

Analysing a digital euro – A status update

Filip Caron

An important increase in the pace of change as well as strong potential for disruption are being observed in the retail payments market. Fintech, Bigtech and incumbents have focused on streamlining retail payment – initiation and processing – processes and on improving user experience.

Central banks have the responsibility of fostering efficiency and safety of retail payments in their jurisdiction. In addition to providing a safe and liquid settlement asset by issuing banknotes, central banks play three distinct roles in the retail payments market: operating wholesale payment systems that support transactions between payment service providers in the retail payments market; acting as a catalyst or facilitator of innovation, efficiency and safety in the payments market; and overseeing the resilience, safety and integrity of payment systems.

Recent innovations in retail payments and the continued digitalisation of the economy may weaken central banks' ability to effectively achieve their objectives related to payments, monetary policy and financial stability. Widespread adoption of stablecoins in a foreign currency could impact the effective transmission of monetary policy. Declining use of cash may reduce private individuals' access to a safe and liquid settlement asset. Absence of governing entities in certain crypto-asset arrangements reduces the effectiveness of moral suasion in further enhancing cyber resilience.

Central banks have started to investigate the effectiveness of a central bank digital currency (CBDC) as a response to the challenges they experience in meeting their objectives. More specifically, they are looking into a general purpose CBDC, commonly defined as a digital payment instrument denominated in the national unit of account and a direct liability of the central bank.

The Eurosystem central banks recently published a report outlining key principles and requirements for a digital euro, i.e. a general purpose CBDC (European Central Bank, 2020). According to that report, a digital euro should not compromise economic or financial stability; a digital euro should coexist with cash and non-central-bank money; and a digital euro should promote innovation and efficiency in the retail payments market.

The first section of this article highlights the future scenarios for the retail payments market in which a digital euro could be a viable option to achieve the central banks objectives. Sections 2 and 3 identify key design decisions for a digital euro and its supporting infrastructure, followed by a discussion of the related trade-offs in section 4. The final section discusses the next steps in the continued analysis of the issuance of a digital euro.

A digital euro as a viable option to meet central bank objectives

Continued digitalisation of retail payments has been observed and has even accelerated during the COVID-19 pandemic (e.g. the portion of contactless payments – compared to all retail payments in Belgium – more than doubled over the course of 2020 (Febelfin, 2021)). Moreover, as retail payments solutions are subject to network economics, where a solution becomes more useful as the number of users increases, a recent push for further globalisation under the impetus of Bigtech firms has been observed (e.g. the Libra/Diem project supported by Facebook). Both digitalisation and globalisation could have an impact on achievement of central bank objectives.

The Eurosystem has identified a series of realistic future scenarios for the retail payments market, in which a digital euro could be a viable option to meet central bank objectives. These possible scenarios have not materialised yet and should not be considered as mutually exclusive.

Supporting further digitalisation of the economy by meeting emerging payment needs

General purpose CBDCs filling gaps in the current provisioning of digital payment services could facilitate further digitalisation of the financial sector and the broader economy. For example, a digital euro could foster inexpensive pan-European digital payment services that are not subject to data analysis. So, a digital euro could become an important building block for an integrated, secure and efficient pan-European retail payment infrastructure.

Despite all efforts to further integrate the retail payments market in Europe, the European Central Bank has noted limited cross-border acceptance for domestic card schemes (European Central Bank, 2019). Ten European countries' national card schemes still do not accept cards from other EU Member States. Foreign payment solutions have benefited from this gap in the European payment ecosystem and have taken the lead here. Most cross-border payments within Europe go through two international card schemes: Visa and MasterCard.

Widely adopting foreign payment solutions should not be an issue if the same business, same risk, same regulation principles are followed, and if there is appropriate oversight. However, the changing geopolitical context has been marked by an increase in protectionist policies. Geopolitical sanction regimes or even exclusions from payment systems could result in significant risks of payment disruptions in certain jurisdictions.

A digital euro could support the recent pan-European retail payment strategy. This strategy centres on five key objectives: "full pan-European reach and unified customer experience; convenience and cost efficiency; safety and security; European identity and governance; and, in the long run, global acceptance". By design, a digital euro would be a pan-European solution with appropriate attention for efficiency and safety. Furthermore, research by the Bank for International Settlements has confirmed that a general purpose CBDC could foster competition (Bank for International Settlements, 2020).

The objective should not be to crowd out private solutions. Both a digital euro and the European Payments Initiative (EPI) could form an integral part of this strategy. A public-private partnership for distributing and supporting payments in central bank money would validate the intermediated model which is preferred by the Eurosystem.

Other gaps in the provision of payment solutions and functionalities may occur, including the lack of programmability and support of micropayments. For instance, the digital euro report examines the possibility of including conditional payments. Micropayments or small low-cost payments will be needed to support the development of the Internet of Things.

Providing a digital form of public money in response to a significant decline in the use of cash

If the use of cash is marginalised, greater dependence on private forms of money and their supporting infrastructure would be observed. The Eurosystem may decide to issue a digital euro to continue guaranteeing access to a form of public money, characterised as a widely accessible, cheap and safe payment instrument. Bearer instruments for a digital euro would continue to support financial inclusion across the euro area in an increasingly digitalised payments market. Furthermore, the Eurosystem central banks will never analyse payment data for upselling or marketing purposes.

The European Central Bank's 2020 Study on the payment attitudes of consumers in the euro area (SPACE) confirmed that consumers predominantly use cash as a payment instrument for person-to-person and business-to-customer transactions (European Central Bank, 2020). The latter includes both payments for online purchases and purchases at physical points of sale. In 2019, 58 % of retail payments in Belgium were carried out using cash as the payment instrument. With the reported 73 % of retail payments volume conducted using cash, the stakes are even higher for the euro area.

However, the self-reported preferences for payment instruments in the SPACE report indicate that about half of the respondents prefer cards or other cashless payment instruments. Another quarter is indifferent between cash or a cashless payment instrument. This may highlight a mismatch between the end user's preference and the accepted payment instrument in various situations.

Furthermore, there are countries in the euro area that have been observing a significant decline in the use of cash, e.g. only a third of retail payments in the Netherlands were made in cash.

Tackling monetary sovereignty issues when non-euro denominated money becomes omnipresent in the euro area

Widespread adoption of alternative digital currencies, e.g. a foreign CBDC or private non-euro denominated stablecoins, could severely affect the status of the euro as a unit of account. This could have implications for monetary policy, financial stability and the safety and efficiency of European payments. An efficient and convenient digital euro could reduce the risk of currency substitution.

Maintaining price stability is the primary objective of monetary policy. To this end, the ECB Governing Council sets the interest rates at which financial institutions borrow euros from and deposit euros at the central bank¹, which in turn affects borrowing conditions in the economy. The effectiveness of the monetary policy transmission of a central bank is largely based on the strong dominance of the currency it issues.

Secondly, the ability of the central banks in the euro area to act as lender of last resort could be significantly weakened, if financial institutions start to accept substantial deposits in alternative currencies. Central banks cannot provide unlimited quantities of alternative digital currencies to solvent banks during liquidity crises.

Thirdly, increasingly dominant alternative digital currencies could pose major challenges for the Eurosystem in maintaining the efficiency and safety of payment systems. Alternative digital currencies offered by entities outside the supervisory scope of the European authorities could be made available to European citizens. There are no guarantees that these entities are following the same strict safety and efficiency standards as those overseen and supervised by the European authorities.

Fourthly, the financial intermediation strategies and the incentives of entities issuing alternative currencies remains unclear. There are no guarantees that financial institutions in the euro area could play any significant

¹ Since the financial crisis, non-standard measures have been taken as well.

intermediation role, which could mean significant risks for financial stability. But incentives for the issuers of alternative currencies could pose important risks, too. For example, these issues may decide to create money in excess of the money demand to generate additional seigniorage for its shareholders, which may result in a heightened inflation.

Currently, the currency substitution scenario is not materialising but there are important risks related to the speed at which it may materialise. BigTech firms could leverage strong international user bases to gain a substantial market share for an alternative digital currency. Additional competitive advantages stem from their extensive experience in designing integrated and user-friendly solutions. Furthermore, extensive reward schemes offered by BigTech firms could be an effective tool in stimulating the adoption of alternative digital currencies.

Reinforcing monetary policy transmission

An interest-bearing and universally accessible digital euro could further improve the effectiveness of the monetary policy. The ECB's Governing Council could adapt the remuneration of a digital euro to influence the level of investment and consumption in the euro area. Reducing remuneration during economic crises could boost aggregate investment and consumption.

The remuneration offered by a digital euro will act as a floor for deposit rates offered by commercial banks. Researchers have suggested that offering depositors an outside option will be enough to influence the deposit market and make it more competitive, even if the CBDC is not widely accepted (Davoodalhosseini *et al.*, 2020).

In contrast to cash, a digital euro could be negatively remunerated. Removing this effective lower bound would require important restrictions on the usage of cash, to avoid a move into cash to escape from negative interests. Examples of these restrictions include limiting cash withdrawals and deposits; removing large-denomination notes; or even eliminating cash. A negatively remunerated digital euro explicitly violates the principles set out by the Eurosystem and is therefore not considered in the current analyses (European Central Bank, 2020).

Additionally, a digital euro could theoretically be used for the distribution of helicopter money. Fair distribution of helicopter money would require access for all citizens, as well as the ability to uniquely identify individual citizens in the underlying infrastructure (to avoid "double spending" by the government).

Preparing for extreme events

Cyber incidents, natural disasters and other extreme events form an integral part of the threat landscape in which financial institutions and retail payments operate. Prolonged outages of payment solutions like card payment schemes and mobile payment applications could affect European retail payments and erode trust in the overall financial system.

The European Systemic Risk Board recently identified cyber threats as a source of systemic risk for the financial systems, deeming that it could have severe negative consequences for the European economy (European Systemic Risk Board, 2020). Furthermore, different service providers appear to be increasingly dependent on a small set of technologies and service providers (e.g. cloud providers). As a result, a major incident related to these technologies and/or service providers could have a significant impact across various retail payment solutions.

Currently, cash acts as an effective back-up system during extreme events, i.e. cash immediately guarantees the transfer of funds in exchange for delivered goods or services. This would no longer be possible in a future scenario characterised by much lower or even marginalised cash use.

A widely adopted digital euro could act as a back-up system, under strict conditions. Firstly, the underlying payment infrastructure should be independent from current solutions and developed with technology diversity in mind (i.e. based on different technology wherever possible). Secondly, the underlying payment infrastructure should comply with the strictest security and resilience requirements.

Designing an attractive payment instrument

The instrument design analysis should formulate an opinion on three fundamental questions. Should a digital euro be remunerated? Should access to and/or holdings in digital euro be restricted? Should digital euro holdings and transactions be private?

Remuneration and incentive design

The inability to pay or receive interest on physical cash is an important technological constraint, which could be overcome with a digital euro.

If a digital euro were remunerated, a series of additional incentive design decisions would need to be considered. Firstly, the interest rate could be positive but (theoretically) a negative interest rate could be set, too. A negative interest rate would require political acceptance.

Secondly, the incentive design could include various types of interest differentiation. A tiering of the interest rate has been presented in multiple publications (Bindseil & Panetta, 2020). This implies that the remuneration of the digital euro is relatively attractive up to a quantitative ceiling, while significantly lower interest rates are applied for holdings above the interest rate. But interest differentiation could also be implemented based on stakeholder type. For example, for corporates or foreigners, the quantitative ceiling could be set to zero or calculated based on presumed payments needs (Bindseil, 2020).

Finally, the conceptual design will need to consider whether the interest rate should be fixed or allowed to fluctuate over time.

Restrictions on access to and holdings in a digital euro

The instrument design may define limits on the amount of digital euro that each individual, household or business could hold. These restrictions on access could reinforce a role as payment instrument.

Implementing maximum holding limits should be technically straightforward for centralised infrastructures, which are based on currently dominant architectures. Payees would not be able to accept payments that would result in their current balance exceeding the maximum holding. This solution could be considered sub-optimal as it would implicitly expose sensitive information on the current balance of the payee. Moreover, it would create additional friction as payments could be automatically rejected. Alternatively, the amount in excess of the maximum holding limit could be directly transferred to an account held by the payee with an authorised financial institution (Panetta, 2018). This second solution would require each user of a digital euro to open an account with a financial institution in the euro area.

The feasibility of implementing maximum holding limits in a DLT-based back-end infrastructure has been demonstrated in a proof-of-concept developed by European System of Central Banks' EUROchain research network (European Central Bank, 2019). If the maximum holding limit of the payee were exceeded by accepting the payment, the payment would be automatically rejected.

Furthermore, access and holding restrictions for individuals and businesses outside the euro area will need to be reviewed. Only a limited number of these stakeholders are expected to have access to an account with a financial institution in the euro area.

Degree of privacy offered by a digital euro

Different privacy constructs could be considered when designing a digital euro. The conceptual analysis should consider which types of information need to be kept private under which conditions and from whom to keep it secret. There is no binary choice between full anonymity and full disclosure.

Information regarding digital euro holdings and transactions could be shielded from a variety of stakeholders, including transaction counterparties, payment service providers, governments and the general public. A recent article pointed to a series of interesting techniques that could be adopted in the design (Darbha & Arora, 2020). Zero-knowledge proofs can be used to prove claims about data without disclosing any actual data, which could be used to prove that a payer has sufficient funds. Homomorphic encryption could be used to calculate the remuneration that needs to be paid while the balance remains encrypted. Multi-signature approaches could allow for decryption of sensitive data if an appropriate number of entities agree to its disclosure.

A recent proof-of-concept developed by the European System of Central Banks demonstrated that it is technically feasible to offer different levels of privacy depending on the value of the transaction (European Central Bank, 2019). This would allow for high degrees of privacy for lower-value transactions, whereas large-value transactions would be subject to AML/CFT¹ checks by a dedicated authority.

Designing a system to support the digital euro

The Eurosystem will examine all the different options to support payments in a digital euro. At the core of the settlement process lies a ledger to record the underlying transfers of central bank liabilities. Different alternatives to initiate payments in digital euro could be considered, as well as the potential role of financial intermediaries.

Back-end infrastructure

A broad variety of ledger design and structure options have emerged lately. The back-end infrastructure could be based on a centralised or decentralised architecture, as well as account-based or value-based. Additionally, the ledger could potentially be further enriched with smart contract functionality, resulting in programmable money. Infrastructure design choices should be grounded in user requirements, and not be dictated by technology choices.

Decentralised and distributed ledgers have been adopted by a vast series of cryptocurrencies. Research has identified potential opportunities for enhancing both the efficiency and safety of this technology for payment systems (Committee on Payments and Market Infrastructures, 2017). Furthermore, a decentralised infrastructure could more easily facilitate offline peer-to-peer transactions. The design must ensure that digital euro holdings and transactions are recorded in line with the rules set by the central bank.

But centralised ledgers with the central bank as intermediary to record all transactions, should not be excluded without proper analysis. Centralised ledgers may facilitate an easier implementation of fraud and compliance detection (Bank for International Settlements, 2020). With the TARGET instant payment settlement (TIPS)

¹ Anti-money-laundering / Combating the financing of terrorism.

system, the Eurosystem has already established the core components of such an architecture (European Central Bank, 2020).

Two alternative authentication approaches are commonly discussed: value-based and account-based authentication. A value-based digital euro would centre on the users' ability to verify that the digital object is genuine, typically through encryption keys. This approach could enable offline payments.

Account-based authentication relies on a third party – like the central bank or an accredited third-party – to verify the users' identity to confirm the validity of a transaction. Account-based authentication is compatible with both centralised and decentralised ledgers, examples include respectively TIPS and Ethereum. While scaling-up the number of accounts may sound straightforward and not necessarily innovative, multiple researchers have suggested that significant technical challenges would need to be addressed (Bindseil, 2020).

Finally, programmable money has been garnering a great deal of attention. In addition to simple record-keeping, the back-end infrastructure could verify whether payment conditions have been met. End users could specify timing and sequencing conditions for payments. Other applications could include the earmarking of specific balances – e.g. for healthcare or food expenses – which result in the creation of non-fungible money.

Access via intermediaries

Central banks could opt to provide the public with direct access to a general-purpose CBDC or with access through supervised intermediaries. The former may imply that the central banks conduct a series of end-user-facing services, like customer identification, compliance checks and end-user support. This would imply a significant expansion of the scope of central banks' activities.

The Eurosystem expressed a clear preference for the intermediated model (European Central Bank, 2020). Two distinct roles could be attributed to supervised intermediaries, i.e. intermediaries could be mere gatekeeper or full settlement agents. Intermediaries acting as a gatekeeper would focus on authenticating end users and conducting the end-user-facing activities. These are activities similar to those conducted by commercial banks in the distribution of cash.

Supervised intermediaries could also act as settlement agents. End users provide payment instructions to the supervised intermediary of their choice, e.g. a commercial bank. These settlement agents instruct or execute the transfer of digital euro units on behalf of their customers. As the central bank would only interact with supervised intermediaries, the number of connections to the system would be significantly lower.

Appropriate supervision should ensure that the activities of these intermediaries do not affect trust in a digital euro and that appropriate measures to preserve the central bank liability nature are implemented. This includes measures that prevent the creation of additional digital euro units as a result of errors or misconduct.

Access solutions

Access solutions link stakeholders with the back-end infrastructure. Stakeholders include private individuals holding digital euro, merchants accepting payments in digital euro and all supervised intermediaries. Access solutions should support authentication and authorisation requirements, enable universal access and guarantee interoperability with other services in the European financial ecosystem.

A broad variety of software-based payments solutions have been widely adopted in the euro area, including mobile banking apps and web browser-based online banking. These solutions support various use cases, ranging from peer-to-peer transactions to payments in the context of e-commerce. The underlying concepts are valid for gaining access to digital euro holdings or initiating payments in digital euro.

Hardware-based payment solutions or payment devices serve multiple purposes, including financial inclusion and offline transactions. Offering payment devices to private individuals potentially without a smartphone will increase financial inclusion and support the universal access objective. Dedicated devices could theoretically also support offline device-to-device payments, which may also reinforce resilience under extreme circumstances. In a recent publication, the Bank for International Settlements suggests active engagement with cognitively- or sensory-impaired users to further enhance financial inclusion (Bank for International Settlements, 2020).

Additional application programming interfaces (APIs) could enable supervised intermediaries to integrate the digital euro in their service offering. Furthermore, design choices on the interoperability with non-euro payment systems could have a significant impact on a digital euro's global reach. Due attention needs to be paid to compatibility solutions, as well as links with other CBDC systems that may emerge.

Interplay between design choices and central bank objectives

Decisions regarding the design of the digital euro are not discrete and interdependent. Agreeing on a coherent set of design decisions will be essential to the development of an effective and efficient digital euro.

Additionally, design decisions will impact the efficiency of the digital euro as a tool to achieve central bank objectives. Design decisions typically impact multiple central bank objectives; and could be supportive of one objective while at the same time negatively impacting another.

Privacy is a top priority for prospective users of a digital euro, as was highlighted in a recent consultation organised by the Eurosystem. However, an interesting trade-off between privacy and the desire to reduce the scope for criminal activity has been identified. This trade-off should not be considered the sole responsibility of the central banks, but part of a broader discussion in the European community.

This section will further elaborate on the interplay between design choices and central bank objectives and highlight important interactions between the central bank objectives (limited to those important in the context of a CBDC).

Effects on financial institutions and safeguarding financial stability

Issuing an efficient digital euro will almost inevitably result in a partial substitution of cash and commercial bank deposits for that digital euro. A substitution of commercial bank deposits for digital euro holdings will lead to a reduction in funding for banks, which, if not appropriately covered, may imply disintermediation.

Commercial banks may seek to reduce the level of disintermediation through bundling of services (including mortgage and other loans) or more attractive remuneration than the digital euro. The latter could have an important impact on the commercial banks' cost of funding. Alternatively, commercial banks could replace lost deposit funding with longer-term deposits or central bank funding. But these alternatives could also raise the overall cost of funding.

If commercial banks do not want to erode their franchise value, they could revise the terms of the loans which they provide to the economy. An increase in the cost of borrowing may result in a lower volume of lending and impact economic activity, all else being equal. Or commercial banks could decide to take on greater risks to safeguard their profitability.

Multiple researchers have suggested that a CBDC could further facilitate a run on the banking system. Especially if a digital euro were easily (and unrestrictedly) convertible into other forms of euro denominated money.

During financial crises, a risk-free asset like the digital euro could be considered immensely more attractive by households and businesses.

The design of a digital euro may highly influence the extent of the disintermediation effect. Remuneration will likely be an important driver of the attractiveness of a digital euro. To minimise disintermediation, the central bank may opt not to remunerate or offer a rather unattractive rate compared to that offered by the commercial banks.

Adopting tiered remuneration could allow for an attractive payment instrument while removing the incentive to use a digital euro as a store of value. This would require attractive remuneration up to a quantitative ceiling (tier one), while above that threshold, an unattractive remuneration would be applied (tier two). It could be decided to cap digital euro holdings to the quantitative ceiling altogether.

Effects on monetary policy

An attractively remunerated digital euro with wide access – not limited to financial institutions – could support the implementation and transmission of monetary policy to the real economy. If the digital euro design allows for negative remuneration, it could help alleviate the effective lower bound, particularly if combined with reduced supply of non-remunerated cash. This is discussed in the monetary policy future scenario, but would violate the requirements specified by the Eurosystem. Digital euro designs in which access and/or holding restrictions are adopted reduce the scope for a more direct pass-through of the policy interest rates.

Remuneration is a design factor that will determine the impact on both the financial stability and monetary policy, as a digital euro could compete with bank deposits. In the event of large bank runs, central banks could mitigate the impact on commercial banks by reducing (considerably) the rate of remuneration of a digital euro.

Flows into and out of digital euro may have an impact on the central banks' balance sheets. For example, if bank deposits are substituted for digital euro units or unrestricted access for non-residents would be allowed, the central bank's liabilities would increase. As a result, central banks will need to acquire more assets on their balance sheets. The Eurosystem central banks have discretion in selecting the assets that they will hold, e.g. any kind of collateralised lending or asset holdings. But subject to the overall supply of different asset classes (as well as changes thereof) and the volatility in demand of a digital euro, central banks might face additional duration, liquidity and credit risks.

The cost-benefit analysis of using a digital euro as an additional monetary policy tool is not yet clear. Doubts have been raised about the need to strengthen the transmission channels, as well as the effectiveness of a digital euro in attaining monetary policy objectives (Bindseil, 2016). Furthermore, other conventional tools may be as effective in achieving the monetary policy objectives.

Outlook

With its October 2020 report on a digital euro, the Eurosystem defined a set of key principles and requirements for a digital euro. The report formed the basis for a dialogue with all stakeholders on the objectives and potential design options. Initial consultation responses identified privacy as the most requested feature of a potential euro (mentioned in 41 % of the replies), followed by security (17 %) and pan-European reach (10 %).

Between October 2020 and July 2021, the Eurosystem central banks conducted a series of practical experiments to further explore the technical feasibility of the different systems and instrument design options. This is to be

followed by a formal decision of the Governing Council on whether or not to continue investigating a digital euro. No decisions regarding the issuance of a digital euro have been made yet.

The NBB and ECB will continue to proactively interact with the different stakeholders in a digital euro – including prospective end users and supervised intermediaries – to accurately sound out their requirements.

In addition to the technical and functional analyses, the Eurosystem continues to actively examine policy-oriented challenges and the legal aspects of a potential digital euro.

Bibliography

- Bank for International Settlements, 2020. BIS Annual Economic Report 2020. [Online] Available at: <https://www.bis.org/publ/arpdf/ar2020e3.pdf>.
- Bank for International Settlements, 2020. Central bank digital currencies: foundational principles and core features. [Online] Available at: <https://www.bis.org/publ/othp33.pdf>.
- Bindseil, U., 2016. Evaluating monetary policy operational frameworks. [Online] Available at: <https://www.kansascityfed.org/~media/files/publicat/sympos/2016/econsymposium-bindseil-paper.pdf?la=en>.
- Bindseil, U., 2020. Tiered CBDC and the financial system (working paper series No 2351). [Online] Available at: <https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2351~c8c18bbd60.en.pdf>.
- Bindseil, U. & Panetta, F., 2020. Central bank digital currency remuneration in a world with low or negative nominal interest rates. [Online] Available at: <https://voxeu.org/article/cbdc-remuneration-world-low-or-negative-nominal-interest-rates>.
- Committee on Payments and Market Infrastructures, 2017. Distributed ledger technology in payment, clearing and settlement. [Online] Available at: <https://www.bis.org/cpmi/publ/d157.pdf>.
- Darbha, S. & Arora, R., 2020. Privacy in CBDC technology. [Online] Available at: <https://www.bankofcanada.ca/2020/06/staff-analytical-note-2020-9/#:~:text=Bank%20of%20Canada%20research%20has,of%20anonymity%20or%20full%20disclosure>.
- Davoodalhosseini, M., Rivandenyra, F. & Zhu, Y., 2020. CBDC and monetary policy. [Online] Available at: <https://www.bankofcanada.ca/2020/02/staff-analytical-note-2020-4/>.
- European Central Bank, 2019. Card payments in Europe – Current landscape and future prospects: a Eurosystem perspective. [Online] Available at: https://www.ecb.europa.eu/pub/pdf/other/ecb_cardpaymentsineu_currentlandscapeandfutureprospects201904~30d4de2fc4.en.pdf.
- European Central Bank, 2019. Exploring anonymity in central bank digital currencies. [Online] Available at: <https://www.ecb.europa.eu/paym/intro/publications/pdf/ecb.mipinfocus191217.en.pdf?3824c3f26ad2f928ceea370393cce785>.
- European Central Bank, 2020. Report on a digital Euro. [Online] Available at: https://www.ecb.europa.eu/pub/pdf/other/Report_on_a_digital_euro~4d7268b458.en.pdf.
- European Central Bank, 2020. Study on the payment attitudes of consumers in the euro area (SPACE). [Online] Available at: <https://www.ecb.europa.eu/pub/pdf/other/ecb.spacereport202012~bb2038bbb6.en.pdf>.
- European Systemic Risk Board, 2020. Systemic cyber risk. [Online] Available at: https://www.esrb.europa.eu/pub/pdf/reports/esrb.report200219_systemiccyberrisk~101a09685e.en.pdf?fdefe8436b08c6881d492960ffc7f3a9.
- Febelfin, 2021. Coronamonitor voor januari 2021. [Online] Available at: <https://www.febelfin.be/sites/default/files/2021-01/Dashboard-2021-01-28-NL.pdf>.
- Panetta, F., 2018. 21st century cash: Central banking, technological innovation and digital currencies. [Online] Available at: <https://www.suerf.org/policynotes/3251/21st-century-cash-central-banking-technological-innovation-and-digital-currencies>.