behaviour can be coordinated by the operator rather than by open standards. Functionally, a smart contract on a private network may differ little from a conventional platform's automated logic. Views differ on whether the distinctive contribution of smart contracts is realised most fully in open or interconnected environments, or whether permissioned settings deliver comparable results within their own boundaries.

In practice, the distinction is not binary. Networks operate along a spectrum of permissioning models, across which interoperability remains equally important. New entities, such as crypto securities registrars, transfer agents and tokenisation managers, are also emerging to perform specific roles within and across these networks. The priorities for harmonisation therefore vary by context. On public networks, common token and contract standards are preconditions for trust and interoperability. On private networks, the greater need is for common data and process definitions, as well as interoperability between different networks.

Up to this point, supranationals, sovereigns and commercial banks, among others, have issued DLT-based debt securities through a diverse set of platforms. Banks are also exploring the deployment of smart contracts for intraday repo and collateral mobility.[86] While these developments demonstrate the growing interest in the market, they also evidence the existing fragmentation of the industry, with a diverse set of solutions that lack interconnectivity. As consistently highlighted by ICMA and across the industry, harmonisation of the developing DLT-based fixed income market is therefore critical to its growth and scalability.

By way of example, EIB and other supranational and private sector issuers have issued several digital bonds governed by Luxembourg law, most recently, a DLT-native commercial paper on the Clearstream D7 platform described in Section 4.6, which was mobilised through Clearstream's triparty collateral management solution and the Eurosystem Collateral Management System (ECMS) for financing with the Bundesbank. The issuance relied on Luxembourg's technology-

84 Chainlink, *Understanding Public vs Private Blockchains*, last updated on 6 April 2026.
85 DZ BANK and KfW, Smart Bond Contract, Disintermediating the Life Cycle of a Tokenized Security, Pilot Report, published in March 2026.
86 Examples can be found in the ICMA FinTech and Digitalisation Tracker of New FinTech Applications in Bond Markets webpage.

neutral legislative framework for DLT-based dematerialised securities. It illustrates how DLT-based lifecycle processes can function within an intermediated, regulated structure, although the extent to which the platform relies on smart contracts as defined in this paper, rather than centrally operated automation, varies by design.

Naturally, the harmonisation of smart contracts is therefore a legitimate and pressing focus. Industry efforts to define common data taxonomies for bond terms, such as the BDT, machine-readable and executable representations of contractual events, and shared token standards are therefore valuable: they would allow smart contracts on different platforms to be understood, compared and integrated on a consistent basis, supporting interoperability, reducing duplication of development and legal cost, and giving investors confidence that a "digital bond" behaves predictably regardless of where it is issued. Standardised identifiers (such as the Digital Token Identifier) embedded within the BDT could play a role here, allowing for consistent identification of an instrument regardless of the smart contract implementation or platform used.

Looking forward, the potential of harmonised smart contracts within DLT-based fixed income markets is considerable and multifaceted, as can be seen by the selected initiatives listed in Section 4, bringing tangible gains in efficiency through the automation of back- and mid-office processes that currently require step-by-step confirmations. A future in which collateral can move freely between venues, in which repo and bond markets share consistent representations of the same instrument, and in which new entrants can build against well-understood templates rather than proprietary code, is only achievable if the industry builds towards a harmonised approach.

The ultimate goal should be interoperable standards that allow assets, data and contract logic to move consistently across platforms, networks and jurisdictions. Harmonisation achieved only within one environment risks being lost at its boundary, limiting its effects.

4. Key questions:
Do harmonisation priorities differ between public and private networks in your experience, and if so, how? How could you and your institution get involved in supporting or advancing the harmonisation of smart contracts? Where interoperability is the objective, which boundaries matter most in practice: those between networks, jurisdictions, or DLT-based and legacy infrastructure?

7. Conclusion

Drawing on the discussion set out above, this paper invites the market to consider where the harmonisation of smart contracts should sit among its priorities, and how to mitigate the risk of fragmentation and help scale DLT-based fixed income markets.

The value of smart contracts is well recognised within the capital markets. Industry initiatives are addressing fragmentation at different and complementary layers: live systems are processing institutional volumes daily, institutional DLT networks are emerging to provide shared, neutral infrastructure, regulated market infrastructures are extending into DLT-based issuance and settlement, and repo and collateral stand out as areas where scaled implementations could deliver even greater gains.

Official sector initiatives, meanwhile, look to both accelerate this work and set appropriate guardrails for it. At the supranational level, entities such as the BIS and IOSCO are also engaged, albeit focusing on the broader environments and products in which smart contracts are deployed rather than on the smart contracts themselves.

It is clear that smart contract harmonisation is a legitimate and pressing priority, albeit one that differs between public and private networks. Given the fragmentation evident across the industry, harmonised smart contracts would allow instruments on different platforms to interoperate and be transacted consistently, while delivering tangible efficiency gains through the automation of back- and mid-office processes, with the relevance of harmonisation differing by context.

Where, then, should the focus lie? This paper shows that the matter is no longer whether smart contracts can be deployed in the fixed income markets, but how their impact can be maximised. Rather than pre-empting that answer, this paper presents three possible pathways: (i) converging on common standards within platforms, for smart contracts and the data they require; (ii) addressing the settlement bottleneck, which calls not only for forms of digital money that can be used easily across platforms, but also for their regulatory recognition for settlement purposes and for legal certainty as to finality where DLT-based and legacy components coexist; and (iii) building connections between platforms, so that assets, data and contract logic can move consistently across networks, across jurisdictions and between DLT-based and legacy infrastructure.

ICMA welcomes feedback from members and the wider industry on the key questions highlighted throughout this paper, which will help inform and guide the future development of DLT-based bond markets.

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