

MiCAR and beyond: regulating DLT-based assets, services and infrastructure in the EU

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Abstract: This article examines the evolving European Union regulatory framework for distributed ledger technology (DLT)-based assets, services and market infrastructures, focusing on the Markets in Crypto-assets Regulation (MiCAR) and the DLT Pilot Regime. These instruments represent the most comprehensive effort to integrate crypto-assets and DLT-based financial activities into the EU's financial regulatory system. This framework functions through new asset classifications, harmonised licensing regimes, and tailored supervisory requirements. The article argues that, despite significant harmonisation in the regulation of crypto-assets and market actors, the EU framework remains ill-equipped to address the risks arising from on-chain infrastructures that enable the issuance and transfer of such assets. It highlights the structural limits of the current approach in responding to the decentralised nature of DLT-based financial ecosystems.

Keywords: *crypto-assets, digital finance, DLT Pilot Regime, financial supervision, Markets in Crypto-assets Regulation (MiCAR), regulatory harmonisation*

1. Introduction

This paper examines the evolving EU regulatory framework applicable to distributed ledger-based assets, services and market infrastructures, with a particular focus on the Markets in Crypto-assets Regulation (MiCAR, see ‘Council regulation (EU) 2023/1114’, 2023) and the DLT Pilot Regime (‘Council regulation (EU) 2022/858’, 2022). These two instruments represent the most comprehensive attempt to date to integrate crypto-assets and DLT-based financial activities into the Union’s existing system of financial regulation, through a combination of new asset classifications, licensing regimes and tailored supervisory requirements. While EU law has achieved a significant degree of harmonisation in the regulation of crypto-assets and market actors, this paper argues that EU law is struggling to address the risks posed by on-chain infrastructures that enable the issuance and transfer of such assets.¹

The gap is particularly evident in decentralised finance (DeFi), where technological infrastructures do not only facilitate services but directly perform intermediary-like functions and generate comparable risks, while largely escaping traditional supervisory oversight. Crucially, the implications are not confined to DeFi. They also arise in increasingly common hybrid configurations, where regulated intermediaries authorised under MiCAR provide access to, or integrate, decentralised systems within their service offerings. This raises serious concerns not only in relation to crypto finance but also when viewed against the currently gradual migration of core trading and post-trading functions onto distributed ledgers under the DLT Pilot Regime.

Challenges in reconciling technological possibilities with the rule of law also stem from the increasingly felt entrepreneurial drive to tokenise real-world assets (RWAs), where foundational private-law questions underpinning digital ownership and enforceability remain unaddressed. Such unanswered questions pose limitations to anchoring and circulating digitised rights pertaining to RWAs.

Against this background, the paper proceeds as follows: Section 2 outlines MiCAR’s scope and token classification, together with the regulatory

¹ For the purposes of this paper, the term ‘on-chain infrastructures’ refers to the combination of distributed ledgers and smart contracts that jointly enable execution and settlement, irrespective of their specific technological implementation.

treatment of issuers and crypto-asset service providers. Section 3 examines the DLT Pilot Regime and its role in the gradual institutionalisation of DLT-based market infrastructures. Section 4 critically assesses the legal feasibility of RWAs beyond securities, highlighting the unresolved private-law constraints that continue to limit its practical implementation. Section 5 turns to on-chain infrastructures and DeFi arrangements, arguing that the absence of a coherent legal conceptualisation of infrastructure-level intermediation constitutes the central regulatory blind spot of the current EU framework. The paper concludes by reflecting on the conditions under which on-chain infrastructures may acquire legal relevance, and on the implications this holds for the future evolution of EU digital finance regulation.

2. Understanding Markets in Crypto-assets Regulation (MiCAR)

2.1 Introducing MiCAR's scope and its token classification

MiCAR represents the first attempt at a harmonised EU regulation that is directly applicable across all Member States, aiming to provide legal certainty for specific categories of DLT-based cryptographic tokens. This Regulation introduces a risk-based framework under which activities are classified and subjected to differentiated regulatory treatment.² It imposes rigorous licensing requirements and prudential supervision on certain issuers, as well as on financial intermediaries providing services related to such assets. Central to this framework is the concept of 'crypto-assets', which the Regulation formally defines as a digital representation of value or rights that may be transferred and stored electronically using distributed ledger technology or equivalent decentralised systems.

The applicability of MiCAR rests precisely on the assessment of whether a given asset qualifies as a 'crypto-asset' as defined by the Regulation. Where an asset is neither legally fungible nor transferable, it loses relevance for MiCAR, thus falling out of scope.³ Conversely, if these fundamental

² A risk-based approach can be observed throughout the regulatory framework and is expressly reflected in the principle of "same activities, same risks, same rules", as stated in Recital 9 of MiCAR. More recently, ESMA (2026, p. 3) has reiterated that a risk-based approach also underpins the supervision of financial markets in the Union and plays a critical role for national competent authorities.

³ Fungibility is a characteristic whose absence places an asset outside the scope of MiCAR pursuant to Article 2(3), whereas transferability is an express requirement under Article 3(1)(5).

characteristics are present, a further distinction must be analysed: if the token functions as a DLT-based equivalent for assets already regulated by established EU frameworks—such as financial instruments, deposits or derivatives (hereinafter collectively referred to as ‘TradFi Asset Classes’)—it remains subject to those specific EU directives or regulations, thereby falling outside the remit of MiCAR (Article 2(4)). Consequently, the focus is on the substantive legal nature of the token rather than the underlying technology used for its issuance or circulation.⁴

On the other hand, should a cryptographic, fungible and tradable asset not fall within one of the TradFi Asset Classes, it may be classified as a crypto-asset subject to MiCAR. These are divided into three subcategories. First, asset-referenced tokens (ARTs), which are a specific iteration of stablecoins which purport to maintain a stable value by referencing another value or right, or a combination thereof, including one or more official currencies (for example, a stablecoin pegged to the value of gold) (Article 3(1)(6)). Second, electronic money tokens (EMTs), which is the most prominent category of stablecoins, which purport to maintain a stable value by referencing an official currency (Article 3(1)(7)). Third, crypto-assets other than ARTs and EMTs, meaning a miscellaneous residual category encompassing tokens that do not qualify as ARTs or EMTs because they are not backed by any underlying asset (and for this reason also referred to as ‘unbacked tokens’).⁵ This group includes ‘utility tokens’, expressly defined under MiCAR (Article 3(1)(9)) as crypto-assets intended only to provide access to a good or service supplied by their issuers, as well as other crypto-assets that, while not specifically defined by the regulation, are nonetheless intended to be captured by its provisions. This latter group encompasses native blockchain tokens (issued at the protocol level), governance tokens (typically issued at the SC level and used to exercise voting rights within decentralised arrangements) and meme coins (community hype-driven tokens, generally lacking functional utility) as long as they have identifiable issuers.⁶

On this basis, MiCAR establishes a layered regulatory framework addressing issuers, offerors or other persons seeking admission to trading, as well as crypto-asset service providers (CASPs).

⁴ Recital 9 expressly refers to the principle of technological neutrality. Also, the definition set out in Article 3(1)(5) does not confine the scope to distributed ledger technology alone, but also encompasses “similar technology”. Moreover, the adoption of a “substance-over-form” approach to the classification of crypto-assets is further expressly recalled in Recital 11.

⁵ Cross-refer to Article 1(6), Article 1(7), and Recital 18 of MiCAR, as well as Mattia Suardi (2024).

⁶ Crypto-assets without an identifiable issuer are out of scope based on Recital 22.

2.2 Token issuers, offerors and persons seeking admission to trading

Drawing upon the aforementioned token classification and borrowing from the framework of the Prospectus Regulation ('Council regulation (EU) 2017/1129', 2017), which already regulates the public offering and admission to trading of financial instruments, MiCAR regulates issuers, offerors and persons seeking admission to an authorised trading platform (the specific services authorised under MiCAR will be examined in the following subsection). Given the different risks posed by each crypto-asset category, MiCAR encompasses several distinct regulatory approaches and exemptions to address these risks.

First, it should be clarified that, regardless of the crypto-asset category, private sales remain outside the scope of the Regulation. This includes, for instance, token investments governed by privately negotiated agreements, such as simple agreements for future tokens (SAFTs). Such pre-sale instruments, widely utilised within the industry to inject capital into startups during the early stages of a project, should not trigger the application of MiCAR. However, when a public offer or admission to trading is made, thereby involving public solicitation of investment, differentiated regulatory regimes under MiCAR may apply.

Title II of MiCAR captures offers to the public and admission to trading of crypto-assets other than ARTs and EMTs. For this miscellaneous asset class, it adopts a "light-touch" approach that does not require prior written authorisation by a national competent authority (NCA). Nevertheless, the Regulation requires that a MiCAR-compliant white paper is drawn up and notified to a Member State competent authority.⁷ This document should not be confused with traditional commercial white papers used to describe business projects. Instead, it is a regulatory disclosure document, conceptually akin to a securities prospectus, and must include detailed transparency disclosures, investor warnings, and comply with specific formal requirements, including those relating to its electronic format ('Commission implementing regulation (EU) 2024/2984', 2024). While these assets are not subject to a formal authorisation regime and do not trigger ongoing prudential supervision of the offeror, NCAs nonetheless retain the power to suspend or prohibit a

⁷ For the core requirements applicable to a MiCAR-compliant offer to the public, see Article 4(1). Exemptions from certain of these requirements are provided for under Article 4(2) and (3). For the core requirements applicable to a MiCAR-compliant admission to trading, see Article 5(1).

public offer or admission to trading in cases of a missing or non-compliant white paper.⁸ The obligation to notify a MiCAR white paper pursuant to Article 8 falls upon the token offeror in the case of a public offer (regulated under Article 4) or the person seeking admission to trading (regulated under Article 5). Notably, under MiCAR, it is irrelevant whether the unbacked token is offered to the public by the issuer itself, another group entity or even by a CASP during the provision of its services.⁹ Whoever directs the offer to the public must notify a white paper in accordance with MiCAR. The same approach applies to the admission to trading of unbacked crypto-assets, irrespective of whether admission is sought by an entity linked to the underlying project or initiated by a crypto-asset service provider on its own initiative (Article 5, paras. 1 and 2). In our view, this aligns with a risk-based approach, targeting the entity that generates the risk by publicly soliciting investors. In this sense, it is correct to state that Title II does not necessarily target token issuers directly.

A significantly more stringent regulatory approach is applied to stablecoins, reflecting the complexity of their underlying business models and the specific risks that EU lawmakers seek to mitigate. MiCAR places particular emphasis on the maintenance of highly liquid and adequately over-collateralised reserves, with a view to mitigating de-pegging risks, safeguarding tokenholder redemption rights and containing potential run scenarios (see, in particular, Articles 36–39, 47, 49 and 55). To enable effective supervision of these and related aspects, MiCAR directly targets stablecoin issuers, requiring them to qualify as authorised and supervised financial entities established in the Union.

More specifically, with regard to asset-referenced tokens (ARTs), which are regulated under Title III of MiCAR, issuance is restricted to entities that are either expressly authorised as ART issuers under MiCAR or already operate under a credit institution licence (i.e., banks), and are duly established and authorised in a Member State (Article 16(1)). While a person other than the issuer may offer ARTs to the public or seek their admission to trading, this is without prejudice to the issuer's regulatory requirements and is conditional upon the issuer's prior written consent (Article 16(2)). Limiting the issuance

⁸ This can be inferred from a combined reading of the powers listed under Article 94.

⁹ Article 4(1) subjects to the relevant regulatory obligations the “person” making the offer to the public, irrespective of its business activity. Accordingly, the possibility that a crypto-asset service provider itself may qualify as such a person—whether intentionally or unintentionally, in the course of providing its services—has been expressly acknowledged both by ESMA and by national regulators (see ESMA, 2025b; see also the Financial Market Authority Austria, no date).

of ARTs to authorised and supervised entities reflects the fact that the entire lifecycle of an ART, including its backing reserves and redemption mechanisms, is intrinsically linked to the issuer's operations. Accordingly, the EU has opted to regulate the issuer directly, effectively subjecting it to a regime of ongoing prudential supervision as a regulated financial entity. This entails close scrutiny of the issuer's business and operational profile, governance and management arrangements, reserve asset investment policies, staffing and technological infrastructure.

A similar regulatory framework applies to issuers of e-money tokens (EMTs), albeit subject to further restrictions. Under MiCAR, no standalone authorisation exists for EMT issuance as such; rather, only entities already authorised in the Union as credit institutions or electronic money institutions (EMIs) may offer EMTs to the public or seek their admission to trading (Article 48(1)). As in the case of ARTs, a person other than the issuer may offer EMTs to the public or seek their admission to trading, without prejudice to the issuer's regulatory requirements and provided that the issuer has given prior written consent (Article 48(2)).

These pervasive interventions have the potential to purge the EU market of certain actors while facilitating those already advanced in their compliance efforts. The initial impact is already evident, with well-known industry players forced to exit the EU market due to non-compliance, resulting in their de-listing from EU trading platforms. In the ART sector, the most notable exclusion is undoubtedly Pax Gold (PAXG), a gold-pegged stablecoin that currently has no EU-authorised issuer under MiCAR. Regarding EMTs, the most prominent absentee is the fintech giant Tether, whose USDT remains, for the time being, outside the EU regulated market.¹⁰ This stringent approach to private stablecoin issuance unfolds in parallel with the Union's exploration of a central bank digital currency, which is outside the scope of MiCAR (Recital 13), and follows an entirely different institutional and legal logic.¹¹ While MiCAR seeks to regulate privately issued monetary substitutes through prudential supervision, initiatives concerning central bank digital currencies reflect the continued centrality of public monetary sovereignty.

¹⁰ Authorised entities can be verified in the ESMA register established pursuant to Article 109, available at: <https://www.esma.europa.eu/esmas-activities/digital-finance-and-innovation/markets-crypto-assets-regulation-mica#InterimMiCARRegister>.

¹¹ Refer to 'Council proposal COM/2023/364 final' (2023), 'Council proposal COM/2023/368 final' (2023) and 'Council proposal COM/2023/369 final' (2023), jointly referred to as Single Currency Package. More info is available at: https://finance.ec.europa.eu/publications/digital-euro-package_en.

2.3 Crypto-asset service providers: in scope and out of scope

As anticipated, MiCAR introduces licensing requirements for entities providing services related to crypto-assets. For its purposes, the fifth EU AML Directive (AMLDV; ‘Council directive (EU) 2018/843’, 2018) established two baseline categories of service providers: “exchange services between virtual currencies and fiat currencies” and “custodian wallet provider”.¹² For the purpose of MiCAR, such categories are revisited and complemented by new categories inspired by traditional financial regulation, particularly MiFID II (‘Council directive 2014/65/EU’, 2014). More specifically, MiCAR establishes authorisation requirements for ten distinct crypto-asset services, all of which share a common feature: they are client-facing.¹³ Consequently, certain market participants, such as pure market makers, fall outside the scope of MiCAR on the grounds that, in line with the European regulatory tradition, they do not maintain direct client relationships by definition.¹⁴

The services subject to authorisation begin with the custody and administration of crypto-assets on behalf of clients, defined as the safekeeping or controlling on behalf of clients, of crypto-assets or of the means of access to such crypto-assets, where applicable in the form of private cryptographic keys (Articles 3(16)(a) and 3(17)). This definition is deliberately broader than that of a mere custodian wallet provider and is conceived as the equivalent of the ancillary service referred to in Section B, point (1), of Annex I to MiFID II (Article 60(3)(a)).

MiCAR then contemplates the operation of a trading platform for crypto-assets, defined as the management of one or more multilateral systems which bring together, or facilitate the bringing together of, multiple third-party buying and selling interests in crypto-assets, in accordance with the rules of the system, in a manner that results in a contract, either by the exchange of crypto-assets for funds or by the exchange of crypto-assets for other crypto-assets (Articles 3(16)(b) and 3(18)). The EU legislator expressly envisages this as the equivalent of operating a multilateral trading facility (MTF) or an organised trading facility (OTF) pursuant to Section A, points (8) and (9) of Annex I to MiFID II (Articles 3(16)(c) and 3(19)).

¹² See Article 1 of the Directive, which amends Article 2(1) of Directive (EU) 2015/849 by adding points (g) and (h).

¹³ The requirement of a client relationship is expressly provided for in Article 3(1)(15).

¹⁴ This had been perceptively observed in the literature and was later confirmed by ESMA (Pantaleo and Vianelli, 2024; ESMA, 2025a).

MiCAR(Article 60(3)(b)) further addresses the exchange of crypto-assets for funds, meaning the conclusion of purchase or sale contracts concerning crypto-assets with clients for funds through the use of proprietary capital. This service must not be confused with the aforementioned exchange services under the AMLDV, as Article 60(3)(c) clarifies that it is equivalent to dealing on own account as referred to in Section A, point (3), of Annex I to MiFID II. In such cases, the provider internalises the order and executes the conversion using its own capital, thereby acting as the principal rather than as the agent (ESMA, 2025c). A related but distinct service covers the exchange of crypto-assets for other crypto-assets, which mirrors the same mechanism, except that the conversion takes place between crypto-assets, implying that the provider must hold a proprietary reserve of crypto-assets in order to perform the service (Articles 3(16)(d) and 3(20)). In both instances, the mere routing of an order to a third party does not constitute an exchange service, as such routing would instead trigger the requirement to hold a licence for the reception and transmission of orders, as detailed below (ESMA, 2025c).

MiCAR (Articles 3(16)(e) and 3(21)) also regulates the execution of orders for crypto-assets on behalf of clients, defined as the conclusion, on behalf of clients, of agreements to purchase or sell one or more crypto-assets or to subscribe for them, including the conclusion of contracts to sell crypto-assets at the time of their public offering or admission to trading. This constitutes a genuine brokerage service, where the CASP acts as an agent, equivalent to the execution of orders on behalf of clients referred to in Section A, point (2) of Annex I to MiFID II (Article 60(3)(d)).

The placing of crypto-assets, defined as the marketing of crypto-assets to purchasers on behalf of, or for the account of, the offeror or of a party related to the offeror, constitutes another MiFID-derived category. This category is intended to capture intermediaries that act as the equivalent of the underwriting or placing of financial instruments on a firm-commitment basis and placing without a firm-commitment basis, as referred to in Section A, points (6) and (7) of Annex I to MiFID II (Articles 3(16)(f), 3(22) and 60(3)(e)). The definition is sufficiently broad to encompass providers offering the service in a platform-based manner, as illustrated by the fact that the Decubate launchpad obtained precisely this licence in the Netherlands.¹⁵

¹⁵ Refer to the ESMA register established pursuant to Article 109, available at: <https://www.esma.europa.eu/esmas-activities/digital-finance-and-innovation/markets-crypto-assets-regulation-mica#InterimMiCARRegister>.

Further, MiCAR (Articles 3(16)(g) and 3(23)) includes the reception and transmission of orders (RTO) for crypto-assets on behalf of clients, defined as the reception of an order to purchase, sell or subscribe to one or more crypto-assets from a person and the transmission of that order to a third party for execution. This activity and the corresponding authorisation cover any order-routing activity in which the CASP does not internalise execution but routes the order to third parties in an agency capacity (ESMA, 2025c). It corresponds to the service listed in Section A, point (1), of Annex I to MiFID II (Article 60(3)(f)).

Provision of advice on crypto-assets—defined as offering, giving or agreeing to give personalised recommendations to a client, either at the client’s request or on the initiative of the service provider, concerning transactions or the use of crypto-asset services—is treated as equivalent to investment advice under Section A, point (5), of Annex I to MiFID II (Articles 3(16)(h), 3(24) and 60(3)(g)).

Furthermore, portfolio management, defined as managing portfolios under mandates on a discretionary client-by-client basis, where such portfolios include one or more crypto-assets, is likewise aligned with the portfolio management service under Section A, point (4), of Annex I to MiFID II (Articles 3(16)(i), 3(25) and 60(3)(h)).

Lastly, MiCAR (Articles 3(16)(i) and 3(25)) regulates the provision of transfer services for crypto-assets on behalf of clients, defined as the transfer, on behalf of a natural or legal person, of crypto-assets from one distributed ledger address or account to another. The service bears a close functional resemblance to regulated payment services under PSD2. This similarity acquires legal significance in relation to EMTs, which are expressly qualified as electronic money within the meaning of ‘Council directive 2009/110/EC’ (2009, Article 48(2) and Recital 66), the transfer of which requires authorisation under PSD2 (‘Council directive (EU) 2015/2366’, 2015). Given that the transfer of electronic money falls within the scope of PSD2, the question arose as to whether transfer services concerning EMTs should likewise require PSD2 authorisation. The answer is affirmative and took the form of a no-action letter issued in June 2025 by the European Banking Authority (EBA), which qualified such services as payment services under PSD2 (EBA, 2025, pp. 1–2, 8). A corollary of this interpretation is that a wallet offered by a CASP which supports EMT transfers constitutes the functional equivalent of a payment account under PSD2 and must be authorised accordingly (EBA, 2025, pp. 1–2, 8). This situation is unsatisfactory as

it introduces a dual-licensing requirement under both MiCAR and PSD2 for what is, in substance, a single service. The EBA itself has encouraged reform, advising the EU Commission, Council and Parliament to make use of the PSD3/PSR legislative process. In particular, it has suggested either strengthening MiCAR through the replication or cross-reference of relevant PSD3/PSR requirements to achieve substantive equivalence, or—failing that—pursuing targeted amendments within the ongoing PSD3 / Payment Services Regulation legislative package, with a view to avoiding double authorisation for CASPs (EBA, 2025, p. 3).

Borrowing and lending explicitly remain outside the scope of MiCAR (Recital 94), as does staking in and of itself, although the custody and administration of crypto-assets that may be ancillary to staking are regulated as discussed above (ESMA, 2024). The broader concept of DeFi is likewise not in the scope of this Regulation.¹⁶ Yet where a service falls within one of the ten regulated categories illustrated above, MiCAR requires it to be fully decentralised—in the sense of being provided without any intermediary—in order to lie outside its scope, as Recital 22 stipulates. The absence of further criteria to determine what constitutes “fully decentralised” leaves significant uncertainty as to the regulatory treatment of many decentralised exchanges (DEXs). One should not assume that the use of automated market makers (AMMs), which is a foundational element of DEXs, automatically makes a DEX MiCAR-exempt.¹⁷ This form of automation might not, alone, make the service fully decentralised. MiCA’s regulatory technical standards on trading platforms explicitly contemplate AMMs as one possible trading mechanism used by entities that are still subject to MiCAR (‘Commission delegated regulation (EU) 2025/417’, 2025). Given that, NCAs are required to assess what constitutes a fully decentralised service provided without any intermediary on a case-by-case basis.¹⁸

As a concluding remark to this overview of MiCA, it is worth noting that, taken together, MiCA’s regulatory architecture demonstrates a clear preference for regulating identifiable market actors and client-facing activities, while

¹⁶ However, Articles 140(1)(t) and 142(2)(a) lay down specific actions and deadlines under which the Commission, after consulting the EBA and ESMA, is required to report to the European Parliament on developments in decentralised finance, including, where appropriate, the submission of legislative proposals. The deadline is 30 June 2027.

¹⁷ AMMs are algorithmic mechanisms that determine prices and execute trades according to predefined formulas, typically via liquidity pools enabled by SCs and funded by users, replacing the traditional order book with a continuous pricing function.

¹⁸ See, among the others, EBA and ESMA (2025) as well as ESMA (2025d), which discusses the difficulties of ascertaining whether a service is provided in a partially decentralised manner or in a fully decentralised manner.

leaving the technological infrastructures enabling such activities largely unexamined as regulatory objects in their own right.

3. DLT Pilot Regime and proposed amendments (Market Integration Package)

While MiCAR largely operates by extending and adapting existing regulatory categories to crypto-assets and service providers, the DLT Pilot Regime represents the Union's first structured attempt to accommodate DLT at the level of core market infrastructures. Adopted and entering into application prior to MiCAR—the DLT Pilot Regime entered into force on 23 June 2022 and has applied since 23 March 2023—the DLT Pilot Regime has so far remained somewhat in the shadow of other EU digital finance initiatives. This is largely due to its experimental nature and time-limited duration, at least initially, as a reform is currently underway. Nonetheless, its significance should not be underestimated, particularly considering the more recent proposals for its revision, which will be discussed below.

To proceed in an orderly manner, it should first be noted that the DLT Pilot Regime does not aim to regulate new asset classes. Rather, it applies to tokenised financial instruments, which fall outside the scope of MiCAR and are therefore carved out from its regime (Recital 3 and Article 2(11)). To this end, the Regime introduces a dedicated authorisation framework for so-called DLT market infrastructures (DLT MIs), a concept encompassing DLT multilateral trading facilities (DLT MTFs), DLT settlement systems (DLT SSs) and DLT trading and settlement systems (DLT TSSs) (Recital 12 and Article 2(5)).

DLT MIs may request limited exemptions from certain requirements under existing EU financial legislation—most notably MiFID II and the CSDR—provided that they comply with the conditions attached to those exemptions, as well as with any compensatory measures imposed by the relevant national competent authority.¹⁹

With respect to the three categories of DLT MIs, a DLT SS is defined as a settlement system operated by a central securities depository (CSD) that settles transactions in DLT financial instruments (Articles 2(7) and 5(1)). A DLT MTF, by contrast, is a multilateral trading facility operated by an

¹⁹ For requirements and exemptions, refer to Articles 4–7.

investment firm or a market operator authorised under ‘Council directive 2014/65/EU’, or by a credit institution authorised to act as an investment firm or market operator under that Directive, and which has obtained a specific permission under the DLT Pilot Regime (Recital 13 and Article 2(6)).

The most significant innovation introduced by the Regime concerns the third, hybrid category. For reasons of risk segregation, trading and post-trading services have traditionally been provided by separate entities (Recital 14). EU lawmakers have nevertheless recognised that the use of DLT may enable the execution and settlement of transactions in near real time, thereby offering an opportunity to reconsider this long-standing separation to the extent that the use of DLT is involved (Recital 14). Accordingly, under the DLT Pilot Regime, a single entity may be authorised to provide both trading and settlement services as a DLT TSS. Such permission may be granted either to an entity originally authorised as an investment firm—typically not involved in settlement activities—or to a CSD, which is traditionally dedicated to settlement but not to trading (Recital 15). This could make trading faster and more efficient by reducing intermediaries and, in turn, the costs and time required from negotiation to settlement, while enabling near real-time and potentially continuous (24/7) trading and settlement.

Due to its experimental nature, the DLT Pilot Regime is subject to strict limitations concerning both the types of financial instruments admitted and the volumes involved. At present, DLT MIs may admit or record only shares of issuers with a market capitalisation below EUR 500 million, bonds with an issuance size below EUR 1 billion and UCITS with assets under management below EUR 500 million (Article 3(1)). Moreover, the total market value of DLT transferable securities recorded at a DLT MI may not exceed EUR 6 billion at the moment of admission to trading or initial recording (Article 3(2)). Where the aggregate value of DLT financial instruments traded or recorded on a DLT MI reaches EUR 9 billion, the infrastructure must implement a predefined transition strategy (Article 3(2)).²⁰ These quantitative thresholds must be read together with the limited duration of the authorisations granted under the Regime, which are capped at six years (Article 8(11)). Taken together, these limitations have rendered the DLT Pilot Regime unattractive as a vehicle for experimentation, a conclusion supported by the limited uptake observed to date. At the time of writing, only one DLT SS, one DLT MTF and four DLT TSSs have sought and obtained authorisation under the Regime.²¹

²⁰ Which in turn refers to Article 7(7).

²¹ ESMA, List of Authorised DLT Market Infrastructures, available at https://www.esma.europa.eu/sites/default/files/2024-10/Authorised_DLT_Market_Infrastructures.xlsx.

However, there is another limiting factor, which constitutes a real “bottleneck”. The DLT Pilot Regime regulates market infrastructures, and thus primarily addresses services that become relevant at a post-issuance stage. The EU framework currently lacks a harmonised framework governing the issuance itself. It is akin to constructing the roof in the absence of supporting pillars. This gap is not accidental. Corporate law has traditionally remained fragmented across Member States, while the regulation of financial markets has long been pursued through directives requiring national transposition—such as MiFID and MiFID II—rather than through directly applicable regulations establishing uniform rules from the outset, as MiCAR does. In other words, each Member State has its own modalities governing the issuance and record-keeping of stocks and other tradable securities. This may be one of the reasons why the creation of a genuinely harmonised single market for issuance remains particularly challenging. Such an outcome could, however, be facilitated in the future by the establishment of a common framework covering the incorporation and lifecycle of companies, which could take shape through the development of a so-called 28th Regime.²²

Notwithstanding this structural bottleneck at the issuance level, a proposal currently before the European Parliament, included as part of the Market Integration Package, proposed on 4 December 2025,²³ seeks to considerably expand the scope and reach of the DLT Pilot Regime.

In particular, Article 8 of the proposal introduces a series of amendments to the DLT Pilot Regime, aimed at moving it beyond its experimental nature. To that end, the proposal provides for the removal of the current six-year limit on the permissions granted under the Regime, thereby overcoming the time-limited nature of the existing framework.

Having set out this important premise, the scope of market infrastructures eligible under the Regime is expanded. In particular, the proposal introduces

²² The term ‘28th Regime’ refers to an optional, EU-level legal framework that is expected to be introduced alongside national legal regimes, which market participants may choose to apply on a voluntary basis. The regime took shape with the ‘Council proposal COM/2026/321 final’, presented on 18 March 2026. In the context of company and financial market law, it has been discussed as a potential tool to overcome fragmentation stemming from divergent national corporate laws, by offering a uniform and directly applicable set of rules without replacing domestic regimes. (See, in particular, Letta, 2024; EIB, 2024, p. 4.)

²³ The Market Integration Package refers to a set of reforms aimed at further integrating the Union’s financial markets into a single market, centred on the ‘Council proposal COM/2025/943 final’ (2025). More information on the package is available at the official landing page on the EU Commission’s website: https://finance.ec.europa.eu/publications/market-integration-package_en.

the broader concept of a DLT trading venue (DLT TV), which is meant to encompass both DLT MTFs (as the current regime) and, for the first time, also OTFs. In addition, the proposal provides for the deletion of Article 3(1), which previously limited the scope of the Regime to specific categories of financial instruments. As a result, all categories of financial instruments would fall within the scope of the Regime as reformed.

Moreover, the proposal intervenes on the applicable thresholds, as the overall cap on the total aggregated market value of DLT financial instruments admitted to trading or recorded on a DLT market infrastructure is maintained but significantly increased from EUR 6 billion to EUR 100 billion, while product-specific thresholds are removed.

Amendments would also affect Article 4, expanding the scope of entities eligible to operate a DLT TV and a DLT trading and settlement system (DLT TSS). In addition to investment firms and CSDs, CASPs authorised under MiCAR to operate a crypto-asset trading platform would be permitted to operate these forms of DLT market infrastructures. In doing so, CASPs would become subject to the applicable EU trading and post-trading regulatory frameworks concerning financial instruments—namely MiFID II, MiFIR and the CSDR—while benefiting from targeted and justified exemptions comparable to those available to other DLT market infrastructure operators.

Furthermore, the proposal would amend Article 3 and introduce a new Article 7a in order to establish a simplified regime for smaller DLT market infrastructures providing CSD services. Operators remaining below a threshold of EUR 10 billion in total market value of recorded DLT financial instruments would benefit from proportionate regulatory treatment tailored to the scale of their activities. Depending on the services provided, eligibility for this simplified regime would remain conditional upon holding an underlying authorisation, such as that of a CSD, an investment firm or a CASP.

In addition, the proposal contains several additional provisions that are not examined in detail here, aimed at improving the operational functioning of DLT market infrastructures by refining and extending the regulatory framework to enable and supervise new aspects of their activity.²⁴

More broadly, the reformed framework signals a significant shift in regulatory strategy: the DLT Pilot Regime is no longer conceived merely as a temporary sandbox for isolated experimentation, but as a scalable and durable

²⁴ Refer to new Articles 4a and 5a, new Articles 10a to 10g, as well as to amendments to Article 5.

component of the Union's market infrastructure architecture. By expanding the scope, lifting quantitative constraints and integrating CASPs into the perimeter of market infrastructures, the proposal aims to normalise the use of DLT within core trading and post-trading activities, while preserving market integrity, financial stability and effective oversight. In this sense, the reform reflects a move from tolerance-based experimentation towards the progressive institutionalisation of DLT-based market infrastructures within the single market.

4. RWA beyond the hype: legal constraints and implementation challenges

Following the foregoing overview of EU-wide financial regulatory frameworks applicable to DLT-based tokens and related service providers, a natural question arises as to whether, and to what extent, such frameworks are adequate to address the use cases promoted by the industry in relation to RWA tokenisation. This term is commonly used to refer to assets that are not natively on-chain, including securities, real estate and intellectual property rights. The securities dimension has already been addressed in the preceding section of this paper, which discussed the DLT Pilot Regime and the need for robust and harmonised primary market issuance foundations across the EU. It is therefore unnecessary to revisit this matter here.

When moving to non-securities RWAs, the matter becomes more complex and nuanced. A complete and holistic allocation of rights, obligations and liabilities relating to such assets would likely require firm normative anchoring in Member States' domestic law, with particular emphasis on the role of private law and the recognition of proprietary rights in digital assets. Despite the work undertaken by UNIDROIT to foster debate and harmonisation through its *Principles* (UNIDROIT, 2023), the legal landscape remains far from providing such anchors. As a result, industry, legal practitioners, public enforcement authorities, and ultimately courts—once the first judicial cases begin to emerge—are left to examine the specific business case and determine whether it can be mapped onto an existing asset class covered by EU financial law, including MiCAR, together with the legal consequences of such characterisations.

The true starting point should thus always be to move beyond the generic and sensationalistic label of 'RWA' and to understand, in concrete legal

terms, what exactly becomes the object of tokenisation. Superficially similar use cases may indeed lead to entirely different legal outcomes. To support this view, the reader should consider the following illustrative and non-exhaustive examples.

Consider the real estate domain. If one were to tokenise a right to use a venue or recreational facility for a defined number of days per year, making such right transferable, one would likely create something very close to a utility token.²⁵ Here a first important distinction emerges. If such tokens are fungible—meaning that an identical set of tokens exists, conferring exactly the same legal rights—they would be classified as genuine utility tokens subject to MiCAR and would therefore trigger the obligation to notify a MiCAR-compliant white paper pursuant to Article 8. Conversely, a non-fungible token representing unique or non-standardised rights, despite its utility, would fall outside the scope of MiCAR. Remaining within real estate, if what is tokenised are passive rental returns of the property—for instance, participation in the revenue generated by the leasing of office space or commercial premises—the tokens would likely fall within the regulatory perimeter of financial instruments. As can be observed, the industry remains the same, yet the regulatory characterisation becomes entirely different.

Still within real estate, certain business models may not be feasible at all. For example, if one sought to fractionalise actual ownership of a property, it would require first a legal and then a technological infrastructure linking traditional property registers to on-chain events. Otherwise, a party might purport to fractionalise and transfer the ownership of a given property to multiple persons. However, if the on-chain event does not correspond to the transfer events recorded in the official property registers of the Member States, such a transfer may lack validity or, at a minimum, enforceability against third parties, depending on how domestic law addresses such mismatches. In such scenarios, the artificial workaround would be to place the property within a special purpose vehicle and fractionalise the share capital of that vehicle, transferring the shares instead. Alternatively, a securitisation transaction may be structured, whereby the vehicle issues debt instruments. Such assets would constitute tokenised transferable rights entitling token holders to participate in the profits of the vehicle. Yet, once again, the challenge shifts from tokenising real estate per se to tokenising securities. This also entails assessing which categories of financial instruments are supported by national legal frameworks permitting their issuance on DLT, which may vary from one Member State to another.

²⁵ For the definition of this asset class, reference is made to Section 2.2 above.

A parallel set of considerations emerges in the context of intellectual property rights. Here, too, seemingly similar tokenisation use cases may lead to divergent legal outcomes depending on what, in legal terms, is being tokenised. If the token merely represents a non-fungible digital collectible depicting a creative work without conferring any enforceable IP entitlement, it would typically fall outside the scope of MiCAR as a non-fungible token. Where the token instead operates as a fungible access right to a digital service—for instance, reproduction or streaming of content—the construct may approach that of a MiCAR utility token, provided that all tokens confer identical rights and are thus legally fungible. By contrast, if the token embodies a right to participate in the economic exploitation of the underlying IP, such as entitlement to a share of the artist's future royalty income, the construct may enter the perimeter of financial instruments. Consequently, the IP domain illustrates once more that the regulatory characterisation does not depend on industry buzzwords but on the precise legal nature of the tokenised entitlement.

In short, hype should not confuse matters: not everything that entrepreneurs envision is currently implementable, or at least not implementable in the linear manner they might desire. However, as should now be evident, this remains insufficient to accommodate the full spectrum of tokenisation use cases. The EU's regulatory frameworks offer a wide range of regulated asset classes and financial business authorisations upon which new digitised business models may be constructed, both within MiCAR and traditional finance regimes.

The underlying reason for this is structural. Both MiCAR and the DLT Pilot Regime regulate markets and intermediaries but not the foundational events underpinning the origin, legal recognition and enforceability of digitised rights. As a result, RWA tokenisation ultimately exposes the same conceptual blind spot identified throughout this paper: EU financial regulation governs market activity while remaining largely agnostic as to the technological infrastructures—and corresponding private-law anchors—through which rights are instantiated and exercised. Accordingly, the real challenge extends well beyond crypto finance regulation as such and concerns the future of digital assets in a broader legal sense, which would require firmer integration with national property law frameworks than is currently available.

5. Regulating on-chain infrastructures

5.1 Technological infrastructures as the missing link

So far, the analysis has focused on the regulatory treatment of crypto-assets and tokenised traditional financial assets, particularly in terms of token classification and the regulatory framework applicable to issuers, intermediaries and market infrastructures. The discussion has examined how financial regulation delineates regulatory perimeters by reference to asset classes, regulatory obligations and licensing regimes. Yet, these regulatory instruments operate on the plane of financial market regulation, not on the underpinning technological layers through which the minting of the tokens, execution and settlement are realised.

This omission becomes particularly consequential when discussing the operations of both regulated entities and DeFi arrangements, which pose many overlooked and unaddressed risks. This section precisely discusses risks posed by technological infrastructures that enable on-chain transactions and automated service provision through a nuanced approach that distinguishes between several configurations, as illustrated below.

5.2 Regulated entities and operational resilience

When the actors under scrutiny are regulated entities subject to prudential supervision—whether authorised under MiCAR, MiFID II or other EU financial frameworks—a portion of the risks associated with the technological infrastructure is indirectly addressed through existing supervisory mechanisms. Financial frameworks are designed around licensing principles which require applicants to demonstrate beforehand the organisational and operational capacity to perform regulated activities in a reliable and resilient manner. In practical terms, as far as technology is concerned, this includes describing the technological stack through which regulated services are provided, as well as demonstrating that ICT risks are managed in a manner consistent with both the entity's internal governance structure and applicable Union legislation.

This naturally leads to the 'Council regulation (EU) 2022/2554 on digital operational resilience for the financial sector (DORA)', which constitutes the EU's most ambitious attempt to develop an integrated cyber-resilience framework for financial entities, including CASPs. DORA establishes uniform requirements for ICT risk management, incident reporting,

penetration testing, information sharing and the oversight of critical ICT service providers. Among its key innovations is the treatment of ICT outsourcing: critical ICT functions outsourced to third parties must be documented contractually, monitored and subjected to regulatory visibility. The rationale is that operational resilience cannot be achieved if regulated entities rely on opaque technological intermediaries that fall outside the supervisory chain and in relation to which contractual risk management is poorly implemented.

However, DORA is meant to address cases involving regulated entities on the one hand and identifiable ICT service providers on the other, with whom regulated entities can enter into contractual relations. This paradigm collapses when confronted with permissionless distributed ledgers. Public permissionless blockchains are not outsourcing arrangements in the conventional sense; they are infrastructures without unitary operators and without a specific contractual counterparty. ESMA itself is of the view that the use of permissionless DLT does not constitute an outsourcing arrangement under Article 73 of MiCAR, since no contractual relationship—such as a service-level agreement—exists between the CASP and the decentralised blockchain infrastructure (ESMA, 2023). In practical terms, a regulated entity that relies on Ethereum or Solana to settle transactions has not “outsourced” that function to a traditional third-party ICT provider; rather, it relies on a continuously evolving shared infrastructure operated by heterogeneous and globally dispersed actors that maintain the operation of the distributed ledger. Because such actors cannot be contracted, monitored or made subject to DORA oversight, the regulatory apparatus designed for cloud computing, data-centres or other ICT providers cannot be extended to said blockchains without substantial conceptual modifications and enforcement difficulties that seem very challenging.

5.3 Blockchain agents and DeFi arrangements as the rapture point

The challenges associated with meaningfully establishing legal relationships with distributed decentralised infrastructures increase when the regulation of ‘blockchain agents’ and DeFi arrangements, which—at the time of writing—remains outside the scope of EU financial regulation. Within the realm of operators enabling blockchains and providing DeFi arrangements, there are no entities recognised and treated as financial intermediaries or operational risk regulation to traditional contractual

models. DeFi ecosystems typically rely on SCs for execution, blockchains for settlement finality and user-controlled cryptographic keys (self-hosted wallets) for custody, without resorting to centralised service providers. A regulated CASP may provide an access point to a DeFi protocol, but this may not change the fact that the CASP may not have any direct or indirect control (through contractual relations) over the parties that maintain a genuine DeFi environment. This substitution of institutional machinery with technological machinery explains why DeFi is the environment in which automated contracting exhibits its most radical potential.

To understand the risks that such infrastructures create, and to assess whether they may warrant EU regulatory intervention, it is necessary to examine the components that enable such automated financial services.

The first analytical point is that distributed ledgers, though frequently promoted by crypto enthusiasts as “trustless”, host a number of operational intermediaries that may generate risks analogous to those created by intermediaries in traditional finance. Public blockchains, such as Ethereum, rely on a chain of actors—the blockchain agents referred to above—such as block builders, proposers and validators (EBA and ESMA, 2025; Barczentewicz, 2023, pp. 7–10). By observing transactions in the public mempool²⁶ and taking advantage of the absence of a single queue, certain actors may reorder transactions to maximise private benefit (IOSCO, 2023, p. 34). Therefore, these roles are not passive computational functions; rather, they entail discretionary power over transactional outcomes. The phenomenon of maximal extractable value (MEV) illustrates this reality: actors involved in block construction may reorder or select transactions in order to capture value from arbitrage opportunities, liquidations or price movements (ESMA, 2025e; EBA and ESMA, 2025; Barczentewicz, 2023; 2024, p. 13). The existence of such extraction demonstrates that block construction is not a neutral commodity function but a locus of informational asymmetry and discretionary influence. The risk has been analysed in academic literature and is currently under scrutiny by both the EBA and ESMA (2025; ESMA, 2025e; Barczentewicz, 2023; 2024, p. 13).

In sum, it is important to stress that, from a regulatory standpoint, such blockchain agents that operate at the level of the DLT nodes are neither mere software executors nor passive data transmitters. They are gatekeepers of transaction settlement. No existing piece of EU financial legislation qualifies

²⁶ A so-called ‘mempool’ consists of the set of transactions that are awaiting processing by the operators of a given DLT network. Within a public and permissionless blockchain, the mempool is publicly visible (IOSCO, 2023, p. 34).

or recognises their role. They are not treated as financial intermediaries under EU financial laws, nor as ICT third-party providers under DORA. This regulatory void is substantial: if the technological infrastructure layer becomes a site of economically material discretion and market abuse, the absence of supervisory visibility may undermine the very objectives underpinning EU financial regulation. Put differently, public blockchains may introduce new forms of intermediation that escape existing institutional categories. In this regard, it is worth highlighting that the EU Commission is expected to present a report and, where appropriate, a legislative proposal on decentralised crypto-asset systems by 30 June 2027. In our view, any such initiative should adequately consider the risks identified above and concerning the blockchain agents that maintain public permissionless blockchains.

Moving up a layer, SCs function as the operational logic of automated contracting environments. They may therefore be defined as the engine that enables a DeFi system to operate without traditional intermediaries processing transactions. This entails financial implications across various components of DeFi protocols. In AMMs, pricing, matching and settlement occur simultaneously and without discretionary intervention. In lending protocols, collateralisation, liquidation and interest rate adjustments are handled by on-chain logic. Such examples illustrate that functions traditionally associated with intermediaries are replaced by deterministic execution provided via SCs. This raises two questions: First, does EU law recognise the legal relevance of such automation? Second, does it regulate the entities who design, deploy or control such code?

At present, EU law does not recognise automated execution via SCs as a self-standing form of legal contracting subject to a dedicated set of rules. This need not be inherently problematic, insofar as SCs are ultimately a form of software, provided that the law can effectively deal with the risks they pose and the responsibility of the actors deploying them. However, at the time of writing, EU law remains largely silent on both SC safety requirements and the role of SC deployers, despite the fact that their influence over DeFi protocols can be so significant as to blur the boundary between software deployment and financial intermediation.²⁷

²⁷ A central point emphasised in the ESMA–EBA *Joint report on DeFi* (January 2025) is that many ostensibly decentralised protocols are, in practice, governed by small, identifiable groups. Even where governance tokens are distributed, voting power is often concentrated, delegated or effectively coordinated by core developers or foundations. Moreover, governance frameworks can include privileged actors with the ability to propose upgrades, execute parameter changes or steer protocol evolution.

Also, it is worth highlighting that attributing liability or regulatory obligations to specific agents is particularly difficult in DeFi ecosystems, which are inherently open: SCs deployed by known entities may call, or be called by, SCs deployed by unknown actors, which makes the mapping of agents and allocation of obligations and liabilities extremely difficult.

That said, the notion of “control” may constitute a useful analytical key for future regulatory approaches to DeFi. Deployers may choose between immutable and upgradeable architectures;²⁸ they may retain administrative functions or relinquish them; they may encode emergency pause functions or hard-code determinism; they may implement governance through multisignature schemes or token-based voting. Each of these choices constitutes a locus of control. A system that is immutable, ungoverned and forkable diffuses control; a system that is upgradeable, pausable or parameterisable concentrates it. For regulatory purposes, the relevant legal question should not be whether a system falls within the common understanding of DeFi, but whether any person exercises any form of control that financial regulation associates with intermediation and financial risks to be addressed via regulation and ongoing prudential supervision.

Notably, the notion of control is not foreign to EU crypto regulation. It already underpins MiCAR’s definition of the service of custody and administration of crypto-assets, which deliberately moves beyond the narrower concept of mere wallet provision adopted under the AMLDV and also lies at the core of the UNIDROIT *Principles on digital assets and private law* (UNIDROIT, 2023, 2.3–2.17) in delineating the proprietary aspects of digital assets. For these reasons, control may offer a coherent criterion for identifying when a person effectively performs intermediary functions through technological means. In this respect, it would be desirable for the Commission’s report scheduled for 2027 and any subsequent legislative initiative on DeFi to take due account of the role played by SCs, and in particular of those actors who deploy such contracts or embed them within systems meant for the centralised provision of services.

²⁸ Refer to ‘Joseph Van Loon *et al.* v. Department of the Treasury *et al.*’ (2024). Although arising in a non-EU context, this Tornado Cash judgment is nonetheless noteworthy for drawing a critical distinction between mutable (or upgradable) smart contracts, which may be altered by a managing party, and immutable smart contracts, which cannot be modified or removed from the blockchain once deployed. This distinction was relied upon to argue that the Tornado Cash protocol, being based on immutable contracts, could not be subjected to OFAC sanctions.

The final layer concerns user access. While distributed ledgers underpin transaction settlement finality and SCs provide execution logic, front-end interfaces provide users with access to the system. These interfaces frequently reintroduce intermediation. They may aggregate liquidity, route orders, initiate transactions, store user preferences or enforce compliance. In some arrangements, the front-end is functionally neutral and can be bypassed entirely by interacting directly with the SC. In others, the front-end may embed operational logic that shapes user outcomes. This is significant under both MiCAR and MiFID II: if the access layer provider exercises discretion or control over execution, it may constitute a form of intermediation, regardless of whether the underlying protocol is autonomous. Yet, EU law does not expressly categorise or recognise such DeFi user access providers as regulated entities. Nevertheless, they may be captured by MiCAR, MiFID II, or even PSD2, where their services, in substance, meet the definitions of regulated services under those frameworks (e.g., execution of orders, RTO and transfer). Against this background, the Commission's report and any possible legislative proposal on DeFi should consider whether it is appropriate to explicitly extend the scope of existing categories of crypto-asset services under MiCAR so as to capture services based on access to, or integration with, DeFi systems, or whether instead the introduction of new categories of regulated activities would be warranted.

5.4 Weak signals of legal significance outside finance

Although EU law has not yet addressed on-chain infrastructures as regulatory objects in their own right, two developments outside financial regulation provide weak but meaningful signals of how legal relevance may eventually emerge.

Under eIDAS 2, electronic ledgers provided by a qualified trust service provider classify as 'qualified electronic ledgers' and therefore benefit from enhanced evidentiary value before courts ('Council regulation (EU) 2024/1183', 2024, Article 3(53)). Specifically, "data records contained in a qualified electronic ledger shall enjoy the presumption of their unique and accurate sequential chronological ordering and of their integrity" ('Council regulation (EU) 2024/1183', 2024, Article 42k(2)). Although the Regulation does not meaningfully engage with private law themes such as digital ownership, transfer or automated contracting, it nevertheless characterises ledgers by attributing reinforced evidentiary force to qualified electronic ledgers. This could encourage Member States' domestic law to recognise

legal effects operating on such infrastructures, given that the evidentiary dimension has already been harmonised at the Union level. However, this does not address the challenges posed by public permissionless blockchains, as the enhanced legal effects under eIDAS 2 appear to presuppose ledger provision in a centralised manner and, therefore, private or, at best, federated ledgers.

The second development is the *Data Act* ('Council regulation (EU) 2023/2854', 2023), which introduces in Article 36 functional requirements for SCs used in data-sharing agreements, treating them as operational tools that must incorporate safeguards such as access controls, termination functions and auditability. The practical utility of this provision is unclear. First, the terminology is misleading: in technology jargon, 'smart contracts' has become synonymous with code deployed on-chain, whereas the definition of the *Data Act* is considerably broader and meant to capture both on-chain and off-chain SCs ("The notion of 'smart contract' in this Regulation is technologically neutral. SCs can, for example, be connected to an electronic ledger"; see *Data Act*, Recital 104, Article 2(39)). Second, it is unclear why, in practice, on-chain SCs would be used to automate data-sharing agreements in the first place, given the limitations of this technology when it comes to handling large amounts of data and costs in terms of network fees (technological limitations are further unpacked below). Third, the requirements under eIDAS 2 include provisions on safe termination and interruption, which once again presuppose the existence of a contract that is not fully autonomous after deployment but rather remains governable by one or more parties. Why would one choose to rely on a technology characterised by immutability in use cases where the law does not permit recourse to that very feature?

In sum, neither eIDAS 2 nor the *Data Act* meaningfully engage with truly decentralised and disintermediated technological environments, as both frameworks presuppose elements of centralisation and control over the technology.

This latter point is revealing a more radical one: decentralised technology as such is receiving scant attention as an object of regulation in its own right, not because the EU has deliberately prioritised blockchain-based finance over blockchain-based digital infrastructures, but because the latter have failed to demonstrate meaningful long-term utility outside finance and therefore have not acquired significant legal relevance beyond the financial domain. However, this does not mean that infrastructures should be ignored: as shown in the previous sections, solely regulating centralised

finance that uses decentralised technologies, leaving said technologies and their operators completely unaddressed, generates risks to market integrity and resilience. Furthermore, it leaves DeFi completely unaddressed, which is problematic, given that DeFi is a grey area where the boundary between financial intermediation and digital infrastructure becomes porous, and the supposed technological agents may generate risks typically associated with financial intermediaries.

In this respect, the most plausible conclusion is that, should EU lawmakers eventually address blockchain-based infrastructures directly, such intervention is likely to be motivated by risks emerging from actual use cases. Given that, to date, the only domain in which those risks truly materialise is finance, extending the financial regulatory perimeter to encompass on-chain infrastructures appears the only coherent avenue. At present, the absence of meaningful adoption outside finance simply precludes the emergence of risks that would warrant digital regulation beyond the financial domain.

Several factors appear to contribute to this lack of relevance outside finance. First, distributed ledgers are subject to limitations in transaction processing capacity compared to centralised infrastructures: their architectural design prioritises decentralised verification by network nodes of both data integrity and consistency with prior transactional states over bandwidth and speed. Second, state replication imposes inherent data-minimisation constraints: when every node stores or validates the same data, informational efficiency is sacrificed. Distributed ledgers are therefore best suited for low-entropy operations involving small transactional payloads rather than use cases involving large volumes of data or computationally intensive software execution. Third, SCs are executed in deterministic environments, where reliance on external information (or “oracles”) introduces epistemic uncertainty and trust dependencies. For most non-financial transactions, the complexity exceeds what deterministic code executed on peer-to-peer networks can feasibly express. The cumulative implication is that integration with property registries, judicial enforcement mechanisms or other private law institutions or instruments may prove difficult or simply not cost-efficient. As a result, public blockchains and SCs may remain transactional execution and settlement mechanisms rather than infrastructures capable of being meaningfully integrated into legal mechanisms beyond finance.

The paradox, then, is that digital infrastructures become legally relevant precisely where they are technologically most successful. This is currently the case only in digital finance, where adoption translates into risks for

customers and for market integrity. Within this context, DeFi constitutes the highest-risk segment due to the structural issues identified above and the absence of a regulatory perimeter.

6. Concluding remarks

This analysis has shown that the EU has made substantial progress in regulating crypto-assets and market actors, yet continues to struggle in conceptualising and addressing the on-chain infrastructures through which digital assets, services and rights are instantiated, transferred and enforced. MiCAR and the DLT Pilot Regime exemplify two complementary regulatory strategies: the former extends existing financial regulation to new crypto-asset categories and service providers, while the latter cautiously integrates distributed ledger technology into core traditional market infrastructures. However, both remain anchored to an entity- and service-centric regulatory logic that presupposes the existence of legally recognised assets and intermediaries while leaving the technological and legal foundations of digitised rights largely unaddressed.

This structural limitation manifests in different yet interconnected ways. In decentralised finance, on-chain infrastructures perform functions that are economically and legally analogous to financial intermediation yet escape regulatory visibility because they do not fit within established institutional categories. In hybrid configurations, regulated intermediaries authorised under MiCAR increasingly provide access to, or integrate, decentralised systems within their service offerings, thereby blurring the boundary between regulated services and unregulated infrastructure.

Crucially, this regulatory mismatch is not confined to questions of public law or supervisory perimeter-setting. Rather, it directly conditions the viability of decentralised infrastructure under private law. This is because the legal recognition of rights, entitlements and remedies over tokenised assets remains frustrated by the absence of legal and institutional mechanisms capable of bridging the gap between on-chain functionality and off-chain mechanisms for the recognition of legal effects and enforcement. At a more foundational level of private law, this dynamic becomes particularly visible in the tokenisation of RWAs, where the absence of harmonised legal anchors for digital ownership and enforceability constrains the viability of many industry-promoted use cases.

Outside finance, EU law has so far produced only fragmented and indirect signals of legal relevance for on-chain infrastructures, which do not crystallise into a coherent regulatory or private law framework. This does not seem to be the result of a deliberate policy choice but rather reflects the fact that distributed ledger infrastructures have not yet demonstrated sustained utility beyond use cases capable of generating financial risks. Consequently, the EU legal system has had limited incentive to engage with such infrastructures as objects of regulation in their own right. This situation, however, risks translating into a significant regulatory miscalculation: core segments of centralised finance are progressively being migrated onto decentralised technological infrastructures that the EU legal system has not yet learned how to govern, and whose risk profile is only now beginning to emerge more clearly.

Unless EU law develops conceptual tools capable of addressing infrastructure-level intermediation and the legal foundations of digitised rights, regulatory intervention will continue to focus on market actors and transactional effects, leaving a persistent blind spot at the core of the digital asset ecosystem. Such a blind spot may generate substantial risks for use cases that are already achieving market adoption while simultaneously erecting structural barriers to the emergence and development of other potential applications.

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