

Trautmann, Simon; Hellenkamp, Detlef

Working Paper

The Digital Euro at the Nexus of Payments Sovereignty, Consumer Adoption and Bank Intermediation: Design Requirements and Banking-Sector Implications of a Retail CBDC in the Euro Area

Suggested Citation: Trautmann, Simon; Hellenkamp, Detlef (2026) : The Digital Euro at the Nexus of Payments Sovereignty, Consumer Adoption and Bank Intermediation: Design Requirements and Banking-Sector Implications of a Retail CBDC in the Euro Area, SSRN, Rochester, NY, <https://doi.org/10.2139/ssrn.6880062>, <https://ssrn.com/abstract=6880062>

This Version is available at:

<https://hdl.handle.net/10419/343664>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

The Digital Euro at the Nexus of Payments Sovereignty,
Consumer Adoption and Bank Intermediation:
Design Requirements and Banking-Sector Implications of a Retail CBDC
in the Euro Area

Simon Trautmann
Detlef Hellenkamp

4 June 2026

Simon Trautmann, B.A.
Meerbusch, Germany

Prof. Dr. Detlef Hellenkamp
Head of Banking Department
Duale Hochschule Baden-Württemberg Stuttgart (DHBW)
Baden-Wuerttemberg Cooperative State University Stuttgart, Germany

Keywords: Digital euro; Retail central bank digital currency (CBDC); European payments sovereignty; Consumer adoption; Bank intermediation; Payment systems; Financial stability; Offline payments

JEL Classification: E42, E58, G21, G28

Legal Notice and Disclaimer

Authors:

Simon Trautmann, Detlef Hellenkamp Publication Date: 4 June 2026

Contact:

Prof. Dr. Detlef Hellenkamp Duale Hochschule Baden-Württemberg (DHBW) (Baden-Wuerttemberg Cooperative State University Stuttgart), Herdweg 23, 70174 Stuttgart, Germany

Working Paper

The Digital Euro at the Nexus of Payments Sovereignty, Consumer Adoption and Bank Intermediation: Design Requirements and Banking-Sector Implications of a Retail CBDC in the Euro Area

Copyright

This work, including all its parts, is protected by copyright and intended for personal, non-commercial academic use. Any use or exploitation beyond the limits explicitly permitted by copyright law is prohibited without the authors' prior consent.

Trademark and Branding Notice

The use of generally descriptive designations, trade names, company names, product descriptions, etc., in this work does not imply that such names are exempt from relevant protective laws and regulations or that they may be used freely by anyone. Even without specific marking, these may be protected trademarks and must be observed in accordance with the applicable legal provisions.

Disclaimer for External Links

The authors assume no liability for the content of third-party websites linked or referred to in this work. The authors do not adopt these contents as their own, but refer exclusively to their status at the time of the first publication of this work.

Disclaimer of Warranty

The contents of this work have been researched, compiled, and reviewed with the greatest possible care. Nevertheless, the possibility of errors, omissions, or inaccuracies cannot be entirely excluded. All information in this work is provided, either explicitly or implicitly, without any guarantee (without warranty). The information contained herein is for educational and informational purposes only. The authors do not provide any legal, financial, medical, behavioural, or other professional advice, nor does this work constitute a solicitation to act or refrain from acting. The authors assume no legal or any other liability, despite the care taken in the preparation of this work.

Note on the Use of Generative AI

The authors employed generative AI tools in the preparation of this manuscript. Specifically, ChatGPT by OpenAI and Gemini by Google were used. The responsibility for the final content, the accuracy of the statements, and the academic argumentation rests solely with the human authors.

Table of Contents

Abstract	1
1. Introduction	1
2. The Digital Euro: Objectives, Project Status and Relevant Design Parameters	2
2.1 Strategic and Regulatory Context	2
2.2 Relevant Design Parameters	4
3. Consumer Benefits and Adoption	5
3.1 Payments Environment and Changing Usage Patterns	5
3.2 Potential Benefits and Barriers to Adoption	5
4. Banking-Sector Implications and the Role of Intermediaries	7
4.1 Functional Involvement of Supervised Payment Service Providers	7
4.2 Deposit Reallocation, Funding and Financial Stability	8
4.3 Cost Structure, Remuneration and Scope for Innovation	9
5. International CBDC Experiences and Transferable Lessons	10
5.1 Comparative Cases: Sweden, Nigeria and China	10
5.2 Comparative Assessment	12
6. Discussion: Trade-offs and Design Requirements	12
6.1 User Appeal versus Financial Stability	14
6.2 Privacy versus Regulatory Traceability	14
6.3 Public Infrastructure versus Private-Sector Innovation	14
7. Conclusion	15
References	17

Abstract

The digital euro is intended to preserve access to public central bank money in an increasingly digital payments landscape while strengthening European payments sovereignty. Its potential success, however, will not depend on institutional legitimacy alone. The decisive question is whether it can offer consumers a discernible advantage over established payment instruments and be embedded in a viable intermediated model. This working paper therefore examines the design requirements under which a digital euro could generate tangible everyday utility while preserving the intermediation role of commercial banks.

Methodologically, the analysis draws on recent primary sources issued by European institutions and central banks, relevant academic literature and selected international CBDC case studies. The findings indicate that user-friendliness, privacy, online and offline functionality, a sufficiently broad acceptance network and robust integration into existing payment infrastructures are particularly important. At the same time, the digital euro gives rise to tensions between attractiveness and financial stability, privacy and regulatory traceability, and public infrastructure and private-sector innovation.

Holding limits, waterfall and reverse-waterfall mechanisms, and an appropriately calibrated remuneration model may help to mitigate these tensions. The digital euro can therefore contribute to European payments sovereignty, provided that it is designed as a user-oriented public infrastructure and underpinned by the functional and economically viable involvement of commercial banks.

1. Introduction

The payments landscape in the euro area is undergoing structural change. Cash remains relevant across a wide range of payment situations, while digital payment methods continue to gain importance in physical retail, e-commerce and person-to-person transactions. This raises an increasingly pressing question: how can public money remain universally accessible in a payments environment that is becoming ever more digital? Cash currently fulfils this function as the physical form of central bank money. For digital payments, by contrast, consumers rely predominantly on privately provided payment instruments and infrastructures.

This development has a strategic dimension. Key segments of the European payments market depend on a limited number of international, predominantly non-European providers. The Eurosystem regards this dependence as a potential vulnerability to external and technological risks. The digital euro is therefore intended to provide an additional electronic form of central bank money that complements rather than replaces cash. It is also embedded in a broader European payments strategy: public central bank money should continue to anchor the two-tier monetary system in an increasingly digital economy, while strategic autonomy, resilience, competition and private-sector innovation in European payments are strengthened (Deutsche Bundesbank, 2026; European Central Bank [ECB], 2026a, 2026b).

This institutional rationale does not, however, constitute a sufficiently compelling user proposition in itself. The digital euro would enter a mature payments market in which

consumers already have access to established card, wallet and mobile-payment solutions. Its success will therefore depend largely on whether it offers a discernible advantage in everyday use. Ease of use, a high level of security, credible privacy safeguards, broad usability and both online and offline functionality may contribute to such an advantage. A sufficiently extensive acceptance network across physical and online retail will be equally important. Access to digital central bank money represents an institutional benefit, but widespread adoption will require this benefit to be translated into tangible advantages for users.

The design of the digital euro also has implications for the role of commercial banks. Under the current concept, the Eurosystem would not establish direct relationships with end users. Instead, supervised payment service providers, particularly commercial banks, would distribute the digital euro and deliver the principal user-facing services. Their involvement therefore performs a functional role within the envisaged intermediated model. At the same time, the digital euro gives rise to banking-sector tensions: a reallocation of commercial bank deposits into digital central bank money could affect liquidity and funding, while operational burdens and the design of a viable remuneration framework must also be considered. The scale of these effects will depend substantially on the final design.

Against this background, the working paper addresses the following research question:

Under what design conditions can a digital euro offer consumers a discernible advantage while strengthening European payments sovereignty, and what tensions would this create for the intermediation function of commercial banks?

The study adopts a structured, literature-based and critically reflective approach. It draws on recent primary sources issued by European institutions and central banks, relevant academic literature and selected international CBDC case studies. No original empirical data are collected. International experiences are considered as context-specific sources of insight rather than directly transferable blueprints.

Section 2 outlines the objectives, project status and relevant design parameters of the digital euro. Section 3 examines its potential benefits and the conditions for consumer adoption. Section 4 analyses the banking-sector implications and the role of supervised intermediaries. Section 5 discusses selected international CBDC experiences. Section 6 brings the findings together in a systematic discussion of the principal trade-offs. Section 7 concludes.

2. The Digital Euro: Objectives, Project Status and Relevant Design Parameters

2.1 Strategic and Regulatory Context

The digital euro is envisaged as a digital form of central bank money for retail payments in the euro area. It is intended not to replace cash, but to complement it, thereby ensuring that consumers retain access to public money in an increasingly digital payments environment. Unlike privately provided means of payment, the digital euro would constitute a direct claim on

the Eurosystem. It would not represent a new currency, but an additional form of the euro (ECB, 2026b).

This distinction has a strategic dimension that extends beyond the technical processing of payments. Significant segments of the European payments market depend on international card schemes and global platform providers. Against this background, the digital euro is intended to contribute to a more resilient and integrated European payments landscape. The ECB does not regard it as an isolated central bank project, but as part of a broader strategy designed to combine public central bank money, private-sector payment solutions and infrastructures governed in Europe. The objective is a payments ecosystem that is resilient, innovative, competitive and accessible throughout the euro area (Deutsche Bundesbank, 2026; ECB, 2026a).

The project has become considerably more concrete since its initial conceptual stages. Following an investigation phase from 2021 to 2023, the Eurosystem conducted a two-year preparation phase between November 2023 and October 2025. This phase included the further development of a draft Digital Euro Scheme Rulebook, the selection of potential providers for platform components, the examination of technical issues and research into user requirements. Since the conclusion of the preparation phase, the Eurosystem has focused on further technical work, more intensive engagement with market participants and support for the ongoing legislative process. Subject to the adoption of the necessary EU legal framework during 2026, the ECB is working towards a potential first issuance of the digital euro in 2029. A twelve-month pilot exercise is expected to begin in the second half of 2027. A final decision on whether to issue the digital euro has therefore not yet been taken (ECB, 2025d, 2026b).

The introduction of the digital euro requires a legal basis at EU level. In June 2023, the European Commission presented a proposal for a regulation. Among other provisions, the proposal would grant the digital euro legal-tender status, support its basic usability throughout the euro area and require essential basic services to be provided to consumers free of charge (European Commission, 2023).

In December 2025, the Council of the European Union adopted a negotiating mandate that further specified the proposed mandatory acceptance of the digital euro and the relevant exemptions. The Council's position is that an unrestricted obligation applying to all payees would be disproportionate. It therefore provides for exemptions, including for certain payees that do not accept digital payments at the point of interaction and in cases involving temporary technical impediments. At the same time, mandatory acceptance is intended to ensure that the digital euro would be genuinely usable in everyday transactions rather than undermined by an insufficiently broad acceptance network (Council of the European Union, 2025).

As at 31 May 2026, the legislative process had not yet been completed. The European Parliament continued to list the procedure as "awaiting committee decision". It is therefore essential, both legally and analytically, to distinguish between existing law, the Commission proposal, the Council's position and the current Eurosystem concept. The Governing Council of the ECB will decide whether and when to issue the digital euro only after the relevant regulation has been adopted (European Parliament, n.d.; ECB, 2026b).

2.2 Relevant Design Parameters

Under the current concept, the retail digital euro would operate on a centralised settlement platform. Its core architecture would not be based on distributed ledger technology (DLT) or blockchain. Certain design principles derived from DLT concepts may nevertheless be used to enhance resilience, efficiency and technical reliability. The retail digital euro must therefore be clearly distinguished from DLT-based wholesale initiatives, privately issued stablecoins and tokenised commercial bank money (ECB, 2026b).

Distribution would follow an intermediated model. Supervised payment service providers, particularly commercial banks, would serve as the primary interface with end users and deliver essential services such as onboarding, wallet provision, customer support and the identification and verification procedures required by regulation. A wallet could be opened through a bank, a post office or another supervised payment service provider. Payments are intended to be possible both online and offline and through different devices, including smartphones and smart cards. An advanced draft of the Digital Euro Scheme Rulebook is intended to establish common rules, standards and procedures throughout the euro area. The draft remains provisional, however, and will need to be aligned with the final legal framework (ECB, 2025b, 2026b).

The tiered privacy architecture is particularly significant. For online payments, the Eurosystem should not be able to attribute transactions directly to specific individuals. Supervised payment service providers would nevertheless remain responsible for compliance with regulatory obligations, particularly those relating to anti-money laundering. Offline payments, by contrast, are intended to provide a level of privacy resembling that of cash: personal transaction details would generally be known only to the payer and the payee. The technical and regulatory robustness of this offline functionality will need to be validated as the project progresses (ECB, 2026b).

Holding limits are intended to ensure that the digital euro functions primarily as a means of payment rather than as an unlimited store of value. Their precise level has not yet been determined. In addition, linking a digital euro wallet to a commercial bank account should allow payments to be executed automatically where they exceed the holding limit or where the available balance in the wallet is insufficient. Conversely, incoming amounts above the permitted threshold could be transferred automatically to the linked commercial bank account. These waterfall and reverse-waterfall mechanisms are intended to reconcile usability with financial-stability considerations (ECB, 2026b).

Finally, the digital euro is not intended to constitute programmable money. Its use could therefore not be restricted to particular goods, periods of time or payees. Conditional payments would, however, remain possible. In such cases, the execution of a payment would be linked to a predefined event, such as confirmation that goods have been delivered. This distinction is important: it preserves the fungibility of money while leaving scope for private-sector value-added services (ECB, 2026b).

These parameters are not merely technical details without independent economic significance. They will determine whether the digital euro can generate a discernible advantage for consumers and how commercial banks would be integrated into the future payments ecosystem. The following sections examine these two perspectives in greater detail.

3. Consumer Benefits and Adoption

3.1 Payments Environment and Changing Usage Patterns

The digital euro would not be introduced into an undeveloped market. Consumers already have access to a broad range of established payment instruments serving different purposes: cash, debit and credit cards, bank transfers, direct debits, mobile payment solutions and digital wallets. Its adoption cannot therefore be inferred solely from its status as digital central bank money. The decisive question is whether consumers perceive a discernible advantage over existing payment instruments.

Payment behaviour is changing, although cash has not lost its relevance. In Germany, cash still accounted for 51% of recorded transactions in 2023. In terms of transaction value, however, its share had fallen to 26%. Debit cards have become the most important non-cash payment instrument, while mobile payment solutions are also gaining ground (Deutsche Bundesbank, 2024). A comparable, albeit differentiated, pattern can be observed across the euro area. In 2024, cash was used for 52% of payments at the point of sale, down from 59% in 2022. In value terms, cards accounted for the largest share, at 45%, while cash represented 39%. Online payments also continued to grow, accounting for 21% of day-to-day transactions by number and 36% by value in 2024 (ECB, 2024).

These findings do not indicate a linear substitution of cash by digital payment methods. Rather, a hybrid payments environment is emerging. In 2024, 55% of euro-area consumers stated that they preferred cards or other non-cash payment instruments in physical retail, whereas only 22% preferred cash. At the same time, 62% regarded the continued availability of cash payments as important or very important. The principal advantages attributed to cash included privacy protection and greater control over spending (ECB, 2024). The digital euro must therefore compete not only with technically sophisticated private-sector payment solutions. It must also address the challenge of transferring selected cash-like attributes into the digital sphere.

3.2 Potential Benefits and Barriers to Adoption

The principal institutional benefit of the digital euro lies in providing access to public central bank money for digital payments. This abstract characteristic is not, however, sufficient to support everyday use. Consumers are likely to use the digital euro on a sustained basis only if its functional attributes prove convincing in specific payment situations. Relevant factors include ease of use, a high level of security, a robust privacy architecture, usability in both physical and online retail, and the ability to make payments offline.

Recent academic analysis supports the relevance of individual design parameters. Lambert et al. (2024) model potential demand for the digital euro as a function of its specific characteristics and consumers' payment preferences. Their findings indicate that demand should not be treated as a fixed quantity. It depends, rather, on whether users perceive the digital euro as having characteristics closer to cash or to bank deposits. Relevant attributes include privacy, instant settlement and the automatic coverage of insufficient wallet balances through a linked

commercial bank account. The reverse-waterfall mechanism is therefore important not only from a financial-stability perspective, but also for practical ease of use.

The envisaged offline functionality is particularly significant. It could enable payments in the absence of an internet connection and is intended, under the current Eurosystem concept, to provide a level of privacy resembling that of cash. This could strengthen payment-system resilience, protect privacy and promote financial inclusion. Offline functionality should not, however, be regarded as an automatic driver of adoption. Its practical relevance will depend on whether it can be integrated into everyday use in a technically reliable, readily comprehensible and frictionless manner.

Qualitative user research conducted by Ipsos complements this perspective. The study covered small merchants and vulnerable consumer groups across all euro-area countries. Older participants and those with lower levels of digital affinity emphasised the importance of clear guidance, intuitive usability, personal support and a trusted provider. Security, speed, simplicity and ease of expenditure control were identified as key characteristics of an ideal payment instrument. Established banks and public institutions were frequently regarded as suitable providers. Small merchants also stressed the need for seamless integration into existing systems and highlighted the relevance of transaction costs (Ipsos, 2025).

The provision of a technically sophisticated digital euro would not in itself ensure widespread use. Consumers do not choose payment instruments solely on the basis of abstract institutional characteristics. Established behavioural patterns, perceived switching costs and network effects also shape their decisions. Cards, wallets and mobile payment solutions are already convenient in many everyday situations. An additional payment method must therefore offer a sufficiently clear advantage or be integrated so seamlessly into existing applications that it does not create material additional frictions.

Merchant acceptance is central in this respect. A payment instrument can generate meaningful everyday utility for consumers only if it can be used reliably in the relevant payment situations. In 2024, non-cash payment methods could have been used for 89% of point-of-sale transactions in the euro area, an increase of eight percentage points compared with 2022. Nevertheless, 24% of consumers reported that their preferred payment method had not always been available at physical payment locations during the preceding month (ECB, 2024). The technical availability of a digital euro must therefore be distinguished from the existence of a sufficiently broad acceptance network.

Privacy concerns also remain relevant. In the SPACE 2024 survey, 58% of euro-area consumers expressed concerns about privacy when making digital payments or conducting other banking activities (ECB, 2024). The tiered privacy architecture of the digital euro could offer an advantage in this respect, particularly if offline payments are designed to provide cash-like attributes. Communication must nevertheless remain precise: a cash-like level of privacy for offline payments is not equivalent to complete anonymity across all transactions.

Georgarakos et al. (2025) highlight the potential importance of clear communication. In a representative survey experiment, a short informational video explaining key features of the digital euro increased stated willingness to adopt it by 12 percentage points relative to a control

group. This finding suggests that public perceptions depend not only on product attributes themselves, but also on how clearly they are communicated. It should not, however, be interpreted as a forecast of actual usage. The study captures stated intentions under hypothetical conditions rather than observed adoption in real-world settings.

The adoption of the digital euro should therefore be understood neither as an automatic consequence of its introduction nor as a purely technical design question. A viable proposition must offer tangible everyday utility, communicate privacy and security credibly, account for the needs of different consumer groups and be supported by a broad acceptance network. These conditions are closely linked to the role of supervised payment service providers. Their responsibilities, costs and economic incentives are therefore examined in the following section.

4. Banking-Sector Implications and the Role of Intermediaries

4.1 Functional Involvement of Supervised Payment Service Providers

The introduction of a digital euro would not eliminate the role of commercial banks in the payments market, but it would alter that role. Under the current concept, the Eurosystem would not establish direct relationships with end users. Instead, supervised payment service providers would distribute the digital euro and deliver the relevant user-facing services. These providers would include commercial banks as well as other regulated payment service providers. They would serve as the principal points of contact for consumers, merchants and businesses and assume key operational responsibilities, including onboarding, wallet provision, customer support, and the identification and verification procedures required by regulation (ECB, 2026b).

This intermediated structure should not be regarded merely as an institutional concession to the banking sector. It performs a functional role. Commercial banks already possess established customer interfaces, technical infrastructures and regulatory processes. Their involvement could help to scale distribution, facilitate consumer access and integrate the digital euro into existing payment solutions. Key responsibilities relating to anti-money-laundering compliance and customer identification would remain with supervised payment service providers. The Eurosystem, by contrast, would provide the public infrastructure and settlement in central bank money.

A common Digital Euro Scheme Rulebook is intended to establish consistent rules, standards and procedures throughout the euro area. The current draft seeks to ensure that essential services are delivered consistently, irrespective of the Member State in which a user resides or the participating payment service provider through which the digital euro is accessed. This approach could reduce fragmentation and foster a uniform user experience across the euro area. The draft remains provisional, however, and will need to be aligned with the final regulatory framework (ECB, 2025b).

Beyond the operational burdens involved, the proposed division of responsibilities may also create strategic opportunities for the banking sector. Under the current Eurosystem concept, private-sector solutions should remain capable of integration into the future payments

ecosystem. Options under consideration include integration into existing wallets, co-badging arrangements and private-sector value-added services. Commercial banks could thereby strengthen their customer interfaces and develop additional services on the basis of the public infrastructure (Hellenkamp, 2025, The Drivers of Digital Transformation in Banking). Whether these opportunities can be realised in practice will depend on the technical standards, the regulatory framework and the economic incentives provided to intermediaries (ECB, 2025c, 2026b).

4.2 Deposit Reallocation, Funding and Financial Stability

The most sensitive banking-sector issue concerns the potential reallocation of commercial bank deposits into digital euro holdings. Whereas sight deposits constitute claims on commercial banks, the digital euro would represent a direct claim on the Eurosystem. Consumers could therefore transfer part of their readily available funds from bank deposits into digital central bank money. For commercial banks, this would initially reduce their deposit base and lead to a corresponding outflow of central bank reserves.

This does not automatically imply a contraction in lending or a threat to the two-tier banking system. The actual effects would depend on several factors: the scale and speed of demand for the digital euro, the liquidity position of individual institutions, the functioning of the interbank market, the availability of collateralised funding, and the responses of banks and central banks. Banks could respond to deposit outflows by drawing on existing liquidity buffers, obtaining market-based funding or accessing additional central bank refinancing. More far-reaching effects on lending would arise only indirectly, through adjustments in funding costs and balance-sheet structures (Bouis et al., 2024).

The design of the digital euro as a means of payment rather than an unlimited store of value is therefore particularly important. Under the Commission proposal and the current Eurosystem concept, individual holding limits are envisaged, although their precise level has not yet been determined. Such limits would cap the amount of digital euro that an individual could hold without necessarily restricting the size of individual payment transactions. They are intended to moderate structural deposit outflows and reduce the risk of accelerated shifts into digital central bank money during periods of financial stress.

Meller and Soons (2023) examine the implications of an illustrative holding limit of €3,000 per person under different scenarios. Their simulations suggest that such a limit could help to contain the effects on liquidity risk, funding structures and the Eurosystem balance sheet even under adverse assumptions. In 2025, the ECB also analysed alternative hypothetical holding limits in response to a request arising from the legislative process. According to the Eurosystem's assessment, the configurations examined would not be expected to endanger financial stability in the euro area, even under conservative crisis scenarios (ECB, 2025e). These findings should nevertheless be interpreted as the results of model-based and scenario-based analyses. They do not permit definitive conclusions about actual consumer behaviour once the digital euro is in operation.

Waterfall and reverse-waterfall mechanisms are intended to reconcile practical usability with constraints on the store-of-value function. If an incoming payment exceeded the permitted

holding limit, the surplus would automatically be transferred to a linked commercial bank account. Conversely, a payment could still be executed if the available digital euro balance were insufficient: the shortfall would be covered automatically from a linked commercial bank account. The reverse-waterfall mechanism would therefore reduce the need to maintain larger balances permanently in a wallet. Its operational robustness will, however, need to be validated during technical implementation and the planned pilot exercise (ECB, 2026b).

The banking-sector implications must therefore be assessed from a differentiated perspective. Deposit reallocation represents a relevant risk, but not a deterministic process. Bindseil and Senner (2024) note that macroeconomic models frequently assume different CBDC designs and are therefore only partially comparable. Any assessment must account for the specific design architecture: a non-interest-bearing retail CBDC with holding limits and automated waterfall mechanisms would have different implications from an unlimited or interest-bearing digital central bank liability. Design is therefore not a secondary consideration in the banking-sector analysis; it is constitutive of that analysis.

4.3 Cost Structure, Remuneration and Scope for Innovation

In addition to balance-sheet effects, the digital euro would create operational and economic challenges. Supervised payment service providers would need to implement technical interfaces, adapt processes, comply with regulatory requirements and provide customer support. These requirements would add to the structural transformation pressures already affecting business models, risk management, operational resilience and the organisational adaptability of credit institutions (Hellenkamp, 2025, Institutional Transformation in the Banking Sector). The actual costs would depend substantially on the final design, the reuse of existing infrastructures and the scope for cost-sharing across the banking sector.

In October 2025, the Eurosystem published an assessment of the potential investment costs for the euro-area banking sector. According to this estimate, one-off implementation costs could amount to approximately €4–5.8 billion in total. This range would be equivalent to annual expenditure of around €1–1.44 billion over a four-year period. The figures are based on estimates provided by banks and banking associations, an assessment of the incremental costs attributable specifically to the digital euro, and assumptions concerning synergies and the shared use of existing infrastructure (ECB, 2025a). They should therefore be interpreted not as a definitive cost forecast, but as an institutional scenario estimate.

The economic viability of the intermediated model will depend critically on the remuneration framework. Under the European Commission's proposal, essential basic services would be provided to consumers free of charge. At the same time, the current concept would allow payment service providers to levy merchant charges, subject to an applicable cap. The Eurosystem would bear the costs of establishing the scheme infrastructure and would not levy scheme or processing fees. Existing technical infrastructures should also be reused wherever possible (European Commission, 2023; ECB, 2026b).

This architecture seeks to reconcile several objectives. Consumers should benefit from low barriers to access; merchants should be protected against excessive charges; and supervised payment service providers should retain sufficient economic incentives to support distribution, integration and customer service. These objectives are not fully aligned. Insufficient

remuneration could weaken the active participation of intermediaries and discourage the development of private-sector value-added services. Excessive merchant charges, by contrast, could undermine acceptance of the digital euro and weaken the policy objective of establishing a cost-effective European payment instrument.

International experience and institutional analysis suggest that the active involvement of payment service providers requires an appropriate remuneration model (Koonprasert et al., 2024). The challenge of reconciling low barriers to consumer access, limited burdens on merchants and adequate economic incentives for intermediaries therefore remains a central design issue.

5. International CBDC Experiences and Transferable Lessons

International CBDC projects cannot serve as direct templates for the design of the digital euro. Institutional frameworks, payment habits, regulatory requirements and policy objectives differ substantially across jurisdictions. Selected projects can nevertheless provide specific insights. For the purposes of this working paper, Sweden, Nigeria and China are particularly relevant. The three cases represent distinct stages of development and different analytical challenges: technical piloting, limited adoption following market launch, and the integration of a retail CBDC into an already highly digitalised payments ecosystem.

5.1 Comparative Cases: Sweden, Nigeria and China

Sweden: Offline Functionality as a Technical and Operational Challenge

Sveriges Riksbank has been examining the potential introduction of an e-krona as a digital complement to cash for several years. No decision to issue an e-krona has yet been taken. The fourth and final phase of the technical pilot focused on whether a secure balance-based offline solution could be implemented. The Riksbank tested, among other features, transfers to and from payment cards, offline payments at merchants, direct transfers between end users, and the subsequent synchronisation of offline transactions with the online system (Sveriges Riksbank, 2024).

The findings demonstrate that offline functionality cannot be reduced to an additional technical feature. It creates substantial requirements relating to secure storage, the prevention of double spending, synchronisation and regulatory integration. The Riksbank concludes that a robust offline solution appears technically feasible, but that further work is required across technology, regulation and operational processes (Sveriges Riksbank, 2024).

This finding is relevant to the digital euro. Offline payments could strengthen the resilience of the payments system and transfer cash-like attributes into the digital sphere. They could therefore become an important point of differentiation from existing digital payment solutions.

Their practical value will, however, depend on whether they can be implemented reliably, intuitively and at scale under everyday conditions.

Nigeria: Technical Launch without Sufficient Active Use

Nigeria launched the eNaira in October 2021 as Africa's first CBDC. Its stated objectives included advancing financial inclusion, improving payment efficiency and potentially facilitating cross-border remittances. The system operated largely without technical disruption during its first year. Active use nevertheless remained limited (Ree, 2023).

The Nigerian experience illustrates the importance of network effects. A CBDC can offer consumers sufficient practical value only if it can be used in relevant payment situations. Conversely, merchants have an incentive to accept it only if a sufficiently large number of consumers use the new instrument. According to an IMF analysis, 98.5% of eNaira wallets remained unused one year after launch (Koonprasert et al., 2024). The number of registered wallets is therefore not an adequate indicator of sustained adoption.

The Nigerian case cannot be extrapolated directly to the euro area. The differences in financial inclusion, the informal economy, payments infrastructure and the institutional environment are substantial. It does, however, highlight a general design requirement: the technical availability of a CBDC does not ensure active use. A credible value proposition, a viable distribution model and appropriate incentives for consumers, merchants and intermediaries are also required.

China: A Two-Tier Architecture and Integration into Existing Ecosystems

China is testing the e-CNY in an extensive pilot programme. The system follows a two-tier architecture. The People's Bank of China is responsible for issuance, redemption and the overarching management of the wallet ecosystem. Authorised operators, particularly commercial banks, provide end-user services and facilitate the exchange and use of e-CNY. Additional banks and payment service providers may also participate in its circulation (Working Group on E-CNY Research and Development of the People's Bank of China, 2021).

The architecture pursues several objectives. It is intended to provide access to digital central bank money, strengthen the resilience of retail payments, promote financial inclusion and complement existing payment systems. The e-CNY is designed for both online and offline payments. It also follows a tiered privacy model: smaller transactions are subject to lower identification requirements, whereas larger transactions remain more readily traceable. Conditional payments and smart-contract-based applications are also being tested (Working Group on E-CNY Research and Development of the People's Bank of China, 2021).

Quantitative indicators require cautious interpretation. Koonprasert et al. (2024) report approximately 120 million registered wallets and an outstanding balance of RMB 16.5 billion as at June 2023. This represented only 0.16% of China's M0 monetary aggregate. The authors

emphasise that the e-CNY remained significantly less widely used than established private payment applications such as Alipay and WeChat Pay. Wallet registrations, outstanding balances and actual usage must therefore be distinguished carefully.

The Chinese experience is only partially transferable to the euro area because of its distinct institutional and political context. It nevertheless suggests that the involvement of established intermediaries, integration into existing payments ecosystems and a user-oriented access architecture may be important preconditions for broader use.

5.2 Comparative Assessment

The cases do not provide a directly transferable blueprint for the digital euro. They nevertheless highlight three overarching requirements. First, offline functionality must be designed with sufficient technical, regulatory and operational robustness. Secondly, adoption should not be assessed on the basis of registered wallets, but in terms of active usage, merchant acceptance and transaction intensity. Thirdly, the international experiences suggest that existing customer interfaces and payment systems should be incorporated into the distribution of a retail CBDC.

More broadly, the comparison demonstrates that technical readiness alone is insufficient. A retail CBDC must offer a discernible advantage over established payment instruments.

6. Discussion: Trade-offs and Design Requirements

The preceding analysis demonstrates that the potential relevance of the digital euro cannot be reduced to a single value proposition. Neither its status as digital central bank money nor its institutional foundations would automatically ensure widespread use. The decisive question is whether its different objectives can be reconciled within a coherent design architecture.

Table 1 summarises the principal parameters and trade-offs

Table 1

Summary of design parameters, value propositions and banking-sector trade-offs

Design parameter	Relevance to consumers	Relevance to commercial banks	Economic or regulatory trade-off	Evidentiary status	Key sources
Holding limit	Usability in everyday transactions; constraint on the store-of-value function	Limitation of potential deposit outflows and funding effects	User appeal and convenience versus financial stability and bank intermediation	Model-based analysis; precise level remains open	Meller and Soons (2023); ECB (2025e)
Waterfall mechanism	Automatic transfer of incoming amounts above the holding limit	Return of surplus funds to commercial bank accounts	User convenience versus technical and process complexity	Commission proposal and Eurosystem concept	European Commission (2023); ECB (2026b)
Reverse-waterfall mechanism	Execution of payments without the need to top up the wallet manually in advance	Link between the digital euro and commercial bank accounts	Seamless usability versus the need for robust real-time processes	Eurosystem concept; technical validation required	ECB (2026b)
Online privacy	Protection against direct attribution of transactions by the Eurosystem	Know-your-customer and anti-money-laundering obligations remain with supervised payment service providers	Privacy versus regulatory traceability	Eurosystem concept	ECB (2026b)
Offline privacy	Cash-like level of privacy and additional resilience	Limited transaction visibility; requirements relating to funding and defunding	Cash-like attributes versus misuse prevention and operational robustness	Eurosystem concept; further piloting required	ECB (2025b, 2026b)
Role of supervised payment service providers	Established customer interfaces, guidance and technical support	Distribution, compliance, customer support and integration into existing systems	Scalability through existing structures versus additional operational burdens	Eurosystem concept and Commission proposal	European Commission (2023); ECB (2025b, 2026b)
Free access to basic services and remuneration	Low barriers to access	Cost and revenue implications depending on the remuneration model	Universal access versus the economic viability of the intermediated model	Regulatory and economic design not yet finalised	European Commission (2023); ECB (2025a, 2026b)
Interoperability with private payment solutions	Potential integration into existing applications	Opportunities for innovation, synergies and possible competitive effects	Complementarity versus displacement of private-sector solutions	Empirically open	Aurazo et al. (2024); ECB (2025c, 2026a)

6.1 User Appeal versus Financial Stability

The first trade-off concerns the balance between the everyday usability of the digital euro and the stability of the two-tier banking system. An excessively restrictive design could limit its perceived advantage over established payment instruments. Conversely, digital central bank money should not be available to consumers as an unlimited store of value if this would encourage substantial reallocations of deposits away from the commercial banking system.

The holding limit therefore serves as a key calibration mechanism. Its calibration is not merely a technical detail, but an economic balancing exercise. Model-based analyses suggest that holding limits can constrain potential deposit outflows. Their actual effects will nevertheless depend on the specific design, consumer behaviour, the liquidity positions of individual institutions and the potential responses of the Eurosystem (ECB, 2025e; Meller & Soons, 2023). Waterfall and reverse-waterfall mechanisms may further mitigate this trade-off by combining payment convenience with a constrained store-of-value function. Their operational robustness will need to be validated during technical implementation and the planned pilot exercise.

6.2 Privacy versus Regulatory Traceability

The second trade-off concerns the relationship between a credible privacy proposition and the regulatory requirements applicable to digital payments. A digital euro can offer a discernible advantage over existing payment instruments only if it protects privacy effectively. At the same time, requirements relating in particular to anti-money laundering and counter-terrorist financing must be met.

The envisaged distinction between online and offline payments forms the core of the privacy architecture. For online payments, the Eurosystem should not be able to attribute transactions directly to specific individuals. Offline payments, by contrast, are intended to offer a level of privacy resembling that of cash. Supervised payment service providers would remain responsible for compliance with regulatory obligations (ECB, 2026b). This architecture must not be equated with complete anonymity. Its acceptance will also depend on whether its operation is communicated precisely and clearly: the digital euro should be presented neither as a fully anonymous payment instrument nor as a tool for comprehensive state monitoring of transactions.

6.3 Public Infrastructure versus Private-Sector Innovation

The third trade-off concerns the relationship between public payments infrastructure and private-sector service provision. The digital euro is intended to preserve access to public money in digital payments and to strengthen European payments sovereignty. It does not follow, however, that private-sector solutions should be displaced. Rather, the Eurosystem positions the digital euro within a broader payments ecosystem in which public and private actors perform complementary functions (ECB, 2025c, 2026a).

The intermediated distribution model is intended not only to support operational scalability, but also to preserve scope for private-sector innovation. At the same time, it creates additional burdens. Intermediaries would need to adapt technical systems, implement compliance processes and provide operational services. Under the Commission proposal, basic services would be free of charge to consumers. Whether the envisaged remuneration model will provide sufficient economic incentives remains unresolved. These tensions call for a regulatory framework that safeguards resilience and integrity without disproportionately increasing complexity, implementation costs and barriers to innovation (Hellenkamp, 2025, Regulatory Agenda 2025 and Its Outlook).

The relationship between the digital euro and private European payment solutions cannot therefore be reduced to a binary distinction between competition and cooperation. Both complementary arrangements and competitive effects are conceivable. Which of these effects would predominate cannot be determined conclusively before implementation.

Integrative Assessment

The research question can be answered only conditionally. A digital euro can offer consumers a discernible advantage while strengthening European payments sovereignty if three sets of requirements are reconciled. First, it must provide tangible everyday utility, particularly through ease of use, reliable online and offline payments, and a sufficiently broad acceptance network. Secondly, it requires a credible privacy architecture and a calibrated constraint on its store-of-value function in order to reconcile consumer interests with regulatory requirements and financial-stability objectives. Thirdly, supervised payment service providers must be involved in a functionally and economically viable manner without unduly impairing private European payment solutions or incentives to innovate.

The digital euro should therefore be understood neither as a purely technical modernisation project nor as an inevitable response to the digitalisation of payments. Its potential significance lies in combining public money, European sovereignty and private-sector innovation. Its further design should be assessed against these requirements.

7. Conclusion

The digital euro could help to preserve access to public central bank money in an increasingly digital payments environment and strengthen European payments sovereignty. Such a contribution would not, however, arise automatically from its introduction. The digital euro would enter a mature market characterised by established payment instruments and must therefore offer consumers tangible utility in everyday use.

Its viability will depend on a coherent design architecture. User-friendliness, security, privacy, online and offline functionality, and a sufficiently broad acceptance network are essential from a consumer perspective. At the same time, the potential implications for the commercial

banking system must be taken into account. A calibrated constraint on the store-of-value function and automated waterfall mechanisms may help to reconcile payment convenience with financial stability. Supervised payment service providers, particularly commercial banks, will remain functionally important for distribution, regulatory compliance and integration into existing payment solutions. Their economically viable involvement is therefore a central requirement.

The experiences of Sweden, Nigeria and China do not provide a directly transferable blueprint, but they highlight the importance of robust technical solutions, a discernible value proposition and viable incentive structures. Whether the digital euro will ultimately satisfy these requirements cannot be assessed conclusively before the legislative process has been completed, the envisaged pilot exercise has been conducted and reliable evidence on actual usage has become available. Under the current timetable, the pilot exercise is expected to begin in the second half of 2027, while the Eurosystem aims to be ready for a potential first issuance during 2029 (ECB, 2025d, 2026b).

References

- Aurazo, J., Banka, H., Frost, J., Kosse, A., & Piveteau, T. (2024, December 3). Central bank digital currencies and fast payment systems: Rivals or partners? (BIS Papers No. 151). Bank for International Settlements. <https://www.bis.org/publ/bppdf/bispap151.pdf>
- Bindseil, U., & Senner, R. (2024). Macroeconomic modelling of CBDC: A critical review (ECB Working Paper Series No. 2978). European Central Bank. <https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2978~277df84e22.en.pdf>
- Bouis, R., Gelos, G., Miettinen, P. A., Nakamura, F., Nier, E., & Soderberg, G. (2024). Central bank digital currencies and financial stability: Balance sheet analysis and policy choices (IMF Working Paper No. 2024/226). International Monetary Fund. <https://doi.org/10.5089/9798400290794.001>
- Council of the European Union. (2025, December 17). Proposal for a regulation of the European Parliament and of the Council on the establishment of the digital euro: Mandate for negotiations with the European Parliament (ST 16695/25). <https://data.consilium.europa.eu/doc/document/ST-16695-2025-INIT/en/pdf>
- Deutsche Bundesbank. (2024, December 1). Zahlungsverhalten in Deutschland 2023 [Payment behaviour in Germany 2023]. <https://www.bundesbank.de/de/publikationen/berichte/studien/zahlungsverhalten-in-deutschland-2023-934826>
- Deutsche Bundesbank. (2026, March 24). Der digitale Euro: Kernelemente und Perspektiven [The digital euro: Core elements and perspectives]. <https://publikationen.bundesbank.de/publikationen-de/berichte-studien/monatsberichte/der-digitale-euro-kernelemente-und-perspektiven-988548>
- European Central Bank. (2024, December). Study on the payment attitudes of consumers in the euro area (SPACE) – 2024. https://www.ecb.europa.eu/stats/ecb_surveys/space/shared/pdf/ecb.space2024~19d46f0f17.en.pdf
- European Central Bank. (2025a, October 10). A view on recent assessments of digital euro investment costs for the euro area banking sector. https://www.ecb.europa.eu/euro/digital_euro/timeline/profuse/shared/pdf/ecb.deprep251010_a_view_on_recent_assessments_of_digital_euro_investment_costs_for_the_euro_area_banking_sector.en.pdf
- European Central Bank. (2025b, June 30). Draft digital euro scheme rulebook v0.9. https://www.ecb.europa.eu/euro/digital_euro/timeline/profuse/shared/pdf/ecb.derdgp250731_Draft_digital_euro_scheme_rulebook_v0.9.en.pdf
- European Central Bank. (2025c, October 30). Fit of the digital euro in the payment ecosystem report. https://www.ecb.europa.eu/euro/digital_euro/timeline/profuse/shared/pdf/ecb.deprep251030_digital_euro_fit_payment_ecosystem_report.en.pdf

- European Central Bank. (2025d, October 30). Preparation phase of a digital euro – Closing report.
https://www.ecb.europa.eu/euro/digital_euro/progress/shared/pdf/ecb.deprp202510.en.pdf
- European Central Bank. (2025e, October 10). Technical annex on the financial stability impact of the digital euro.
https://www.ecb.europa.eu/euro/digital_euro/timeline/profuse/shared/pdf/ecb.deprep251010_technical_annex_financial_stability_impact_digital_euro.en.pdf
- European Central Bank. (2026a, March 31). The Eurosystem's comprehensive payments strategy.
<https://www.ecb.europa.eu/press/pubbydate/2026/html/ecb.eurosystemcomprehensiv epaymentsstrategy202603.en.html>
- European Central Bank. (2026b, March 5). FAQs on the digital euro.
https://www.ecb.europa.eu/euro/digital_euro/faqs/html/ecb.faq_digital_euro.en.html
- European Commission. (2023, June 28). Proposal for a regulation of the European Parliament and of the Council on the establishment of the digital euro (COM(2023) 369 final).
<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52023PC0369>
- European Parliament. (n.d.). Establishment of the digital euro [Procedure file 2023/0212(COD)]. Legislative Observatory. Retrieved June 1, 2026, from
<https://oeil.europarl.europa.eu/oeil/en/procedure-file?reference=2023%2F0212%28COD%29>
- Georgarakos, D., Kenny, G., Laeven, L., & Meyer, J. (2025). Consumer attitudes towards a central bank digital currency (ECB Working Paper Series No. 3035). European Central Bank. <https://doi.org/10.2866/7598290>
- Hellenkamp, Detlef (2025). The Drivers of Digital Transformation in Banking: From AI and Cloud Adoption to Customer-Centric Platforms (November 13, 2025). Available at SSRN: <https://ssrn.com/abstract=5743322> or <https://doi.org/10.2139/ssrn.5743322>
- Hellenkamp, Detlef (2025). Institutional Transformation in the Banking Sector: Multidimensional Analysis of the Impact of Digitalization, ESG, Demographics and Banking Regulation on German and European Credit Institutions (May 08, 2025). Available at SSRN: <https://ssrn.com/abstract=5247332> or <https://doi.org/10.2139/ssrn.5247332>
- Hellenkamp, Detlef (2025). Regulatory Agenda 2025 and Its Outlook: Between Complexity and Necessity - A Critical Analysis of the European Banking Sector (April 26, 2025). Available at SSRN: <https://ssrn.com/abstract=5232151> or <https://doi.org/10.2139/ssrn.5232151>

- Ipsos. (2025, October 30). Digital euro user research report. European Central Bank. https://www.ecb.europa.eu/euro/digital_euro/timeline/profuse/shared/pdf/ecb.deprep251030_digital_euro_user_research_report_ipsos.en.pdf
- Koonprasert, T. T., Kanada, S., Tsuda, N., & Reshidi, E. (2024). Central bank digital currency adoption: Inclusive strategies for intermediaries and users (IMF Fintech Note No. 2024/005). International Monetary Fund. <https://doi.org/10.5089/9798400289422.063>
- Lambert, C., Larkou, C., Pancaro, C., Pellicani, A., & Sintonen, M. (2024). Digital euro demand: Design, individuals' payment preferences and socioeconomic factors (ECB Working Paper Series No. 2980). European Central Bank. <https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2980~5f64961c8f.en.pdf>
- Meller, B., & Soons, O. (2023). Know your (holding) limits: CBDC, financial stability and central bank reliance (ECB Occasional Paper Series No. 326). European Central Bank. <https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op326~d5c223d9b4.en.pdf>
- Ree, J. (2023). Nigeria's eNaira, one year after (IMF Working Paper No. 2023/104). International Monetary Fund. <https://doi.org/10.5089/9798400241642.001>
- Sveriges Riksbank. (2024, March). E-krona pilot phase 4. <https://www.riksbank.se/globalassets/media/rapporter/e-krona/2024/e-krona-pilot-phase-4.pdf>
- Working Group on E-CNY Research and Development of the People's Bank of China. (2021, July). Progress of research & development of E-CNY in China. People's Bank of China.