



AUGUST 2022

AHEAD OF THE DIGITAL EURO

Public Digital Euro Working Group
Recommendations

Digital Euro Association

Digital Euro Association

Public Digital Euro Working Group

Chairpersons

Anne-Sophie Gógl
Filippo Zatti

Members

Erik Ahlborn	David Mangini
Cizar Bachir Brahim	Marlene Marz
Suleiman Barada	Dominik Merz
Lucia Suarez Barcia	Christian Mouton
Rosa Giovanna Barresi	Talha Ocal
Jim Ford	Sarah Palurovic
Dercio Frade	Jannah Patchay
Juan Gutierrez	Maxime Polis
Thomas Haas	Deyan Radev
Philipp Hartmannsgruber	Amnon Samid
Anja Kamping	Selin Sezer
Deniz Baytemür Köksal	Luca Vanini
Conrad Kraft	

Abstract

Which primary characteristics must a digital euro possess to guarantee being a serious alternative to physical money in the future? The answer to this question is provided by systematically reviewing three different levels of analysis. First, the various design dimensions of a digital euro; second, how a digital euro would fit into the European payments landscape; and third, the legal requirements for implementing a digital euro. The paper concludes with well-considered recommendations on all three levels of analysis. The outcomes are particularly aimed at those central banks involved in the development of a central bank digital currency.

**The views expressed in this paper are the authors' own and do not necessarily reflect the views of their employers or the Digital Euro Association (DEA). The DEA would like to thank its supporting members, whose support was instrumental in making this work possible.*

List of abbreviations

ACH	Automated Clearing Houses
AML	Anti-Money Laundering
API	Application Programming Interface
BIS	Bank of International Settlements
CBDC	Central Bank Digital Currency
CDD	Customer Due Diligence
CFT	Combating the Financing of Terrorism
DEA	Digital Euro Association
DLT	Distributed Ledger Technology
ECB	European Central Bank
ECON	European Parliament Committee on Economic and Monetary Affairs
eIDAS 2	Electronic Identification, Authentication and Trust Services
EU	European Union
EURO1	EBA CLEARING Company
eWpG	Gesetz über elektronische Wertpapiere
FATF	Financial Action Task Force
FinTech	Financial Technology
FX	Foreign Exchange
IMF	International Monetary Fund
IoT	Internet of Things
KYC	Know-Your-Customer
MiFID	Markets in Financial Instruments Directive
ML	Money Laundering
NCB	National Central Bank
PoS	Point of Sale
PSD	Payment Service Directive
PSD2	Revised Payment Services Directive
PSP	Payment Services Provider
RTS	Regulatory Technical Standards
SCT Inst	SEPA Instant Credit Transfer
SDD	Simplified Due Diligence
SEPA	Single Euro Payments Area
SCA	Strong Customer Authentication
SCT	SEPA Credit Transfer
SWIFT	Society for Worldwide Interbank Financial Telecommunication
TARGET2	Trans-European Automated Real-time Gross Settlement Express Transfer System
TF	Terrorism Financing
TIPS	Target Instant Payments Service
WEF	World Economic Forum

Table of contents

1. Introduction	1
2. Design dimensions of a digital euro	2
2.1 CBDC architecture and the role of commercial banks	2
2.2 Impact of a digital euro on the financial system	3
2.3 Technology design	3
2.4 Programmability	4
2.5 Data privacy and security	4
3. Payment relevant aspects of a digital euro	5
3.1 The European payments landscape today	5
3.2 Requirements for distribution and usage for a digital euro	6
3.3 Implementation issues – interoperability, standardization & regulation	7
3.4 Programmable payment services – examples	8
4. Legal considerations for the digital euro	9
4.1 ECB’s mandates and digital euro as legal tender	9
4.2 AML requirements/standards	11
4.2.1 Global Standards: FATF analysis and the European follow up	11
4.2.2 KYC requirements/standards	12
4.2.3 Travel rule	13
4.3 Consumer protection and transparency	14
4.3.1 Means of payment	14
4.3.2 Investment	14
5. Recommendations	15
5.1 Design dimensions	15
5.2 Payment relevant aspects	15
5.3 Legal considerations	16
References	17

1. Introduction

This paper comes at a crucial time for decision-making on the future shape of the international monetary system and the path of the digital euro project. The working group has met over the past few months to contribute, through the interdisciplinary and professional expertise of its members, to the many facets being debated regarding the development of the digital euro.

Much water has flowed under the bridge since January 2017, when the European Parliament Committee on Economic and Monetary Affairs (ECON) report “FinTech: the influence of technology on the future of the financial sector” recommended that the European Central Bank (ECB) conduct experiments on the digital euro, a central bank digital currency (CBDC) issued by the ECB. The stalled Libra-Diem project and the declining use of cash as a means of payment cleared the field of indecision and spurred the ECB to announce the start of an investigation phase for a digital euro. A recent Bank for International Settlements (BIS) survey on CBDCs (BIS, 2021) reports that most central banks (around 90%) are involved in CBDC initiatives. Many are at an advanced stage of exploring CBDC adoption. Almost one-fifth of central banks are developing or testing a retail CBDC, twice as many as those focused on a wholesale CBDC.

The questions posed to the members of the working group started from the three aspects considered most relevant for determining the characteristics a digital euro should possess. Firstly, the analysis of the technical and organizational designs of the digital euro. Second, the interoperability of a digital euro with payment systems and its relevant implications. And thirdly, determining the need to reform the current legislative and regulatory framework concerning the euro. These points – design models, payment relevant aspects, and regulatory framework – are, in fact, closely linked. Slightly more than two-thirds of central banks are considering a public-private model (or, more specifically, a 'two-tiered model'), where the private sector fulfills the functions of know your customer (KYC), anti-money laundering (AML) and combating the financing of terrorism (CFT) compliance, retail payment processing, and transaction recording.

The ECB has, on multiple occasions, noted that there is a need to amend the regulatory framework to include the digital euro alongside the physical euro as legal tender (ECB, 2020). This need for amendment is not unique to the digital euro. In other jurisdictions too, change is required to allow monetary authorities to issue digital money. More than a third of the central banks considering issuing digital money will have the power to do so within 2022 (BIS, 2021). Only a quarter are not yet in a position to do so, and the rest are uncertain whether legislative intervention is necessary. The issue is quite delicate. In the case of the euro, the literature that has dealt with it has grasped discordant aspects, starting from divergent hypotheses. This is not surprising. The question of a digital currency is not only a legal one, but also technical. As is seen from the recommendations of the DEA Public Digital Euro Working Group, there are various possibilities of integrating with the ongoing and emerging legislative framework. However, the most delicate knots that need to be unraveled are those which can guarantee the homomorphism of CBDC with physical money. The Commission and the ECB face what is probably the most significant challenge facing the

eurozone since its inception. This document concludes with an analysis and set of recommendations that the DEA Public Digital Euro Working Group presents for the utility of policymakers and the monetary authority in the 'constituent spirit' that this process inevitably requires, contributing to the preservation of public money in an increasingly digital economy.

2. Design dimensions of a digital euro

2.1 CBDC architecture and the role of commercial banks

Today, commercial banks play a key role in the distribution and management of physical banknotes and coins to the public. In a digital euro scheme that follows a tokenized digital banknote model of CBDC, similar services will be required. The ECB retains exclusive authority to create and issue a digital euro and commercial banks should continue to distribute the currency to the public and support their payment needs, together with payment service providers.

The digital euro fulfills the vision of restoring the old way of payment with cash fit for the digital age that is distributed directly to and capable of being owned, held and used directly by the general public, enabling instantaneous, convenient, direct, peer-to-peer transactions, with similar levels of privacy as physical cash, for users. To allow the entire ecosystem to participate in the digital euro deployment, including the private and public sectors (which is essential for ongoing innovation in this ever-evolving digitalization challenge) the digital euro should be interoperable with commercial banks, existing financial institutions, payment providers within the eurozone, generally accepted payment standards, and network protocols. It should also be interoperable with other public payment programs such as the Trans-European Automated Real-time Gross Settlement Express Transfer System (TARGET2) and EBA CLEARING Company (EURO1).

The digital euro could have a profound impact on commercial banks and monetary policy if its design includes the ability to be interest-bearing. A digital euro that is interest-bearing represents a significant distinction from the bearer token model of cash. These distinctions are as follows: (1) An interest-bearing digital euro may disintermediate commercial banks by competing with demand deposits at institutions and creating unanticipated rapid flows of capital in times of economic stress (bank runs); (2) Implementing a different monetary policy for an interest-bearing digital euro may, in the most extreme cases, result in the loss of par value with euro banknotes and coins, with the digital euro trading at a discount or premium to physical cash. The digital euro will likely enter an already advanced and complex ecosystem of modern payment instruments and services offered by the private sector. Rather than replacing cash or other methods of payments, the digital euro will exist in parallel and become an additional payment choice for the public while other market changes are introduced, including those from the Payment Services Directive 2 (PSD2). In this complex mix of changing regulations and policies, there will emerge a new balance in the roles of the ECB, commercial banks, and payment service providers.

These private banking institutions serve critical roles towards enabling lending and capital investment for the growth of the economy, therefore, the ECB should structure the digital

euro in such a way as to not compete with or diminish the services offered by these institutions. The digital euro enables a new public-private partnership that is not possible with banknotes and coins. With the introduction of a digital euro - the private sector will be able to develop innovative business models, furthering public-private partnerships.

2.2 Impact of a digital euro on the financial system

Analysis of the risks to the financial system, and therefore financial stability and monetary transmission, indicate that the digital euro should meet many criteria and requirements. In particular, policymakers should consider, under several scenarios, the various levels of demand for the digital euro, as well as different levels of interchangeability between the digital euro and other forms of private money. In addition, the ECB must consider the various constraints that stakeholders in the issuance, provision, and use of the digital euro are subject to (such as collateral requirements and prudential regulation). Policymakers and the ECB will have to pay special attention to evaluating the implications of a digital euro on various aggregates and mechanisms that matter to the banking system, the financial system, and the economy. This comprises, among others, bank profitability and lending conditions, risk of disintermediation in times of bank runs, capital flow, bank liquidity risk, aggregate lending and economic activity, the transmission of monetary policy, and systemic liquidity. Finally, stress testing according to the different design specifications and calibrations to achieve the general economic policy objectives of the general economic policy objectives as specified by the treaties of the European Union is essential and is expected to be prioritized within the staggered approach of the ECB.

2.3 Technology design

We argue that the technology (traditional databases, distributed ledger technology (DLT) etc.) that could underpin the digital euro requires close attention since it will have significant impact on resilience, sustainability, speed, usability, and macroeconomic/microeconomics aspects of the digital euro.

The chosen technology should introduce eurozone citizens to a broad scope of features that will make the digital euro more attractive over other payment rails. Additionally, the technology underpinning the digital euro should be cyber-attack resilient, centrally-minted, while traded in a decentralized manner. Whether based on DLT or not, the technology should be widely accepted while achieving the following:

- financial inclusion;
- user-controlled privacy;
- not being a shelter for illicit activities; and
- offline payments during short or perhaps even long periods without internet connection or electricity.

It would be prudent of the ECB to test a range of technologies (such as, DLT-based and non-DLT-based, hybrid (i.e., the creation of coins is not DLT-based, while the trading is DLT-based, etc.)) from various vendors before determining which is most suitable. Apart from technology options that are already being tested by other central banks, it is recommended that infrastructure which mitigates cyber security threats be explored. It is noted that the Chinese central bank has already built and tested a two-tier retail CBDC,

named Q-pay, in which token creation is based on quantum-randomness (an approach acknowledged by the WEF), which is resilient against attacks by quantum computers.

2.4 Programmability

One has to distinguish between programming transactions (i.e, programmable payments) and programmable money (Gross et al., 2020). A programmable euro could support most features enabled by programmable payments, but in a more efficient manner, and offer additional functionality that is currently not possible with programmable payments. For example, a programmable digital euro token could be fractionalized into any desired resolution by a mobile phone application or an Internet of Things (IoT) device, without the need to connect to a ledger. Such a feature would enable autonomous IoT payments, as well as continuous payment, per time or per use (e.g., per Kwh in charging electric vehicles) in a fast and efficient manner.

Programmability also refers to putting terms of use on the digital euro coin itself ("tethered-money"). The digital euro could be cryptographically 'fused' with pre-defined terms of use to prevent misuse and discourage corruption and fraud. In the event of a disaster, a programmable euro with embedded conditions may facilitate grants and disaster relief funds that hinder fraud and misuse.

2.5 Data privacy and security

Privacy is a fundamental right and is thus a consideration that will impact the design choice of the digital euro significantly. The demand for privacy of transactions was evidenced by the outcomes of the three-month long public survey on the digital euro conducted by the ECB during the digital euro project investigation phase (ECB, 2021).

Except for the discrete transfer of cash, bilateral payment is non-existent today. At present, card and commercial bank transfer payments cannot replace minted fiat coins and banknotes because they do not meet the basic experience of bilateral payment privacy. An outcome from the evolution of consensus algorithms and cryptography-based digital currencies is the possibility of a new approach that puts users in charge of their data. This level of versatility should be a dominant factor in developing the digital euro. The protocol of choice will ideally possess built-in capacity to draw a balance between privacy and law enforcement, while further having the ability to adjust this balance as may be required.

Additionally, the ECB should prioritize future security as a core feature, as noted by the WEF, the BIS, and the IMF (IMF, 2021) (e.g., IMF: Vulnerable algorithms will need to be transitioned to post-quantum cryptography).

3. Payment relevant aspects of a digital euro

3.1 The European payments landscape today

Last year, the ECB started a two-year “investigation phase” on the digital euro, evaluating the design of a CBDC as a complement to existing means of payment (Panetta, 2021). A report on payment preferences was published on 30 March 2022 as part of the digital euro investigation phase (ECB, 2022). The revised Payment Services Directive (PSD2) aims to secure digital payments with a focus on Regulatory Technical Standards (RTS) for Strong Customer Authentication (SCA) (EBA, 2018). As the Open Banking ecosystem continues to grow toward Open Finance, areas such as fraud, Application Programming Interface (API) standards and SCA need to be improved towards overcoming the fragmentation in the European Union (EU) member states. The European Payments Council (EPC) defined standards for harmonized payment instruments towards the implementation of the Single Euro Payments Area (SEPA): the schemes (rulebooks) for credit transfers (SEPA Credit Transfer - SCT), direct debits (SEPA Direct Debit), and for card payments (SEPA Card Framework) (Renzetti et al., 2021).

In 2017, the EPC introduced the standard scheme for instant payments in euro: the SEPA Instant Credit Transfer (SCT Inst), based on the pre-existing SEPA credit transfer (SCT) scheme. With the implementation of SCT Inst, all Payment Service Providers (PSPs) ensure the execution time for each individual transaction must not exceed 10 seconds, the service is guaranteed all year round, 24 hours a day, with a maximum limit per transaction of €100 000 (Renzetti, 2021).

SEPA is in the unique situation of already being served by two instant payment systems: RT1 managed by EBA Clearing (EBA, 2021) (owned by the European Banking Association, which went live in 2017) and Target Instant Payments Service (TIPS), managed by the Eurosystem which went live in 2018 (Renzetti, 2021). TIPS is an instant payment system operating 24/7, executing retail payments in real time, in central bank money, and at a very low fee of €0.002 per transaction until 2023. During specially engineered performance tests, TIPS was able to process 500 payments per second, peaking at 2000 payments per second, for a total of 40 million payments per day (Renzetti et al., 2021).

However, SEPA instant payments are still less than 10% of the total number of retail transactions, with cash and cards still being the preferred methods of payment since merchants are still wary of real-time bank transfers being more unreliable than card-based payments.

Even if the use of the SCT Inst is on the rise, as of the end of 2020, none of the Automated Clearing Houses (ACH) could guarantee the ability of PSPs to send instant payments to any other PSP in the SEPA area. The ACHs’ fragmentation and limited interoperability, people’s habits, and poor support of the instrument by PSPs, limit the usage of instant payments (Renzetti, 2021).

Physical cards cover about 48% of transactions and are still the preferred method of payment in the euro area (ECB, 2020). The deduction applied to the sales price for computing the actual amount paid to the merchant is called a Merchant Service Charge.

About 70% of it is determined by the so-called “credit card interchange fees” set by the payment networks, such as Visa and MasterCard. After several investigations from the Directorate General for Competition and judicial proceedings at the European Court of Justice, the European Parliament approved a cap of 0.2% on debit cards and 0.3% on credit card interchange fees (EU Commission, 2015).

If any payment means are to achieve adequate diffusion, the critical factor would be the merchant acquiring industry supporting the complex network of payment terminals and forwarding payments orders to commercial banks. European banks still directly acquire more than half of the total number of transactions. After a two-year consolidation effort, the main players are French-based Worldline and Italian-based Nexi.

Phone-based digital wallets (e.g., Apple-pay, Google Pay) have become the most used payment method for e-commerce in Europe, accounting for 26% of all online e-commerce payments in 2020.

The European Payments Initiative (EPI) currently comprises thirteen European banks and aims to create a pan-European payment system based on the SEPA SCT Inst scheme (European Payments Initiative, 2020). Its intended goal is to become the new standard means of payment for retail and “peer-to-peer” transactions for European consumers and merchants, by offering an international solution that can integrate or replace domestic solutions such as Swish, the Swedish mobile payment system used by more than two-thirds of Swedes (Fawthrop, 2019). Another national system, called Ideal, allows Netherlands-based customers to buy from Internet merchants using direct online transfers from their bank account.

As CBDC technology is still evolving, its integration with present-day instant payment systems is an open issue, and the digital euro project will be one of the first attempts to solve this problem (ECB, 2021). This brings us back to the TIPS instant payment system, a multi-currency, state-of-the-art, real-time payment service, managed by the Eurosystem. Thanks to its low costs and reliability, TIPS is attracting new partners, like the National Bank of Sweden. The interconnection between TIPS and RIX (the National Swedish RTGS) is called RIX-INST (Sveriges Riksbank, 2021) and started in May 2022. The Danish Central Bank is also planning to connect to TIPS by November 2025 (Danmarks Nationalbank, 2021).

3.2 Requirements for distribution and usage for a digital euro

As for any currency, the adoption of the digital euro by the public directly depends on the opportunities to spend it: payment use cases. The current digital payment landscape in the eurozone is vast in terms of use cases. It offers European citizens and businesses many convenient opportunities to pay for goods, services or taxes, or to donate using euros they hold in bank accounts or e-money accounts. Use cases range from person-to-person transfers, to payments at toll-gates and in-app purchases. New fields are opening to payments, such as digital asset trading, which could also be an application field for the digital euro, bringing the guarantee of fiat currency and competing with private stablecoins or cryptos. In the same way, the deployment of a digital euro could accompany the development of IoT micropayment use cases.

This multiplicity of payment use cases is offered to the public thanks to a large and dynamic ecosystem of PSP. PSPs provide the technical devices and infrastructure to merchants for them to receive payments made with various instruments. A merchant can be anything from a street market shopkeeper to a public hospital. The functional addition of a digital euro requires the integration of each PSP with the entities holding CBDC wallets on behalf of the public as they currently integrate with commercial banks for payments in private money. Technical integration means developing APIs and connecting interfaces implementing routing rules, in addition to the PSP upgrading its own software in servers and Point of Sale (PoS). There is a need for defining the common behavioral and technical rules and such things as the retribution of the parties: some “CBDC payment scheme” could be established.

PSPs are needed to create the necessary functional conditions for adoption, but acceptance of CBDC payments by merchants is based on trust on the complete payment chain, including, of course, the CBDC wallet service provider. Banks and PSPs (including payment card networks) have built brands over years for this purpose, and the digital euro would benefit from this legacy. Of course, all the conditions described above can only be met if the business framework allows viable business models for each type of stakeholder, starting with the coverage of costs for the integration of the digital euro with legacy channels. Building such a framework will be one of the ECB’s challenges.

3.3 Implementation issues – interoperability, standardization & regulation

At present, the ECB is primarily focused on a retail CBDC (ECB, 2020). Following the retail approach, the digital euro will be primarily a means of payment which can be used by the public. Theoretically, there is the possibility for the central bank to centrally and directly operate the digital euro ecosystem. As noted in Chapter 1, since commercial banks and financial institutions are the “first point of contact” for consumers, the ECB will most likely follow an intermediated “tiered” system. It will therefore outsource services such as on-boarding customers and enabling payments services around the digital euro to commercial banks. Following this approach, the central bank will issue the digital euro and intermediaries like commercial banks will distribute the digital euro to the public and provide payment services (ECB, 2020).

Thus, the ecosystem of the digital euro will consist of different participants. These participants will include commercial banks, financial institutions or PSPs as intermediaries taking on the role of distributing the digital euro to the public, the merchants who will provide payment services to the public at the PoS, and consumers, who will be able to use the digital euro for payments. It is important to mention at this point that the digital euro would be a form of central bank money, thus, a liability of the central bank. It has to be considered that the digital euro will be used by consumers who expect a uniform user experience, especially at the PoS. Hence, this new digital euro system needs to be integrable with existing payment solutions (see Chapter 2.1).

To ensure bank interoperability, a standardization of the infrastructure and processing of payment transaction flows is necessary. This involves specifications, requirements, and regulations. Standards such as ISO 20022 or regulations such as PSD2 should be considered in the digital euro design. For example, ISO 20022 as a globally uniform standard for all types of financial transactions between financial institutions, market infrastructures, end customers, and regulatory authorities, could enable seamless

communication and interoperability – even across borders. Without a common standard, there could be the risk that commercial banks or payment service providers will build isolated solutions.

A standardized infrastructure would also mean that every commercial bank, financial institution, or PSP could implement and participate in the digital euro ecosystem. For example, they could be forced to fulfill certain criteria to connect to the digital euro “network”. API functionality could be used to connect and onboard commercial banks as distributors to the CBDC platform, which can be operated by the ECB.

As mentioned above, a CBDC infrastructure could follow an account-based, a token-based approach or an approach which is a mixture of both (a hybrid version) (Auer & Böhme, 2020). It is recommended to opt for a hybrid or mixed approach to fulfill more requirements on the digital euro and, in the end, have a more flexible CBDC design. The digital euro could be provided by commercial banks to end users by offering a digital wallet app which can be used on smartphones or wearables. It is possible to link/couple the digital euro wallet to a bank account following a hybrid or quasi-account based approach. This has the advantage that users with a bank account (in Europe, a large share of Europeans have, at least, one bank account) can easily obtain digital euros from their commercial bank via their own bank account (e.g., switching commercial bank money into digital euro tokens). This would also improve usability to customers. Commercial banks would also have the ability to provide additional financial products and services around the digital euro to customers.

Users that do not have a bank account could, under certain circumstances, access digital euros for everyday payments only via the digital wallet app. The payments budget for unbanked users could be limited to facilitate anonymity or private transactions for small transactions. This method is used by the People’s Bank of China for the e-CNY (Wang, 2022).

3.4 Programmable payment services – examples

The issuance of a digital euro, whether public or private, provides the opportunity to rethink the concept of currency and possibly incorporate additional functionalities to its monetary value.

One way of incorporating the programmability features introduced in Chapter 1 in a public digital euro is to allow programmable payments by automation of different payment processes where money transfer conditions are predetermined. Automation of payments between machines (M2M,) payments between humans and IoT devices, or pay-per-use payments are among the most common domains where programmable payments carry great potential by providing trust and efficiency in costs and time. Some examples include a smart vehicle handling the payment automatically at a gas station (Jamil et al., 2022), smart consumer electronics ordering supplies that are low in stock, and machines selling their sensor data to interested services (Mercanet al., 2021).

On the other hand, the properties of the money itself can include certain constraints that would enforce behaving differently under different circumstances, therefore creating programmable money. As previously mentioned, the concept of programmable money mostly implies usage restrictions that might enable stricter control over funds and reduced

risk of misuse. Donations, loans, social welfare programs (Royal et al., 2018), and vouchers (Kolehmainen, Laatikainen, Kultanen et. al., 2021) are some of the application domains where programmable money can prove useful.

Although digital euro programmability might create a trusted base for the transformation of business models, improve digitalisation, and create new opportunities in money utilization, requirements for the technical infrastructure and related risks need to be carefully investigated. To provide a trusted base for such an infrastructure might be costly and complicated. Furthermore, the required input data to run payment logic in real-time needs to be continuously available, and depending on the type of data, there might be a need for regulations on governance and processing of these data. Finally, the factors that affect user acceptance should also be examined and privacy requirements should be clearly set.

4. Legal considerations for the digital euro

4.1 ECB's mandates and digital euro as legal tender

As an institution of trust that is bound by the principle of attribution of powers, the actions of central banks must have a clear mandate, and therefore any activity undertaken by a central bank must be within the scope of the legal powers and frameworks applicable. Therefore, if the issuance of a digital currency is not to be associated with the mandates of the ECB, it may be necessary to create a new legislation, or to amend the existing regulation.

Before examining whether the ECB is competent to issue a digital euro, it is advisable that the ECB consider issuing a digital euro to duly fulfill its given tasks (manage the euro, keep prices stable and conduct EU economic & monetary policy). While banknotes are not the tools used to transmit monetary policy, they are a precondition to satisfy central bank tasks (Grünewald et al., 2021). The decline in cash usage and the increase in available payment tools pose a potential threat to the ECB's ability to successfully fulfill its obligation of implementing monetary policy, while the wider adoption of privately issued digital currencies may put the transmission of monetary policy at risk, as they compete with the euro and traditional financial services (Lupinu, 2021). Moreover, extensive usage of privately issued digital payment instruments, particularly stablecoins pegged to foreign currencies, may harm the ubiquity of the euro. It is noted that USD Tether (a USD pegged stablecoin) has \$75 billion in daily transaction volume on average, while Stasis Euro (a EUR pegged stablecoin) has less than \$25 million (CoinMarketCap, 2022). To overcome these potential network effects, it might be preferable for the ECB to develop a digital euro sooner rather than later.

Although central bank money is regarded as a liability, it does not entitle the banknote holder to raise a claim directly against the central bank (Kumhof et al., 2020, and Bossu et al., 2020). Therefore, there is no contractual relation between central bank and banknote holders. This also underpins the difference between a banknote and a bearer instrument. Therefore, issuance of a CBDC would not create an obligation between the central bank and the CBDC holder, but rather entitle the holder to a *sui generis* claim which would be limited to proper use of a CBDC. The ECB has already made it clear that the digital euro "would be a central bank liability offered in digital form for use by citizens and businesses for their retail

payments” and “would complement the current offering of cash and wholesale central bank deposits” (ECB, 2020).

Since the digital euro would be a central bank liability in the form of a currency, the first source of mandate may be the function (or the power) to issue currency. The tasks of the ECB under Article 3 of the Statute of the European System of Central Banks and of the European Central Bank (the Statute) do not include issuance of currency. However, the mandate to issue currency is conferred by Article 16 of the Statute, in conjunction with Article 128 of the Treaty on the Functioning of the European Union (O.J. 2012, C 326/47), which confers upon the Eurosystem (comprising the ECB, along with the national central banks (NCBs) of participating Eurozone Member States), the power to issue banknotes and coins. While these articles do not refer to a general mandate to issue currency, it might be argued that the ECB has the mandate to issue a digital euro based on the reasoning that the digital euro is a digital form of a euro banknote.

In this context, it is argued that a central bank liability, created as a form of digital token is simply a new form of banknote (Geva et al., 2021), which are currently only available in physical form. This argument is based on the rationale that there is no prescriptive rule that banknotes must be issued physically and might also be supported by Article 16(2) of the Statute.

As the legitimate issuer of currency, it would be desirable for this new instrument, issued by the Eurosystem, to enjoy legal tender status. Should the digital euro be issued as a new form of banknote, these digital banknotes would automatically be conferred with the status of legal tender (Commission Recommendation 2010/191/EU of 22 March 2010). Although legal tender is not defined by law, the Commission has laid down the effect of a legal tender instrument, which are: (1) mandatory acceptance, (2) acceptance at full face value, (3) power to discharge from payment obligations. Since the monetary object must be as inclusive as possible (Lupinu, 2021, and Zellweger-Gutknecht et al., 2021), legal tender status of the digital euro would not be advisable initially, considering that not everyone is likely to have immediate access to a digital environment. A remedy to the said obstacle might be the use of (public) digital identity (Lupinu, 2021). However, a monetary object issued by the ECB without a legal tender status would not only impair the monetary policy benefit of the digital euro, but could also obstruct its widespread use in payments and the achievement of network effects. A digital euro can arguably enjoy legal tender status from the beginning or at a later point in time after its launch to mitigate potential financial stability risks.

In contrast to banknotes, the possession, circulation and transfer of digital euros would require a (payment) system (Bank of Canada et al., 2021,) supporting a payments market infrastructure composed of various actors (including but not limited to banks and payment institutions). Maintaining the typical design of such payment systems, it is highly likely that the actors providing digital euro services would require compensation, in contrast with banknote payments, which do not impose a monetary cost on the parties to a transaction.

Another legal barrier to the issuance of a digital euro as a form of banknote might be its uncertain status under civil law. As a chattel, banknotes (and coins) are possessed (held in

possession) (Grünwald et al., 2021) that is, they are movable properties. Not only is their status under civil law well-defined, but there are also rules in place to protect *bona fide* acquisition of banknotes (Fox, 1996). Furthermore, there is at present no uniform understanding, across different jurisdictions, on whether intangible things may be deemed as property. For example, Austrian law defines “things” (*Sache*) as everything that serves the use of people and is distinguished from a person. This definition is broad enough to capture intangible objects. On the other hand, Bürgerliches Gesetzbuch § 90 refers only to physical (*körperliche*) objects as “things” (*Sache*). The possession exists with tangible things (Czelk et al. 2018, Bruder Müller et al., 2020). Without a clear legal provision, the status of a digital object as a “thing” is not recognized under German law (Pieper, 2022). Therefore there are detailed rules to govern the possession, title and transfer of objects that might be deemed as intangible things, such as electronic securities (*elektronische Wertpapiere*). The Law (Gesetz über elektronische Wertpapiere (eWpG) § 2) explicitly acknowledges the status of these intangible objects as a “thing”. The same reasoning would apply to a digital euro. Being the currency of the European Union, there is no room for ambiguity on the legal status of the digital euro. As the digital euro would have its own procedures of issuance, possession and transfer, the rules governing banknotes, as they currently stand, would likely be insufficient and not proper to encompass the unique attributes of the digital euro. Being issued as a different monetary object than a banknote, the digital euro would require its own rules to provide protection against counterfeiting. Though being technologically neutral, the current legal framework against euro-counterfeiting may be insufficient to address digital needs. To illustrate, private digital assets containing “euro” in the name or referring to “digital euro” would need to be regulated accordingly to prevent counterfeiting and misperception by the public.

Following on from the arguments presented above, we conclude that it is preferable for the ECB to be given an explicit legal mandate on which to issue the digital euro, and in line with monetary policy objectives, the digital euro should have a limited legal tender status at the outset, which would eventually evolve over time.

4.2 AML requirements/standards

4.2.1 Global Standards: FATF analysis and the European follow up

International efforts on AML/CFT are coordinated by the Financial Action Task Force (FATF), manifested in the form of FATF recommendations and accompanying guidance documents. Whilst FATF has issued guidance on virtual assets, it does not specifically address CBDCs. For AML/CFT purposes, FATF standards apply to CBDCs, on the face of it, similar to any other form of fiat currency issued by a central bank. FATF considers that CBDCs can have unique money laundering and terrorism financing (ML/TF) risks, when compared with physical fiat currency, and depending on their specific design. Such risks should be addressed in a forward-looking manner before the launch of any CBDCs (FATF, 2021).

Following a given jurisdiction's launch of a CBDC, financial institutions, virtual asset service providers, and other designated non-financial businesses and professions that provide services and transact in the CBDC, will have the same AML/CFT obligations as they do regarding fiat currencies and cash at present (FATF, 2020). Key AML duties include

customer due diligence (CDD) obligations such as KYC, ongoing monitoring of transactions, record retention and suspicious transaction reporting.

The European Union, as an FATF member, has been following the FATF recommendations and reports, which have been translated into the 5th AML Directive (European Parliament, 2018). Currently, this Directive is under review, with a draft of a 6th AML Directive already issued (European Parliament, 2021a). The EU Commission has also issued its Proposal of the Travel Rule Regulation, which, in the context of the ongoing Russian activity in Ukraine, has become a key consideration (European Parliament, 2021b). The Proposal also includes provisions regarding CDD enhancement. These steps are part of a larger initiative to develop a standalone EU AML authority.

However, none of the new regulatory drafts make specific reference to CBDCs and to the rules applicable to them. For example, if CBDC-enabling legislation establishes that the digital euro should be treated in line with fiat or electronic money for AML /CTF purposes, then the digital euro would benefit from the existing simplified due diligence (SDD) provided for in the travel rule, applicable to transactions below €1,000. On the contrary, cryptocurrencies do not benefit from this exemption, and virtual asset service providers cannot apply SDD for any crypto asset transactions. Therefore, if the digital euro is considered as equivalent to cryptocurrencies for these purpose—based on DLT and with the potential to be used by virtual asset service providers, even in the DeFi space – then no SDD rule would apply, even if it is a currency backed by the central bank. However, this question cannot be answered yet.

In summary, the treatment of this new paradigm of public currencies should either be clarified by future digital euro-specific regulation, or the AML regulation itself should be amended to clarify the scope, approach, and risk considered regarding a potential digital euro.

4.2.2 KYC requirements/standards

The design of the digital euro should be compliant with AML/CFT requirements in order to ensure financial integrity. In this sense, there is a natural tension between privacy and transparency. On the one hand, a token-based CBDC design allowing for anonymous transactions can provide cash-like usability and flexibility, whilst offering strong privacy. In this case, AML/CTF risks inherent in the use of physical cash will also apply to the digital euro, without the limitations of portability associated with physical cash. On the other hand, a transparent CBDC design, with transactions fully visible to authorities, can violate relevant laws on data protection and human rights on privacy. A balance in the digital euro design is therefore required.

From a CDD perspective, the identity of digital euro users, at least above certain transaction thresholds, should be known to at least one regulated institution and the regulator in the CBDC network, in order to validate the compliance of transactions with the AML/CFT requirements of the 5th AML Directive. However, for transactions below a certain threshold, simplified CDD requirements may be implemented.

There are also design options to consider. A direct CBDC design would require the ECB to be responsible for KYC, which would result in a significant increase in expenditure and change to its operational model. This would not be an optimal design choice, as KYC is a time-consuming task (as is provision of consumer account services) that is not typically undertaken by a central authority.

Conversely, a two-tier design would introduce a layer of financial institutions acting as intermediaries between the central bank and the end-users, and would require the financial institutions to undertake KYC duties which already apply to their business under the existing European regulatory framework and its local transpositions. Another possible design option could be for the core ledger to store pseudonymous accounts and balances, thus offering strong privacy guarantees. Each account in the core ledger could then subsequently be linked to a financial institution which knows the identity of the user and bears responsibility for obligations such as KYC and reporting of suspicious transactions (BoE, 2020).

It should be borne in mind that the current set of KYC rules may, in the future, be heavily impacted by other initiatives that aim to stimulate digital innovation from the identity perspective, such as the eIDAS 2 proposal (European Parliament, 2021c). This regulation proposes the establishment of a sovereign digital identity system in the EU, potentially enabling KYC onboarding procedures to be sped up.

4.2.3 Travel rule

At present, Regulation (EU) 2015/847 of the European Parliament and of the Council of 20 May 2015 on information accompanying transfers of funds, covers neither virtual assets, nor CBDCs. There is a draft amendment underway (European Parliament, 2021d); however, CBDCs appear currently to be beyond the scope of the proposal, as they are neither considered as crypto-assets under MiCA, nor as fiat currencies. Should a digital euro be introduced, this omission from the existing draft regulation would need to be addressed with the aim of issuing a regulation that would be valid at the time it is formally approved. Otherwise, the digital euro may not be subject to adequate and proportionate due diligence and therefore, the risk of its use for financial crime purposes could potentially be higher compared to cryptocurrencies and electronic money transfers.

Moreover, in relation to this requirement, a DLT-based CBDC would face additional compliance challenges, including capturing the details of the originator and beneficiary before or at the time of the digital euro transaction (ordering institution according to chapter III, section 1 of the proposed European regulation). A non-DLT-based CBDC would also need to comply with travel rules and therefore, both MiCA and the proposal for a travel rule regulation would have to be made sufficiently generic that they may embrace any type of new technological solutions.

According to the current draft regulation, the beneficiary institution would be responsible for ensuring that the required information is accurate, complete and not truncated (chapter III, section 2 of the proposed European regulation). These requirements would need to be fulfilled prior to or at the time of a transaction. Digital euro solutions must therefore be designed and developed via a public-private collaboration approach if they are to comply with this proposed regulation in an efficient and scalable way. Potential solutions include the

development of messaging layers in the DLT, which could work similar to the information exchange messages used by the Society for Worldwide Interbank Financial Telecommunication (SWIFT) (e.g., MT 199). Other options include the introduction of AML oracle solutions, implementing transaction filtering rules, that would be able to work as a link between the on-chain and the off-chain environments.

There is also undoubted potential for blockchain analytics solutions – that are already operating in the market, such as Elliptic, Coinbase Analytics, Chainalysis or Cypher Trace – to be employed for transaction monitoring and filtering of DLT-based transactions, both within the private sector and by supervisors (in the case of a DLT-based CBDC).

Further analysis will be required with respect to other challenges, such as how on-chain information may be fed into traditional off-chain KYC systems, transaction monitoring systems or transaction filtering systems, especially in the case of financial institutions potentially working with both fiat transactions and CBDC. Ultimately, a single customer view is required for effective financial crime management, and therefore, an optimized standard and uniform tool would be extremely beneficial.

This issue is currently a topic of relevance due to the impact that the present lack of such regulations and controls is having in the Russian-Ukrainian conflict. As a response to the sanction orders issued by different authorities globally, and following the banning of Russian banks from the SWIFT system, a spike in cryptocurrency trade volumes and Rouble-Tether exchanges has been identified (Wilson, 2022).

4.3 Consumer protection and transparency

4.3.1 Means of payment

One of the main reasons for the use of existing CBDCs is as a means of payment, and it is expected that the same will also apply to a public digital euro. Therefore, the specific provisions of the Payment Service Directive (PSD) must also apply to digital euro payments, and to CBDC payments in other sovereign digital currencies, in addition to private crypto asset payments in private digital euro and other cryptocurrencies.

This would ensure that the same rules currently applied to fiat euro payments (involving both consumers and non-consumers) - with respect to transparency of information on ordering party and beneficiary, on transparency of fees including the ban of intermediary fees, on transparency of FX conversion fees as per EU Regulation 518, and on time of delivery - would also apply to intra-EU CBDC payments and to one-leg-out CBDC payments.

4.3.2 Investment

The same principles from Markets in Financial Instruments Directive (MiFID) and other EU regulations currently applicable for investment in euro sight deposits by consumers, should be redesigned to apply to investments in public digital euro investments, considering the different nature of the investment (i.e., public money vs. private money) but also the need for customer protection and account segregation.

5. Recommendations

5.1 Design dimensions

(1) The digital euro architecture should follow the two-tier market model that includes authorized financial intermediaries to operate within systems which circulate the currency through transactions ordered by the users. This is akin to the role they provide for physical inside money, and to a lesser extent, cash. These institutions will receive the digital euro tokens from the ECB, distribute them to the wallets of users in exchange for physical cash or exchanges with deposit accounts, and will provide services and support to the end users.

(2) In line with the staggered approach, the digital euro should be defined at first as non-interest bearing to avoid the risks involved in competing with commercial bank deposits and mimic the zero remuneration guarantee of cash. The chosen technology should, however, potentially allow for the interest-bearing feature to allow for future policy changes if needed.

(3) Failure to implement a robust cyber-attack-resilient strategy from day one (i.e., not just as a layer or complexity to be bolted-on) would not only compromise citizens' data and funds, but could put the entire eurozone stability at risk.

(4) The digital euro architecture should guarantee privacy by design, and must be comprehensive and consider all risks, enabling the full spectrum of features and capabilities like cash does, act as a social lifeline, being universally desirable and inclusive.

(5) It is recommended that the ECB invites proposals from private and public vendors to design, program and execute proof-of-concept pilots in order for shortlisted vendors to execute “field test pilots” of different solutions/technologies e.g., token-based electronic versions of the euro.

5.2 Payment relevant aspects

(6) The diffusion of any digital currency depends on the support of a merchant capture network and on a reliable infrastructure. The direct availability of TIPS at the PoS level will lower settling risk and increase the velocity of the circulation of money.

(7) Digital wallet offline protocols may enable instant payments without any third-party support. This may foster the establishment of a subsidized economy right after catastrophic events, even when the mobile network becomes unreliable. However, the secure use of offline protocols requires security features from the users' devices, and such features are not yet widely available in the field.

(8) A digital wallet is the easiest way of introducing the digital euro to the public, provided that it will gain general support by merchants. A digital wallet supporting multiple payment methods and biometric authentication allows a moderate level of financial privacy.

(9) To ensure bank interoperability, a standardization of infrastructure and processing of payment transaction flows is necessary. There could be a need to enhance international standards such as ISO 20022 by a digital euro standard.

(10) It is recommendable to opt for a hybrid or mixed approach to fulfill varying requirements on a digital euro towards ultimately having a more flexible and adjustable design of a digital euro.

(11) Programmability features in different forms might bring an important added-value to payments with digital euro and should be investigated thoroughly as it might affect the design choices for the digital euro infrastructure. Specifically, DLT technologies should be considered as a suitable candidate for a trusted common infrastructure that enables seamless cross-links between different applications.

5.3 Legal considerations

(12) It is preferable for the ECB to be given an explicit legal mandate, by the European Commission, to issue a digital euro which would eventually enjoy a legal tender status.

(13) From a financial crime perspective, FATF has already indicated that CBDCs may have the potential to be used similarly to cryptocurrencies, and therefore, similar AML/CTF measures should be applicable. However, if the digital euro is considered equivalent to electronic money, a different treatment would apply, specifically regarding the simplified due diligence measures that could become applicable to transactions under the travel rule proposal (if the digital euro is considered equivalent to electronic money, transactions below €1,000 would be subject to SDD, whilst if it is considered similar to cryptocurrency, then SDD would not apply and full CDD would be required for all transactions, irrespective of their value). This is, however, yet to be confirmed.

(14) Depending on the design choices and the degree of privacy supported by a digital euro, the level of risk associated with digital euro transactions and therefore, the due diligence requirements in terms of KYC, transaction monitoring and transaction filtering, could vary considerably.

(15) The current crop of draft EU regulations regarding crypto assets and digital currency consider private crypto assets only, and do not contemplate a digital euro scenario and how it would need to be approached in terms of financial crime controls. Regulators will need to wait for the finalized design and governance model of a potential digital euro, to assess the associated level of risk and the control framework required by the institutions supporting it. Likewise, a better understanding of the potential usage of a digital euro will be required – including whether it is likely to be used in decentralized finance applications - to fully evaluate the risks that these usages would entail.

References

- Adleman, L., Schmidt R. (2018). Designing Money [Extended Abstract]. [<https://adleman.usc.edu/aurum-digital-currency/> (access: July 22, 2022)].
- Auer, R., Böhme, R. (2020). The technology of retail central bank digital currency, BIS Quarterly Review [https://www.bis.org/publ/qtrpdf/r_qt2003j.pdf (access: July 28, 2022)].
- Bank of Canada, European Central Bank, Bank of Japan, Sveriges Riksbank, Swiss National Bank, Bank of England, Board of Governors Federal Reserve System, Bank for International Settlements (2021). Central bank digital currencies: system design and interoperability". [https://www.bis.org/publ/othp42_system_design.pdf (access: July 12, 2022)].
- Bank of England (2020). Central bank digital currency. Opportunities, challenges and design. [<https://www.bankofengland.co.uk/paper/2020/central-bank-digital-currency-opportunities-challenges-and-design-discussion-paper> (access: July 25, 2022)].
- Böhme, R. (2020). The technology of retail central bank digital currency. BIS Quarterly Review, March, pp. 85–96., [https://www.bis.org/publ/qtrpdf/r_qt2003j.pdf (access: July 28, 2022)].
- Bossu, W., Itatani, M., Margulis, C., Rossi, A. (2020). Legal aspects of central bank digital currency: Central Bank and Monetary Law Considerations. IMF Working Paper 2020/254. [<https://www.imf.org/-/media/Files/Publications/WP/2020/English/wpiea2020254-print-pdf.ashx> (access: July 25, 2022)].
- Brudermüller, G., Palandt, O. (2020). Palandt bürgerliches gesetzbuch : (79th ed.). C.H. Beck, [<https://beckassets.blob.core.windows.net/product/inhaltsverzeichnis/27373768/inhaltsverzeichnis-palandt-buergerliches-gesetzbuch-bgb-9783406738005.pdf> (access: July 23, 2022)].
- Chaum D., Grothoff C., Moser T. (2021). How to issue a central bank digital currency, SNB Working paper [https://www.snb.ch/en/mmr/papers/id/working_paper_2021_03 (access: July 14, 2022)].
- Chen, J., & Micali, S. (2022). Algorand: A secure and efficient distributed ledger, from [https://www3.cs.stonybrook.edu/~jingchen/papers/Algorand_A%20secure%20and%20efficient%20distributed%20ledger_TCS.pdf (access: July 17, 2022)].
- CoinMarketCap (2022). Top stablecoin tokens by market capitalization [<https://coinmarketcap.com/view/stablecoin/> (access: July 18, 2022)].
- Czelk, A., Meder, S. (2018). Grundwissen sachenrecht (3rd ed.). Mohr Siebeck.

- Danmarks Nationalbank (2021). Target DKK. [https://www.nationalbanken.dk/en/bankingandpayments/interbank_payments/Documents/Memo%20TARGET%20DKK%20version%201.0.pdf (access: July 28, 2022)].
- Druey, J. (2000). Die Schuldurkunde: Das Wertpapierrecht. Guhl, T. (Ed.). Das schweizerische obligationenrecht, Zürich: Schulthess, 893-906.
- EBA (2022). Final report, draft regulatory technical standards amending Commission Delegated Regulation (EU) 2018/389 supplementing Directive (EU) 2015/2366. [https://www.eba.europa.eu/sites/default/documents/files/document_library/Publications/Draft%20Technical%20Standards/2022/EBA-RTS-2022-03%20RTS%20on%20SCA%26CSC/1029858/Final%20Report%20on%20the%20amendment%20of%20the%20RTS%20on%20SCA%26CSC.pdf (access: July 23, 2022)].
- EBA clearing (2022). New RT1 specifications to help users benefit from future TIPS set-up. [https://www.ebaclearing.eu/news-and-events/media/press-releases/23-april-2021-new-rt1-specifications-to-help-users-benefit-from-future-tips-set-up/ (access: July 22, 2022)].
- EU Commission (2015). Commission welcomes European Parliament vote to cap interchange fees and improve competition for card-based payments. [https://ec.europa.eu/commission/presscorner/api/files/document/print/en/ip_15_4585/IP_15_4585_EN.pdf (access: July 24, 2022)].
- European Central Bank (2020). Report on a digital euro. [https://www.ecb.europa.eu/pub/pdf/other/Report_on_a_digital_euro~4d7268b458.en.pdf (access: July 25, 2022)].
- European Central Bank (2020). Study on the payment attitudes of consumers in the euro area (SPACE). [https://www.ecb.europa.eu/pub/pdf/other/ecb.spacereport202012~bb2038bbb6.en.pdf?05ce2c97d994fbcf1c93213ca04347dd (access: July 28, 2022)].
- European Central Bank (2021). The Eurosystem's retail payments strategy. [https://www.ecb.europa.eu/pub/pdf/other/ecb.eurosystemretailpaymentsstrategy~5a74eb9ac1.en.pdf?819e76c55e01ed236dac589f980189a2 (access: July 13, 2022)].
- European Central Bank (2021). Digital euro experimentation scope and key learnings, p.1 ss. [https://www.ecb.europa.eu/pub/pdf/other/ecb.digitaleuroscopekeylearnings202107~564d89045e.en.pdf (access: July 16, 2022)].
- European Central Bank (2021). The Eurosystem's retail payments strategy. [https://www.ecb.europa.eu/pub/pdf/other/ecb.eurosystemretailpaymentsstrategy~5a74eb9ac1.en.pdf?819e76c55e01ed236dac589f980189a2 (access: July 22, 2022)].
- European Central Bank (2022). Study on new digital payment methods, Report. [https://www.ecb.europa.eu/paym/digital_euro/investigation/profuse/shared/files/dedocs/ecb.dedocs220330_report.en.pdf (access: July 28, 2022)].

- European Central Bank (2022). Digital euro privacy options euro group. [https://www.ecb.europa.eu/paym/digital_euro/investigation/governance/shared/files/ecb.degov220404_privacy.en.pdf?39c27f3bda85972b8070c318bb4e3578 (access: July 28, 2022)]
- European Payments Initiative (2020). Major eurozone banks start the implementation phase of a new unified payment scheme and solution the European Payment Initiative (EPI). [https://ec.europa.eu/commission/presscorner/api/files/document/print/en/ip_15_4585/IP_15_4585_EN.pdf (access: July 25, 2022)].
- Eurogroup (2022). The euro as a digital currency – state of play. [https://www.ecb.europa.eu/paym/digital_euro/investigation/governance/shared/files/ecb.degov220225_update.en.pdf?ab5c786b31b09cdb53186206d8b3e78f (access: July 18, 2022)].
- European Commission (2010). Commission recommendation on the scope and effects of legal tender of euro banknotes and coins (2010/191/EU) OJ L83/70.
- European Commission (2015). Payment services (PSD 2) - Directive (EU) 2015/2366. [https://ec.europa.eu/info/law/payment-services-psd-2-directive-eu-2015-2366_en (access: July 13, 2022)].
- European Parliament (2018). Directive (EU) 2018/843 of the European Parliament and of the Council of 30 May 2018 amending Directive (EU) 2015/849 on the prevention of the use of the financial system for the purposes of money laundering or terrorist financing, and amending Directives 2009/138/EC and 2013/36/EU. European Parliament, Strasbourg, France. From https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32018L0843 (access: July 17, 2022)].
- European Parliament (2021). Proposal for a directive of the European parliament and of the council on the mechanisms to be put in place by the Member States for the prevention of the use of the financial system for the purposes of money laundering or terrorist financing and repealing Directive (EU) 2015/849 COM/2021/423 final. [https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021XX1229(01) (access: July 22, 2022)].
- European Parliament (2021). Proposal for a regulation of the European parliament and of the council on the prevention of the use of the financial system for the purposes of money laundering or terrorist financing. [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0420 (access: July 24, 2022)].
- European Parliament (2021). Proposal for a regulation of the European parliament and of the council amending Regulation (EU) No 910/2014 as regards establishing a framework for a European Digital Identity COM/2021/281 final. [https://www.europarl.europa.eu/RegData/etudes/STUD/2021/695465/IPOL_STU(2021)695465_EN.pdf (access: July 28, 2022)].

- European Parliament (2021). Proposal for a Regulation of the European Parliament and of the Council on information accompanying transfers of funds and certain crypto-assets (recast) COM/2021/422 final.
- Eyal, I., Gencer, A., Siner E., Van Renesse, R. (2016). Bitcoin-NG: A Scalable blockchain protocol. In Proceedings of the 13th USENIX symposium on networked systems design and implementation.
- FATF (2020). FATF Report to G-20 on so-called Stablecoins. [<https://www.fatf-gafi.org/publications/fatfgeneral/documents/report-g20-so-called-stablecoins-june-2020.html> (access: July 15, 2022)].
- FATF (2021). Virtual assets and virtual asset service providers - updated guidance for a risk-based approach [<https://www.fatf-gafi.org/publications/fatfrecommendations/documents/guidance-rba-virtual-assets-2021.html> (access: July 17, 2022)].
- Fawthrop, A. (2019). What is Swish? The mobile payment systems used by more than two-thirds of Swedes. [<https://www.nsbanking.com/analysis/swish-payments-sweden/> (access: July 23, 2022)].
- Fox, D. (1996). Bona fide purchase and the currency of money. *The Cambridge Law Journal*, 55(3), 547–565. [<http://www.jstor.org/stable/4508252> (access: July 28, 2022)].
- Geva, B., Grünewald, S., Zellweger-Gutknecht, C. (2021). E-banknote as a ‘Banknote’: A monetary law interpreted. *Oxford Journal of Legal Studies*, 41(4), 1119-1148 [doi:10.1093/ojls/gqab019. (access: July 23, 2022)].
- Gross, J., Bechtel, A., Sandner, P., Von Wachter, V. (2020). Programmable money and programmable payments. [<https://jonasgross.medium.com/programmable-money-and-programmable-payments-c0f06bbcd569> (access: July 25, 2022)].
- Gross, J., Sedlmeir, J., Babel, M., Bechtel, A., & Schellinger, B. (2021). Designing a central bank digital currency with support for cash-like privacy. Available at SSRN 3891121.
- Grünewald, S., Zellweger-Gutknecht, C., Geva, B. (2021). Digital euro and ECB powers. *Common market law review*, 58(4), 1029-1056. [<http://dx.doi.org/10.2139/ssrn.3807855> (access: July 28, 2022)].
- Kosse, A., Mattei, I. (2022). Gaining momentum – Results of the 2021 BIS survey on central bank digital currencies. [<https://www.bis.org/publ/bppdf/bispap125.pdf> (access: July 17, 2022)].
- Kolehmainen T., Laatikainen G., Kultanen J. (2021). Using blockchain in digitalizing enterprise legacy systems: an experience report.

- Kumhof, M., Jason, A., Bateman, W., Lastra, R., Gleeson, S., Omarova, S. (2020). Central Bank money: liability, asset, or equity of the nation? Cornell Legal Studies Research Paper 20-46 [<http://dx.doi.org/10.2139/ssrn.3730608>. (access: July 18, 2022)].
- Lee Kuo Chuen D. (2022). Handbook of digital currency, interMint solution to ensure interoperability of CBDC Mints, ch 20.
- Lupinu, P. (2021). Digital Euro: opportunity or (legal) challenge?, *Ianus* n.22/2020, 37-62.
- Mercan S., Kurt A., Akkaya K. (2022). Cryptocurrency solutions to enable micropayments in consumer IoT, *IEEE Consumer Electronics Magazine*.
- Panetta, F. (2022). Fabio Panetta: Designing a digital euro for the retail payments landscape of tomorrow. [<https://www.bis.org/review/r211123k.htm> (access: July 18, 2022)].
- Panetta F. (2022). A digital euro that serves the needs of the public: striking the right balance, *speech*. [https://www.ecb.europa.eu/press/key/date/2022/html/ecb.sp220330_1~f9fa9a6137.en.html (access: July 24, 2022)].
- Pieper, C., Müller, M. (2022). Gesetz über elektronische Wertpapiere (eWpG) Kommentar. C.H. Beck.
- Renzetti, M., Bernardini, S., Marino, G., Mibelli, L., Ricciardi, L., & Sabelli, G. (2022). Tips - TARGET Instant payment settlement the pan-european infrastructure for the settlement of instant payments. [https://www.bancaditalia.it/pubblicazioni/mercati-infrastrutture-e-sistemi-di-pagamento/questioni-istituzionali/2021-001/en-MIS-20210129.pdf?language_id=1 (access: July 28, 2022)].
- Riksbank (2021). Report e-Krona pilot- phase one. [<https://www.riksbank.se/globalassets/media/rapporter/e-krona/2021/e-krona-pilot-phase-1.pdf> (access: July 18, 2022)].
- Royal, D., Rimba, P., Staples, M. (2018). Making Money Smart - Empowering NDIS participants with Blockchain technologies”.
- Samid,G. (2015). Tethered money – managing digital currency transactions, *elsevier academic press, international edition*.
- Samid, G. (2020). BitMint hard wallet: digital payment without network communication: no internet, yet sustained payment regimen between randomness-verifiable hard wallets.
- Samid, G. (2022). A leVeL-playing-field: cryptographic solutions towards social accountability and financial inclusion, *cryptology ePrint archive: Report 2022/130*. <https://eprint.iacr.org/2022/130> (access: July 14, 2022)].

- Sveriges Riksbank (2020). The Riksbank to join the ECB's TIPS platform. [<https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/press-releases/2020/the-riksbank-to-join-the-ecbs-tips-platform/>] (access: July 12, 2022)].
- Swish business app (2022). Swish business app is launched to the market. [<https://www.swish.nu/newsroom/news/swish-business-app-is-launched-to-the-market>] (access: July 28, 2022)].
- UNCITRAL (2017). Model law on electronic transferable records. [https://uncitral.un.org/sites/uncitral.un.org/files/media-documents/uncitral/en/mletr_ebook_e.pdf] (access: July 26, 2022)].
- Urbinati R. (2021). A digital euro: a contribution to the discussion on the technical design choices, MISP, Banca d'Italia, n.10, p. 21 ss. [https://www.bancaditalia.it/pubblicazioni/mercati-infrastrutture-e-sistemi-di-pagamento/questioni-istituzionali/2021-010/N.10-MISP.pdf?language_id=1] (access: July 24, 2022)].
- Wang, H. (2022). China's approach to Central Bank digital currency. Available at SSRN.
- Wilson, T. (2022). Rouble-crypto trading soars as sanctions hit Russian currency. [<https://www.reuters.com/markets/europe/rouble-crypto-trading-soars-sanctions-hit-russian-currency-2022-02-28/>] (access: July 14, 2022)].
- World Economic Forum (2021). 4 key cybersecurity threats to new central bank digital currencies. [<https://www.weforum.org/agenda/2021/11/4-key-threats-central-bank-digital-currencies/>] (access: July 16, 2022)].
- Zellweger-Gutknecht, C., Geva, B., Grünewald, S. (2021). Digital Euro, monetary objects, and price stability: A legal analysis. *Journal of Financial Regulation*, 7(2), 284-318. [<https://doi.org/10.1093/jfr/fjab009>] (access: July 28, 2022)].



Digital Euro Association e.V.
Thurn-und-Taxis-Platz 6
60313 Frankfurt am Main



<https://www.digital-euro-association.de/>



team@digital-euro-association.com



@DigiEuro



Digital Euro Association