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Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot?

Contents

Abstract

Central banks have been discussing the introduction of a retail central bank digital currency (rCBDC) for some time. However, potential obstacles to its adoption by consumers and retailers remain largely unexplored in the academic and policy literature. This paper surveys the key elements involved in the adoption of any new means of payment and discusses failed and ongoing initiatives with public digital money. It concludes that ensuring the desired level of adoption of rCBDCs may impose significant constraints on central bank design choices and policy goals. In fact, in some settings, central banks may find themselves on the horns of a dilemma in seeking to balance the needs to (i) preserve the central bank's hierarchy of policy goals, (ii) increase the chances of adoption and use of rCBDCs by consumers and retailers, and (iii) avoid any adverse economic effects.

Keywords: central bank digital currency, means of payment, demand for money.

JEL codes: E42, E58, D12.

Non-technical summary

In recent years, central banks and academics have been investigating the possible issuance a new form of digital money called central bank digital currency (CBDC). Like cash, which is also issued by central banks, a retail CBDC (rCBDC) would be used by consumers and merchants to make everyday transactions. Much of policy and academic discussion revolves around the policy goals behind any eventual issuance of this payment instrument. For example, there is broad consensus among central banks that an rCBDC could achieve improvements in the payments market. However, issuing an rCBDC might also have undesirable side effects for the economy; these are also being carefully investigated.

As happens with any other new means of payment, rCBDCs will likely face challenges in entering the market and being adopted by consumers and merchants. This paper shows that this important aspect has so far attracted scant attention in public debate by central bankers and academics; its findings provide a basis for addressing this aspect through more systematic discussion. It explores the design elements that, according to the relevant academic literature, need to be present to increase the likelihood of adoption. The paper also identifies potential obstacles to adoption and suggests strategies to overcome them. Finally, it extracts lessons from two failed initiatives with digital payment instruments issued by central banks (the Finnish "Avant" and the Ecuadorian "Dinero Electrónico") and from a selection of ongoing CBDC initiatives.

The paper concludes that further investigation is needed to determine the essential features that must be in place for the successful adoption of CBDCs. We argue that central banks might, in some instances, be faced with difficult choice in seeking to balance the following three aspects: (i) keeping the current order of priority for policy goals, (ii) opting for designs and strategies that could increase the likelihood of adoption, and (iii) using designs that avoid negative economic effects.

1   Introduction

The issuance of a retail central bank digital currency (rCBDC), a new form of central bank money to be used in retail payments, has been widely discussed in recent years. Ninety percent of central banks worldwide are currently engaged in digital currency work, ranging from research only to actual roll-outs (see Kosse and Mattei, 2022). As regards the reasons for issuing an rCBDC, various surveys and academic research point to common themes, such as improving payments markets, financial stability, monetary policy and financial inclusion (Kosse and Mattei, 2022).

Although the relative importance of each motive for rCBDC issuance varies across central banks, a precondition for attaining the stated policy goals is the achievement of a minimum level of adoption and acceptance of this new means of payment by consumers and retailers. For instance, adapting central bank money to increasingly digitalised payments markets, a goal shared by most central banks, might only be achieved if consumers were to adopt rCBDCs in their daily payments. Similarly, using rCBDCs to supplement the monetary policy toolbox might require the existence of non-negligible demand for such a currency. Most of the ongoing research efforts by central banks and academics have focused on the possible design features, goals and economic implications of an rCBDC. However, despite these efforts, the questions of how exactly central banks would achieve the desired level of adoption, and how they would overcome potential obstacles to doing so, largely remain to be discussed. Any new means of payment would have to be aligned with consumer expectations and provide the public with added value in terms of universe of available payment options, in a highly competitive market which has been evolving rapidly in recent years.

This paper suggests that, when including considerations on the adoption and use of rCBDCs in their broader investigation of the topic, central banks may be facing a design choice problem that is more complex than generally assumed in policy reports and research literature. Put simply, this design choice problem is as follows: how to maximise the number of desired policy goals effectively implemented, subject to constraints[1] such as (i) sufficient adoption by and demand from consumers and merchants to fulfil the desired policy goals and (ii) the so-called "do no harm" principle, or avoiding negative economic implications. But in cases where adoption-related considerations conflict with certain policy goals, central banks might even be find themselves in the horns of a dilemma requiring them to decide between: (i) preserving the hierarchy of policy goals, (ii) ensuring widespread adoption of the rCBDC, and (iii) preventing adverse economic effects.

This paper is an initial attempt to systematically cover the aspects central banks need to consider in trying to achieve their desired level of adoption and use. At present, empirical literature exploring the factors behind, and obstacles to,

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[1]   Arguably, there are also other constraints related to technical feasibility (see, for example, Deutsche Bundesbank, 2021) and legal imperatives in some jurisdictions (e.g. regulations on money laundering and countering the financing of terrorism) which are not analysed in this paper.

the potential adoption of rCBDCs is scant, but is growing in scope and extent. However, it generally focuses on a given aspect of adoption or on a certain geographical region. Our paper aims to systematically explore several aspects of rCBDC adoption by surveying the literature available, in particular with respect to the conditions necessary for adoption and the main obstacles encountered by previous failed rCBDC initiatives. To this end, the following topics are addressed: (i) central banks' stated main goals for rCBDC and the design requirements to achieve these goals (Section 2); (ii) the key elements of the adoption of new means of payment, including the models for the diffusion of new payment technologies, as well as the observed preferences and behaviour of consumers and retailers (Section 3); and (iii) a discussion of lessons learnt in terms of potential obstacles to adoption that can be extracted from past and ongoing rCBDC initiatives (Section 4). Finally, Section 5 provides the conclusions.

2 Current discussion of rCBDCs: an overview

The majority of central banks are exploring the idea of issuing a digital currency usable in retail payments, also known as an rCBDC. According to a recent survey covering 81 central banks, which represent 94% of global economic output (Kosse and Mattei, 2022), 90% of central banks surveyed were actively engaged in some form of work relating to rCBDCs. Current discussions mainly revolve around central banks' reasons for issuing an rCBDC – that is to say, how rCBDCs can contribute to achieving central banks' goals – and around the design features that would be needed to fulfil central bank objectives. In addition, the growing academic literature on rCBDCs has been analysing the economic impact of different design choices (see, for example, Auer et al., 2022).

Academic and policy debate mainly focuses on policy-related reasons for issuing rCBDCs and on analysing their economic implications; less attention has been given to the design choices that would ensure their wide adoption. Section 2.1 provides an overview of central banks' main policy goals as regards rCBDCs, as well as the design requirements that rCBDCs would have to exhibit to fulfil them.

2.1 Central banks' main goals and motives for issuing rCBDCs

With regard to the introduction of an rCBDC, most central banks' strategic goals relate to enhancing performance in four main areas: (i) payments markets, (ii) financial stability, (iii) monetary policy, and (iv) financial inclusion[2]. For each of these four main areas, different design options are being considered with a view to formulating clearly specified policy objectives. Each central bank's hierarchy of policy goals – that is to say the relative importance of the policy goals – depends on its individual strategies and its local country or currency-related circumstances. The relative importance of these goals has varied over time (Kosse and Mattei, 2022). Also, central banks' motives in advanced economies differ from those in emerging markets and developing economies. In this regard, in advanced economies, improvements in payment markets (such as enhanced payment safety) are found to be a major driver for introducing an rCBDC. Conversely, the average importance of monetary policy as a motive has decreased over time in those same

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[2] See Barontini and Holden, 2019; Boar et al., 2020; Boar and Wehrli, 2021; Kosse and Mattei, 2022, and the reports published by Bank of Canada et al., 2020; European Central Bank, 2020a; Bank of England, 2020; Bank of Canada et al., 2021a; Board of Governors of the Federal Reserve System, 2022. Some policy objectives may not be strictly related to these four themes (e.g. facilitating fiscal transfers, preserving seigniorage income, or contributing to central banks' reputational management). However, the themes broadly cover most policy proposals and motives for the introduction of rCBDCs.

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? – Current discussion of rCBDCs: an overview

6

economies (Kosse and Mattei, 2022). In emerging economies, however, central banks generally attach more importance to financial inclusion.

1. **Improvements in the functioning of payments markets.** Recent surveys of central banks (Boar and Wehrli, 2021; Kosse and Mattei, 2022) find that rCBDCs may facilitate certain improvements in the functioning of payments markets, including:

    (a) **Payment safety and robustness:** according to the Bank of Canada (2020), digital banknotes would allow households and businesses accessing risk-free money through central banks and improve operational resilience through, for example, offline capabilities.

    (b) **Domestic payment efficiency:** some authors consider that rCBDCs could improve domestic payment efficiency by increasing competition and fostering innovation in payments markets (Ponce, 2020; Usher et al., 2021).[3]

    (c) **Payment efficiency in cross-border environments:** fragmentation in payment systems currently generates frictions in cross-border payments, which are therefore often costly and slow and lack wide accessibility, adequate traceability and transparency (Auer et al., 2022). A survey of central banks shows that a quarter of them are thinking of introducing a CBDC with interoperable features to reduce these frictions (Auer et al., 2021).

    (d) **Other payment-related considerations:** for example, the decreasing use of cash (Bank of Canada et al., 2020; European Central Bank, 2020a; Bank of England, 2020; Board of Governors of the Federal Reserve System, 2022) or the economic consequences of potential widespread adoption of private digital currencies.

2. **Financial stability.** Central banks see financial stability as one of the main reasons for issuing rCBDCs (Kosse and Mattei, 2022).[4] The following key topics in this regard were found in the literature examined.

    (a) **Positive impact of rCBDCs on financial stability:** the research suggests that a digital, risk-free, and government-issued instrument might improve the stability of the financial system (Auer et al., 2022). Some authors suggest that the introduction of an rCBDC could reduce fragility in the financial system by sounding an alert where there is a risk of bank runs (Keister and Monnet, 2022) or reducing the impact of any such runs (Williamson 2022), thus protecting deposits against forced liquidation (Fernández-Villaverde et al., 2021), easing liquidity pressures (Mancini-

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[3]   More generally, researchers also suggest that introducing an rCBDC could bring efficiency gains, depending on the structure of the banking sector (Chiu et al., 2019; Keister and Sanches, 2021; Andolfatto, 2021), or could modify the banking structure itself (Garratt and Zhu, 2021).

[4]   Over time, this motive has become more important in the central banks of emerging and developing economies, according to Boar and Wehrli, 2021.

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? –
Current discussion of rCBDCs: an overview

7

Griffoli et al., 2018) or reducing liquidity and solvency risks (Stevens et al., 2017).

(b) **Adverse impact of rCBDCs on financial stability:** a much-discussed issue is the potential adverse impact on financial stability if an rCBDC had certain design features (e.g. similarity with bank deposits and positive remuneration) (Bank of Canada et al., 2020). Engert and Fung (2017) assert that the main advantage of rCBDCs over bank deposits is their risk-free nature. If interest-bearing status were to be granted, depositors might find rCBDCs more attractive, which could lead to disintermediation and faster bank runs (Committee on Payments and Market Infrastructures and Markets Committee, 2018). In contrast, other authors argue that rCBDCs would be unlikely to change the triggers for bank runs as much as originally argued (Auer et al., 2022).[5]

(c) **Modulation of the effects on financial stability depending on design choice:** central banks would decide the impact of an rCBDC by selecting the design features it exhibits. Some authors suggest possible responses or design choices (for example, limited convertibility or position limits) to avoid adverse consequences (Mancini-Griffoli et al., 2018; Kumhof and Noone, 2018; Bindseil, 2020).

3. **Monetary Policy.** The reasons cited by central banks for issuing an rCBDC include the possibility of equipping themselves with new monetary policy tools. Most policy makers and academics consider that central banks could indeed create an additional monetary policy instrument, for example, by introducing a yield-bearing rCBDC. Among other things, an rCBDC could help in relaxing the zero lower bound constraint (Bordo and Levin, 2017), strengthen the transmission of monetary policy through its direct implementation (Davoodalhosseini, 2021), or improve the allocation of transfers (Davoodalhosseini, 2021). However, discussions of rCBDCs and monetary policy are still at an early stage. Questions remain about the existence and extent of the positive and negative effects for monetary policy objectives of establishing an rCBDC (see, for example, Davoodalhosseini, 2021; Pfister, 2020; Meaning et al., 2018; García et al., 2020; Jiang and Zhu, 2021). In general, central banks have not reached any major decisions on the use of rCBDCs to enhance monetary policy (for example, to the best of our knowledge no trials launching remunerated rCBDCs have been conducted).

4. **Financial inclusion.** Some central banks aim to use rCBDCs to ensure continued access to electronic payments and central bank money (Kosse and Mattei, 2022). In developing economies, structural deficiencies often reduce access to formal financial services (transactions, payments, savings, credit and insurance). In advanced economies, where access to electronic media is more widespread, the increase in digitalisation can lead to a digital divide between sectors of the population (Bank of Canada et al., 2020). Central banks aim to

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[5] The above description of the effects of rCBDCs on financial stability is not exhaustive. For further theoretical work on this matter (see Brunnermeier and Niepelt, 2019; Skeie, 2020; Schilling et al., 2020; Niepelt, 2020; Fernández-Villaverde et al., 2021; Williamson, 2021 and Williamson, 2022).

provide universal access to a simple, reliable, risk-free and flexible electronic means of payment, especially if its design features replicate or outperform certain cash-like features (Committee on Payments and Market Infrastructures and World Bank Group, 2020). In this regard, in countries where cash use is declining and cash has become increasingly marginalised (for example, Sweden), central banks argue that rCBDCs could serve as a means for the general public to access central bank money (Sveriges Riksbank, 2020b). However, the effectiveness of the use of rCBDCs for financial inclusion objectives would vary depending on the local causes of exclusion (Bank of Canada et al., 2020) and other solutions might be more efficient, for example access-to-cash policies where cash is difficult to obtain and use (Mancini-Griffoli et al., 2018; Zamora-Pérez, 2022).

The design features of any rCBDCs and their implementation will partly depend on the motives set out above. However, the research points to the sometimes-difficult interaction and potential trade-offs between achieving a given goal and the potentially adverse economic impact of the features themselves. Table 1 provides a non-exhaustive list of correspondences between policy goals and the design features that rCBDCs should aim for and exhibit, as reported in selected surveys and reports. As the table shows, design requirements come with different degrees of specificity, ranging from very vague adjectives describing their design objectives (such as "efficient" or "competitive") to concrete design features or functionalities (such as "remuneration" or "offline functionalities"). An important aspect not shown in Table 1 is the interaction between some of the goals and design requirements, which are sometimes subject to trade-offs as discussed above. For example, the adverse impact of a possible set of rCBDC features (for example, remuneration to facilitate monetary policy objectives) may give rise to new requirements (for example, holding limits to avoid bank disintermediation). Moreover, some of the technologically feasible design alternatives might exhibit a given feature (for example, anonymity or a high level of privacy) but the rCBDC itself would need to adhere to money laundering and terrorism financing requirements. In certain jurisdictions this would therefore exclude certain of the available options from the set of possible design choices. In this regard, the Bank of International Settlements, together with a group of central banks in advanced economies, have identified three foundational principles that should be observed in deciding the design of rCBDCs (Bank of Canada et al., 2020). Two of these principles are the necessity to "do no harm" and the need to achieve stable coexistence with private money (for example, commercial bank accounts) and other forms of central bank monies (for example, cash).

Table 1

Central banks' main policy motives for issuing rCBDCs and the design requirements for rCBDCs to partly fulfil each motive

MAIN POLICY MOTIVES	DESIGN REQUIREMENTS
(i) Payments markets	
Improve payment safety and robustness	Digital, innovative, competitive, robust/resilient, safe, cyber-resilient, offline capabilities, back-up system, user access requirements
Improve domestic payments efficiency	Competitive, convenient, low-cost, fast, flexible/adaptable
Improve cross-border payments efficiency	Competitive, low-cost, allowing international use, ease of access for tourists, geolocation possibilities, geo-limits, user access requirements
Prevent any negative consequences of the adoption of digital private currencies	Competitive features, low cost
(ii) Financial stability	
Strengthen financial stability	Risk-free, digital (e.g. improving information available to central banks on potential bank runs)
Avoid financial instability	Limits to holding rCBDC, limits to convertibility
(iii) Monetary policy	
Use of rCBDC as a monetary policy tool (e.g. interest rate channel)	Remuneration, universal access for the public
(iv) Financial inclusion	
Increase access to digital payments and central bank money	Universal access, physical support, ease of use, no need for a bank account, low cost for end users

Sources: Barontini and Holden (2019), Boar et al. (2020), Kosse and Mattei (2022), Bank of Canada et al. (2020), European Central Bank (2020a), Bank of England (2020), Board of Governors of the Federal Reserve System (2022).

A less explored constraint to achieving policy goals is the intended degree of adoption of each rCBDC, which would partly determine its design features.
Most studies assume that rCBDCs will attract sufficient demand to ensure that central banks' policy goals are achievable. It has been argued that a real risk exists of some rCBDC implementations actually failing as a result of their own success (that is to say that rCBDCs could become so attractive to consumers that they could significantly displace the private sector, especially if they take the form of accounts similar to, but less risky than, accounts with commercial banks). However, the most popular uses for rCBDCs would seem to be as a new means of physical payment (for example, point-of-sale (POS) and person-to-person transactions) or remote payment (for example, for online commerce or recurrent payments, such as bill payments). In the case of retail payments, central banks and rCBDCs would be targeting market shares already occupied by existing products. Hence, they would need to address the question of whether the design requirements to achieve their policy goals (as exemplified in Table 1) also fulfil the conditions for a new means of payment to be adopted and could attain the desired market share in the payments market. These considerations seem to be in line with a recent report by a group of advanced economy central banks led by the Bank of International Settlements. The report discusses initial guidelines for potential adoption, but shows that discussions are at a very early stage (Bank of Canada et al., 2021b). Some authors who are aware of the importance of adoption have argued that rCBDCs should be widely adopted and accepted but with steps being taken to ensure that they do not become so widespread that they crowd out private solutions (Bindseil et al., 2021; Brunnermeier and Landau, 2022; Ahnert et al., 2022). In any case, a consensus

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? –
Current discussion of rCBDCs: an overview

10

seems to be growing among central banks in some regions that the focus must be on users' needs and that a certain level of adoption needs to be achieved (Panetta, 2022; Balz, 2022). In the following section we survey the main trends in retail payment markets, as well as the conditions that must be fulfilled to ensure the widespread adoption and use of any new means of payment.

3 What do consumers want from a new means of payment? Major trends in retail payments markets, and choice and adoption determinants

As seen in the previous section, ongoing discussions of rCBDCs by central banks and academics are not, for the most part, focused on their widespread adoption as a means of payment. In general, widespread adoption is either not mentioned at all, being taken as a given, or, in the few cases where the importance of adoption for the success of an rCBDC is mentioned, not thoroughly analysed. An early example of the latter is given in Mancini-Griffoli et al. (2018), which looks at the criteria applied by users in judging different forms of money. They argue that users need a form of money that can maximise private benefits (for example, by facilitating payments on demand of any size and with no limits or acceptance restrictions) and minimise the associated costs (for example, by applying lower fees). Auer and Böhme (2020) remark that rCBDC design would have to match consumers' needs but do not describe these needs in detail. Examples provided by the authors include universal accessibility and ease of use, together with assured transaction privacy. Bindseil et al. (2021) suggest that the three key factors contributing to the success of an rCBDC are: (i) merchants' acceptance, (ii) the support of intermediaries in distribution of the rCBDC, and (iii) an attractive value proposition for individuals and merchants. Recently, Bank of Canada et al. (2021b) outlined several considerations of importance to the adoption of rCBDCs, but the discussions are at a preliminary stage. Khiaonarong and Humphrey (2022) argue that, to ensure wide adoption and use, central banks will likely design rCBDCs by replicating some of the benefits of existing cash substitutes (for example, convenience, transaction speed, fraud control, etc.) and by including additional benefits, such as lower transaction fees.

Only a small, albeit growing, number of empirical papers have analysed the factors that facilitate adoption, but vary in terms of the methodology adopted and the local nature of the data used. Using Canadian survey data, Huynh et al. (2020) suggest that central banks could increase customer acceptance by developing designs exhibiting features that were relevant for payment choice. The factors that they found to be vital to adoption success were (in order of importance) transaction costs, followed by consumers' expectations in terms of ease of use, availability, and security. Li (2021) predicts household demand for rCBDCs. By modelling rCBDCs and close substitutes, as product bundles of different attributes, using Canadian survey data, the author shows that demand for rCBDCs could vary considerably depending on different design attributes, such as budgeting usefulness, the degree of anonymity, the rate of return and the bundling of bank services. Using a panel of Dutch consumers, Bijlsma et al. (2021) found that consumers perceive rCBDCs as distinct from current and savings accounts already offered by commercial banks. The higher the trust in banks in general, the greater the

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? – What do consumers want from a new means of payment? Major trends in retail payments markets, and choice and adoption determinants

12

willingness to adopt an rCBDC. The need for privacy and protection was also found to be significant. The study's results further suggested that a successful rCBDC design should include interest rates on rCBDCs, given that consumer adoption was found to be dependent on price incentives. A survey run by Deutsche Bundesbank (2021) used a representative survey and conducted qualitative research interviews of German consumers to investigate users' perceptions of a digital euro (that is to say, the Eurosystem's CBDC project[6]). The results showed that consumers would like a free-of-charge rCBDC that ensures a high degree of privacy. The survey also found that cash payers tended to have a more negative attitude towards a digital euro, but that people who had heard of the digital euro and those who were more familiar with digital payments tended to have a more favourable view of the issuance of an rCBDC. More recently, Kantar Public (2022) presents the results of a qualitative survey of individuals and merchants in the euro area. The study provides a comprehensive qualitative analysis of the attributes of any new means of payment that euro area consumers and merchants would value. The respondents were also asked about their knowledge and understanding of the digital euro, as well as their perceptions of its backing by central banks.

Research efforts to extend the empirical literature referred to above are of paramount importance, but more comprehensive investigation of local retail payments markets and exploration of the other strands of literature are equally important to attain the desired level of rCBDC adoption. The literature discussed above provides valuable insights into several dimensions of rCBDC adoption, but other dimensions should also be considered in judging possible rCBDC designs. Works basing their conclusions with respect to rCBDCs on consumer preferences for existing means of payment fail to address a considerable number of adoption obstacles in the early stages of new means of payment (see, for example, the failed means of payment cases discussed in Jiang (2020) or, for an rCBDC example, Grym (2020)). Similarly, surveys on early perceptions of rCBDCs may have low predictive value in terms of consumer behaviour. As the research shows, for well-established means of payment that consumers know well (such as cards and cash), self-reported preferences diverge from actual use (European Central Bank, 2020b; van der Cruijsen et al., 2017). Arguably, the gap between stated preferences and actual behaviour may be wider for a means of payment that is still at the discussion phase and whose final features are, necessarily, not known to consumers. Finally, as payment choice preferences and behaviour may vary significantly between countries (Bagnall et al., 2016), data specific to any given country might not be valid for others.

A systematic discussion of the key factors for potential rCBDC adoption is therefore absent from the academic and policy literature. If we consider the limited available data in most jurisdictions as well as the uncertainty about the design alternatives, it is difficult to forecast the likely levels of adoption.[7] However, it is

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[6] The results of a public consultation on the digital euro project were published in European Central Bank, 2021, signalling the Eurosystem's intention to focus on consumers' needs. Although participation was voluntary and the results were not therefore representative, participants reported that privacy, security, usability throughout the euro area, the absence of additional costs and offline usability would be the most important features for a digital euro.

[7] Adalid et al. (2022) discuss the different approaches to estimating the potential demand for CBDCs, but assert that these approaches are sensitive to key design choices.

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? –
What do consumers want from a new means of payment? Major trends in retail payments
markets, and choice and adoption determinants

13

important to identify the main determinants for the adoption of rCBDCs across jurisdictions. This section provides a discussion, organised around four aspects: (i) identifying the most notable trends in the retail payments markets to assess their competitiveness and innovation capacity, (ii) identifying research that explains the factors facilitating (or hindering) the diffusion of new mobile technologies and their application to retail payment markets, (iii) outlining the attributes identified in the literature as affecting payment method decisions, and (iv) describing the importance of the two-sided nature of the retail payments market.

3.1 Major trends in the retail payments market

The global retail payments market has been characterised in recent years by intense innovation and changing consumer habits, followed by gradual but steady changes in the use of payment instruments and the choice of payment channels. The most notable recent trends – now strongly accelerated by the COVID-19 pandemic – are as follows: i) the shift from in-store shopping to e-commerce, ii) the increasing adoption of contactless payments and digital wallets, iii) the displacement of cash transactions, and iv) the rapid rise, in some regions, of instant payments (Boston Consulting Group, 2020; McKinsey & Company, 2020; Boston Consulting Group, 2021; Capgemini, 2022). Other methods are also being increasingly used, such as quick response (QR) code-based mobile payments and invisible payments[8]. It is estimated that next-gen payments will be the major driver of the new payments mix; according to some forecasts, instant payments and e-money payments will account for over 25% of cashless transactions by 2025 (Capgemini, 2022). A likely scenario in a more distant future is that stablecoins will have a significant impact on the global retail payments market (ECB Crypto-Assets Task Force, 2020).

These changes are the result of technological and business innovations in a context of fierce and increasing competition. Technological innovations are taking place in several dimensions of the retail payments markets. Innovations in front-end devices (for example, cards and smartcards, smartphones, wearables), initiation channels (for example, remote payments or proximity channels, such as near field communication (NFC) or QR code scanning), and back-end payment infrastructures (for example, the development of application programming interfaces (APIs), distributed ledger technology, applications of artificial intelligence and machine learning, the internet of things) all have an impact in the evolving landscape (European Central Bank, 2019). At the same time, new types of competitors are developing applications using these innovations, together with new business models. Newcomer banks and non-traditional (bigtech and fintech) players are progressively crowding the market and challenging incumbent banks and payment service providers, forcing the latter to accelerate the pace of innovation (Boston Consulting

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[8]   An example of an invisible payment is where consumers pay for the services of ride-hailing companies (such as Uber), with the transaction being charged to them without further interaction.

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? – What do consumers want from a new means of payment? Major trends in retail payments markets, and choice and adoption determinants

14

Group, 2020; Capgemini Research Institute, 2020; Boston Consulting Group, 2021[9]). This, in turn, has led to a need for strategic alliances and mergers and acquisitions between different players. Regulators in some regions have further encouraged competition and innovation by establishing a framework for open banking[10] that may lead to more effective collaboration among industry players and contribute to expansion of the suite of payment methods (Capgemini, 2020).

Amid increasing demand for security and privacy, both governments and the industry have been detecting and tackling the main vulnerabilities of payment innovations. As data privacy and security awareness grows, it is becoming increasingly important for industry players to instil trust in payments.[11] A recent survey on data privacy found that one in three United States citizens has been exposed to data compromises, and almost half of consumers report having little to no control over their data (Sides et al., 2019). Another survey shows that 30% of banking consumers claim that payment data usage is "an invasion of privacy that should be prohibited" (A.T. Kearney, 2019). Regulators have therefore been addressing data privacy and protection issues, together with other payments-related vulnerabilities such as money laundering and terrorism financing, through digital ID solutions (Capgemini, 2020; Capgemini, 2022).[12] In any event, ensuring complete consumer trust might be hard to achieve. According to a US-based survey, only 25% of consumers are very or extremely confident about United States regulations protecting personal data privacy and security (A.T. Kearney, 2019). Hence the industry will have to innovate to find better ways to address the trade-off between increased consumer privacy to generate trust and the use and sharing of consumers' data for commercial purposes. In this regard, the extent to which cryptocurrencies and blockchain technology might play an important role in the future by finding a niche among segments concerned with privacy is as yet unknown.

Alongside the race in the private sector to improve users' experience, the share of non-cash payments has increased in recent years. For payment instrument providers to succeed, securing top-of-wallet status[13] is imperative given that consumers typically use only a few payment instruments (Bagnall et al., 2016; McKinsey & Company, 2019; Boston Consulting Group, 2020). To achieve this, they have adopted a number of strategies to make cashless means of payment more convenient, simpler, and based on consumers' profiles. At the same time, survey evidence suggests that the share of cash payments in major geographical regions has decreased over recent years, and more markedly during the COVID-19 pandemic (see, for example, Coyle et al., 2021; Tamele et al., 2021). This decline in

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[9] One survey found that 30% of consumers claimed that they used a bigtech company for payment services and 50% are using challenger banks for some payments. During the pandemic lockdown (from April 2020) 38% of consumers discovered new payment providers.

[10] A notable case is the European Union through the revised Payments Service Directive (PSD2).

[11] Or, alternatively, offer some form of compensation in exchange for personal data (A.T. Kearney, 2019; Martin et al., 2020).

[12] Despite the perceived need for new legal frameworks, some argue that regulation and compliance might generate increased costs to meet new requirements and that this would drive a shift of resources away from the development of new solutions (BNY Mellon, 2014). Against this background, the industry is increasingly outsourcing compliance with data-related regulations to specialist firms (Capgemini, 2020).

[13] That is, ensuring that the payment instrument they offer is the first seen and used by consumers when they open their wallet.

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? – What do consumers want from a new means of payment? Major trends in retail payments markets, and choice and adoption determinants

15

the transactional use of cash is a result of increased acceptance and use of non-cash means of payment (Fung et al., 2012; Huynh et al., 2014; Arango-Arango and Suárez-Ariza, 2020; Brown et al., 2020).

However, overall demand for cash has not decreased globally. On the contrary, despite the growing adoption of payment innovations, major currencies have experienced a continuous growth of cash in circulation (Jobst and Stix, 2017; Bech et al., 2018; Ashworth and Goodhart, 2021; Zamora-Pérez, 2021). Indeed, the increase in non-cash payment usage seems to have no or little effect on total banknote demand (Bech et al., 2018; Brown et al., 2020). This is usually attributed to increased store-of-value demand as a result of low interest rates, increased uncertainty and other factors, such as the ageing of the population. For currencies with a strong international role, a significant share of cash in circulation can also be explained by demand from abroad (Judson, 2017; Lalouette et al., 2021). Although this may change in the future, some commentators note that countries with decreasing cash in circulation in recent years, such as Sweden, might be outliers rather than front-runners in the much-announced global trend towards a less-cash society (Armelius et al., 2020).

3.2   Technology adoption: insights from the literature

In designing digital currencies, central banks can tap into the findings of a wealth of research investigating the factors influencing the adoption of innovations in competitive markets. The technology acceptance model (TAM), originally applied to information technology in Davis (1989), is that most widely used to model how users come to adopt, and subsequently use, a new technology. Of the many reasons explaining the use of a technology, perceived usefulness and ease of use are found to be the most important. Perceived usefulness is usually defined as the degree to which users believe a technology will improve the performance of a task it aims to support. Perceived ease of use is the degree to which the consumer feels that using the technology would require little to no effort. Venkatesh and Davis (2000) extended this model by showing how perceived usefulness depends on social influence. This implies that influence by other people (subjective norms) or a perceived gain in social status after usage (image) also affect adoption decisions. Usefulness, and hence user acceptance, are also influenced by cognitive processes, such as comparability tests, that eliminate innovations unsuited to performing the job at hand (job relevance) and perceptions of tangible results from using the innovation (result demonstrability). The literature has further expanded the TAM to include other attributes, such as behavioural traits (Venkatesh et al., 2003).

More recently, the TAM and its extensions have been applied to innovations in mobile technologies (in particular, mobile payments) and e-commerce. Mobile technologies are two-way pagers, that is to say, wireless telecommunications devices, such as smartphones and tablets, that receive and display text or voice messages. Mobile payments involving the exchange of purchase and payment information through wireless means (such as short message services, NFC, QR codes, mobile digital wallets, etc.) are among the capabilities of these technologies.

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? –
What do consumers want from a new means of payment? Major trends in retail payments
markets, and choice and adoption determinants   16

The diffusion of these innovations and their adoption by consumers, although now increasing, got off to a slow start (Chandra et al., 2010; Schierz et al., 2010). The TAM, in conjunction with the innovation diffusion theory, have been applied to investigate which factors are behind the slow initial adoption of mobile payments.[14] Once again, the factors influencing the behavioural intention to use these technologies in the early stages of adoption are, generally, perceived ease of use and perceived usefulness (Kim et al., 2010). Other predictors of adoption are trust (Gao and Waechter, 2017; Chandra et al., 2010) and factors such as compatibility with existing behaviours and experiences, the degree to which an individual pursues, or is capable of pursuing, a mobile lifestyle, and a social environment perceiving mobile payments as desirable (Schierz et al., 2010; Oliveira et al., 2016). Some barriers to mobile payment adoption are also identified, such as premium pricing, complex payment procedures, a lack of widespread merchant acceptance, and perceived security risks (Mallat, 2007; Arvidsson, 2014). Finally, the adoption of initiation channel innovations, such as NFC and QR code mobile payments (Liébana-Cabanillas et al., 2015) or e-commerce (Pavlou, 2003), have also been studied by using and extending the scope of the TAM.

As with mobile payments, the initial diffusion and adoption of rCBDC payments might face obstacles, unless these are identified and addressed in the conception and initial design stages. Davis and Venkatesh (2004) find that predicting the measure of user acceptance during the very early stages of the design process is viable through prototype testing. Using the TAM as the theoretical lens, their experiment-based findings show that perceived ease of use can be predicted by direct hands-on usage data provided by consumers actually interacting with the system. However, perceived usefulness can be more simply predicted by giving users access to information about the system's functionality, even if they do not have hands-on experience of its use. Non-interactive prototypes that only outline system features are therefore sufficient to allow users to form accurate perceptions of the future usefulness of the system. Prototype testing can be essential in reducing operational blindness and cutting costs, as less than 25% of the total costs of a new project would have been incurred by the time that the functionalities are specified. Thanks to the feedback obtained through testing, if the prototype does not fulfil users' needs and the project is dropped, 75% of the total costs can be saved (Davis and Venkatesh, 2004).

3.3 Payment instrument attributes and other determinants affecting payment choice

The design of rCBDCs and implementation of their roll-out could also benefit from research on the determinants affecting payment choice. Once payment instruments have been adopted and usage reaches a critical mass, decisions by consumers to use any one instrument (such as cash, cards or another instrument) are based on multiple determinants. The work undertaken by Huynh et al. (2020) and Li (2021) that is summarised above provides valuable examples of how to use

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[14]   For factors determining continued issuance (post-adoption), see Zhou (2014).

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? – What do consumers want from a new means of payment? Major trends in retail payments markets, and choice and adoption determinants

17

survey data on preferences for certain attributes of existing means of payment to extract useful conclusions for rCBDC design. This subsection therefore surveys the main factors that, according to the literature in different countries, critically affect payment choice, including payment instrument attributes and circumstantial determinants. A ranking of these different factors cannot be extracted easily from the literature, given the different survey designs, consumers' preferences, which vary depending on the region analysed, and the research methodologies used.

The literature uses consumer survey data to identify the key attributes of payment instruments that influence consumers' decisions to pay with cash, cards, or other instruments. The attributes most often analysed in this literature are as follows:

- **Costs** are among the most important factors determining payment choice. They include surcharge fees, penalties, postage and interest (Koulayev et al., 2016). For example, consumers respond negatively to fees levied on debit card transactions (Borzekowski et al., 2008).

- **Benefits and rewards**, such as "miles" or "points", are found to have a positive effect on the use of payment methods (Esselink and Hernández, 2017). Nonetheless, reducing benefits on credit or debit cards does not seem to significantly change their usage (Ching and Hayashi, 2010).

- **Ease of use** generally refers to the convenience of a payment instrument at the time of the transaction, that is to say time spent in remembering a PIN, signing for transactions or making a change in the event of mistake (Arango et al., 2015b). As with initial adoption, there is evidence that the perceived ease of use of one payment instrument compared with another is strongly and positively correlated with the adoption and usage of that payment instrument (Bagnall et al., 2016).

- **Transaction speed** is the length of time between a transaction and confirmation that it has been successful (Schuh and Stavins, 2016). It has been found that speed at checkout positively influences payment instrument choice and adoption by consumers, given that some payment methods require more time for a transaction to be completed (Arango et al., 2015b).

- **Privacy** is linked to a reduced risk of consumers' personal information being obtained by third parties without their consent. Lack of privacy of payment instruments has a negative effect on usage (Schuh and Stavins, 2016).

- **Security** is related to the risk of theft or the fear of losing money. Overall, while security risks have a negative effect on some payment options, their effect on choice and usage is less than for other attributes (Koulayev et al., 2016).

- **Budgeting usefulness**, or features of payment instruments that allow households to track their expenses and set payment constraints (for example, establishing a budget), provides utility to consumers and helps them to reduce overspending (von Kalckreuth et al., 2014; Hernández et al., 2017). Some payments might be more transparent than others, thus making it easier to

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? –
What do consumers want from a new means of payment? Major trends in retail payments
markets, and choice and adoption determinants

18

control spending. For example, Esselink and Hernández (2017) show that consumers' preference for cash is affected by the need to have a clear overview of expenses. This characteristic has been found to positively affect payment choice (Runnemark et al., 2015).

Circumstantial determinants, and not just the concrete features of a payment instrument, also affect payment choice. These determinants vary widely given that they may relate to a given situation and the characteristics of a transaction, the state of development of the retail payments sector, the individual's payment habits, or society's norms. The most notable of these factors are set out below.

- **Transaction size** is sometimes expressed as the price of the transaction plus its square value (Bounie and François, 2008). The consensus in the literature is that the use of cash decreases as transaction size increases (Bounie and François, 2008; Bagnall et al., 2016; Wang and Wolman, 2016; Wakamori and Welte, 2017).

- **Point of sale (POS) location** influences the use of different means of payment. It has been shown that the share of different payment instruments varies depending on the transaction venue (for example, grocery stores, gas stations, semi-durable goods outlets, services or entertainment venues) (Bagnall et al., 2016; European Central Bank, 2020b). For example, whereas the probability of cash being used in small stores is higher than for bank cards, the probability of cheques and cards being used is always higher than for cash in other points of sale (Bounie and François, 2008).

- **Cash-first rule** means the increased likelihood of cash being used for transactions when the amount of cash held is higher (Bagnall et al., 2016; Arango et al., 2015a; Arango et al., 2015b), that is to say, consumers who carry more cash have a higher propensity to use it for transactions.

- **Perceived acceptance** means people's perception of whether the merchant accepts the relevant means of payment, for example whether cards and other non-cash means of payment are accepted or a cash-only policy applies (European Central Bank, 2020b). The literature suggests that higher cash usage is associated with lower levels of perceived card acceptance at the POS (Bagnall et al., 2016; Wakamori and Welte, 2017). Consumers' preference for a payment instrument may, in turn, drive merchant acceptance (Bounie et al., 2017).

- **Habit stickiness** can be defined as a customer's long-term use of a payment instrument (von Kalckreuth et al., 2014). Habits explain the choice of payment instrument and may play a significant role in explaining the discrepancy between how consumers prefer to pay and how they actually pay (van der Cruijsen et al., 2017).

- **Social norms** can be classified as injunctive norms, that is to say, people's perception of what behaviour others expect of them, and descriptive norms, that is to say perceptions of the behaviour of other people. The stronger a person's

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? –
What do consumers want from a new means of payment? Major trends in retail payments
markets, and choice and adoption determinants

19

perception that other people use a payment instrument, the greater the likelihood that this person will also use that payment instrument (van der Cruijsen and van der Horst, 2019).

3.4 The two-sided nature of retail payment markets and legal tender status: implications for adoption

As some retail payment systems are two-sided markets, it is likely that rCBDC adoption will also depend strongly on merchant acceptance.[15] For instance, a successful payment card requires both consumer usage and merchant acceptance, with its value to consumers depending on the number of merchants who accept card payments, and its value to merchants depending on the number of customers who use them (McAndrews and Wang, 2012).

Perceived acceptance by merchants is found to play an important role in the continued use of cash as a payment method. Arango et al. (2015b) show that introducing rewards on credit cards leads to a decrease in cash usage. However, after controlling for merchant's acceptance and for endogeneity, consumers are found to continue to use cash in many transactions because of its non-pecuniary benefits, such as ease of use, speed of transacting, and anonymity. This last factor partly explains why merchants do not universally accept payment cards and sheds light on two-sided market interactions. Huynh et al. (2019) estimated network effects by considering the response of one side of the market to changes in costs on the other side. Their analysis of the equilibrium usage probabilities suggests that network effects originating from the consumer side of the market are stronger than those originating from the merchant side. This implies that the best strategy to influence equilibrium usage probabilities is to devise consumer-centric policies.

Another possible strategy to increase merchant acceptance is to confer legal tender status on rCBDCs, although, in general, the effects of this measure have not been thoroughly assessed in the literature. Rather than measures designed to appeal consumers and merchants, some jurisdictions might opt to grant legal tender status to rCBDCs (Committee on Payments and Market Infrastructures and Markets Committee, 2018).[16] However, there has been little discussion of this option (one exception is Bindseil et al., 2021). Related academic discussions do not generally focus on the introduction of new payment instruments denominated in an existing currency (for example, introducing digital money alongside cash), but on the

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[15] A two-sided market is defined as two sets of agents interacting through a platform or intermediary in which the decision of one agent affects the outcome of the other through externalities (Rysman, 2009). The interactions between the parties give rise to a chicken-egg problem where "to attract buyers, an intermediary should have a large base of registered sellers, but these will be willing to register only if they expect many buyers to show up" (Caillaud and Jullien, 2003). Moreover, the utility that a user derives from the consumption of a good depends on the number of other people consuming the good. The pricing policy of the two-sided network thus differs from standard pricing, where marginal revenues are equal to marginal costs. The price for the service should be set at a level which will be distributed between the two sides of the market, depending on the demand elasticity of the two parties. The side of the market with the lowest price elasticity of demand should potentially bear more costs.

[16] The definition of legal tender varies across legal systems. The traditional definition is that a currency that is legal tender is that accepted by a creditor in payment of a debt. In its strictest definitions, it would involve obliging merchants or other intermediaries to accept rCBDCs for payments.

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? –
What do consumers want from a new means of payment? Major trends in retail payments
markets, and choice and adoption determinants

20

introduction of new currencies. However, some findings may be relevant for rCBDCs. For example, monetary history shows that legal tender laws may not be sufficient to guarantee the acceptability of a new currency, and that the old currency might continue to circulate where such a law cannot be adequately enforced and the number of people using the new currency is too low (Selgin, 1994; Lotz and Rocheteau, 2002). History also shows cases in which a new payment instrument denominated in an existing legal tender currency failed to be adopted; this was the case with the Susan B. Anthony dollar coin (see Caskey and St. Laurent, 1994). Although these conclusions cannot be directly extrapolated to rCBDCs, this literature shows that further research would be needed to determine to what extent and under what conditions legal tender would increase adoption and what the associated costs would be for private players. For example, the Finish Avant, a digital money issued by the Bank of Finland in the 1990s (see Section 4.1), was not legal tender because it was considered to be unreasonable to oblige merchants or creditors to accept e-money given that they would have to invest in new equipment (Grym, 2020). But the mandatory participation of certain private players to kick-start network effects might be important for the adoption of public payment infrastructures (although not strictly related to rCBDCs, this was seen in the case of the Pix, the Brazilian retail instant payment system (see Duarte et al., 2022)).

3.5 Conclusions: lessons relating to users' needs and rCBDC adoption

Business, economic, and innovation research can help central bankers frame their investigations of rCBDC adoption. The considerations set out in the business reports surveyed and the strands of literature analysed in this section may help in narrowing down the set of feasible design options available to central banks to fulfil their stated policy goals. A set of possible lessons extracted from this section are set out below.

- **In a highly competitive market with an increasing number of players challenging incumbents, central banks would need to enter into appropriate strategic alliances.** Central banks, with no experience in the retail payments markets, are unlikely to succeed alone. They should seek to partner with banks or non-bank players to ensure the success of any rCBDC. One possible way of doing this is to develop a framework through which the private sector could make innovations to improve consumers' experience of rCBDCs (for example, a platform that could also be used by the private sector to develop consumer interfaces, such as mobile apps). Some authors even suggest that there is no need for an rCBDC in current payments markets and that a retail payment system organised, or orchestrated, by the central bank might be a better alternative (Bofinger and Haas, 2020).

- **Central banks should carefully assess the perceived usefulness and ease of use of their product as compared with existing and future products in the market.** Judging from publicly available information (see Table 1 in the previous section), most design requirements discussed by central banks are still

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? – What do consumers want from a new means of payment? Major trends in retail payments markets, and choice and adoption determinants

21

very vague (for example, they use adjectives such as "innovative" or "competitive"). To ensure adoption, there should, at the very least, be a concrete assessment of how the new technology will improve consumers' experience in making retail transactions and the degree of effort they will perceive when using it, which should be little or none. With regard to the more concrete design requirements set out in Table 1, such as the need to exhibit cash-like features or offline functionalities, previous cases of failed means of payment introduced in the market might provide valuable insights. For example, Jiang (2020) discusses how Mondex conducted 50 trials around the world in the early 1990s to test acceptance of a stored-value card aimed at replacing cash. The card had little success given that it did not seem to have clear advantages over cash. Similarly, Grym (2020) discusses how the Finnish rCBDC launched in the 1990s was designed to resemble cash as much as possible, but failed to achieve the expected adoption success (as discussed in detail in Section 4). These considerations may greatly narrow the design options as well as the use cases discussed by central banks to fulfil their stated goals.

- **To increase the likelihood of adoption, rCBDCs should exhibit attributes that have been found to positively influence payment choice, as investigated in the research literature.** To foster adoption success, central banks should aim to achieve top-of-wallet status for any future rCBDC front-end devices. Huynh et al. (2020) and Li (2021) show how certain payment attributes could increase consumers' preference for a given rCBDC. The literature surveyed in this section suggests that the attributes positively affecting payment choice are primarily: a reduced cost to the consumer, benefits and rewards, transaction speed, ease of use, privacy, security (reduced risk of theft or loss of the payment instrument) and budgeting usefulness. These attributes are clearly defined and could help concretise the desired features.

- **As with mobile payments, obstacles might arise in the early stages of the diffusion and adoption of rCBDC payments unless they are addressed at the initial conception and design stages, for example through prototype testing.** The literature exploring the determinants for adoption of an innovation in the early stages, together with success and failure case studies of new means of payment introduced in retail payment markets (see, for example, Amoroso and Magnier-Watanabe, 2012) might provide valuable lessons for central banks that would enable them to mitigate these potential problems. Prototype testing is one possible strategy that might serve as a predictor of perceived usefulness, ensure that costs are reduced and lead to more successful adoption (Davis and Venkatesh, 2004).

- **Initial strategies might focus on concrete uses (store of value or person-to-person transactions) to attract consumers and promote other uses at a later stage (for example, POS transactions).** For instance, and strictly from a users' perspective, it has been argued that the current increase in demand for safe assets (for example, banknotes in circulation) shows that rCBDCs could fulfil a store-of-value function for consumers (Berentsen and Schär, 2018; Bofinger and Haas, 2020, Muñoz and Soons, 2022). Arguably, this could lead to

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? –
What do consumers want from a new means of payment? Major trends in retail payments
markets, and choice and adoption determinants

22

stronger initial adoption of rCBDCs in certain implementations. However, as seen in the previous section, this seems to run counter to the views of some central banks given the increased risks of financial disintermediation. Some middle-ground solutions, such as holding limits, would probably not be attractive to users who have alternative options available that have no limitations. Focusing on just some concrete payment-related use cases could also build inertias that would work against the adoption of other uses at a later stage. Jiang (2020) suggests that enabling rCBDCs for person-to-person transfers could promote their use in person-to-business transactions at a later stage, as happened with successful payment systems such as Swish in Sweden, WeChat in China or Interac e-Transfer in Canada.

- **rCBDC projects should also adapt their design strategies to clear trends observed in the retail payments market, such as increasing privacy and security awareness.** Given that fraud and data breaches are widespread in some regions, consumers are increasingly demanding privacy and security in payments. Central banks could take this opportunity to offer technologies that ensure privacy given that this is likely to generate trust in rCBDCs and has been found to be an important factor in the adoption of innovations (Chandra et al., 2010; Gao and Waechter, 2017). In this regard, current discussions show that central banks are aware of the importance of privacy to consumers and of the necessary balance between providing privacy and ensuring compliance with money laundering and similar requirements. The question will be whether innovations originating in the private sector could outcompete solutions offered by rCBDCs, for example if consumers were to perceive private solutions as being more effective than central bank options at ensuring privacy and security.

- **Central banks should bear in mind that payment choice is also influenced by circumstantial determinants, which could be helpful in finding niches where other payment instruments do not have an existing advantage.** These determinants vary widely given that they tend to be related to the situation and the characteristics of a transaction, the individual's payment habits, or society's norms. They are generally driven by constraints (for example, cards are less widely accepted for small-value payments). For strategic purposes, central banks might want to design rCBDCs in such a way that they overcome these constraints, for example by focusing on certain transaction sizes or greater use in certain physical locations.

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? – What do consumers want from a new means of payment? Major trends in retail payments markets, and choice and adoption determinants

23

4 Lessons from past and ongoing rCBDC initiatives

In addition to the dimensions analysed in the previous section, past and ongoing rCBDC initiatives provide lessons for central banks about potential obstacles to adoption that may be unique to public digital monies. This section describes certain rCBDC and digital public money initiatives. Although small in number and with their own particularities, they could provide additional lessons on potential obstacles to rCBDC adoption, supplementing those extracted in Section 3. To that end, Section 4.1 describes two past retail public digital money initiatives, Section 4.2 analyses the available information on a number of selected rCBDC initiatives, and Section 4.3 extracts lessons from the initiatives described in the previous two points.

4.1 Past rCBDC initiatives: the Finnish "Avant" and the Ecuadorian "Dinero Electrónico"

Valuable lessons can be drawn from what can be considered to be the world's first rCBDC, the Finnish "Avant", launched by the Bank of Finland in the 1990s. According to Grym (2020), the Avant smart card was based on an advanced technology that was ahead of its time, similar to that used by today's debit and credit cards. The design was intended to replicate cash features as far as possible. The idea was to make Avant cards easy to use, widely accepted, anonymous, free of charge, enable offline transactions, efficient and safe. Avant was positioned as a low-value payment card given that no fees were supposed to be charged for payments, unlike debit and credit card transactions. Its issuance cycle was similar to that of the cash cycle. It was expected that reloadable Avant smartcards would replace up to half of coins and small denomination banknote transactions, thereby becoming a dominant payment method for low-value transactions.

We may wonder why Avant, with such superior technology and careful design, did not succeed. A few years after its roll-out, the Bank of Finland sold the Avant technology to commercial banks. However, once debit cards became less expensive and commercial banks adopted smart card technology, the Avant card became obsolete and was subsequently discarded. Grym (2020) explains that even in its infancy the Avant project attracted a degree of distrust on the part of the banking sector which saw the card as a possible competitor to existing instruments. However, both the central bank and the private sector shared the common goal of potentially reducing cash handling costs through the issuance of Avant. Lastly, Avant card usage fees were gradually aligned, in practice, with those of debit cards and demand for it consequently plummeted. This increase in fees arose from the costs of the operating system for reloading cards, which had not been accounted for at Avant's inception. All in all, even though it exhibited cash-like features such as anonymity

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? –
Lessons from past and ongoing rCBDC initiatives

24

and central bank backing (a feature which was not perceptible by the everyday user), Avant did not achieve the goals of replacing demand for cash and reducing cash handling costs.

The Ecuadorian "Dinero Electrónico" (DE) version of electronic money also provides valuable insights into potential obstacles to the adoption of rCBDCs. The DE was a mobile payment system developed under the centralised administration of the Central Bank of Ecuador between 2014 and 2018 (Campuzano Vásquez et al., 2018; Arauz et al., 2021). According to Arauz et al. (2021), it was intended to increase financial inclusion and reduce the need for the central bank to hold and distribute cash (that is to say, US dollar banknotes). Despite considerable effort by the Ecuadorian Government, such as a major information campaign (Campuzano Vásquez et al., 2018) and an incentive programme consisting of a rebate of two percentage points on the VAT applied for DE users, it was eventually discontinued. DE was subject to continuous criticism from the time of its implementation, in particular as a result of (i) the perception that it was not fully backed by cash and hence placed dollarisation at risk, (ii) the fact that it could not be used to make international payments, (iii) its potential to act as a surveillance programme, (iv) strong opposition by cash users, who preferred a more tangible form of money, and (v) the opposition of high-street banks, which saw the DE as a threat to their own payments business (Arauz et al., 2021). Lack of trust in the system seems to have been a crucial factor in the DE's failure (White, 2018). Arauz et al. (2021) point to a number of factors that could have led to a better outcome for the DE. Notably, enabling the banking ecosystem to expand the number of cash-in or loading outlets, using the DE for public-sector expenditure, adequately addressing tensions with the private banking sector and incentivising adoption through a positive starting balance in new accounts.

4.2   Ongoing pilot projects and roll-outs

In the wake of the Avant and DE initiatives, some central banks have rolled out or are conducting pilot projects aimed at the issuance of rCBDCs. Some of these pilot projects are restricted to assessing the technological feasibility of rCBDC implementations and therefore do not provide useful insights into users' perspectives. Other pilot projects and roll-outs consist of deployments of rCBDCs in a real environment, with an open or restricted number of participants depending on the country. However, as central banks issuing rCBDCs or conducting pilots in a real environment have not yet resulted in significant adoption or use data being available, the lessons that can be extracted are limited at present. We have selected five major projects, at different stages of progress, which are described below.

* **People's Bank of China's digital yuan or e-CNY:** in April 2020 the People's Bank of China became the first central bank of a major world economy to roll out a pilot CBDC. At the end of 2020 China began testing the digital yuan in different cities across the country, with users being selected through a lottery. The main stated goal of the e-CNY is to provide a convenient and secure retail payment system to increase financial inclusion and preserve monetary

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? –
Lessons from past and ongoing rCBDC initiatives

25

sovereignty. By the end of 2021, the e-CNY app had 261 million users and had been used in transactions with a value of RMB 87.6 billion (around USD 12.5 billion) (The People's Bank of China, 2022). This implies that each wallet was used for transactions with an average total value of only around RMB 317 (under USD 50). In this regard and based on more comprehensive official data for October 2021, some analysts find that most wallets were empty at that time and not actively used for transactions, the average balance being around RMB 3 (under USD 0.5) (Kumar, 2022).

- **Central Bank of Nigeria's eNaira:** the Central Bank of Nigeria officially launched the "eNaira" on 25 October 2021. The stated objectives are increased financial inclusion, improvement of the payment system, and revenue and tax collection (Central Bank of Nigeria, 2021). Customers will be able to access the eNaira through the eNaira wallet in their phone's app store. Nearly 500,000 people downloaded the digital wallet in the first three weeks following its roll-out (Onu, 2021), with around NGN 62 million (corresponding to approximately EUR 130,000) of this virtual currency being traded since its introduction. In August 2022, Central Bank of Nigeria's Governor stated that the eNaira app had been downloaded about 840,000 times and had about 270,000 active wallets, used to carry out transactions worth NGN 4 billion (under USD 10 million) (Crawley, 2022). This implies that, almost one year after its roll-out, each eNaira wallet was used for transactions of an average total value of under NGN 5000 (around USD 11) and that the wallets are currently actively used by less than 0.15% of Nigerian citizens.

- **Eastern Caribbean Central Bank (ECCB) DCash:** in March 2021 the ECCB launched its DCash CBDC pilot project. The project was set to last for twelve months and to include six ECCB country members.[17] The aim is to achieve deeper financial inclusion, economic growth, resilience and competitiveness (Eastern Caribbean Central Bank, 2021). Although no progress report or adoption and use data have been published, it would seem that DCash experienced major technical difficulties leading to service interruption from January 2022 to March 2021. According to an Eastern Caribbean Central Bank press release, this event serves as a "learning experience" for the entire central bank digital currency community (Eastern Caribbean Central Bank, 2022).

- **Central Bank of the Bahamas (CBOB) Sand Dollar:** the CBOB launched Sand Dollar in October 2020. The intention was that Sand Dollar would resemble the experience and convenience of cash, allowing for reduced service delivery costs, increased transactional efficiency, and an improved overall level of financial inclusion in the country. At present, data on adoption and use is scarce. International Monetary Fund (2022) shows that the Sand Dollar represents less than 0.1 percent of currency in circulation and that there are "limited avenues" for its use. According to this institution, although the Sand Dollar has the potential to foster financial inclusion, continuing efforts are

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17 Anguilla, Antigua and Barbuda, Grenada, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and The Grenadines.

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? –
Lessons from past and ongoing rCBDC initiatives

26

required to strengthen its security and systems resilience and to safeguard financial integrity.

- **Sveriges Riksbank's e-krona:** Sveriges Riksbank's "e-krona" project has completed a pilot stage that was designed to show the technical feasibility of rCBDC implementations and what a future rCBDC could look like (Sveriges Riksbank, 2020b). As cash is currently the only central bank-issued form of money available to the public and its use is declining,[18] Sveriges Riksbank believes that a digital complement to cash would preserve the safety and efficiency of the payment system. Although Sweden is moving forward somewhat faster than other advanced economies with rCBDC projects, no decision has yet been made on the issuance of an rCBDC.

4.3   Conclusions: lessons from past and ongoing rCBDC initiatives

Previous and ongoing initiatives with digital monies issued by central banks can provide lessons about obstacles to adoption. However, there are few such cases and all of them have their national peculiarities, so that any conclusions should be treated with caution. Given the limited adoption and the scant use data available, it is still too early to extract clear lessons from ongoing rCBDC initiatives such as the pilot projects and recent roll-outs. However, early data on wallets and total transaction values (for example, for the e-CNY and eNaira), together with the service interruption experienced by DCash, may suggest that that ongoing rCBDCs initiatives are not without important adoption obstacles or technical challenges. The conclusions that could be extracted from these initiatives are summarised below.

- **Real-world trials provide more valuable lessons than controlled experiments.** Kim and Mohan (2020) believe that projects fully rolled out in real-life situations are more valuable than controlled experiments in gauging the interests and considerations of private-sector and government stakeholders. These aspects have far-reaching consequences that are too complex to be detected even in a highly controlled pilot environment. This seems to be borne out by the examples of the Finish Avant and the Ecuadorian DE, as discussed above. Countries such as China, Nigeria, the Bahamas, and the Eastern Caribbean countries are currently following this real-world trial approach. In this regard, given the complexity of anticipating which design options would work best based on research or expert investigation, or even through controlled pilot projects, some analysts suggest that rCBDCs are characterised by a last-mover rather than first-mover advantage (Koning, 2020).

- **Some of the features assumed by central bankers to be a comparative advantage for rCBDCs may turn out not to be essential for consumers.** In this regard, it would seem that, in some instances, digitally replicated cash-like

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[18]   Based on Sveriges Riksbank statistics, the currency in circulation in Sweden has decreased continuously since 2007. However, in 2018 circulation increased by 7.2%. The annual variation in 2019 and 2020 was 2,1% and -1%, respectively (Sveriges Riksbank, 2020a).

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? – Lessons from past and ongoing rCBDC initiatives

27

features may only have a limited impact on wider adoption, all other adoption factors being equal. Despite the careful design of the Finnish Avant to replicate cash-like features (anonymity, ease of use, offline payments, intended use for low-value payments, a similar issuance cycle, etc.), it did not manage to replace the transactional function of cash or reduce cash handling costs, as it was expected to do. Furthermore, the fact that it was central bank money or central bank-backed was not really perceived by the everyday user (Grym, 2020), which seems to match with the findings of a recent survey (Deutsche Bundesbank, 2021). This should prompt central banks to reassess whether their more concrete design requirements are in line with consumers' expectations (as analysed in Section 3) and, if so, to what extent this advantage can really make a difference as compared with other means of payment.

- **Superior technology does not ensure wider adoption.** Of the design requirements described in Table 1, one that is typically mentioned by central banks is that rCBDCs should be innovative. It might be tempting to interpret this as meaning that they should be technologically superior to other payment systems or devices. In the 1990s Avant cards were based on state-of-the-art technology superior to that of credit and debit cards. However, this did not lead to widespread adoption. Innovativeness should, therefore, always be focused on the subjective perceptions of consumers, for example by increasing the perceived usefulness or perceived ease of use as compared with current payment options.

- **Implementations with an intended zero cost for users may not consider costs occurring at a later stage.** In the Avant case, although the new means of payment was intended to be free of charge for users, the costs of operating the system obliged banks to add fees at a later stage. Today too, commercial banks in some countries are attempting to pass on to consumers the costs related to cash (Zamora-Pérez, 2022), which had been free of charge to users. The assumption that rCBDCs will be of no cost to users just because they are free of charge may therefore be too strong. The costs, or lack of them, may depend on the design of the back-end system and issuance cycle. It is likely that operating and logistical costs will be incurred and central banks will need to decide who should bear those costs (users, private intermediaries or taxpayers).

- **Collaboration and synergies between public authorities and private companies would seem essential if rCBDCs are not to be perceived by the market as a threat.** This lesson is particularly apparent from the – now extinct – Avant and DE initiatives. Commercial banks, other financial institutions and technology partners can contribute with their knowledge to making a success of rCBDCs. In addition, including these players and giving them room to grow within the rCBDC network could stimulate competitiveness and efficiency in the market. In this regard, Kim and Mohan (2020) note that the Bahamas Sand Dollar development team have focused on creating an open front-end rCBDC solution where financial intermediaries can introduce rCBDC-based financial

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? –
Lessons from past and ongoing rCBDC initiatives

28

products and services. In analysing the early lessons of the Sand Dollar project, they highlight the fact that "grassroots engagement is vital".

- **Information campaigns and tax incentives may not make up for a lack of consumer trust in and support for rCBDCs.** The case of Ecuador's DE provides an example of how strong communication initiatives or economic incentives may not be sufficient to counter a lack of trust on the part of the market and the public (White, 2018; Arauz et al., 2021). However, it is difficult to know how to gain consumers' trust and support. It is also difficult to judge, from the available data, the extent to which support for a product (rCBDC) will be influenced by trust in the issuer (central banks), potential intermediaries (commercial banks) or related entities (the government).

Ensuring adoption of central bank digital currencies – An easy task or a Gordian knot? –
Lessons from past and ongoing rCBDC initiatives

29

5 General conclusions: the importance of adoption in the rCBDC design choice conundrum

Central banks intending to introduce an rCBDC face, or are likely to face, a design choice problem where they have to reconcile several dimensions, one of which is achieving the desired level of rCBDC adoption. At the risk of oversimplification, the rCBDC design choice problem faced by central banks can be summarised as follows: how to maximise the effectiveness of the desired and implemented policy goals, subject to certain constraints[19] such as (i) the "do no harm" principle or avoiding negative effects for the economy and (ii) ensuring sufficient adoption and acceptance by consumers and merchants. The hierarchy of policy goals varies among central banks, both over time and as a result of local specificities. However, irrespective of this hierarchy, central banks would need to investigate how to achieve the desired level of adoption of their rCBDC by consumers and merchants. This paper shows that, as opposed to the other constraint, namely the potential adverse economic impact of rCBDC issuance, rCBDC adoption has not yet attracted sufficient attention in public debate nor among researchers, with only a few published works contributing to the public discussion thus far. In many research papers and policy reports, adoption is taken as a given. The purpose of this paper is to discuss whether this assumption holds true by investigating the necessary, though not yet sufficient, elements to be adopted in rCBDC designs and to outline some of the adoption obstacles faced by previous means of payment or rCBDC initiatives.

The paper suggests that for certain design elements central banks may find themselves on the horns of a dilemma in making design choices. In some settings, in choosing certain design features to fulfil certain goals, central banks would need to decide between two of the following three aspects: preserving the hierarchy of their desired goals, avoiding negative economic effects, or adopting strategies to increase the likelihood of rCBDC adoption. For example, the paper shows that the store-of-value function of cash has been in high demand in recent years, and as a design element it could increase initial adoption rates. Although this is more speculative, this could, in turn, promote other (transactional) uses at a later stage, and hence contribute to the general rCBDC goal of bringing improvements in retail payments markets. However, most central banks would seem to prefer to avoid the potential bank disintermediation effect and would propose store-of-value limits for rCBDCs. Deciding between these two options may depend on the central bank's hierarchy of desired policy goals (improvements in retail payment markets vs. financial stability), as well as the estimated risk of bank disintermediation. Another example is the use of negative remuneration to augment central banks' monetary

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[19] As indicated in the introduction, other constraints, such as technical feasibility and legislation and regulations in the relevant jurisdiction, such as those relating to money laundering, are not analysed in this paper.

policy toolbox. Research shows that cost is an essential attribute in the choice of a means of payment. If negative remuneration results in consumers facing higher costs, they are likely to move away from the rCBDC. This would lead to insufficient demand for the monetary policy tool, potentially making it ineffective. In sum, we suggest that exploring in detail the overlooked constraint of ensuring wide rCBDC adoption might lead to a reconsideration of certain policy goal hierarchies.

A comprehensive analysis of the multiple dimensions affecting adoption may help in assessing how, and to what extent, design requirements established by central banks match consumers' preferences. As seen in Section 2, most academic literature and policy reports on rCBDCs do not consider consumers' needs and preferences in sufficient depth. In addressing design requirements to fulfil policy goals, most of them are still vague (for example stating that rCBDCs should be "innovative", "competitive", "efficient", etc.). Similarly, no in-depth analysis has been published that would make it possible to ascertain whether more concrete design features really tally with consumers' expectations. One exception to the inadequacy of existing analyses is the scant but growing body of empirical literature exploring the factors behind, and obstacles to, potential adoption. However, given that the findings are generally based on specific aspects of adoption (such as data on early perceptions of rCBDC introduction or preferences for existing means of payment), it is still too early to extract any general conclusions and further research is needed. With this paper, we aim to provide a more systematic framework for consideration of the main aspects of adoption that would make it possible to extract relevant lessons and discuss in detail design choices that might meet consumers' needs.

Valuable lessons on the design features that are generally attractive to users can be obtained from market and business reports, the literature on the adoption and diffusion of innovations, and the literature on payment choices. The lessons extracted are discussed in Section 3.5 and include: (i) finding strategic alliances in a highly competitive market with increasing numbers and types of competitors; (ii) developing rCBDCs that exhibit the elements of perceived usefulness and perceived ease of use, as described in the literature; (iii) designing rCBDCs with the attributes that are clearly defined in the literature and have been found to influence continued use of means of payment, such as reduced costs, transaction speed, ease of use and budgeting usefulness; (iv) identifying potential adoption obstacles from the rCBDC's inception, for example through early prototype testing; (v) developing early strategies to increase initial adoption, for example focusing on concrete uses, such as store of value or person-to-person transactions, that might prompt other uses in later stages; (vi) trying to exploit recent trends in the retail payment markets, such as increasing privacy awareness; and (vii) bearing in mind during the design process the fact that circumstantial determinants also influence payment choice (these determinants usually come from external constraints that rCBDCs could be designed to overcome).

Past and ongoing rCBDC initiatives seem to point to adoption obstacles that cannot be properly identified solely by research on adoption and payment choices. In Section 4, we describe past initiatives of public digital monies that did not succeed, as well as ongoing pilot projects and roll-outs. However, there are few

such cases and all of them have their national peculiarities, so that any conclusions should be treated with caution. Given the limited adoption and the scant use data available, it is still too early to extract clear lessons from ongoing rCBDC initiatives such as the pilot projects and recent roll-outs. However, early data on wallets and total transaction values (for example, for the e-CNY and eNaira), together with the service interruption experienced by DCash, may suggest that that ongoing rCBDCs initiatives are not without important adoption obstacles or technical challenges. The following set of lessons are discussed in Section 4.3: (i) real-world trials are needed to understand potential adoption obstacles, and, in this regard, rCBDCs may be characterised by a last-mover advantage; (ii) some design features assumed by central bankers and researchers to be a comparative advantage of rCBDCs may turn out not to be essential for consumers; (iii) payment systems or devices with superior technology to that of existing products does not necessarily ensure wider adoption, hence innovativeness should be focused on increasing consumers' subjective perception of usefulness; (iv) implementations with an intended zero cost for the user may not consider infrastructure-related costs that might be incurred at a later stage; (v) partnerships with the private sector, at least to avoid being perceived as a threat, would seem essential; and (vi) communication campaigns and tax incentives may be not be enough to offset a lack of consumer trust in rCBDCs, and the question of how to achieve that trust is still open.

The above recommendations are not exhaustive and are intended as a contribution to the necessary discussion of the still largely unexplored topic of rCBDC adoption. More attention needs to be devoted to this topic if the likelihood of achieving the desired rCBDC adoption targets is to be increased. Market and innovation research, empirical work based on quantitative and qualitative survey data, prototype testing and, in particular, more data on real trials would also help to identify more key elements for, and potential obstacles to, rCBDC adoption, and how these depend on the particular features of local markets and varying consumer and merchant preferences. This paper can help central banks and academics cover all these topics in order to provide a systematic framework for the investigation of rCBDC adoption and encourage academic discussion of aspects that have, thus far, been neglected in the public discussion.

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