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DOI: 10.15290/oes.2026.02.124.10

DIGITAL BONDS IN EUROPE: REGULATORY LANDSCAPE, MARKET EVIDENCE AND ECONOMIC POLICY OPTIONS[1]

Summary

Purpose | We document how tokenised bonds have progressed from pilots to routine issuance in the EU, mapping the DLT Pilot Regime and three enabling Member State regimes (Germany's eWpG, Luxembourg's dematerialised-securities law, Italy's Fintech Decree) and linking law to market practice.

Research method | Documentary analysis of primary EU/national legal acts, supervisory reports and verifiable issuer communications; triangulation with transaction evidence from leading SSA and corporate deals.

Results | We find operational gains in distribution and lifecycle processing and credible pathways to delivery-versus-payment in central bank money (Eurosystem 2024 designs). Adoption, however, remains concentrated in SSAs and development banks, as well as large investment-grade corporates; SMEs see limited benefit where settlement stays in commercial bank money and interfaces are bespoke.

Originality/value/implications/recommendations | We synthesise law-market-technology interactions into an incremental policy agenda: (i) codify a technologically neutral gateway for DvP in central bank money; (ii) standardise token/event disclosures (ICMA Bond Data Taxonomy).

[1] Article accepted on 20.054.2026.

Keywords: blockchain, tokenised bonds, DLT Pilot Regime, central-bank-money settlement

JEL classification: G23, G28, E58, E44, O33

1. Introduction

European fixed-income markets have spent the past five years testing whether distributed-ledger technology (DLT) can be embedded into ordinary issuance and settlement workflows. Union-level rules already accommodate MiFID-class (Markets in Financial Instruments Directive) securities on DLT (MiFID II/MiFIR – Markets in Financial Instruments Regulation, Central Securities Depositories Regulation – CSDR), Markets in Crypto-assets Regulation (MiCA) generally excludes them, and the Digital Operational Resilience Act (DORA) sets a technology-neutral ICT floor. The DLT Pilot Regime (DLTR) supplies supervised space to trade and settle instrument tokens. Several Member States add issuance-law certainty (e.g., Germany's eWpG, Luxembourg's dematerialised-securities law, Italy's Fintech Decree). These legal and institutional pieces now interact with a small but growing body of transactions by public issuers and corporates.

Research gap. While policy notes and industry reports describe individual pilots, the academic literature gives little integrated evidence linking (i) issuance-law certainty and cash-leg design to (ii) observed platform choices (permissioned versus public) and (iii) economic-policy implications for routine issuance and settlement.

Research questions. We have formulated the following research questions: RQ1: Which regulatory and market-design features best explain issuers' revealed preferences between permissioned and public-chain implementations in 2021–2025? RQ2: How does access to delivery-versus-payment (DvP) in central bank money (CeBM) affect feasibility beyond pilots for sovereign/supranational/agency (SSA) issuers and corporates?

Contributions and method. We (i) map the EU framework (DLTR, MiFID/MiFIR–CSDR linkages, MiCA/DORA interfaces) and three enabling national regimes;

(ii) assemble a descriptive dataset of DLT-based fixed-income transactions (2021–2025) from verifiable issuer/supervisor communications and market compilers; and (iii) discuss market-design and policy implications for routine CeBM DvP and data/disclosure standards. Methods combine documentary analysis of primary legal acts and supervisory materials with cross-checked transaction evidence. Unless explicitly referenced, interpretations of platform choice and cash-leg design are the authors' own synthesis of the evidence.

The article proceeds as follows. Section 2 sets the EU framework and national regimes. Section 3 documents market activity across public and corporate issuers. Section 4 analyses frictions at the law-market-technology interface, with emphasis on settlement. Section 5 develops discussion and policy implications. Section 6 concludes.

2. Regulatory and institutional framework in the EU

The European Union has not created a separate "digital bond" legal species. Instead, tokenised / fractionalised bonds are brought under existing capital-markets law, with targeted exemptions under the DLT Pilot Regime (Regulation (EU) 2022/858, "DLTR"). DLTR allows market infrastructures to operate with time-limited waivers from parts of MiFID II/MiFIR, CSDR, and related legislation, within quantitative caps and supervisory safeguards (notably for settlement finality, investor protection and operational risk). Recent European Securities and Markets Authority Report on the Functioning and Review of the DLT Pilot Regime [ESMA, 2025], published on 25 June 2025 pursuant to Article 14 of Regulation (EU) 2022/858 (DLTR), shows that only a handful of DLT market infrastructures have been authorised so far, with tight volume caps and cautious use of exemptions.

For issuance and disclosure, tokenised bonds remain subject to the Prospectus Regulation, where applicable (thresholds and exemptions unchanged), the Market Abuse Regulation (MAR) (inside information/market manipulation rules technology-neutral), and – in post-trade – CSDR (settlement discipline, CSD oversight). DORA applies to ICT risk management across regulated entities, including those operating DLT market infrastructures. These instruments

collectively ensure technological neutrality while recognising DLT-specific risks (governance of validators / nodes; key management; smart-contract controls).

Settlement in central bank money is the pivotal constraint for scaling. The Eurosystem's 2024 exploratory work tested three interoperability approaches between market DLTs and RTGS (real-time gross settlement) services: (i) a Trigger solution (a technical bridge linked to T2), (ii) TIPS (TARGET Instant Payment Settlement) Hash-Link (API-based interaction with TIPS accounts), and (iii) Full-DLT interoperability (a central-bank-operated DLT layer). Evidence so far points to practical short-term advantages of interoperability solutions, with functional parity increasing across models and no departure from CeBM as the settlement asset [ECB/Banca d'Italia, 2024–2025].

At the national level, several Member States adjusted private-law and securities-law foundations to recognise DLT registers:

- Germany – the eWpG ("Gesetz für elektronische Wertpapiere", Electronic Securities Act, in force since 2021) enables bearer bonds and other instruments to exist as electronic securities via either a central register or a crypto-securities register; detailed register requirements are set in the eWpRV ("Verordnung über Anforderungen an elektronische Wertpapierregister", Electronic Securities Register Ordinance), and scope extensions were made via KryptoFAV ("Verordnung über Kryptofondsanteile", Crypto Fund Shares Regulation). These reforms coexist with EU post-trade rules and allow on-chain issuance under German law.
- Luxembourg – starting with the 2019 and 2021 blockchain laws that clarified DLT use for holding/transfer, Luxembourg adopted "Blockchain Law IV" (voted on 19 Dec 2024; in force since 2025), modernising custody chains and facilitating tokenisation across finance laws (including dematerialised securities).
- Italy – Decree-Law No. 25/2023, as converted by Law No. 52/2023, implements DLTR domestically and creates a civil-law basis for issuance/circulation of financial instruments in digital form, alongside adjustments to the regulatory sandbox.

Disclosure and documentation sit at the law-market-technology interface: prospectus obligations (where applicable) remain off-chain documents;

MAR-compliant disclosure can reference on-chain events; and contractual terms (including smart-contract logic) must map unambiguously to the legal terms and the chosen governing law. In practice, national reforms (eWpG/LU/IT) increase legal certainty for recognising DLT registers as issuance or holding accounts, while DLTR and Eurosystem trials address the cash-leg constraint (CeBM).

Authorial contribution statement. The synthesis above reflects the authors' own assessment of the EU framework and selected Member State reforms, informed by ESMA/ECB primary documents and the legal commentary [Priem, 2022; Maume, Kesper, 2023].

Literature anchors. The legal–institutional view above aligns with academic analyses of DLT in post-trade and issuance law. Economic and microstructure effects of shared ledgers in settlement are discussed by Benos, Garratt and Gurrola-Perez [2019]; legal admissibility and the calibration of the DLT Pilot Regime are examined by Priem [2022]; and the custody/holding frictions of moving from indirect to more direct forms of record-keeping are addressed by Micheler and von der Heyde [2016]. On the design side, Malamas et al. [2023] and Schär [2021] map token standards and lifecycle automation relevant to disclosure and corporate actions. Institutional evidence on central-bank-money settlement comes from BIS [2020] (Project Helvetia) and the Eurosystem's 2024–2025 interoperability work, while OECD [2020] reviews the broader implications for fixed-income tokenisation. Unless otherwise cited, the synthesis in this section reflects the authors' interpretation of these sources in the EU context.

The next section specifies the methods used to compile the descriptive market dataset and to structure the literature review feeding the analysis.

3. Methods and European market evidence (2021–2025)

This section explains how we assembled the evidence on digital bonds and then summarises what it implies for the scale and structure of the market.

The article does not estimate causal effects. The aim is to answer two descriptive questions: how far EU law and national frameworks have translated into actual issuance of digital bonds, and to what extent settlement in central bank money is already available in practice. We therefore combine three strands of material: primary EU and national legislation and supervisory documents (Section 2), a targeted mapping of academic and policy literature, and a hand-built dataset of transactions and issuance volumes.

On the transaction side, we first compiled a list of EU digital bond deals between 2021 and mid-2025. We defined a "digital bond" as a fixed-income instrument where the issuance and/or register is maintained on a distributed ledger that is recognised in law as a valid form of security representation. We excluded purely synthetic exposures, tokenised funds and generic securitisations. Candidate deals were identified from The Association for Financial Markets in Europe (AFME) DLT-based capital-market reports, Eurosystem documentation, The International Capital Market Association (ICMA) and market-infrastructure publications, and then cross-checked against issuer, National Competent Authority (NCA) and Central Securities Depository (CSD) announcements [AFME, 2025a, 2025b; ECB, 2024, 2025; ESMA, 2025; ICMA, 2024; EIB, 2021, 2023; Siemens, 2023; Clearstream/Deutsche Börse Group, 2024; The Intesa Sanpaolo Group, 2024; Linklaters, 2021; NautaDutilh, 2021; Societe Generale, 2022; BME/BBVA/IDB, 2022].

From this list we selected representative European transactions for Table 1, keeping diversity in four dimensions: sovereign/supranational/agency versus corporate and financial issuers; public versus permissioned ledgers; domestic versus cross-border structures; and different legal chassis (for example, German *eWpG*, Luxembourg's DLT laws, Italy's FinTech Decree). Size, dates and venue information follow issuer or market-infrastructure releases; the classification of the cash leg (commercial-bank money versus central-bank money) is based on Eurosystem communications and NCA or CSD disclosures.

To capture global scale and trajectory, we then built Table 2 using AFME's DLT-Based Capital Market Report and Eurosystem figures. AFME provides annual volumes and counts for DLT-based fixed-income issuance (bonds, bills, commercial paper, covered bonds and structured notes) and distinguishes

central-bank trials from "organic" market deals. Eurosystem reporting adds the number and value of transactions settled in its 2024 DLT experiments [AFME, 2025a, 2025b; ECB, 2024, 2025]. All values are expressed in euro at the amounts reported by AFME and by the Eurosystem. Table 2 is therefore our own compilation, but the underlying numbers (72 deals and about €5.0bn of primary DLT-based issuance in 2021–2024, of which roughly €3.0bn in 2024 alone) follow AFME and Eurosystem sources closely.

The literature mapping serves two roles. First, it anchors our description of market microstructure and post-trade processes in existing analytical work – on the economics of DLT settlement, the legal status of electronic and tokenised securities, and the design of wholesale CBDC and interoperability solutions [Benos et al., 2019; Micheler, von der Heyde, 2016; OECD, 2020; Cucculelli, Recanatini, 2022; Priem, 2022; Maume, Kesper, 2023; BIS, 2020; Panetta, 2022; Lee, Lipton, 2022; Malamas et al., 2023; Nassr, 2023; Schär, 2021]. Second, it informs our choice of classification variables in Tables 1– 2, especially the distinction between CeBM and commercial-bank money settlement, and between "walled-garden" platforms and more open architectures. The mapping is targeted rather than fully systematic, but covers the main strands of peer-reviewed and institutional work at the intersection of DLT-based fixed income, EU regulation and central-bank-money settlement.

Against this background, Table 1 lists emblematic EU deals. The European Investment Bank opened the market in April 2021 with a €100 m two-year digital bond on a public blockchain, followed by subsequent issues in euro and sterling using permissioned platforms such as HSBC Orion and Luxembourg's DLT-based legal chassis. KfW's 2024 issues on Clearstream's D7 infrastructure illustrate how large-scale SSA funding can migrate to a DLT-native register while keeping conventional cash-leg arrangements. Corporate and financial issuers follow at smaller scale: Siemens' €60 m 2023 issue on a public chain under *eWpG*; repeated Siemens transactions in 2024; Dutch green bonds for real-estate and aviation projects structured on public chains; Spanish experiments combining BME/Iberclear, BBVA and IDB; and SG-Forge structures admitted to trading in Luxembourg. These transactions differ in platform choice and legal chassis, but share a common pattern: operational improvements in lifecycle management and distribution are achieved without yet changing the nature of the settlement asset.

TABLE 1

Selected EU digital bond transactions (2021–2025)

Issuer (Country)	Date	Size	Platform / ledger	Legal basis / Venue	Settlement (cash leg)
European Investment Bank	Apr 2021	€100 m	Public blockchain (Ethereum)	French law, BdF CBDC experiment	CBDC representation for subscription
European Investment Bank	Jan 2023	£50 m	HSBC Orion + public-chain mirror	Luxembourg DLT law, Lux legal chassis	Conventional payment rails
KfW (DE)	Jun–Jul 2024	€4bn	Clearstream D7 (central register)	eWpG central-register security, Deutsche Börse	Conventional rails, DvP in conventional CSD (on-chain register)
Siemens (DE)	Feb 2023	€60 m	Public blockchain (e.g., Ethereum)	eWpG; direct placement	Conventional rails
Siemens (DE)	Sep 2024	Not disclosed	Public blockchain	eWpG (repeat issue)	Conventional rails
Cassa Depositi e Prestiti (IT)	Jul 2024	€25 m	DLT platform (recording)	Fintech Decree, CONSOB	TIPS Hash-Link (CeBM, T+0)
ABN AMRO → APOC Aviation (NL)	Jan 2023	€0.45 m	Public blockchain	NL securities law, public-chain registration	Conventional rails
ABN AMRO → Vesteda (NL)	Sep 2023	€5 m	Tokeny / Polygon (ERC-3643)	Public-chain registration, Green bond framework	Conventional rails
BME/Iberclear + BBVA + IDB (ES)	Jul 2022	Not disclosed	ioBuilders DLT (registration)	Listed on regulated market (BME)	Conventional rails (via Iberclear)
SG-FORGE (FR → LU listing)	Jan 2022	Not disclosed	Ethereum / Tezos (native tokens)	LuxSE SOL admission	n/a (admission to trading)
Vonovia (DE)	Jan 2021	€20 m	Stellar (registration of claim)	German registered bond, Linklaters note	Conventional rails

Notes: size and dates follow issuer/NCA/CSD releases; "Conventional rails" denotes commercial-bank money settlement through standard payment systems, as stated or implied by the issuer; "CeBM" denotes settlement through Eurosystem rails with atomic linkage to a market DLT.

Source: own compilation based on [EIB, 2021, 2023; Clearstream/Deutsche Börse Group, 2024; Deutsche Börse Group, 2024; Siemens, 2023, 2024; The Intesa Sanpaolo Group, 2024; ABN AMRO, 2023; BME, 2022; IDB, 2022; Linklaters, 2021].

TABLE 2
Global DLT-based fixed-income issuances and values by year (2021–2024)

Year	No. of issuances (deals)	Issuance value (EUR m)
2021	6	270
2022	12	882
2023	15	848
2024	39	3,049
Total 2021–2024	**72**	**5,049**

Source: own compilation based on [AFME, 2025a, 2025b; ECB, 2024].

Table 2 places these transactions in a global perspective. According to AFME, DLT-based fixed-income issuance worldwide reached about €270 m in 2021, €882 m in 2022 and €848 m in 2023, before rising to roughly €3.0bn in 2024, a 260% increase over 2023. Much of the 2024 jump reflects central-bank trials by the ECB and the Swiss National Bank; excluding those pilots, AFME still finds that DLT-based fixed-income issuance roughly doubled year-on-year [AFME, 2025a; ECB, 2025]. Eurosystem experiments alone processed over 200 transactions and settled around €1.59bn between May and November 2024, across three interoperability solutions connecting market DLTs to TARGET Services [ECB, 2024, 2025]. AFME also reports that around three-quarters of 2024 issuance by value originated on public-permissioned blockchains, with platforms such as SDX and HSBC Orion capturing the largest shares of activity [AFME, 2025a]. These facts are reflected in the distribution of volumes in Table 2 and in the selection of deals in Table 1.

Taken together, the evidence suggests that issuance is no longer purely experimental. Volumes remain tiny compared to the conventional bond market, but they are no longer negligible; SSA issuers have demonstrated that multi-billion-euro programmes can be placed on DLT infrastructure, and corporate issuers have validated smaller-scale use cases. At the same time, the cash leg remains largely in commercial-bank money, with only isolated use of central-bank money in pilot settings (for example, Italy's 2024 TIPS Hash-Link digital bond). In the sections that follow we link this pattern back to the regulatory and institutional framework and identify frictions at the law-market-technology interface.

4. Frictions at the law-market-technology interface

The evidence from Sections 2 and 3 suggests that issuance itself is no longer the binding constraint for digital bonds. In the EU, there is now a workable legal basis for representing MiFID-class securities on distributed ledgers; several Member States have made token registers legally effective; and a small but non-trivial body of transactions has been carried out. What remains difficult is to make these arrangements routine: to settle in central bank money (CeBM) at scale, to avoid fragmentation across platforms, and to ensure that documentation and operational-resilience regimes keep up with programmable instruments.

On the cash leg, the technology question is largely answered but the policy decision is not. The Eurosystem's exploratory work has shown that at least three designs can deliver delivery-versus-payment (DvP) in CeBM between market DLTs and TARGET Services: a "Trigger" model that links asset transfers on a DLT to bookings in T2, a "TIPS Hash-Link" model that uses hashes of asset-leg instructions to synchronise with TIPS balances, and a full-DLT approach where a central-bank-operated ledger interacts with market platforms. Central-bank-money settlement is not yet routinely available for digital bonds outside pilots, however, and most transactions still rely on commercial-bank money accounts. The friction is therefore less about technical feasibility and more about turning one or more of these designs into a production service with clear cut-off times, fail-handling and responsibility for operational incidents.

At the level of issuance law, bottlenecks have shifted. For early-moving jurisdictions such as Germany, Luxembourg and Italy, legal uncertainty about whether a token represents a valid security has been reduced by reforms that accept DLT-based registers as issuance or holding accounts. This allows issuers and infrastructures in those jurisdictions to rely on clear private-law and securities-law foundations. What remains uneven is the geographic spread of such frameworks and their interaction with existing custody chains and CSDR-supervised infrastructures. In the absence of broader convergence, issuers outside these regimes may still perceive legal risk in using DLT-based registers for anything beyond pilot projects.

The second friction concerns platform fragmentation and data standards. Public blockchains offer openness and auditability; permissioned platforms offer governance and control aligned with regulated infrastructures. The problem arises when each platform encodes lifecycles, corporate actions and consent processes in its own way. Without a shared event language for coupons, redemptions, restructurings and consents, custodians and data vendors face bespoke mappings for each project and venue, and the benefits of straight-through processing are diluted by middleware and reconciliation layers. Industry efforts such as the ICMA Bond Data Taxonomy and the DLT Bonds Reference Guide move in the direction of common data fields and event codes, but adoption is partial and supervisory expectations about minimum data granularity and access are still emerging.

Documentation is where legal form and code meet. Prospectus obligations and market-abuse rules remain off-chain, but in digital-bond transactions the economic behaviour of the instrument is increasingly defined not only by written terms but also by the configuration of smart contracts and platform rules (for example, conditions for coupon processing, early redemption triggers, fallback procedures in case of oracle or validator failures). If these elements are not described in a consistent way, investors and supervisors may struggle to compare transactions. A short DLT-specific appendix to prospectuses, together with a structured template that can be read both by humans and machines, would make it easier to understand and compare how key management, upgradeability, governance and fallback processes are handled across different issues.

Finally, operational resilience has caught up with tokenisation rather than the other way around. DORA now applies to regulated firms and critical ICT providers regardless of the underlying ledger design. At the same time, wholesale-CBDC and interoperability projects, such as BIS experiments and Eurosystem trials, highlight that key-management, validator governance and incident-reporting need to be robust before DLT-based processes can be treated as ordinary market infrastructure rather than pilots. In practice, this means that tokenised bonds will have to meet the same standards of business continuity, cyber-security and incident handling as conventional systems, with the additional complexity of managing distributed architectures.

None of these frictions reverse the direction of travel. They do, however, explain why digital bonds remain concentrated in sovereign, supranational and agency issuers and a small number of large corporates, and why commercial-bank money still dominates as the settlement asset. They also indicate where relatively targeted policy and market-design interventions – on CeBM access, data and documentation standards, and resilience expectations – could shift digital bonds from proof-of-concept territory into a normal, if still specialised, part of European fixed-income markets. The analysis in this section reflects the authors' own synthesis of the legal and market evidence set out earlier.

5. Discussion and policy implications

The evidence assembled in Sections 2 and 3 allows us to return to the research questions. For RQ1, issuers' revealed preferences between permissioned and public-chain implementations appear to be shaped less by ideological views on decentralisation and more by jurisdictional legal certainty, access to central-bank-money settlement and integration costs with existing infrastructures. Sovereign, supranational and agency (SSA) issuers with access to established dealer networks tend to rely on permissioned or infrastructure-led platforms that can be embedded into existing custody and collateral chains, whereas some corporate and green-bond use cases have experimented with public chains when legal frameworks such as *eWpG* or Luxembourg's DLT laws make token registers clearly admissible as securities. For RQ2, the limiting factor is not whether DvP in central bank money (CeBM) is technically possible – Eurosystem trials and selected national projects show that it is – but whether such functionality is available as a predictable service rather than as a bespoke pilot.

From a policy perspective, the first implication is that regulatory permanence matters more than new special regimes. The DLT Pilot Regime has provided a supervised space for experimentation under waivers from MiFID II/MiFIR and CSDR, but its quantitative thresholds, eligibility restrictions and temporary nature make it difficult to justify large integration projects. ESMA's Article 14 review confirms that only a limited number of infrastructures have entered the regime and that several waivers have been granted on a case-by-case

basis. An incremental, but important, step would be to make the regime permanent on a risk-based footing, widening eligible instruments and size limits while preserving safeguards for settlement finality and investor protection. For market participants this would turn tokenisation from a one-off project topic into something that can be embedded into multi-year issuance and infrastructure roadmaps.

The second implication speaks directly to RQ2: CeBM DvP needs to move from experiment to product. The Trigger model, the TIPS Hash-Link and full-DLT solutions show that atomic settlement between market DLTs and TARGET Services is feasible without changing the nature of central bank money. What is missing is a decision to elevate at least one of these designs into an operational service with published cut-off times, queueing and failure-handling rules, and a clear allocation of responsibilities between the central bank, market infrastructures and participants. Without such a service, most digital bonds will continue to settle in commercial-bank money, with associated credit and liquidity risks, and tokenisation will not deliver the full reduction in principal risk and back-office frictions that the literature associates with DvP in CeBM.

A third implication concerns data and documentation standards. Tokenisation brings the promise of straight-through processing and automated lifecycle events, but this promise is weakened if each platform encodes coupons, redemptions, consents and restructurings in idiosyncratic ways. Industry initiatives such as the ICMA Bond Data Taxonomy and the DLT Bonds Reference Guide provide a starting point for a common event language and machine-readable term sheets, yet adoption remains uneven and supervisory expectations are still forming. A pragmatic option would be to introduce a concise DLT-specific appendix to prospectuses, aligned with such data standards, which describes in plain language and in structured fields how key management, upgradeability, oracle dependencies and fall-back arrangements are handled. This would make transactions more comparable across venues and lower integration costs for custodians, data vendors and supervisors.

Fourth, supervisory expectations could be harmonised at the margin without creating a separate supervisory regime. DORA already supplies a common floor for ICT-risk management; beyond that, a short set of joint principles

from the European Supervisory Authorities could clarify expectations on wallet and key custody and recovery, validator dispersion and governance, incident reporting for oracle and smart-contract failures, and supervisory access to tamper-evident logs. Such guidance would reduce uncertainty for cross-border operations and avoid a situation where similar risks are treated differently solely because they are implemented on DLT.

Finally, measurement of progress should remain modest and operational rather than aspirational. In the near term, success would mean that for a representative subset of SSA and corporate issuers: mandate-to-pricing and pricing-to-settlement cycles are shorter and more predictable; a growing share of digital bonds achieve DvP in CeBM under TARGET-linked solutions; and liquidity indicators – such as bid-ask spreads and turnover relative to size – are broadly comparable to conventional benchmarks once programmes reach scale. Over a slightly longer horizon, one would expect that tokenised and conventional bonds can co-exist in the same issuance programmes and be handled by back-office and risk systems without bespoke workarounds.

These implications are deliberately incremental. They do not require creating a parallel capital-market regime, but rather using existing EU law and infrastructure to normalise a technology that has already proven workable in a series of sovereign, supranational and corporate transactions. The analysis in this section reflects the authors' interpretation of the legal, market and experimental evidence discussed earlier and prepares the ground for the concluding remarks in Section 6.

6. Conclusion

The European experience with digital bonds has moved beyond isolated proofs of concept. Union-level law now accommodates MiFID-class securities on distributed ledgers; several Member States recognise DLT-based registers as a valid form of issuance or holding; and a small but growing body of transactions has been carried out by sovereign, supranational, agency and corporate issuers. Volumes remain modest relative to the conventional bond market,

and most issues still rely on commercial-bank money for settlement, but the combination of regulatory reforms and practical pilots shows that tokenisation can be embedded into existing capital-market infrastructure rather than treated as a separate domain.

Against this background, the article addressed two descriptive research questions. For RQ1, issuers' revealed preferences between permissioned and public-chain implementations appear to be driven primarily by legal certainty in the issuing jurisdiction, the ability to integrate with existing custody and collateral chains, and access to trusted cash-leg arrangements, rather than by a generic preference for one type of ledger. For RQ2, the main constraint for wider adoption is the lack of a routine delivery-versus-payment service in central bank money: Eurosystem trials and selected national projects demonstrate that such settlement is technically feasible, but access remains limited to pilot settings.

The broader implication is that digital bonds should be seen as an incremental infrastructure upgrade rather than a parallel market. Policy steps that would make a difference are relatively targeted: giving the DLT Pilot Regime a more permanent, risk-based footing; turning at least one CeBM DvP design into a production service within TARGET Services; and clarifying minimum expectations for data, documentation and operational resilience so that tokenised instruments can be handled alongside conventional ones. If implemented, these measures would allow issuers and infrastructures to scale up the use of DLT in a way that preserves the existing legal and supervisory framework, while realising practical gains in lifecycle management, settlement risk and data quality. The analysis presented here should be read as a contribution to this incremental agenda and as a basis for further empirical and legal work on digital bonds in Europe.

References

ABN AMRO, 2023, *ABN AMRO Registers First Digital Bond on public Blockchain*, 10.01.2023, https://www.abnamro.com/en/news/abn-amro-registers-first-digital-bond-on-public-blockchain [date of access: 09.09.2025].

AFME, 2025a, *DLT-Based Capital Market Report: Size and Growth of the Global DLT Wholesale Market*, https://www.afme.eu/publications/data-research/details/dlt-based-capital-market-report---size-and-growth-of-the-global-dlt-wholesale-market [date of access: 7.12.2025].

AFME, 2025b, *AFME Launches Data Report Series on DLT-Based Capital Market*, https://www.afme.eu/news-insights/press-releases/afme-launches-data-report-series-on-dlt-based-capital-market [date of access: 7.12.2025].

Banca d'Italia, 6.12.2024, *Eurosystem Completes Tests Using DLT for Central Bank Money Settlement*, https://www.bancaditalia.it/media/notizia/eurosystem-completes-tests-using-dlt-for-central-bank-money-settlement [date of access: 7.12.2025].

Benos E., Garratt R., Gurrola-Perez P., 2019, *The Economics of Distributed Ledger Technology for Securities Settlement*, "Ledger", vol. 4, pp. 1–25, DOI:10.5195/ledger.2019.144.

BIS, 2020, *Project Helvetia Phase I: Settling Tokenised Assets in Central Bank Money*, BIS Innovation Hub Swiss Centre Report, Bank for International Settlements, SIX Group AG and Swiss National Bank, https://www.bis.org/publ/othp35.pdf [date of access: 7.12.2025].

BME, 26.07.2022, *BME*, *BBVA and IDB Issue the First Regulated Bond in Spain Registered with Blockchain*, https://www.bolsasymercados.es/en/media/press-releases/2022/bme-bbva-and-idb-issue-the-first-regulated-bond-in-spain-registered-with-blockchain.html [date of access: 7.12.2025].

BNP Paribas, 01.02.2023, *EIB Achieves Milestone with First Ever Digital Bond in British Pounds*, https://cib.bnpparibas.com/eib-achieves-milestone-with-first-ever-digital-bond-in-british-pounds [date of access: 11.09.2025].

Bundesministerium der Justiz und für Verbraucherschutz, 2025, *Gesetz über elektronische Wertpapiere*, https://www.gesetze-im-internet.de/ewpg [date of access: 11.09.2025].

Clearstream / Deutsche Börse Group, 27.06.2024, *First KfW Benchmark Bond via Deutsche Börse's Digital D7 Platform*, https://www.clearstream.com/clearstream-en/newsroom/240627-4012566 [date of access: 9.09.2025].

Cleary Gottlieb, 21.11.2024, *The Listing Act: New Developments for Financial Markets in The European Union*, https://www.clearygottlieb.com/news-and-insights/publication-listing/the-listing-act-new-developments-for-financial-markets-in-the-european-union [date of access: 9.09.2025].

CONSOB, 2023, *Decree Law No. 25/2023 – the Fintech Decree (DLT Register Managers; National Processes)*, https://www.consob.it/web/consob-and-its-activities/news-in-evidence/documenti/english/en_news/2023/20230330_dl25 [date of access: 9.09.2025].

Cucculelli M., Recanatini M., 2022, *Distributed Ledger Technology Systems in Securities Post-Trading Services: Evidence from European Global Systemic Banks*, "The European Journal of Finance", vol. 28(2), pp. 195–218, DOI: 10.1080/1351847X.2021.1921002.

Deutsche Börse Group, 17.10.2024, *Clearstream's Digital Securities Platform D7 Reaches €10 Billion Milestone*, https://www.deutsche-boerse.com/dbg-en/media/news-stories/press-releases/Clearstream-s-digital-securities-platform-D7-reaches-10-billion-milestone--4147866 [date of access: 9.09.2025].

Deutsche Bundesbank, 2025, *Trigger Solution. New Technologies for Settlement of DLT-based Wholesale Transactions in Central Bank Money*, https://www.bundesbank.de/en/tasks/payment-systems/trigger-solution/trigger-solution-920174 [date of access: 9.09.2025].

EC, 2025, *Investment Services and Regulated Markets*, 4 December 2025, https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/financial-markets/securities-markets/investment-services-and-regulated-markets_en [date of access: 9.09.2025].

ECB, 2024, *Eurosystem Completes Tests Using DLT for Central Bank Money Settlement*, 04.12.2024, https://www.ecb.europa.eu/press/intro/news/html/ecb.mipnews241204.en.html [date of access: 9.09.2025].

ECB, 2025, *Exploratory Work on New Technologies for Wholesale Central Bank Money Settlement*, https://www.ecb.europa.eu/paym/integration/distributed/exploratory/html/index.en.html [date of access: 9.09.2025].

EIB, 2021, *EIB Issues Its First Ever Digital Bond on a Public Blockchain*, 28.04.2021, https://www.eib.org/en/press/all/2021–141-european-investment-bank-eib-issues-its-first-ever-digital-bond-on-a-public-blockchain [date of access: 9.09.2025].

EIB, 2023, *EIB Issues Its First Ever Digital Bond in Pound Sterling*, 31.01.2023, https://www.eib.org/en/press/all/2023–030-eib-issues-its-first-ever-digital-bond-in-british-pounds [date of access: 9.09.2025].

ESMA, 2023, *National Thresholds Below Which the Obligation to Publish a Prospectus Does Not Apply*, 3.07.2023, https://www.esma.europa.eu/sites/default/files/library/esma31-62-1193_prospectus_thresholds.pdf [date of access: 9.09.2025].

ESMA, 2022, *Final Report – Guidelines on Standard Forms, Formats and Templates to Apply for Permission to Operate a DLT Market Infrastructure*, 15.12.2022, ESMA70-460-189, https://www.esma.europa.eu/sites/default/files/library/esma_70-460-206_final_report_on_dltr_gl_on_application_for_permission.pdf [date of access: 7.12.2025].

ESMA, 2025, *ESMA Report on the Functioning and Review of the DLT Pilot Regime – Pursuant to Article 14 of Regulation (EU) 2022/858*, 25.06.2025, European Securities and Markets Authority, ESMA75-117376770-460, https://www.esma.europa.eu/sites/default/files/2025-06/ESMA75-117376770-460_Report_on_the_functioning_and_review_of_the_DLTR_-_Art.14.pdf [date of access: 7.12.2025].

Garratt R., Zhu H., 2021, *On the Advantages of a Tokenized Financial Ecosystem*, "Review of Corporate Finance Studies", DOI: 10.1093/rcfs/cfab010.

ICMA, 2024, *ICMA DLT Bonds Reference Guide*, International Capital Market Association, https://www.icmagroup.org/assets/documents/Regulatory/FinTech/ICMA-DLT-Bonds-Reference-Guide-December-2024-111224.pdf [date of access: 07.12.2025].

ICMA, 2025, *Bond Data Taxonomy Working Group*, https://www.icmagroup.org/fintech-and-digitalisation/fintech-advisory-committee-and-related-groups/bond-data-taxonomy [date of access: 9.09.2025].

IDB, 2022, *BME*, *BBVA and IDB Issue Spain's First Blockchain-Based Regulated Bonds*, 26.07.2022, https://www.iadb.org/en/news/bme-bbva-and-idb-issue-spains-first-blockchain-based-regulated-bonds [date of access: 9.09.2025].

The Intesa Sanpaolo Group, 2024, *CDP Successfully Issues Its First Digital Bond on Blockchain. Intesa Sanpaolo Fully Underwrites the Transaction*, 18.07.2024, https://group.intesasanpaolo.com/en/newsroom/press-releases/2024/07/cdp-successfully-issues-its-first-digital-bond-on-blockchain-int [date of access: 7.12.2025].

Ledger Insights, 2025, *Digital Bonds Show Significant Growth – AFME*, 10.02.2025, https://www.ledgerinsights.com/digital-bonds-show-significant-growth-afme [date of access: 7.12.2025].

Lee J., Lipton A., 2023, *Implications of CBDC for the Operational Resilience of Financial Market Infrastructures*, "Journal of Risk Management in Financial Institutions", vol. 16(4), pp. 342–355.

Linklaters, 2021, *Linklaters Advises Vonovia on the Issue of the First Fully Digital Registered Bond*, 15.01.2021, https://www.linklaters.com/en-us/about-us/news-and-deals/deals/2021/january/linklaters-advises-vonovia-on-the-issue-of-the-first-fully-digital-registered-bond [date of access: 9.09.2025].

Malamas V., Dasaklis T.K., Chondrokoukis G., 2023, *A Blockchain Framework for Digitizing Securities Issuance: The Case of Green Bonds*, "Journal of Sustainable Finance & Investment", online first, DOI: 10.1080/20430795.2023.2275212.

Maume P., Kesper F., 2023, *The EU DLT Pilot Regime for Digital Assets*, "European Company and Financial Law Review", vol. 20(2), pp. 321–350, DOI: 10.1515/ecfr-2023-0014.

Micheler E., von der Heyde L., 2016, *Holding*, *Clearing and Settling Securities through Blockchain/Distributed Ledger Technology: Creating an Efficient System by Empowering Investors*, "Journal of International Banking & Financial Law", vol. 31(11), pp. 652–656.

Nassr I.K., 2023, *Tokenisation of Assets and the Digital Bond Market*, [in:] *OECD Business and Finance Outlook 2023*, OECD Publishing, Paris, DOI: 10.1787/5e6b0840-en.

NautaDutilh, 2021, *New Law Brings Luxembourg to the Forefront of Distributed Ledger Technology*, 17.03.2021, https://www.nautadutilh.com/en/insights/new-law-brings-luxembourg-to-the-forefront-of-distributed-ledger-technology [date of access: 9.09.2025].

OECD, 2020, *The Tokenisation of Assets and Potential Implications for Financial Markets*, OECD Blockchain Policy Series, OECD Publishing, Paris, DOI: 10.1787/afe2e3c9-en.

Osborne Clarke, 2024, *The EU Listing Act: What Are the Key Changes to the Prospectus Regulation?*, 26.11.2024, https://www.osborneclarke.com/insights/eu-listing-act-what-are-key-changes-prospectus-regulation [date of access: 9.09.2025].

Panetta F., 2022, *Demystifying Wholesale Central Bank Digital Currency*, "SUERF Policy Brief", no. 460, https://www.suerf.org/wp-content/uploads/2023/12/f_6530f16bd631f012e7fd07ebe8859a14_56161_suerf.pdf [date of access: 7.12.2025].

Priem R., 2022, *A European Distributed Ledger Technology Pilot Regime for Market Infrastructures: Finding a Balance between Innovation*, *Investor Protection and Financial Stability*, "Journal of Financial Regulation and Compliance", vol. 30(3), pp. 345–361, DOI: 10.1108/JFRC-09-2021-0074.

Regulation (EU) 2022/2554 of the European Parliament and of the Council of 14 December 2022 on Digital Operational Resilience for the Financial Sector and Amending Regulations (EC) No 1060/2009, (EU) No 648/2012, (EU) No 600/2014, (EU) No 909/2014 and (EU) 2016/1011, EUR-Lex, https://eur-lex.europa.eu/eli/reg/2022/2554/oj/eng [date of access: 9.09.2025].

Regulation (EU) 2022/858 of the European Parliament and of the Council of 30 May 2022 on a Pilot Regime for Market Infrastructures Based on Distributed Ledger Technology, and Amending Regulations (EU) No 600/2014 and (EU) No 909/2014 and Directive 2014/65/EU (Text with EEA Relevance), EUR-Lex, https://eur-lex.europa.eu/eli/reg/2022/858/oj/eng [date of access: 9.09.2025].

Regulation (EU) 2023/1114 of the European Parliament and of the Council of 31 May 2023 on Markets in Crypto-Assets, and Amending Regulations (EU) No 1093/2010 and (EU) No. 1095/2010 and Directives 2013/36/EU and (EU) 2019/1937, EUR-Lex, https://eur-lex.europa.eu/eli/reg/2023/1114/oj/eng [date of access: 9.09.2025].

Schär F., 2021, *Decentralized Finance: On Blockchain- and Smart Contract-Based Financial Markets*, "Federal Reserve Bank of St. Louis Review", vol. 103(2), pp. 153–174, DOI: 10.20955/r.103.153-74.

Siemens, 2024, *Siemens Remains a Pioneer – Another Digital Bond Successfully Issued on Blockchain*, 4.09.2024, https://press.siemens.com/global/en/pressrelease/siemens-remains-pioneer-another-digital-bond-successfully-issued-blockchain [date of access: 9.09.2025].

Siemens, 2023, *Siemens Issues First Digital Bond on Blockchain*, 14.02.2023, https://press.siemens.com/global/en/pressrelease/siemens-issues-first-digital-bond-blockchain [date of access: 9.09.2025].

Societe Generale, 2022, *LuxSE Admits Security Tokens Issued by Societe Generale*, 31.01.2022, https://www.societegenerale.com/en/news/press-release/luxse-admits-security-tokens-issued-societe-generale [date of access: 9.09.2025].