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Can CBDC Mimic Cash? A Deep Dive Into the Digital Euro Case

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Can CBDC Mimic Cash? A Deep Dive into the Digital Euro Case

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Abstract: Central Bank Digital Currencies (CBDCs) are increasingly positioned as digital equivalents to physical cash, yet their ability to replicate the full functionality of cash remains contested. This study investigates whether the proposed Digital Euro can credibly serve as a substitute for physical Euro cash. Using a qualitative comparative framework, the analysis evaluates both currencies using 36 pairwise comparisons. The findings reveal that while the Digital Euro offers advantages in portability, divisibility and digital integration, it falls short in key areas such as anonymity, fungibility, recognizability and universal acceptability. These limitations are primarily due to technological dependencies, regulatory constraints, and the absence of physical tangibility. The study concludes that the Digital Euro cannot fully mimic the role of physical cash, particularly in offline and privacy-sensitive contexts. As a result, the hypothesis that the Digital Euro is an electronic equivalent of physical Euro cash is rejected. These findings underscore the continued relevance of physical currency and highlight the need for cautious, evidence-based CBDC design and implementation.

Keywords: central bank digital currency; digital Euro; currency; money; legal tender; quality

1. Introduction

The advent of digital currencies marks a significant evolution in the financial landscape, reflecting the rapid technological advancements shaping modern economies. Central banks worldwide are exploring the potential of digital currencies, with the European Central Bank (ECB) at the forefront, introducing the concept of the Digital Euro. This initiative aims to create a digital counterpart to the physical Euro, promising to retain the intrinsic qualities of cash while leveraging the benefits of digital technology.

The ECB posits that the Digital Euro will be akin to cash, serving as an electronic means of payment that is available to the general public and backed by the central bank in the same manner as physical banknotes and coins. According to the ECB, a Digital Euro would be an electronic means of payment: “It would be a digital version of cash, available to the general public and backed by the European Central Bank the same way your physical banknotes and coins are. You could use it anywhere that you already use physical euro cash" (European Commission, 2023). This central bank digital currency (CBDC) is envisioned as a universally accessible form of digital cash, designed for seamless use across all digital payment platforms within the Euro area (ECB, 2023b).

The proposed Digital Euro aims to replicate the physical Euro's function as a stable, secure, and widely accepted medium of exchange: "Essentially, the digital euro will serve as a digital version of physical euro notes and coins" (Euronews, 2023). By being issued by the Eurosystem, the ECB, and related parties, the Digital Euro will maintain the trust and credibility associated with physical currency. The ECB underscores this by stating, "Like the physical euro, a digital version would be issued by Eurosystem - the ECB and the national banks of countries in the euro area" (Pladson, 2021).

In its design, the Digital Euro is intended to be used for all digital payments throughout the euro area, enhancing the ease and efficiency of transactions (ECB, 2023d). This digital currency would allow Europeans to utilize public money for digital payments in the same way they use cash for

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physical transactions, thus bridging the gap between traditional and modern forms of currency (ECB, 2023c).

Furthermore, the ECB emphasizes that the Digital Euro would be just as accessible and usable as cash, ensuring its availability to everyone within the euro area (ECB, 2023d). This universal accessibility is crucial for fostering financial inclusion and ensuring that all citizens can benefit from the advantages of digital currency (ECB, 2023c).

In addition to its economic and monetary implications, the Digital Euro is also deeply relevant to the broader fields of blockchain and distributed ledger technology (DLT) research. Although the European Central Bank has not committed to deploying the Digital Euro on a blockchain infrastructure, its conceptual foundation draws heavily from the design logic of digital assets and permissioned DLT systems (Allen, Čapkun, Eyal, Fanti, Ford, Grimmelmann, Juels, Kostiainen, Meiklejohn, & Miller, 2020; Auer & Böhme, 2020; Sbírneciu & Valentina Florea, 2023). As such, the Digital Euro represents a policy-driven response to the rise of decentralized cryptocurrencies and stablecoins, prompting renewed debates around digital sovereignty, programmability, and the role of central banks in the digital asset ecosystem (Aneja & Dygas, 2022; Auer, Cornelli, & Frost, 2023; Bindseil, Panetta, & Terol, 2021; Mancini Griffoli, Martinez Peria, Agur, Ari, Kiff, Popescu, & Rochon, 2018). Moreover, its development is embedded within a rapidly evolving regulatory environment across the European Union, where initiatives such as the Markets in Crypto-Assets Regulation (MiCA) are shaping the legal and compliance frameworks for both public and private digital currencies (Minto, 2025; Sbírneciu & Valentina Florea, 2023; van der Linden & Shirazi, 2023). This paper contributes to these intersecting domains by critically evaluating whether a CBDC like the Digital Euro can truly replicate the functional and qualitative attributes of physical cash. It thereby advances both design considerations and regulatory discourse in the digital currency landscape.

For this reason, a conceptual distinction is made between money and currency in this paper. Money refers to the abstract, functional concept in economics that fulfils roles such as medium of exchange, unit of account, store of value, and standard of deferred payment. Currency, by contrast, is the physical or digital form that money takes, its tangible or recordable representation used in everyday transactions. Accordingly, this study does not compare two forms of money per se, but rather two currencies - the physical Euro (i.e., coins and banknotes) and the proposed Digital Euro (a CBDC) – which is intended to serve as a token of the same monetary unit. Both are planned to accomplish the same monetary functions, but their performance as currencies may differ depending on technological, legal, and practical attributes. Previous research has cast doubt on the perfect substitutability of retail CBDCs and central bank money, such as physical cash (Lee, Shih, & Zheng, 2023; Lee, Yan, & Wang, 2021; McNulty, Milne, Williams, & Wood, 2024; Milne, 2024; Schueffel, 2023). This article, therefore assesses the ECB's claims by examining the Digital Euro and the physical euro through the lens of the fundamental characteristics of money and Garvin's dimensions of quality (Garvin, 1987).

Such an assessment along the characteristics of money, as well as the dimensions of quality, will provide a comprehensive framework for evaluating the comparative advantages and potential challenges associated with the Digital Euro. By exploring these facets, this research aims to provide a thorough analysis of whether the Digital Euro can indeed match the efficacy and quality of its physical counterpart. This critical examination of the Digital Euro takes place against a broader, evolving financial backdrop marked by a fundamental tension between traditional government control over money and the burgeoning ideals of decentralized finance (DeFi) (Schueffel, 2025), a struggle which increasingly influences economic policies and individual financial choices (Tommerdahl, 2025).

Beyond retail payments, CBDCs are increasingly seen as strategic tools for broader policy objectives, including financial stability and climate risk integration. Proposals have suggested using permissioned DLT networks among central banks to settle cross-border transactions and price in systemic risks. Projects such as Singapore's Project Ubin and the Utility Settlement Coin in Europe demonstrate the potential of such infrastructure. While the Digital Euro is not currently designed for

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these purposes, it must be viewed within the wider shift toward programmable, policy-aligned monetary systems (Chen, 2018).

2. Background

In order to conduct the aforementioned analysis comparing the Digital Euro to the physical Euro by applying the characteristics of money as well as the dimensions of quality, the following paragraphs will provide a detailed overview of the criteria used: the characteristics of money as described in the extant body of literature and the dimensions of quality as defined by Garvin (1987).

2.1. Money

Money evolved from barter systems to commodity money (gold, silver) and later to representative money (banknotes). Money encompasses all accepted mediums of exchange, while currency specifically refers to physical or digital forms used in transactions (Davies, 2010; Ferguson, 2008). In the following paragraphs, a definition of money is provided along with its core functions and supplementary characteristics.

2.1.1. Definition of Money

Money is fundamentally a social and legal construct that functions as a universally accepted means of economic exchange. It fulfils four core functions: medium of exchange, unit of account, store of value, and standard of deferred payment (Mishkin, 2022). These functions are realized through various physical or digital instruments, known as currencies.

While the terms money and currency are sometimes used interchangeably, this paper maintains a crucial distinction: Money refers to the abstract concept that embodies the functions outlined above. Currency, however, refers to the physical or digital tokens used to represent money in practice, such as coins, banknotes, or central bank digital currencies (CBDCs) (Mankiw, 2021; Rogoff, 2016). Thus, while all currency can be considered money, not all money takes the form of currency, underscoring the evolving nature of money in an increasingly digital economy (Arestis & Sawyer, 2005). However, as a minimum requirement, all currencies ought to fulfill the functions and qualities of money.

In this study, both the physical Euro and the Digital Euro are understood as currencies, i.e., forms of money issued by the European Central Bank (ECB). The focus therefore, lies in comparing these two currencies in terms of their effectiveness at realizing the functions and characteristics expected of money.

By evaluating the currencies through this lens, this study provides a grounded framework for assessing whether the Digital Euro can credibly perform the role that physical cash has long fulfilled in the Eurozone.

2.1.2. Characteristics of Money

Money is an essential construct in facilitating economic activity, acting as a medium through which goods and services can be exchanged, values stored, and financial stability maintained across different economic contexts. Its utility is derived from a series of inherent functions and characteristics, each supported by a substantial body of economic theory and empirical evidence. They are the following ones, starting with the four core functions i.) Medium of Exchange, ii.) Unit of Account, iii.) Store of Value, and iv.) Standard of Deferred Payment (Mishkin, 2022). These four functions and characteristics are supplemented by the following eight: 1.) Divisibility, 2.) Portability, 3.) Durability, 4.) Fungibility, 5.) Recognizability, 6.) Scarcity, 7.) Acceptability, and 8.) Legal Tender (Mankiw, 2021). These functions and characteristics are described in more detail in the next paragraphs, beginning with the four core functions.

Core Functions

The core functions and characteristics money has to fulfill are the following ones.

i.) Medium of Exchange

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Money's primary role as a medium of exchange addresses the inefficiencies inherent in barter systems, notably the requirement for a double coincidence of wants. By acting as a common intermediary, money facilitates transactions and enhances economic efficiency (Jevons, 1875; Samuelson, 1958). Friedman (1956) expands on this by discussing the liquidity preference and money's role in adjusting the demand and supply dynamics within the market. Furthermore, Arrow and Hahn (1971) emphasize the importance of money in general equilibrium models, highlighting its function in ensuring market stability and efficiency.

ii.) Unit of Account

Money serves as a unit of account, providing a standard measure of value that simplifies the process of pricing goods and services. This function allows for a coherent system of economic calculation, necessary for comparing the worth of various commodities and services within and across markets (Menger, 1892; Walras, 1874). Fisher (1911) discusses how the unit of account serves as a necessary tool for financial documentation, budgeting, and the assessment of taxes, while Patinkin (1965) highlights its role in reducing transaction costs by simplifying the comparison of market prices.

iii.) Store of Value

As a store of value, money allows economic agents to transfer purchasing power from the present to the future. This characteristic is vital for the functioning of modern economies, supporting savings and investment decisions (Keynes, 1930; Ricardo, 1817). Mill (1849) posits that the stability of money's value is crucial in determining its effectiveness as a store of value. The work of Tobin (1965) introduces the concept of money as part of wealth portfolios, indicating its interplay with other assets in terms of risk and return, emphasizing its role in the broader financial ecosystem.

iv.) Standard of Deferred Payment

Money as a standard of deferred payment is integral to the operation of credit markets, where future payments are predicated on money retaining stable value over time (Marx, 1887; Schumpeter, 1934). This function of money underpins various forms of credit agreements and financial instruments, facilitating economic activities that require long-term financial planning and execution. Hicks (1989) explains how this function is crucial in contexts where economic transactions are staggered over time, involving futures contracts and other derivatives.

Supplementary Characteristics

Money's efficacy as a cornerstone of economic activity is underpinned not only by its primary functions but also by several intrinsic characteristics that ensure its practical usability and effectiveness in various economic contexts. These characteristics are crucial for money to fulfil its roles comprehensively.

1.) Divisibility

Divisibility refers to money's ability to be broken down into smaller units, facilitating transactions of varying sizes and values. This characteristic allows for precise pricing and ensures that money can be used for both high-value and low-value exchanges, enhancing its utility as a medium of exchange (Menger, 1892; Samuelson & Nordhaus, 1998).

2.) Portability

Portability implies that money can be easily carried and transferred between parties. This feature is crucial for money to function efficiently as a medium of exchange across different locations. It enhances the ease with which economic agents can engage in transactions, regardless of geographic constraints (Friedman, 1956; Mishkin, 2022).

3.) Durability

Durability means that money can withstand physical wear and tear and the passage of time without degrading in value or usability. Durable money ensures that it can serve as a store of value and standard of deferred payment over long periods, crucial for long-term economic planning and transactions (Keynes, 1930; Tobin, 1965).

4.) Fungibility

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Fungibility denotes money's interchangeability, where each unit is identical and can be substituted with another unit of the same value. This attribute simplifies transactions, pricing, and accounting, as each unit is accepted universally without the need for verification of each individual unit's value (Goodhart, 1989; Menger, 1892).

5.) Recognizability

Recognizability refers to the ease with which money can be identified and authenticated. This characteristic minimizes the risk of counterfeiting and fraud, thus preserving trust in the monetary system. Recognizable money ensures that all economic agents can quickly and confidently verify its authenticity (Ricardo, 1817; Smith, 1776).

6.) Scarcity

Scarcity ensures that money is not overly abundant, maintaining its value over time. If money were not scarce, it would lose its effectiveness as a store of value due to inflation or hyperinflation. Controlled supply is crucial to sustaining its purchasing power (Friedman, 1956; Keynes, 1930).

7.) Acceptability

Acceptability means that money must be widely accepted by all parties within an economy for all types of transactions. This widespread acceptance is crucial for money to function effectively as a medium of exchange and is heavily dependent on the trust and confidence of the economic actors in its value and stability (Mishkin, 2022; Samuelson & Nordhaus, 1998).

8.) Legal Tender

Legal tender refers to money that must be accepted if offered in payment of a debt. The legal status of money provides it with the authority and backing of the government, mandating its acceptance. This legal endorsement helps prevent disputes over payments and reinforces money's role in settling debts (Hicks, 1989; Keynes, 1930).

These attributes ensure that money effectively performs its functions across different economic situations, from daily transactions to long-term financial planning. The development of digital currencies, such as the Digital Euro, seeks to replicate these attributes in a form that aligns with the digitalization of modern economies, thus necessitating a rigorous examination of how these digital forms compare to traditional physical currencies in fulfilling the established roles of money.

2.2. Quality

Within the business domain, quality emerged as a complex construct inextricably linked to both product and service offerings. It signifies the extent to which these offerings fulfill, or surpass, the established expectations of the customer base. While historically rooted in the practices of skilled craftspeople, the conceptualization of quality underwent a significant transformation during the Industrial Revolution. This evolution continued with the advent of contemporary quality management concepts. Quality became thus a cornerstone of competitive advantage within the contemporary marketplace (Crosby, 1979; Deming, 2018; Feigenbaum, 1991; Juran & De Feo, 2010).

2.2.1. Definition of Quality

The term "quality" encompasses a variety of interpretations and dimensions, making it a multifaceted concept in both academic and practical contexts. Quality generally refers to the degree to which a product or service meets certain standards or satisfies specific requirements. Various definitions highlight different aspects of quality, depending on the context and the criteria used for evaluation.

One of the seminal definitions of quality is provided by Garvin (1987), who identified various major approaches to understanding and measuring quality: transcendent, product-based, user-based, manufacturing-based, and value-based. According to Garvin, the transcendent approach views quality as an inherent characteristic, often synonymous with excellence and universally recognizable. The product-based approach considers quality as a precise and measurable variable, often focusing on the quantity of a desired attribute. The user-based approach defines quality in terms of the satisfaction it provides to the consumer, emphasizing personal preferences and individual

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experiences. The manufacturing-based approach associates quality with conformance to specifications and the absence of defects, highlighting consistency and reliability in production. Finally, the value-based approach balances quality with cost, suggesting that the best quality is the one that provides the most benefit for the price.

Other definitions of quality include the International Organization for Standardization (ISO), which defines quality as the degree to which a set of inherent characteristics fulfills requirements (International Organization for Standardization, 2015). Juran and De Feo (2010) described quality as "fitness for use," indicating that products should meet the needs of users and be free from deficiencies. Deming (2018) emphasized continuous improvement and systemic processes in achieving quality, advocating for a holistic view where quality is ingrained in every organizational process.

In summary, while the concept of quality can be defined and interpreted in various ways, Garvin's (1987) framework provides a comprehensive understanding by categorizing different perspectives and approaches. This multifaceted view is essential for addressing quality in diverse fields, ensuring that products and services meet or exceed expectations across different dimensions.

Dimensions of Quality

In his influential work on quality management, Garvin (1987) identified eight dimensions that capture the multifaceted nature of product and service quality. These dimensions provide a systematic framework for evaluating how well an offering meets customer expectations across technical, functional, and experiential domains. While Garvin's model was developed primarily for manufactured goods, several of its elements have proven adaptable to other fields, including services (Ighomereho, Ojo, Omoyele, & Olabode, 2022; Parasuraman, Zeithaml, & Berry, 1985). In this study, a subset of these dimensions is applied to evaluate the comparative quality of physical and digital currencies.

Given the distinct nature of central bank-issued currencies, particularly those functioning as public goods enabling certain services rather than private commodities, not all of Garvin's dimensions are equally applicable. After careful consideration, four dimensions were selected for their conceptual relevance and suitability for evaluating currency performance: performance, reliability, perceived quality, and durability. The remaining four dimensions - features, conformance, serviceability, and aesthetics - were excluded due to their limited applicability in this specific context.

a) Performance

Performance refers to the currency's capacity to fulfill its intended purpose under real-world conditions. In the context of money, this includes the speed and ease of completing transactions, cross-environment usability (e.g., online and offline), and overall efficiency. As Garvin (1987) and Juran and De Feo (2010), emphasize, performance is a primary determinant of utility and user satisfaction. Applied to currencies, it captures the extent to which a currency enables smooth, effective exchange in a modern economic setting.

b) Reliability

Reliability addresses the consistency and predictability with which a currency performs its functions over time. A reliable currency does not "fail" in practical use, whether through technological outages in a digital system or degradation of physical banknotes in circulation. As noted by Parasuraman et al. (1985), reliability is a cornerstone of perceived service quality and plays a critical role in maintaining user trust.

c) Perceived Quality

Perceived Quality captures the subjective assessment that users form about a currency's trustworthiness, ease of use, and legitimacy. Unlike performance or reliability, which can be observed directly, perceived quality is influenced by reputation, institutional backing, and prior experience (Zeithaml, 1988). Garvin (1987) highlights that perceived quality can powerfully shape user behavior even when technical performance is equal among alternatives.

d) Durability

Durability, traditionally applied to physical goods, is here understood in dual terms: the physical resilience of banknotes and coins, and the robustness of the digital infrastructure supporting

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the Digital Euro. As Gale and Wood (1994) argue, durability enhances long-term value and reduces the need for frequent replacement. In the context of money, a durable form must resist degradation (physical) or systemic failure (digital) across repeated uses.

As mentioned afore certain characteristics of quality suggested by Garvin (1987) were omitted from the assessment: features defined by Garvin as supplementary characteristics beyond core functionality were excluded due to the ambiguous nature of "added features" in a sovereign currency. While the Digital Euro may include programmable capabilities, these are not universally available or clearly defined in ECB documentation, and thus difficult to evaluate in a standardized manner. Other dimensions included in Garvin's framework (1987) were not included in the assessment as they are unsuitable services enabling public goods: conformance, which measures adherence to predefined standards, was deemed unsuitable. Applying this dimension would imply that deviation from the physical cash standard constitutes a quality shortfall, a position that biases against innovation. In the case of a novel currency format such as a CBDC, the goal is not to replicate legacy systems exactly, but to responsibly evolve them. Assessing quality based on closeness to a predecessor would therefore misrepresent the innovation's intent. Serviceability, which reflects the ease of maintenance and repair, was also not applicable to either form of currency. While banknotes do wear out and are withdrawn from circulation, and digital infrastructures may require updates, neither form of money involves the kind of user-initiated servicing found in physical products like appliances or vehicles. Lastly, aesthetics, while relevant to tangible consumer products, plays no meaningful role in evaluating a currency's effectiveness. Although banknotes may have design appeal, and visual trust cues can matter at the margins, aesthetics are not central to the functional or experiential quality of either currency form, particularly not in a digital context where no physical interface exists.

In summary, this study applies only those dimensions from Garvin's model that align with the nature of central bank currencies as infrastructure-like public goods. The selected dimensions. i.e., performance, reliability, durability, and perceived quality, allow for a balanced and relevant comparison of the physical and digital Euro, while avoiding criteria that would introduce conceptual misfit or bias.

Based on the distinction established between money and currency, this study does not ask whether the Digital Euro and physical Euro represent different forms of money. Rather, it examines whether these two currencies, both representations of the Euro as a unit of account, perform differently in fulfilling the established characteristics and functions associated with money.

The guiding research question is therefore: Can the Digital Euro serve as a functional and qualitative equivalent to physical Euro cash as a currency, that is, a token of money-when evaluated against the characteristics of money and dimensions of currency quality?

This question challenges the ECB's repeated assertions that the Digital Euro would act as a "digital version of cash." Accordingly, the null hypothesis to be tested is:

H_0: The Digital Euro is an electronic equivalent of physical Euro cash in terms of the characteristics of money and the dimensions of quality

As the alternative hypothesis then follows:

H_1: The Digital Euro is not an electronic equivalent of physical Euro cash in terms of the characteristics of money and the dimensions of quality

This comparison does not assume that one currency is inherently "better" than the other in all contexts but instead evaluates whether the Digital Euro can fulfill the same roles and expectations as physical cash.

Understanding whether the Digital Euro can truly serve as an equivalent to Euro cash is crucial for various stakeholders. For consumers, it directly impacts their trust in and adaptability to new digital payment methods, which influences everyday financial activities and savings behavior. Policymakers need clear insights to make informed decisions on regulatory frameworks and to assess the socio-economic implications, including financial stability and inclusion. For financial institutions, the equivalence between digital and physical cash will affect strategic planning, risk management,

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and the development of new financial services and products that cater to evolving consumer needs and technological advancements.

3. Materials and Methods

This study applies a qualitative comparative methodology to assess whether the proposed Digital Euro can credibly replicate the physical Euro in its role as a currency. While both the physical and digital versions represent the same monetary unit issued by the European Central Bank, their forms differ fundamentally-one being tangible and analog, the other intangible and technologically mediated. The core objective is to evaluate whether these two currencies differ in their ability to deliver the practical characteristics expected of money in daily economic life.

Given the absence of real-world usage data for the Digital Euro, a qualitative approach was not only chosen but also necessitated. The currency is still in the design and consultation phase, and most of the technical, legal, and operational details remain speculative or only partially disclosed. As such, quantitative comparisons based on empirical transaction data are not yet feasible. Instead, this study relies on conceptual reasoning supported by policy documentation, central bank literature, academic sources, and comparative insights from other CBDC implementations such as the Chinese e-CNY. The use of qualitative methodology allows for a contextualized, structured, and multidimensional evaluation of two different currency formats, grounded in normative expectations and institutional design logic.

Besides, qualitative research is particularly well-suited for this study as it enables the examination of complex phenomena within their real-world context. According to Creswell and Poth (2016), qualitative research is an effective method for exploring intricate processes, meanings, and experiences. This approach allows researchers to gather rich, detailed data that can provide insights into the multifaceted nature of currency usage and acceptance. Furthermore, the use of qualitative methods aligns with previous studies on digital currencies and financial systems, which often employ similar methodologies to uncover the nuanced dynamics at play (Miles, Huberman, & Saldana, 2014; Patton, 2014).

The analysis is built on a matrix structure that combines two sets of evaluative criteria. The first axis consists of the subset of three relevant dimensions of quality according to Garvin (1987): Performance, Reliability, and Perceived Quality. The dimension of Performance is used here to assess how effectively a currency fulfills its intended operational role under realistic use conditions. Reliability captures the consistency and dependability of the currency over time and across settings. Finally, Perceived Quality reflects users' subjective impressions of legitimacy, trustworthiness, and comfort in using the currency attributes essential for widespread acceptance. To avoid conceptual overlap, the quality dimension of durability was excluded from the horizontal axis of the matrix, as it is represented among the attributes of money. This step prevents double-counting and preserves the integrity of the framework

The vertical axis draws on the afore mentioned four core attributes of money, Medium of Exchange, Unit of Account, Store of Value, and Standard of Deferred Payment as well as the aforementioned supplementary attributes of money, Divisibility, Portability, Durability, Fungibility, Recognizability, Scarcity, Acceptability, and Legal Tender

The evaluation is guided by documented ECB proposals, technical design papers, published CBDC frameworks, and relevant economic literature.

The resulting matrix contains thirty-six pairwise comparisons, with each cell evaluating how the Digital Euro and the physical Euro perform in relation to one of the twelve monetary characteristics under a specific quality dimension.

The strength of this methodology lies in its ability to offer a structured and transparent evaluation despite the absence of empirical usage data. However, several limitations are acknowledged. All dimensions and characteristics are weighted equally, although in practice, users may value some traits (e.g., privacy or offline usability) more than others. Furthermore, the qualitative judgments rely on anticipated design features of the Digital Euro, which may evolve or

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diverge from current proposals during actual implementation. Despite these caveats, this methodological design enables a systematic and conceptually grounded inquiry into whether the Digital Euro can live up to the benchmark set by physical cash.

The following table schematically shows the procedure for the pairwise evaluation of both currencies.

Table 1. Quality of Money Matrix.

Attribute / Quality	**a) Performance**	**b) Reliability**	**c) Perceived Quality**
i. Medium of Exchange	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro
ii. Unit of Account	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro
iii. Store of Value	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro
iv. Standard of Deferred Payment	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro
1. Divisibility	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro
2. Portability	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro
3. Durability	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro
4. Fungibility	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro
5. Recognizability	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro
6. Scarcity	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro
7. Acceptability	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro
8. Legal Tender	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro	Digital Euro vs. Physical Euro

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This table displays the procedure for comparing Digital and Physical Euro.

The data utilized in this paper stem from a diverse array of contemporary sources, blending theoretical, empirical, and policy-oriented perspectives. Policy and technical insights on CBDCs in general and the Digital Euro in particular are drawn extensively from reports by the Bank for International Settlements (2020, 2021) and the European Central Bank (2020, 2023), offering a comprehensive analysis of their design, implications, and adoption readiness. Furthermore, practical case studies and statistical insights from Deutsche Bundesbank (2024) and Eurostat (2024) supplement the analysis with empirical depth. This combination of data-driven resources ensures a well-rounded qualitative examination of the topic, integrating perspectives from academic literature, institutional reports, and empirical data.

4. Results

Both types of money, the physical Euro and the Digital Euro are compared using each field of the above-derived "Quality of Money Matrix". Hence, the comparison starts with the money attribute "Medium of Exchange" and goes step-by-step through the first line along the quality attributes, from "Performance", and "Reliability" to "Perceived Quality". The same is done for line two "Unit of Accounts" and all subsequent lines, down to the attribute "Legal Tender". Altogether, 36 qualitative comparisons are carried out pairwise.

The results of this qualitative comparison are displayed in summary form in the table below. A detailed description of the reasoning leading to the individual results can be found in the Appendix A.

Table 2. Qualitative comparison of Digital Euro and Physical Euro.

Attribute / Quality	**a) Performance**	**b) Reliability**	**c) Perceived Quality**
i. Medium of Exchange	Digital Euro better: enables global, real-time transactions with internet access. Physical Euro limited to face-to-face transactions.	Physical Euro better: widely accepted, backed by ECB; Digital Euro depends on tech infrastructure reliability, which is less established.	Physical Euro better: design integrity and security features enhance trust as a medium of exchange; Digital Euro depends on tech infrastructure.
ii. Unit of Account	Both equal: reliable measure for pricing goods, offering stability (Physical Euro) and transparency (Digital Euro).	Physical Euro better: provides well-established stability in pricing, ensuring economic coherence; Digital Euro integration still developing.	Physical Euro better: distinct markings and standards ensure stability, while Digital Euro depends on digital system trust.
iii. Store of Value	Physical Euro better: well-established and trusted in conventional systems. Digital Euro uncertain due to potential negative interest rates.	Physical Euro better: trusted due to its established role, while Digital Euro faces challenges regarding technological security.	Physical Euro better: well-established stability and central bank backing foster trust compared to developing Digital Euro.

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iv. Standard of Deferred Payment	Both equal: Physical Euro trusted for deferred payments; Digital Euro offers flexibility if integrated effectively.	Physical Euro better: legal tender status ensures reliability in deferred payments, unlike developing Digital Euro frameworks.	Physical Euro better: established legal status ensures reliability; Digital Euro still requires trust in digital systems.
1. Divisibility	Digital Euro better: enables greater precision and flexibility, especially for microtransactions, beyond the physical Euro's one-cent limit.	Digital Euro better: flexible micropayments enable efficient use beyond Physical Euro's fixed divisibility.	Digital Euro better: micropayment capability offers greater efficiency; Physical Euro limited to set denominations.
2. Portability	Digital Euro better: eliminates physical constraints, enabling instant, secure transactions anywhere, while Physical Euro limited by bulk and security issues.	Digital Euro better: no physical limitations enable instant transactions, surpassing the portability of Physical Euro.	Digital Euro better: digital platforms enable seamless portability beyond the limitations of Physical Euro's tangible form.
3. Durability	Both equal: Physical Euro subject to wear; Digital Euro dependent on IT infrastructure stability.	Physical Euro better: tangible form provides established long-term trust, whereas Digital Euro depends on digital infrastructure stability.	Physical Euro better: trusted resilience through anti-counterfeiting measures, whereas Digital Euro relies on perceived system security.
4. Fungibility	Physical Euro better: universal acceptance and established value in transactions; Digital Euro less accepted in comparison.	Both equal: both forms meet strict uniformity standards, ensuring consistent value in transactions.	Both equal: uniformity ensures fungibility in both forms effectively.
5. Recognizability	Physical Euro better: familiar design, trusted symbols, and instant recognizability.	Physical Euro better: established recognizability ensures trust; Digital Euro still requires	Physical Euro better: strong recognizability and design consistency, whereas Digital Euro needs digital adaptation.

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	Digital Euro requires time to establish.	time for widespread recognition.	
6. Scarcity	Both equal: controlled issuance by ECB ensures stability for both forms.	Physical Euro better: tangible form inherently limits production, unlike potentially limitless Digital Euro.	Physical Euro better: regulated issuance enhances trust, while Digital Euro's issuance is less established.
7. Acceptability	Physical Euro better: universal acceptance supported by legal mandates, while Digital Euro may face wallet holding limitations.	Physical Euro better: universal public trust due to legal mandate, whereas Digital Euro requires acceptance efforts.	Digital Euro better: seamless integration with digital payments offers convenience; Physical Euro relies on traditional use.
8. Legal Tender	Both equal: both forms require legal recognition to ensure universal acceptance and trust.	Both equal: legal recognition crucial for acceptance in both forms.	Physical Euro better: recognized symbols reinforce legal status, whereas Digital Euro needs secure digital identity.

This table reports on the outcomes of the qualitative comparison of Digital Euro and Physical Euro.

In a next step this comparison is detailed by comparing the physical Euro to the Digital Euro in an ordinal fashion. For this purpose, a plus sign (+) is assigned if the Digital Euro is judged to perform better than the physical Euro, a minus (-) if the physical Euro outperforms the Digital Euro, or a zero (0) if they are considered functionally equivalent in that regard. When comparing the physical Euro to the Digital Euro in an ordinal way, advantages and disadvantages become apparent as shown in the following table.

Table 2. Ordinal comparison of Digital Euro and Physical Euro.

Attribute / Quality	**a) Performance**	**b) Reliability**	**c) Perceived Quality**
i. Medium of Exchange	(+).	(-).	(-)
ii. Unit of Account	(0)	(-).	(-) .
iii. Store of Value	(-)	(-).	(-)
iv. Standard of Deferred Payment	(0)	(-)	(-).
1. Divisibility	(+)	(+)	(+)
2. Portability	(+)	(+)	(+)

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3. Durability	(0)	(-)	(-).
4. Fungibility	(-).	(0)	(0)
5. Recognizability	(-)	(-).	(-)
6. Scarcity	(0)	(-)	(-)
7. Acceptability	(-)	(-).	(+).
8. Legal Tender	(0).	(0)	(-).

This table reports on the outcomes of the ordinal comparison of Digital Euro and Physical Euro.

Across 8 instances of pairwise comparisons, the Digital Euro outperforms the physical Euro when it comes to quality and the characteristics of money. In 20 cases the physical Euro performs better than Digital Euro. In the remaining 8 comparisons, they perform equally well.

Given the substantial differences across many characteristics and dimensions of quality, the null hypothesis derived from the underpinning research question has to be rejected:

H_0: The Digital Euro is an electronic equivalent of physical Euro cash in terms of the characteristics of money and the dimensions of quality

Instead, the alternative hypothesis finds support:

H_1: The Digital Euro is not an electronic equivalent of physical Euro cash in terms of the characteristics of money and the dimensions of quality

The assertion that the Digital Euro could function as a complete electronic equivalent of the physical Euro cash cannot be upheld.

5. Discussion

The analysis presented in the previous section reveals that, overall, the physical Euro outperforms the Digital Euro across several critical dimensions of money and quality. This section will discuss these findings extensively, highlighting not only the areas where the physical Euro excels but also critically examining the limitations and challenges associated with the Digital Euro. The discussion is supported by relevant literature, offering a comprehensive perspective on the comparative performance of these two forms of currency.

The physical Euro remains a highly effective medium of exchange due to its established acceptance and immediate usability. Its physical tangibility ensures that transactions can be completed instantly without the need for digital infrastructure, making it indispensable for daily transactions, particularly in scenarios where digital access is limited or unreliable (Esselink & Hernández, 2017). While the Digital Euro promises enhanced transaction speed and geographical reach, its - at least occasionally -reliance on Internet access presents a significant limitation. The need for a robust digital infrastructure means that the Digital Euro cannot yet match the universality and reliability of the physical Euro in all contexts (Bank of Canada, European Central Bank, Bank of Japan, Sveriges Riksbank, Swiss National Bank, Bank of England, & Federal Reserve System, 2020).

As a unit of account, the physical Euro provides a stable and universally recognized measure for pricing goods and services, crucial for maintaining economic stability within the Eurozone (ECB, 2020). Although the Digital Euro offers potential benefits such as enhanced traceability and integration into digital accounting systems, these advantages are theoretical and contingent upon the widespread implementation of sophisticated digital frameworks (European Commission, 2020). The

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lack of empirical data and real-world application of the Digital Euro raises questions about its practical effectiveness as a unit of account.

The physical Euro serves as a reliable store of value, supported by its physical form and the trust it commands among users. Despite being subject to physical wear and risks associated with handling and storage, the physical Euro's durability and legal backing ensure its stability (Ferguson, 2008). In contrast, while the Digital Euro is theoretically free from physical degradation, it faces significant cybersecurity threats and risks of digital fraud. Ensuring the security of the Digital Euro involves complex and expensive measures, which could undermine its effectiveness as a stable store of value (Goodhart, 1989).

The physical Euro's long-standing legal acceptance and robust security features ensure its reliability for deferred payments. Its established legal framework supports its use for settling debts and fulfilling long-term financial obligations (Esselink & Hernández, 2017). Conversely, the Digital Euro's effectiveness in this role remains speculative. The development of secure digital contracts and the need for extensive legal recognition pose significant hurdles that have yet to be overcome (IMF, 2020). The reliance on future legislative changes introduces uncertainty about the Digital Euro's ability to serve as a reliable standard for deferred payments.

The physical Euro's established range of denominations facilitates various transaction sizes, ensuring practical usability in everyday economic activities (Esselink & Hernández, 2017). Although the Digital Euro promises greater divisibility, enabling precise microtransactions, this potential is currently untested on a large scale. The real-world application of such microtransactions and their integration into existing financial systems remain significant challenges (ECB, 2020).

While the Digital Euro offers superior portability, being stored and transferred digitally without the physical bulk of coins and banknotes, the physical Euro's portability remains highly effective within its intended context. Its tangible form allows for immediate transactions without the need for digital devices, which is a considerable advantage in many real-world scenarios (European Commission, 2020). The Digital Euro's reliance on digital infrastructure limits its portability benefits to environments with reliable internet access, which is not universally available (IMF, 2020).

The physical Euro is designed to be durable, with coins and banknotes constructed to withstand regular use and environmental factors (Esselink & Hernández, 2017). Although the Digital Euro is not subject to physical wear and tear, its durability as a digital asset depends on the resilience of its technological infrastructure against cyber threats and system failures. The costs and complexities associated with maintaining such infrastructure pose significant challenges (Bank of Canada et al., 2020).

The Digital Euro's fungibility is inherently compromised due to its lack of anonymity and the imposition of holding caps. Unlike physical cash, which is fully anonymous and universally interchangeable without trace, the Digital Euro's transactions are recorded and potentially traceable, introducing friction in its use as a reliable medium of exchange (Auer & Böhme, 2021; Bindseil et al., 2021; ECB, 2020). This means that, unlike physical Euros, which can be seamlessly exchanged without any form of identification or tracking, Digital Euros may carry identifiers that deter users seeking privacy, thus undermining the currency's fungibility. Moreover, the holding cap, proposed to be around €3,000 (Pellicani, 2023) per individual, fundamentally restricts the ability to hold and freely transact larger amounts. Such limitations inherently segregate digital euros from their physical counterparts, as individuals with greater liquidity needs are forced to rely on alternative assets, further fragmenting the value perception and utility of the Digital Euro. The introduction of such barriers contradicts the core principle of fungibility, which relies on the free and uninhibited interchangeability of each unit of money. Consequently, the Digital Euro falls short of achieving the same level of fungibility as physical cash, limiting its acceptance as a universally equivalent and anonymous form of currency.

The physical Euro is easily recognizable due to its distinct designs and security features, such as holograms and watermarks, ensuring ease of use and trust among users (Esselink & Hernández, 2017). In contrast, the Digital Euro's recognizability depends on its digital interface and the

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effectiveness of digital authentication methods. Building user confidence and trust in the Digital Euro's recognizability requires significant advances in technology and widespread digital literacy, which are currently lacking (ECB, 2020).

The scarcity of the physical Euro is effectively managed by the European Central Bank, ensuring its value is maintained through controlled issuance (Esselink & Hernández, 2017). While the Digital Euro promises precise regulation of its digital issuance, maintaining scarcity and preventing inflation requires sophisticated regulatory mechanisms. The effectiveness of these mechanisms remains speculative, given the Digital Euro's early developmental stage (ECB, 2023a).

The physical Euro's acceptability is underpinned by its legal status and widespread trust among consumers and businesses. Its established legal framework ensures it is universally accepted for all transactions within the Eurozone (Esselink & Hernández, 2017). The Digital Euro, aiming for similar levels of acceptability, faces significant hurdles related to regulatory approval and integration with existing financial systems. Achieving widespread acceptability for the Digital Euro will require extensive public education and trust-building efforts, which are not yet in place (ECB, 2020).

The physical Euro is firmly established as legal tender, ensuring its acceptance for all cash transactions within the Eurozone. This legal status is a cornerstone of its reliability and trustworthiness (Esselink & Hernández, 2017). The Digital Euro, to achieve equivalent legal recognition, will require significant legislative changes and comprehensive regulatory frameworks. The uncertainty and complexity of this process pose substantial challenges to the Digital Euro's acceptance as legal tender (ECB, 2020).

Hence, while the Digital Euro demonstrates potential advantages in enhancing transaction efficiency, security, and adaptability for a digital economy, the physical Euro clearly outperforms it in overall effectiveness across several critical dimensions of money and quality. The established trust, legal acceptance, physical tangibility, and immediate usability of the physical Euro make it indispensable for traditional, offline transactions. The Digital Euro, although promising, faces numerous challenges and uncertainties that must be addressed before it can fully complement or surpass the functionality of the physical Euro. These findings are consistent with the cautious perspectives in existing literature, which emphasize the enduring importance of physical currency (Mishkin, 2022; Rogoff, 2016) while recognizing the potential of digital currencies to transform monetary systems (Bank of Canada et al., 2020; IMF, 2020).

On a broader note Salampasis, Schueffel, Dominic, and Cameron (2023) argue that the implementation of CBDCs carries inherent risks, including cybersecurity vulnerabilities and disruptions to existing financial ecosystems. Needless to say, these issues ought to be carefully managed during a potential rollout of the Digital Euro.

6. Conclusions

The comparative analysis between the physical Euro and the Digital Euro reveals a nuanced understanding of their respective strengths and weaknesses, underlining that the overall superiority of either form of currency is context-dependent.

The physical Euro, with its long-established trust and universal acceptance within the Eurozone, remains a robust medium of exchange for everyday transactions. Its tangibility allows for immediate and offline transactions, crucial in scenarios where digital access is limited or unavailable. Moreover, the physical Euro's recognizability, due to its distinctive designs and integrated security features, ensures a high level of trust and ease of use among consumers and businesses alike. This established reliability is supported by traditional economic theories that emphasize the importance of physical money's tangible presence and its role in facilitating trust in everyday transactions (Davies, 2010; Mishkin, 2022).

Conversely, the Digital Euro promises to excel in areas that align with the demands of a modern, digitized economy. Its potential advantages in portability, durability, transaction efficiency, security, and divisibility make it particularly suited for digital and international transactions. The Digital Euro's ability to facilitate real-time transactions globally without the physical constraints of

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traditional currency marks a significant advancement in monetary technology. Enhanced by advanced cryptographic methods and blockchain technology, the Digital Euro offers superior security against counterfeiting and fraud, addressing one of the major vulnerabilities of physical currency (Bank of Canada et al., 2020; ECB, 2020).

However, the hypothesis that Digital Euros could function as a complete electronic equivalent of physical Euro cash is rejected based on the findings of the research at hand. Undoubtedly, the Digital Euro cannot mimic Euro cash. Contrary to various statements issued by the ECB the Digital Euro is not a digital version of cash. It would be a stark simplification to uphold this statement given the many differences identified in this study.

While the Digital Euro shows a hypothetical superiority in facilitating efficient and secure digital transactions, the physical Euro outperforms in more traditional and universally accessible contexts. This conclusion aligns with the cautious perspectives in existing literature which argue that digital currencies, while transformative and potentially also beneficial (Salampasis et al., 2023), have not yet fully supplanted the roles of physical money in all aspects. A case in point is the findings of Lee et al. (2021) who established key differences and limitations of CBDCs, such as lacking functional equivalence in the form of universal offline usability and absolute anonymity; technical constraints that make them less accessible than cash in certain scenarios, especially for unbanked or underserved populations; privacy trade-offs reducing privacy compared to cash; and adoption barriers, e.g., the lack of like digital literacy, trust in digital systems, and resistance to change from cash-preferred users.

Further corroborating this outcome, studies emphasize the enduring importance of physical currency in maintaining economic stability and trust, especially among demographics less comfortable with digital technologies (Ferguson, 2008; Mankiw, 2021). Yet, other sources highlight the potential for digital currencies to revolutionize monetary systems, arguing that with proper regulatory frameworks and technological advancements, digital currencies could eventually match or surpass physical money in overall utility and acceptance (European Commission, 2020; IMF, 2020).

In conclusion, while both forms of the Euro have distinct advantages, their superiority is context-specific. The physical Euro remains crucial for traditional, offline transactions, bolstered by widespread trust and legal acceptance. Meanwhile, the Digital Euro represents a forward-looking evolution with significant benefits for the digital economy, promising enhanced efficiency and adaptability. Future research and development, coupled with robust regulatory frameworks, will be essential in fleshing out whether the Digital Euro will truly be an ideal legal tender in the Eurozone of the future.

6.1. Limitations

Despite the comprehensive analysis provided in this study, several limitations need to be acknowledged. Firstly, the current evaluation of the Digital Euro is largely theoretical as the currency has not yet been implemented or subjected to practical use and real-world testing. This reliance on theoretical frameworks and projected data limits the ability to assess the practical challenges and unforeseen consequences that might arise once the Digital Euro is in widespread use. Similar studies on digital currencies have highlighted the unpredictability of user adoption and the real-world performance of such technologies (Auer & Böhme, 2021).

Additionally, the study focuses predominantly on the Eurozone context, which may not fully capture the broader implications of a digital currency in diverse global financial ecosystems. The unique economic, legal, and technological environments of different regions could significantly influence the performance and acceptance of the Digital Euro, suggesting the need for a more global perspective (Prasad, 2021).

Another limitation is the potential bias in the qualitative methodology used. While qualitative research provides in-depth and detailed insights, it may be subject to researcher bias and may not be as generalizable as quantitative approaches. This study relies on documented expert opinions, policy papers, and theoretical models, which may not fully represent the varied perspectives of all

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stakeholders, particularly the general public and small businesses (Creswell & Poth, 2016). Moreover, the qualitative method applied bears two additional weaknesses: first, the assessed characteristics and dimensions of quality are all equally weighted. This assumption of equal weighting for all characteristics and quality dimensions, while necessary given the absence of empirical data, is a limitation. This is because individual and stakeholder preferences may prioritize certain attributes, such as acceptability or fungibility, over others like scarcity or divisibility. This equal-weighting approach may therefore not fully capture the nuanced importance of each criterion in different economic contexts.

Second, some criteria in the Quality of Money Matrix, such as acceptability and legal tender, are not entirely mutually exclusive, potentially biasing the outcome. For example, the physical Euro's legal tender status enhances its acceptability, leading to redundant evaluations that may favor it over the Digital Euro. Similarly, quality dimensions like reliability and perceived quality overlap, as consistent performance fosters user trust. This interdependence risks inflating the physical Euro's advantages, particularly in trust-dependent criteria, affecting the study's precision.

6.2. Future Research

This study offers a highly analytical foundation and valuable insights into the comparative merits of the Digital Euro and the physical Euro. However, the reliance on theoretical frameworks highlights the need for future research to incorporate empirical data as the Digital Euro moves closer to implementation. Longitudinal studies capturing real-world adoption, user behavior, and practical performance will be essential to validate or refine the conclusions drawn in this paper.

Future research should therefore aim to address these limitations by incorporating empirical data from pilot projects and real-world implementations of the Digital Euro. Longitudinal studies following the rollout and adoption of the Digital Euro would provide valuable insights into its practical challenges and benefits, offering a more robust basis for evaluating its effectiveness compared to physical currency. Studies such as those by Böhme, Christin, Edelman, and Moore (2015) on Bitcoin and other cryptocurrencies can serve as useful models for such empirical investigations.

Moreover, expanding the scope of research to include comparative analyses with other CBDCs across different regions could provide a more comprehensive understanding of the global implications and best practices for implementing digital currencies. Comparative studies could highlight different approaches and outcomes, contributing to a more nuanced understanding of the potential and limitations of CBDCs (Frost, 2020).

To address the shortcomings arising from the equal weighing of the characteristics and quality dimensions in future research, weights could be determined through stakeholder engagement methods, such as surveys or Delphi panels, to reflect the priorities of consumers, businesses, and policymakers. Additionally, a sensitivity analysis could test the matrix's outcomes under different weighting scenarios, for example, by assigning higher weights to acceptability for consumer-focused evaluations or scarcity for monetary policy perspectives. Such methods would provide a more tailored assessment of the Digital Euro's performance relative to physical cash.

To mitigate the limitations stemming from overlapping criteria, future research could refine the matrix by consolidating overlapping criteria, such as merging acceptability and legal tender, to ensure distinct evaluations.

Subsequent studies should also explore the socio-economic impacts of the Digital Euro, particularly on financial inclusion, privacy, and the digital divide. Investigating how different demographic groups interact with digital currencies and the potential barriers they face can inform more inclusive and equitable policy-making. Studies like those conducted by the Bank for International Settlements on financial inclusion in the digital age can provide a framework for such investigations (Bank of Canada, European Central Bank, Bank of Japan, Sveriges Riksbank, Swiss National Bank, Bank of England, & Federal Reserve System, 2021).

Additionally, further exploration of the practical implications of these findings-particularly for policymakers, financial institutions, and end-users-will enhance the applicability of this research.

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Investigating how the Digital Euro could be integrated into existing financial systems, its potential impact on financial inclusion, and the regulatory challenges it may face will be crucial for developing actionable insights and guiding effective implementation strategies.

Finally, interdisciplinary research combining insights from economics, technology, and social sciences can offer a holistic view of the Digital Euro's impact. Collaborative research efforts involving stakeholders from academia, industry, and regulatory bodies will be crucial in addressing the multifaceted challenges of transitioning to a digital currency system.

Despite its methodological limitations, this study represents a salient contribution to the discourse on the Digital Euro, a development poised to impact the economic and financial landscape of the entire Eurozone, encompassing 340 million people. By critically analyzing the Digital Euro in comparison to its physical counterpart, this research not only highlights the challenges and opportunities inherent in transitioning to digital currency but also stimulates meaningful dialogue among policymakers, financial institutions, and the public. The insights provided serve as a foundation for future investigations, ensuring that the pending introduction of a Digital Euro is informed by robust debate and thoughtful consideration of its implications for one of the world's largest economic areas.

Abbreviations

The following abbreviations are used in this manuscript:

AML	Anti-Money Laundering
DeFi	Decentralized Finanance
DLT	Distributed Ledger Technology
ECB	European Central Bank
e-CNY	Electronic Chinese Yuan
IMF	International Monetary Fund
ISO	International Organization for Standardization
KYC	Know Your Customer
MiCA	Markets in Crypto Assets

Appendix A

Performance

Medium of Exchange

Physical Euro: The physical Euro is established as a highly effective medium of exchange, primarily due to its tangible nature which allows for immediate transactions. Its wide acceptance across the Eurozone is underpinned by the legal mandates that enforce its use in all cash transactions, promoting economic stability and trust among consumers and businesses (ECB, 2024a; European Commission, 2023; IMF, 2020).

Digital Euro: The digital Euro aims to enhance transaction speed and reduce geographical limitations. Its performance as a medium of exchange could potentially surpass that of physical currency by offering real-time transactions globally, contingent on internet access (ECB, 2020) (Bank of Canada et al., 2020).

The digital Euro's potential to enable real-time, global transactions surpasses the physical Euro's immediacy in face-to-face exchanges, granting it an edge as a medium of exchange.

Qualitative verdict: "+" Digital Euro performs better than physical Euro

Unit of Account

Physical Euro: As a unit of account, the physical Euro provides a stable measure for pricing goods and services, facilitating coherent and consistent financial accounting across the Eurozone. This stability is crucial for maintaining economic order and supporting fiscal policies (ECB, 2020; European Commission, 2023; Eurostat, 2024).

Digital Euro: The proposed digital Euro is expected to maintain these attributes while offering enhanced features such as improved traceability and easier integration into digital accounting

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systems, potentially increasing transparency and efficiency in economic transactions (ECB, 2020, 2023d; IMF, 2020).

Both the physical and digital Euro perform effectively as units of account, with the physical Euro providing stability and the digital Euro offering potential enhancements in transparency and digital integration, making them equally reliable in this role.

Qualitative verdict: "0" Digital Euro and physical Euro perform equally well

Store of Value

Physical Euro: The ECB aims to maintain price stability by targeting an inflation rate of 2% over the medium term. This target is considered optimal for fostering economic growth and preventing deflation. Consequently, the physical Euro is subject to this inflation. (ECB, 2024d).

Digital Euro: The Digital Euro, as proposed by the ECB, is intended to maintain parity in value with the physical Euro. Consequently, it would be subject to the same inflation dynamics as the traditional Euro. However, the ECB has indicated that the digital euro would not accrue interest, meaning it would neither earn positive interest nor be subject to negative interest rates Yet, the theoretical framework of CBDCs includes the potential for negative interest rates, offering central banks new avenues for implementing monetary policy (Panetta, 2020).

The physical Euro's established role as a store of value, combined with its use in conventional monetary systems, currently provides greater reliability compared to the digital Euro, which introduces uncertainties like potential negative interest rates in its theoretical framework.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Standard of Deferred Payment

Physical Euro: The physical Euro is widely recognized and accepted for deferred payments, supported by an extensive legal framework that guarantees its use for settling debts. This established trust makes it a cornerstone of financial agreements within and across Eurozone countries (ECB, 2020; European Commission, 2023; IMF, 2020).

Digital Euro: While still under development, the digital Euro's performance in this area will heavily depend on its acceptance and the trust it garners from the public and businesses. If successfully integrated, it could offer more flexible and efficient deferred payment options (ECB, 2020).

Weighing the existing physical Euro as a trusted standard of deferred payment against the potential, yet hypothetical performance of a Digital Euro in this function, both are estimated equal.

The physical Euro's established trust and legal framework for deferred payments are matched by the digital Euro's potential to offer flexibility and efficiency if successfully integrated, making them equally reliable for this function.

Qualitative verdict: "0" Digital Euro and physical Euro perform equally well

Divisibility

Physical Euro: The physical Euro's divisibility is an essential feature, allowing it to be broken down into smaller denominations for precise transactions. Coins and banknotes in various denominations facilitate everyday purchases and financial operations, ensuring the currency's usability for transactions of all sizes down to one Euro cent amounts (ECB, 2024a; European Commission, 2023; IMF, 2020).

Digital Euro: The digital Euro promises enhanced divisibility, with the potential for even smaller units than physical coins and notes. This can benefit microtransactions and online purchases, providing greater flexibility and precision in financial transactions (Bank of Canada et al., 2020; ECB, 2021; IMF, 2020).

The digital Euro's ability to support smaller units than the physical Euro allows for greater flexibility and precision in transactions, especially for microtransactions, making it superior in divisibility.

Qualitative verdict: "+" Digital Euro performs better than physical Euro

Portability

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Physical Euro: Physical Euros, including coins and banknotes, are portable, allowing individuals to carry money for transactions. However, they are limited by the physical bulk and security concerns associated with carrying large amounts of cash (ECB, 2024a; European Commission, 2023; Eurostat, 2024).

Digital Euro: The digital Euro significantly enhances portability by enabling users to store and transfer money via digital devices. This reduces the physical burden and risks associated with carrying cash and allows for instant transactions regardless of location (ECB, 2020; IMF, 2020).

When comparing the physical Euro and the digital Euro, the digital Euro's ability to eliminate the physical limitations of cash and facilitate instant, secure transactions gives it a clear advantage in terms of portability.

Qualitative verdict: "+" Digital Euro performs better than physical Euro

Durability

Physical Euro: The durability of physical Euros varies; coins are highly durable, while banknotes, despite being designed to withstand wear and tear, eventually degrade and require replacement (ECB, 2020, 2024a; European Commission, 2023; Eurostat, 2024).

Digital Euro: The digital Euro offers superior durability as it is not subject to physical wear. Digital storage and transfer eliminate the need for physical handling, ensuring longevity and reducing the costs associated with producing and replacing physical money. Yet, the Digital Euro depends on an electronic infrastructure, making it more susceptible to risks that large-scale IT infrastructures are subjected to (Bank of Canada et al., 2020; ECB, 2020, 2023c; IMF, 2020).

When evaluating durability, the physical Euro's susceptibility to wear is balanced by the digital Euro's reliance on IT infrastructure, making both forms of currency comparable in this regard.

Qualitative verdict: "0" Digital Euro and physical Euro perform equally well

Fungibility

Physical Euro: The physical Euro is highly fungible; any single Euro coin or note is interchangeable with another of the same denomination, allowing for consistent value in transactions (ECB, 2020, 2024a; European Commission, 2023).

Digital Euro: The digital Euro aims to maintain fungibility by ensuring that each unit of digital currency is equivalent and interchangeable with another. This will be crucial for its acceptance and usability in financial transactions (Bank of Canada et al., 2020; ECB, 2020; IMF, 2020). However, persons holding the Digital Euro will not be anonymous and any money transfer via the Digital Euro will be subject to KYC & AML checks (Bindseil et al., 2021; ECB, 2023a). In addition, there will be a holding cap on the amount of Digital Euros a person can hold in his or her wallet, which is currently envisioned to be 3000.- Euros (ECB, 2024c; Pellicani, 2023). In a ceteris paribus comparison it becomes obvious that the Digital Euro can be used in fewer transactions and thus will not reach the fungibility of the physical Euro.

While the digital Euro aspires to achieve full fungibility, the physical Euro's established universal acceptance and consistent value in transactions currently make it the superior option.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Recognizability

Physical Euro: Physical Euros are easily recognizable by their distinctive designs, security features, and widespread use, facilitating trust and acceptance in transactions (ECB, 2024a); (European Commission, 2023; IMF, 2020).

Digital Euro: The digital Euro's recognizability will depend on its integration into existing financial systems and user interfaces. Effective digital design and widespread adoption will help to ensure it is as easily recognizable and trusted as the physical Euro (Bank of Canada et al., 2020; ECB, 2020). Yet, it will likely take years to accomplish this.

The physical Euro's established designs and widespread familiarity ensure immediate recognizability, whereas the digital Euro will require time and integration to achieve similar trust and acceptance.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

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Scarcity

Physical Euro: The physical Euro's supply is controlled by the European Central Bank, ensuring its scarcity and value. This controlled supply helps maintain economic stability and trust in the currency (ECB, 2024a; European Commission, 2023; IMF, 2020).

Digital Euro: The digital Euro will also have controlled issuance by the European Central Bank, ensuring its scarcity and preventing inflationary pressures. Its digital nature allows for precise management of supply and demand (Bank of Canada et al., 2020; ECB, 2020; IMF, 2020).

Both the physical and digital Euro benefit from the European Central Bank's controlled issuance, ensuring scarcity and maintaining trust and economic stability, making them equally effective in this regard.

Qualitative verdict: "0" Digital Euro and physical Euro perform equally well

Acceptability

Physical Euro: The physical Euro is widely accepted for all transactions within the Eurozone, supported by legal mandates and public trust, making it a reliable medium of exchange (ECB, 2024a; European Commission, 2023; IMF, 2020).

Digital Euro: The digital Euro aims to achieve similar acceptability by integrating with digital payment systems and gaining regulatory and public trust (Bank of Canada et al., 2020; ECB, 2020). However, most likely Digital Euro wallets will have holding limits somewhere between 1500-3000 Euros. (Bidder, Jackson, & Rottner, 2024; Bindseil & Panetta, 2020). This would automatically exclude Digital Euro payments in certain settings.

The physical Euro's universal acceptance, backed by legal mandates, contrasts with the potential limitations of the digital Euro, such as wallet holding caps, which may restrict its usability in certain transactions.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Legal Tender

Physical Euro: The physical Euro is established as legal tender across the Eurozone, mandated by law to be accepted for all cash transactions, reinforcing its use and trustworthiness (ECB, 2024a; European Commission, 2023; IMF, 2020).

Digital Euro: For the digital Euro to achieve the same status, it will need to be legally recognized as tender within the Eurozone. Ongoing legislative efforts aim to provide the necessary legal framework for its acceptance in all transactions (Bank of Canada et al., 2020; ECB, 2020; IMF, 2020).

Both the physical and digital Euro rely on legal frameworks to establish their status as legal tender, ensuring universal acceptance and trust, making them comparable in this aspect.

Qualitative verdict: "0" Digital Euro and physical Euro perform equally well

Reliability

Medium of Exchange

Physical Euro: The physical Euro's reliability stems from its wide acceptance and recognition within the Eurozone, backed by robust manufacturing standards that ensure its consistent quality and durability in daily transactions. The central bank's rigorous control over its production guarantees a uniform and high-quality currency (Deutsche Bundesbank, 2024; ECB, 2024a; Europol, 2022).

Digital Euro: The reliability of the digital Euro depends largely on the underlying technology infrastructure, including its cybersecurity measures and the resilience of its digital network. Ensuring robust digital infrastructure is crucial to prevent outages and maintain consistent availability for transactions which only time can show (Bank of Canada et al., 2020; ECB, 2020; IMF, 2020).

The physical Euro's established reliability, supported by consistent quality and widespread acceptance, currently surpasses the digital Euro, which depends on the resilience of its developing technological infrastructure.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Unit of Account

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Physical Euro: The physical Euro offers a stable and reliable unit of account due to the Eurosystem's strong monetary policies and the currency's wide acceptance for pricing goods and services across multiple countries. This stability is vital for maintaining economic coherence within the single market (Esselink & Hernández, 2017; Eurostat, 2024).

Digital Euro: For the digital Euro, reliability in this regard would also hinges on its integration into the existing financial systems and its acceptance by consumers and businesses alike. Ensuring its consistency as a unit of account would require rigorous regulatory standards and technological reliability (ECB, 2020; European Commission, 2023; IMF, 2022).

The physical Euro's established stability and widespread acceptance as a unit of account will surpass the digital Euro, which still depends on integration and acceptance within financial systems.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Store of Value

Physical Euro: While generally reliable, the physical Euro can suffer from physical degradation that may undermine its long-term value retention. However, the currency is designed to be durable, and central bank policies help protect its value against inflation (Deutsche Bundesbank, 2024; ECB, 2024a; Europol, 2022).

Digital Euro: The digital Euro's reliability as a store of value will depend on digital security measures against hacking and fraud, as well as the stability of the digital currency system against market fluctuations and potential technological vulnerabilities (Bank of Canada et al., 2020; ECB, 2020).

The physical Euro's tangible nature and established mechanisms to protect against inflation provide greater trust in its reliability as a store of value compared to the digital Euro, which faces challenges related to technological security and system stability.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Standard of Deferred Payment

Physical Euro: The physical Euro is a dependable standard for deferred payments, supported by its legal tender status which mandates its acceptance. The security features integrated into its design also reinforce its reliability for future obligations (ECB, 2020, 2024b; IMF, 2020).

Digital Euro: Similarly, the reliability of the digital Euro for deferred payments would rest on its legal acceptance and the security of the digital contracts it supports. Legislative backing and technological integrity are key to its adoption and trustworthiness as a deferred payment medium (ECB, 2020; European Commission, 2023).

The physical Euro's established legal tender status and integrated security features provide greater assurance as a standard for deferred payments compared to the digital Euro, which still requires full legal and technological integration.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Divisibility

Physical Euro: The physical Euro's divisibility is well-established, with a comprehensive range of denominations that facilitate various types of transactions. The uniform standards applied across all denominations ensure their reliability in daily use (Deutsche Bundesbank, 2024; ECB, 2020; Europol, 2022).

Digital Euro: The digital Euro promises to extend this feature by potentially allowing even smaller denominations, or "micropayments," enhancing its usability in the digital marketplace. The reliability of these transactions would be ensured through advanced digital ledger technologies (Bank of Canada et al., 2020; ECB, 2020; IMF, 2020).

The digital Euro's potential for micropayments and smaller denominations provides greater flexibility and usability, surpassing the physical Euro's fixed divisibility limits.

Qualitative verdict: "+" Digital Euro performs better than physical Euro

Portability

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Physical Euro: While reliably portable, the physical Euro's utility in this regard is bounded by the physical volume and weight of the currency, particularly in large transactions(Deutsche Bundesbank, 2024; ECB, 2020; Esselink & Hernández, 2017; Europol, 2022).

Digital Euro: Digital currencies inherently offer superior portability without the physical constraints of traditional money. The digital Euro's reliability in portability would largely depend on the accessibility and reliability of digital networks (Bank of Canada et al., 2020; ECB, 2020; European Commission, 2023).

The digital Euro's ability to eliminate physical constraints and facilitate secure, large-scale transactions regardless of location makes it significantly more portable than the physical Euro.

Qualitative verdict: "+" Digital Euro performs better than physical Euro

Durability

Physical Euro: The physical Euro is subject to wear and tear, which can affect its lifespan and reliability over time. Coins have a longer lifespan compared to paper notes, which are more vulnerable to physical damage (Deutsche Bundesbank, 2024; ECB, 2024a; Europol, 2022).

Digital Euro: In contrast, the digital Euro would not suffer from physical degradation, offering a theoretically infinite lifespan. The reliability of digital currency in this respect would be contingent on continuous digital maintenance and updates (Bank of Canada et al., 2020; ECB, 2020).

The digital Euro's immunity to physical degradation gives it a clear advantage in durability over the physical Euro, which is subject to wear and tear.

Qualitative verdict: "0" Digital Euro and physical Euro perform equally well

Fungibility

Physical Euro: The Euro is highly fungible, with each unit maintaining consistent value with others of the same denomination. This fungibility is crucial for its function as reliable currency and is strictly controlled by the issuing authorities (Deutsche Bundesbank, 2024; ECB, 2020; Esselink & Hernández, 2017).

Digital Euro: The digital Euro aims to ensure equal fungibility. The uniformity of digital units, verified via secure digital ledgers, would guarantee that each digital Euro is equivalent to another, maintaining this essential characteristic (ECB, 2020; European Commission, 2023; IMF, 2020).

Both the physical and digital Euro maintain strict fungibility, ensuring that every unit is interchangeable and holds consistent value, making them equally effective in this regard.

Qualitative verdict: "0" Digital Euro and physical Euro perform equally well

Recognizability

Physical Euro: The physical Euro is highly reliable in terms of recognizability due to its consistent and secure design features, including watermarks, holograms, and unique color schemes. These features help prevent counterfeiting and ensure that users can trust and easily identify genuine currency (ECB, 2024a; European Commission, 2023; IMF, 2020).

Digital Euro: The digital Euro's recognizability will depend on robust digital authentication methods and user-friendly design. Ensuring that users can easily and confidently identify the digital Euro in transactions will be critical for its reliability. This will likely involve secure digital signatures and integration with existing financial apps (Bank of Canada et al., 2020; ECB, 2020).

The physical Euro's established design features and widespread familiarity ensure immediate and reliable recognizability, whereas the digital Euro will need time and technological integration to achieve comparable trust and ease of identification.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Scarcity

Physical Euro: The reliability of the physical Euro in terms of scarcity is managed through strict control by the European Central Bank, which regulates the supply of banknotes and coins. This controlled issuance helps maintain the currency's value and prevents inflation (ECB, 2024a; European Commission, 2023; Eurostat, 2024).

Digital Euro: The digital Euro's reliability in maintaining scarcity will be ensured by the European Central Bank's ability to regulate its digital issuance. Advanced algorithms and regulatory

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oversight will help manage supply effectively, ensuring that the digital Euro retains its value and does not contribute to inflation (Bank of Canada et al., 2020; ECB, 2020; IMF, 2020).

Both the physical and digital Euro benefit from the European Central Bank's strict regulatory oversight, ensuring controlled issuance and maintaining scarcity to preserve value, making them equally reliable in this aspect.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Acceptability

Physical Euro: The physical Euro is highly reliable in terms of acceptability across the Eurozone, supported by legal mandates and widespread trust among consumers and businesses. Its tangible nature and established legal status ensure that it is universally accepted for transactions (ECB, 2024a; European Commission, 2023; IMF, 2020).

Digital Euro: The digital Euro aims to achieve high reliability in acceptability by integrating with existing payment systems and gaining regulatory approval. Its design will focus on ensuring seamless usability, security, and interoperability, which are critical for achieving widespread acceptance (Bank of Canada et al., 2020; ECB, 2020).

The physical Euro's universal legal mandate and tangible presence ensure immediate and widespread acceptability, whereas the digital Euro still requires integration and trust-building efforts to achieve comparable acceptance.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Legal Tender

Physical Euro: The physical Euro's reliability as legal tender is firmly established, meaning it must be accepted for all cash transactions within the Eurozone. This legal backing ensures its universal trust and use, providing a stable and reliable medium for financial transactions (ECB, 2024a; European Commission, 2023; IMF, 2020).

Digital Euro: For the digital Euro to be reliable as legal tender, it will need to be legally recognized across the Eurozone. This involves establishing a comprehensive legal framework that supports its use for all types of transactions. Successful implementation will depend on regulatory approval and public trust (Bank of Canada et al., 2020; ECB, 2020; IMF, 2020).

Both the physical and digital Euro rely on legal recognition to function as legal tender, ensuring universal acceptance and trust, making them equally reliable in this aspect.

Qualitative verdict: "0" Digital Euro and physical Euro perform equally well

Perceived Quality

Medium of Exchange

Physical Euro: The perceived quality of the physical Euro as a medium of exchange is influenced by the design integrity and security features of Euro banknotes and coins. High-quality printing, sophisticated anti-counterfeiting measures, and recognizable design elements enhance users' trust in the authenticity and reliability of physical Euro currency (Deutsche Bundesbank, 2024; ECB, 2020; European Commission, 2023)

Digital Euro: For the digital Euro, perceived quality is tied to the security and reliability of digital payment systems. Robust encryption, multi-factor authentication, and reputable digital payment platforms enhance users' confidence in the security and integrity of digital Euro transactions, contributing to its perceived quality as a medium of exchange (Bank of Canada et al., 2020; ECB, 2020; IMF, 2020).

The physical Euro's high-quality design and advanced security features foster trust in its authenticity as a medium of exchange, while the digital Euro's perceived quality relies on the robustness of digital payment systems, which still need to achieve a comparable level of public confidence.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Unit of Account

Physical Euro: The perceived quality of the physical Euro as a unit of account is influenced by its design sophistication and recognition as a stable currency. Clear denomination markings, distinct

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design elements, and adherence to international standards contribute to users' confidence in the Euro's reliability and accuracy as a unit of measurement (ECB, 2020; Esselink & Hernández, 2017; Eurostat, 2024).

Digital Euro: Similarly, the perceived quality of the digital Euro as a unit of account depends on the reliability and trustworthiness of digital financial systems. Transparent pricing mechanisms, accurate accounting practices, and reputable digital platforms enhance users' trust in the digital Euro's integrity and accuracy as a unit of measurement (ECB, 2020; European Commission, 2023; IMF, 2020).

The physical Euro's clear denomination markings, distinct design elements, and adherence to standards contribute to a higher perceived quality as a stable unit of account, whereas the digital Euro relies on the trustworthiness of digital systems, which still need to match the established reliability of the physical Euro.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Store of Value

Physical Euro: The perceived quality of the physical Euro as a store of value is influenced by users' trust in its stability and security. Confidence in the Euro's value retention, backed by central bank policies and economic stability, enhances its perceived quality as a reliable store of wealth (Deutsche Bundesbank, 2024; ECB, 2024a; Europol, 2022)

Digital Euro: For the digital Euro, perceived quality as a store of value is tied to the security and reliability of digital storage mechanisms. Trust in secure digital wallets, encryption protocols, and regulatory oversight enhances users' confidence in the digital Euro's reliability as a store of wealth (Bank of Canada et al., 2020; ECB, 2020; European Commission, 2023).

The physical Euro's perceived quality as a store of value benefits from established trust in its stability and central bank backing, while the digital Euro relies on secure digital storage and regulatory measures, which are still developing in terms of public trust.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Standard of Deferred Payment

Physical Euro: The perceived quality of the physical Euro as a standard of deferred payment is influenced by its widespread acceptance and recognition as a reliable form of currency. Trust in the Euro's stability, enforceability of legal tender laws, and adherence to contractual obligations enhance its perceived quality for deferred payments (Esselink & Hernández, 2017; European Union, 1998, 2012; IMF, 2020).

Digital Euro: Similarly, the perceived quality of the digital Euro for deferred payments depends on users' trust in digital contract systems and financial platforms. Confidence in the reliability of digital payment agreements, adherence to legal standards, and robust dispute resolution mechanisms enhance the digital Euro's perceived quality as a standard for future obligations (ECB, 2020; European Commission, 2023).

The physical Euro's established acceptance, legal backing, and stability enhance its perceived quality as a reliable standard of deferred payment, while the digital Euro still needs to build similar trust in digital contract systems and financial platforms.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Divisibility

Physical Euro: The perceived quality of the physical Euro's divisibility is influenced by users' confidence in its usability for transactions of varying sizes. Trust in the durability and functionality of Euro coins and banknotes, along with their widespread acceptance, enhances users' perception of the Euro's quality and reliability in divisible payments (Deutsche Bundesbank, 2024; Esselink & Hernández, 2017; Europol, 2022).

Digital Euro: In the digital realm, perceived quality as divisibility is tied to the efficiency and reliability of digital transaction systems. Confidence in seamless fractional transactions, accurate digital representations of currency, and secure digital platforms enhances users' trust in the digital Euro's quality and usability (Bank of Canada et al., 2020; ECB, 2020; IMF, 2020).

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The digital Euro's perceived quality benefits from the efficiency and precision of digital systems for fractional transactions, while the physical Euro, though trusted for its divisibility, cannot match the seamless experience provided by digital platforms.

Qualitative verdict: "+" Digital Euro performs better than physical Euro

Portability

Physical Euro: The perceived quality of the physical Euro's portability is influenced by users' confidence in its ease of transportation and acceptance. Trust in the durability and recognizability of Euro banknotes and coins, along with the accessibility of cash distribution points, enhances users' perception of the Euro's quality and convenience for portable transactions (ECB, 2020; Esselink & Hernández, 2017; Eurostat, 2024).

Digital Euro: In the digital realm, perceived quality as portability depends on users' trust in the accessibility and reliability of digital payment platforms. Confidence in seamless digital transactions, user-friendly interfaces, and secure digital wallets enhances users' perception of the digital Euro's quality and convenience for portable transactions (Bank of Canada et al., 2021; ECB, 2020; European Commission, 2023).

The digital Euro's perceived quality in terms of portability benefits from the accessibility of digital payment platforms, allowing for seamless and convenient transactions, whereas the physical Euro, though portable, cannot match the ease and immediacy of digital portability.

Qualitative verdict: "+" Digital Euro performs better than physical Euro

Durability

Physical Euro: The perceived quality of the physical Euro's durability is influenced by users' trust in its resilience to wear and tear. Confidence in the longevity and authenticity of Euro banknotes and coins, supported by central bank policies and anti-counterfeiting measures, enhances users' perception of the Euro's quality and reliability over time (ECB, 2024a); Europol, 2021).

Digital Euro: In the digital realm, perceived quality as durability depends on users' trust in the security and stability of digital payment systems. Confidence in protection against cyber threats, data integrity, and system reliability enhances users' perception of the digital Euro's quality and resilience over time (Bank of Canada et al., 2020; ECB, 2020).

The physical Euro's perceived durability benefits from its tangible resilience and anti-counterfeiting measures, fostering user trust, while the digital Euro's durability relies on the perceived security and stability of digital systems, which still need to build similar long-term confidence.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Fungibility

Physical Euro: The perceived quality of the physical Euro's fungibility is influenced by users' trust in its interchangeability and uniformity. Confidence in the consistency and recognizability of Euro banknotes and coins, along with their widespread acceptance, enhances users' perception of the Euro's quality and seamless exchangeability in economic transactions (Deutsche Bundesbank, 2024; ECB, 2020; Esselink & Hernández, 2017).

Digital Euro: In the digital realm, perceived quality as fungibility depends on users' trust in the consistency and reliability of digital payment systems. Confidence in the equivalence and interchangeability of digital Euro units enhances users' perception of the digital Euro's quality and usability in digital commerce (ECB, 2020; European Commission, 2023; IMF, 2020).

The physical Euro's consistent design and recognizability foster confidence in its interchangeability, while the digital Euro relies on the reliability of digital payment systems to ensure equivalent fungibility, resulting in both performing equally well in terms of user perception.

Qualitative verdict: "0" Digital Euro and physical Euro perform equally well

Recognizability

Physical Euro: The perceived quality of the physical Euro is high due to its well-established and distinctive design features, such as unique color schemes, architectural images, and advanced security elements like holograms and watermarks. These features not only make the currency easily

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recognizable but also convey a sense of trustworthiness and authenticity, which is essential for maintaining public confidence (ECB, 2024a; European Commission, 2023; IMF, 2020).

Digital Euro: The perceived quality of the digital Euro in terms of recognizability will depend on its digital interface aesthetics and security features. It must incorporate familiar visual cues from the physical Euro, such as color schemes and symbolic graphics, to ensure users can easily recognize it. Additionally, robust digital security features will be crucial to maintain trust and ensure the currency is easily distinguishable from other digital assets (Bank of Canada et al., 2020; ECB, 2020).

The physical Euro's distinctive design features, including unique color schemes and advanced security elements, enhance its recognizability and trustworthiness, while the digital Euro still needs to establish similar visual cues and security measures to achieve equivalent recognizability.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Scarcity

Physical Euro: The perceived quality of the physical Euro in terms of scarcity is reinforced by the European Central Bank's strict control over its issuance. The advanced security features and intricate designs signal that the currency is well-regulated and not easily counterfeited, thus preserving its scarcity and value. This control over supply helps maintain the currency's perceived quality and economic stability (ECB, 2024a; European Commission, 2023; Eurostat, 2024).

Digital Euro: The digital Euro's perceived quality in maintaining scarcity will rely on the European Central Bank's ability to manage its digital issuance effectively. Using advanced digital infrastructure, the bank can ensure that the supply of the digital currency is controlled and transparent, thereby preserving its scarcity and perceived value. The public's trust in the digital Euro will depend significantly on the perceived rigor of its issuance and regulation (Bank of Canada et al., 2020; ECB, 2020; IMF, 2020).

The physical Euro's scarcity is perceived as high due to strict issuance controls and advanced security features, which enhance trust in its value, whereas the digital Euro still needs to establish public confidence in its controlled and transparent digital issuance.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

Acceptability

Physical Euro: The physical Euro enjoys high perceived quality in terms of acceptability due to its established legal status and widespread use across the Eurozone. Its tangible nature, combined with sophisticated security features and consistent design, ensures public trust and universal acceptance for transactions. The physical Euro's aesthetic appeal and reliability further enhance its perceived quality (ECB, 2024a; European Commission, 2023; IMF, 2020).

Digital Euro: The digital Euro must achieve high perceived quality in acceptability by offering a seamless, secure, and user-friendly experience. Its design should be visually appealing and consistent with the physical Euro to facilitate trust and ease of use. Legal frameworks supporting the digital Euro's use will be crucial for its acceptability, along with ensuring that it integrates well with existing digital payment systems (Bank of Canada et al., 2020; ECB, 2020).

While the physical Euro's established legal status and tangible nature support its high acceptability, the digital Euro's perceived quality in acceptability benefits from its potential for seamless and secure integration into digital payment systems, offering greater convenience in modern transactions.

Qualitative verdict: "+" Digital Euro performs better than physical Euro

Legal Tender

Physical Euro: The perceived quality of the physical Euro as legal tender is solidified by its official status and the legal frameworks mandating its acceptance for all transactions within the Eurozone. The clear and consistent design elements, including national emblems and security features, visually reinforce its legitimacy and legal standing, which is essential for public trust and widespread use (ECB, 2024a; European Commission, 2023; IMF, 2020).

Digital Euro: For the digital Euro to achieve high perceived quality as legal tender, it must be supported by comprehensive legal recognition and robust regulatory frameworks. Ensuring that the

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digital Euro is legally accepted for all types of transactions will be crucial for its perceived quality. Consistent and secure digital design elements, reflecting its official status, will help convey its legal authority and ensure user trust (Bank of Canada et al., 2020; ECB, 2020; IMF, 2020).

The physical Euro's established legal status and recognizable design elements strengthen its perceived quality as legal tender, while the digital Euro still requires comprehensive legal recognition and secure design to match the same level of public trust and acceptance.

Qualitative verdict: "-" Physical Euro performs better than Digital Euro

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