

An analytical review of the main options for the implementation of central bank digital currency

Abstract—This article reviews the main technical issues that would need to be addressed if a central bank decided to operate a public digital currency system, also known as central bank digital currency (CBDC). In particular, it reviews the conditions and motivations that could justify such monetary innovation and its implementation methods. In doing so, it fills a gap in the literature on digital currency, which has so far focused too much on private currencies, while neglecting the opportunities and challenges linked to a system issued by a central bank. Our study reveals that, in addition to the many benefits of a public digital currency system, including the introduction of a reliable and easily accessible means of payment, several critical points remain. In addition, the decision on the technical implementation of the CBDC requires a technical study of arbitration between public digital currency available exclusively to large financial institutions (called wholesale CBDC) or available to the general public (called retail CBDC).

Keywords— *digital currency setup, wholesale CBDC, retail CBDC*

I. INTRODUCTION

‘Because we are a successful and large enough company, we are now able to build systems without precedent ... more sophisticated than many governments have done’ [1]. These were the words of Facebook CEO, Mark Zuckerberg, on the eve of launching the Libra virtual currency project in 2019. These words illustrate the potential that virtual currencies have opened up, allowing the various actors in society (and in particular large companies) to transcend the monopoly of central banks on the issuance of currencies. Governments have been slow to take on board the idea - which Zuckerberg's words seem to imply - that a private company could exercise a comparable degree of control over monetary flows and thus

assume some aspects of the role traditionally attributed to banks power stations; especially since the early 2000s, blockchain – a method of keeping a secure distributed ledger to record transactions in a digital currency – seems to mark a new stage in the evolution of monetary forms, whose advantages and design arouse interest since the launch of Bitcoin in 2008 [2]. This launch has marked the beginning of a phase of pronounced monetary innovation that run autonomously from existing state controls on monetary issue and banking activity [3]. Yet despite this enthusiasm for private digital currencies, such as bitcoin, little attention is currently given to how these autonomous public digital currency systems can operate in practice [4], [5]. A 2018 survey by the Bank for International Settlements [6] shows that central banks are considering the possibility of developing centralized, sovereign versions of digital currency – what will hereafter be called “central bank digital currency” » (CBDC). The study reveals that 70% of the 63 central banks surveyed are already starting exploratory work around CBDCs or were preparing to do so. However, only three central banks have made moves suggesting that they may be able to create a CBDC in the near future [7]. This horizon of inquiry raises questions such as: what could be their effects on monetary policy and financial stability? What challenges could they pose, in terms of surveillance and security? Few questions, however, have been raised about how might they be implemented in practice and how might their adoption be encouraged? This article is an attempt to analyze the latter question. This aims to contribute to an understanding of the conditions and motivations that could justify such monetary innovation, as well as its implementation methods before concluding with a summary of the main options for implementing CBDCs.

II. CONDITIONS AND MOTIVATIONS OF CBDC ISSUE

A CBDC can be thought of as a virtual representation of fiat money, albeit with some differences first and foremost regarding anonymity. A CBDC would be a coin ‘minted’ not on a material substrate but as a code encrypted through an algorithm. Like the physical coin, this ‘coded coin’ would originate from the central bank, which would determine its face value. Like central bank-issued money, this would be acceptable anywhere, and could lead to secure and instant payments using a smartphone or bank card. Blockchain may or may not be used to provide the ledger for recording transactions.

One of the areas currently open for debate is precisely around the technical form CBDCs should take. The most likely option would be to issue a checking account directly hosted by the central bank. Issue by a central bank means that the ledger needed to record and validate transactions might as well be maintained by the central bank (centralised ledger), as opposed to using distributed ledger technology (DLT), i.e., the blockchain, as used for instance by Bitcoin. Each individual entitled to use the CBDC could then hold an account with the central bank, and would be able to use the digital currency as a means of payment to transfer money from his or her account to that of another person or institution. An equally valid alternative would be that of issuing CBDCs as ‘tokens’. The difference between a ‘coin’ and a ‘token’ is that a ‘coin’ would rely on its own infrastructure or ledger or recording transactions, whereas a ‘token’ would rely on and function according to the constraints set by another existing virtual currency infrastructure for recording transactions. Regardless of the specific technical form, a first question concerning CBDC development would be around who it should contemplate as its users, whether individuals and families, companies, or only banking institutions. In this respect, it seems a general trend is emerging in the pioneering work of ‘early adopter’ central banks, suggesting there might really be two kinds of CBDCs in the works: retail (CBDC-R) and wholesale (CBDC-W) CBDCs [8]. Wholesale virtual currencies would be reserved to financial intermediaries (banks), while retail virtual currencies would be intended for general use by businesses and households. States could therefore choose to develop either, both, or neither of these two digital currency variants.

A CBDC-W would be fully controlled by the central bank issuing it. It would therefore adopt a regulated ledger, i.e., a ledger validating transactions through a proof of authority originating directly with the central bank. The alternative of using a public or unregulated ledger such as the blockchain used for Bitcoin would mean that every node on the currency’s operating network could view any transactions carried out on the system (with party names encrypted) and could in turn participate in the transaction validation process. The benefit of the latter system is that it would encrypt information pertaining to any one transaction, and thereby bypass the need for disclosure of such information to ‘trusted’ third parties charged with validating transactions [2]. However, the performance of this kind of distributed ledger is slow compared to most modern payment infrastructures, and it is also expensive in terms of the energy needed for its upkeep [9]. On the other hand, in the case of private or regulated ledgers, transactions are logged on a ‘private’ record kept by a reduced number of institutions, which are ultimately responsible for validating transactions (and with which transaction information needs to be shared). These private ledgers combine faster operation with lower costs, while retaining an acceptable degree of confidentiality over transaction information. Overall, the use of CBDC-Ws is expected to enable financial institutions to achieve efficiency gains, particularly in international transfers and post-trade activities, since it would help reduce liquidity requirements and charges [10], [11].

An important issue that must not be overlooked concerns the cost of inter-bank settlements for digital currency transactions. Indeed, financial institutions need a safe and liquid asset for making settlements and for executing transactions originally undertaken in tokenised assets circulating on existing digital currency networks. The creation of ‘stable coins’ entirely backed by banking assets—like the ‘JPM coin’ issued by J.P. Morgan could be a possible way to ease the settlement process for digital currency transactions [12]. This notwithstanding, any private payment instrument presents liquidity and credit risks of its own: its supply can be insufficient and its issuer can default. Issuing a CBDC directly on an existing ledger (e.g., the Bitcoin blockchain) would be the only way to allow direct circulation of central bank-issued money on a public circuit for digital currency transactions: this would make a perfectly liquid and safe payment instrument available on it. As a result of CBDC issue, therefore, recourse to the blockchain would also

become more attractive to financial institutions. However, this solution to the settlement problem suffers from the already mentioned shortcomings of issuing a CBDC-W on a public or unregulated ledger, namely that it remains a challenge to operate this system combining confidence, speed, and low transaction fees. Somewhat counter-intuitively, it is nevertheless possible to imagine a scenario where the issue of a CBDC-W might act as a stimulus for the further refinement of blockchain technology, and thereby trigger financial innovation in service of lower transaction costs. Given the relatively modest cost of technology support for issuing a CBDC W through the existing blockchain infrastructure, this innovation could indeed encourage contestability in the financial services market [13]. This, it would do by breaking down barriers to entry and encouraging the arrival of new actors. In turn, this dynamic would ultimately benefit the users of financial services by allowing cost savings and efficiency gains, through cutting off of the added layer of intermediation connected to inter-institution settlement.

Shifting to the alternative option of a CBDC-R, its grounds for adoption can easily be found in such benefits as: the dematerialisation of currency, its ease of access, and its robustness in tackling issues of risk and illiquidity [14]. On this last point, a CBDC-R would amount to an injection of liquid financial assets, effectively ‘democratising’ the capability to dispose of an account balance held directly with the central bank (an option that’s currently only open to banks) [15]. Last, but not least, the universal accessibility of fiat money by the general public which a CBDC-R would usher would make it possible to improve social welfare by breaking the current deadlock of incompatibility between universal access to means of payment, the security of assets used for such purpose, and the dematerialisation of those assets. A CBDC-R would be such a remarkable innovation enabling central banks to manage a direct relationship with the public [16]. Issuing a CBDC-R could also help reduce the social costs connected with retail payment infrastructure (e.g., the costs of production, issue, distribution, storage, management, security, and destruction of cash). These have been estimated at almost 1% of GDP in the euro area, and half of that amount is specifically attributable to performance of cash payments [17].

In Sweden, the demand for fiat money (e.g. cash and coins) halved between 2008 and 2018, in favour of bank-issued

money [18]. In response, since 2016 the Swedish central bank has been exploring the issue of a CBDC-R, under the name e-krona [19]–[21]. The demand for electronic currency or transaction purposes is estimated to be between 1% and 2% of GDP, roughly equivalent to the current demand for fiat money [22]. However, the e-krona would be aimed at a wider audience than those who currently use fiat currency the most, mainly individuals spending notes and coins. Suffice it to think of what might be possible, were salaries to be paid directly in e-krona: this would surely increase demand for central bank-issued money and, in turn, reduce reliance on private bank deposits [22].

Issuing a CBDC-R could also help reduce the social costs connected with retail payment infrastructure (e.g. the costs of production, issue, distribution, storage, management, security, and destruction of cash). These have been estimated at almost 1% of GDP in the euro area, and half of that amount is specifically attributable to performance of cash payments [17]. A reduction of those costs would particularly benefit those sections of society that, due to their vulnerability, face the greatest costs in accessing bank-managed payment services [23]. Moreover, a CBDC-R could promote financial inclusion, especially in developing countries where sections of the population are excluded from the banking system. In those countries, a CBDC-R might also be a counter-move to prevent privately issued digital currencies like Facebook’s Libra from displacing sovereign currencies [24]. For this purpose, the mere setup of a CBDC-R infrastructure isn’t enough to guarantee its uptake. Instead, it is necessary that the currency in which the CBDC-R is denominated be stable and easily exchangeable with other types of currency. This is a lesson stemming from the limited uptake of Venezuela’s state-backed digital currency project, the petro, which was issued in February 2018. In such case, uptake of the digital currency has been beset by concerns around political and macroeconomic instability affecting the Venezuelan economy at large.

Another major reason for adopting a CBDC-R is that, amidst trends towards the increasing digitisation of payments, these digital currency schemes would help preserve the seigniorage of the State over money issue in the long term, through an increase (and diversification) of the monetary base, and a reduction in costs. It follows from this that preservation of State seigniorage will also preserve the conditions for effective monetary governance by state authorities. These final considerations shift attention towards the implications of

different CBDC setups by central banks, in order to ensure the most effective financial and monetary governance.

III. OPTIONS FOR CBDC SETUP

A CBDC, like all central bank-issued money, would ultimately be the property of the central bank. This entails it is the central bank that would hold ultimate authority over its creation or removal at all times. Central banks also administer other forms of money, such as banknotes and central bank reserves. A crucial issue has to do with ensuring frictionless conversion between these different forms of money (uniformity of the payment system). Hence, CBDCs ought to be issued and exchanged at par with the other forms of central bank-issued money. Anything else would make the offer of central bank money less than perfectly elastic, and therefore subject it to constraints on holding levels or to conversion costs. In turn, such frictions would then break the parity between the different forms of base money (including CBDCs and this would be a particularly serious problem in times of heightened demand for central bank-issued currency, e.g. during a financial crisis. Another important feature is to do with ensuring that CBDCs attain 24/7 operability, in order to function as means of payment similar to banknotes and electronic money (central bank reserves, currently only held by financial institutions, do not display this feature, and are not—therefore—useable as a generalised means of payment).

Depending on whether it is issued for commercial banks (CBDC-W) or for retail use (CBDC R), a CBDC might display different sets of features. Indeed, questions of implementation, transmission, and dissemination look different, depending on the technology and organisation deployed in each CBDC scheme. In particular, the following questions are key to determine the shape a particular CBDC might take: (i) will the CBDC be reserved only for residents? (ii) will holdings in the CBDC earn a remuneration, and how might that be affected?

In the case of a CBDC-W scheme, holding of the digital currency would be restricted to banks. This addresses from the start two problematic nodes that beset existing virtual currency schemes: (i) the lack of control and regulation, which places them at risk of financing illicit transactions; (ii) the trade-off between collecting and sharing the information generated by users of the digital currency, while meeting confidentiality requirements as set out in applicable banking

regulations [25]. From a technical standpoint, CBDCs will be recorded on a regulated ledger, with access restricted to financial institutions and the central bank. Under a CBDC scheme, the central bank will probably be the only actor to have access to complete information concerning the circulation of the digital currency. That is, the circulation of a CBDC-W will remain traceable by the central bank through its digital currency transaction ledger, whilst taking place outside of the central bank's currency accounts.

Another technical issue concerns the issue of a CBDC-W as a coin (with an independent ledger) or as a token (on a ledger already used by other digital currencies). While the former option presupposes an autonomous ledger specific to each central bank-issued digital currency, issue as token would entail a shared ledger with other digital currencies, thereby allowing the transfer of funds from the CBDC-W to other digital currency accounts held on the same ledger. The risks of fraudulent use of the CBDC-W would obviously be minimised by barring this possibility. However, this would also limit the freedom and speed of circulation of the concerned currency. Another consideration militating against hosting a CBDC-W on a ledger used by other digital currencies is that, assuming one could have a single ledger for large CBDC-W schemes (e.g., the digital dollar or the digital euro), this would risk causing congestion and reducing efficiency, particularly if all the major international financial institutions were allowed to carry out transactions on that ledger.

Moving on to a CBDC-R, i.e., a CBDC scheme accessible to the general public in the form of an intangible fiat currency, the primary question concerns how to prevent disruption of existing forms of cash and scriptural currency. This question advises caution in authorising the offer of additional financial services tied to the CBDC-R, such as long-term savings products or credit. Another issue concerns managing holdings of the CBDC-R by tourists, in a similar way as is currently permitted for banknote holdings by tourists and by other non-residents who are allowed by their national regulations to open accounts denominated in a foreign currency. It is useful here to consider that the orientation of the Swedish central bank in connection to the e-krona is not to ban holding of the CBDC-R by non-residents. At the same time, allowing a virtual monetary asset to be held by non-residents demands a degree of regulatory harmonisation internationally to avoid laundering and prohibited financing [26]. Most central banks

do not have direct experience of managing personal accounts; hence, the eventuality that a CBDC-R could be used for illicit purposes would pose a reputational risk. Such a risk could be mitigated through recourse to financial and payment intermediaries to check regulatory compliance. However, this option would recreate a monetary infrastructure reliant on intermediaries, where transactions would need to be validated ex post by the central bank ledger. In order to prevent this, it seems advisable to start with the simplest possible version of a CBDC-R, namely as electronic money issued directly by the central bank [27].

The availability of a CBDC to the general public poses a range of additional unanswered questions. A first question revolves around the alternative between a token-based model (also called value-based) and an account-based model. The first requires a CBDC-R to be spent through a physical vector, like a card or a smartphone, thereby resembling the usability of cash money or meal vouchers. The second model would feature the opening of accounts held with financial intermediaries: this would expand the range of transactions that could be carried out through the use of the CBDC-R, especially the payment of salaries. The second unanswered question is whether a CBDC-R ought to be deemed legal tender, i.e. a means of payment that could not be refused. Use as legal tender would undoubtedly contribute to the uptake of the CBDC-R. At the same time, practical criteria like ease of access and low transaction costs are probably as crucial for ensuring its widespread adoption. The third unanswered question revolves around the issue of anonymity. Digital currencies were developed within an anti-authoritarian community known as ‘cypherpunks’, who make sure that anonymity could be built into the very design of digital currency schemes (mirroring the anonymity of cash transactions) [9]. This particular feature sounds problematic from the standpoint of a state or a central bank. One possible compromise would be to ensure anonymity, so long as transactions did not exceed a given amount over a stated period. This is already the norm in several countries, when it comes to electronic payments. A more open approach would be to enforce anonymity for all stakeholders, except for the central bank or the institutions managing CBDC-R accounts. There would be nothing exceptional about this proposal, which actually mirrors the solution already in place for card payments [28]. The fourth area of concern revolves around remuneration of CBDC-R holdings. The choice not to remunerate such holdings would de facto transform a CBDC-

R into another form of electronic money. In a period of positive interest rates, this could disincentivise uptake of the CBDC-R in comparison to bank deposits or private bank holdings of central bank reserves. Conversely, in the presence of a significant inflation rate, holdings in CBDC-R could come to be seen as more than a simple means of exchange, but also as a store of value [21]. The opposite choice, i.e. to remunerate CBDC-R holdings, would foster a form of competition that has not previously existed: namely competition for individual deposits between commercial banks and the central bank. In turn, this competition could fuel suspicion towards the decisions of the central bank on the basis of conflicts of interest. For instance, if the central bank were to increase rates (including its rate of remuneration of the CBDC-R), economic actors would no longer know whether this choice was an attempt to address inflation or to collect more deposits [10].

IV. CONCLUSION

In this article, we have charted some of the principal questions concerning the prospect of digital currency issue on the part of central banks. With respect to different models of CBDCs, CBDC-W would pose the least disruption to the functioning of the financial system, by being offered solely to financial institutions, provided appropriate monetary policy safeguards were put in place (e.g., to avoid the conversion of assets held as statutory reserves with the central bank into the CBDC-W). On the other hand, for countries where financial exclusion was a severe issue, a CBDC-R might be able to take advantage of the rapid spread of mobile phones to make available fast and reliable digital payment methods to wider chunks of the population.

Finally, the issue of a new digital currency also creates broader policy questions beyond the realm of financial stability and monetary policy which would need to be addressed in the appropriate *for a* and with the participation of citizens. This, indeed, is the potential for democratisation that digital currencies hold since their inception, by making certain economic options more apparent (for instance around what industries - e.g., in the digital economy might be incentivised through one such development, so as to create jobs in such emerging sectors). More generally, digital currencies were designed with a vision of radical autonomy from state sovereignty. Hence, their adaptation to serve the interests of security and progress of which the state is meant to be a steward remains a challenge: the challenge of putting

digital currencies in service of inclusion and development, beyond individualistic freedom [29].

REFERENCES

- [1] C. Maquet, 'MNBC : tout comprendre de la monnaie numérique de demain', *Siècle Digital*. Accessed: Jun. 28, 2022. [Online]. Available: <https://siecledigital.fr/2020/11/02/mnbc-tout-savoir-monnaie-numerique/>
- [2] M. E. H. El Maknoui and H. Sadok, 'Regulation of virtual currencies in the United Arab Emirates: accounting for the emerging public/private distinction', *Development Studies Research*, vol. 8, no. 1, pp. 346–355, Jan. 2021, doi: 10.1080/21665095.2021.1980413.
- [3] M. S. Hossain, 'What do we know about cryptocurrency? Past, present, future', *CFRI*, vol. 11, no. 4, pp. 552–572, Oct. 2021, doi: 10.1108/CFRI-03-2020-0026.
- [4] A. Benkhayat, A. E. Manouar, and H. Sadok, 'Firm business strategy and IT strategy alignment: A proposal of a new model', in 2015 Xth International Scientific and Technical Conference 'Computer Sciences and Information Technologies' (CSIT), Lviv, Ukraine: IEEE, Sep. 2015, pp. 172–178. doi: 10.1109/STC-CSIT.2015.7325460.
- [5] H. Mahboub and H. Sadok, 'Implementing enterprise digital transformation: a contribution to conceptual framework design', *NBRI*, vol. 14, no. 1, pp. 35–50, Mar. 2023, doi: 10.1108/NBRI-06-2022-0067.
- [6] Bank for International Settlements (BIS), 'Central bank digital currencies', Mar. 2018.
- [7] C. Barontini and H. Holden, *Proceeding with caution - a survey on central bank digital currency*. in BIS papers, no. No 101. Basel: Bank for International Settlements, 2019.
- [8] European Central Bank (ECB), 'Report on a digital euro', p. 55, Oct. 2020.
- [9] H. Sadok and M. E. H. El Maknoui, 'The regulation of virtual currencies in comparative perspective: new private money or niche technological innovation?', *JMLC*, vol. 24, no. 4, pp. 712–724, Oct. 2021, doi: 10.1108/JMLC-09-2020-0101.
- [10] C. Pfister, 'Monnaies digitales et politique monétaire : beaucoup de bruit pour rien?', *Revue française d'économie*, vol. XXXII, no. 2, pp. 37–63, Dec. 2017, doi: 10.3917/rfe.172.0037.
- [11] C. Pfister, 'Les monnaies digitales, un nouvel univers?', *Regards croisés sur l'économie*, vol. n° 24, no. 1, pp. 40–52, Dec. 2019, doi: 10.3917/rce.024.0040.
- [12] Morgan, 'J.P. Morgan Creates Digital Coin for Payments'. Accessed: Apr. 06, 2021. [Online]. Available: <https://www.jpmorgan.com/solutions/cib/news/jpmorgan-creates-digital-coin-for-payments>
- [13] A. El Alami, H. Sadok, and N. Elhaoud, 'Cloud computing & the organizational performance different approach of assessment', in 2015 International Conference on Cloud Technologies and Applications (CloudTech), Marrakech, Morocco: IEEE, Jun. 2015, pp. 1–5. doi: 10.1109/CloudTech.2015.7337007.
- [14] H. Sadok, 'Fight Against Corruption Through Technology: The Case of Morocco', in *Advances in Finance, Accounting, and Economics*, A. Rafay, Ed., IGI Global, 2023, pp. 302–316. doi: 10.4018/978-1-6684-5007-9_ch013.
- [15] H. Sadok, F. Sakka, and M. E. H. El Maknoui, 'Artificial intelligence and bank credit analysis: A review', *Cogent Economics & Finance*, vol. 10, no. 1, p. 2023262, Dec. 2022, doi: 10.1080/23322039.2021.2023262.
- [16] H. Sadok, 'The Initial Coin Offering: Is It a Profitable Tool for Investment?', in *Digital Economy. Emerging Technologies and Business Innovation*, vol. 485, R. Jallouli, M. A. Bach Tobji, M. Belkhir, A. M. Soares, and B. Casais, Eds., in *Lecture Notes in Business Information Processing*, vol. 485, Cham: Springer International Publishing, 2023, pp. 185–194. doi: 10.1007/978-3-031-42788-6_12.
- [17] H. Schmiedel, G. Kostova, and W. Rutenber, 'The social and private costs of retail payment instruments: a European perspective', *European Central Bank (ECB)*, Frankfurt a. M., ECB Occasional Paper 137, 2012. [Online]. Available: <http://hdl.handle.net/10419/154590>
- [18] S. Ingves, *The E-Krona and the Payments of the Future*. Stockholm: Sveriges Riksbank, 2018. [Online]. Available: <https://www.riksbank.se/globalassets/media/tal/engelska/ingves/2018/the-e-krona-and-the-payments-of-the-future.pdf>
- [19] C. Skingsley, 'Should the Riksbank issue e-krona?', p. 13, 2016.
- [20] Sveriges Riskbank, 'The Riksbank's e-krona project', S E, p. 44, 2017.
- [21] Sveriges Riskbank, 'The Riksbank's e-krona project, Report 2', p. 52, Oct. 2018.
- [22] B. Segendorf, 'How Many E-Krona Are Needed for Payments?', *Sveriges Riksbank Economic Review*, vol. 2018, no. 3, pp. 66–78, 2018.
- [23] Banque de France, 'Rapport annuel de l'Observatoire de l'inclusion bancaire – 2018', p. 62, 2018, [Online]. Available: https://publications.banquefrance.fr/sites/default/files/medias/documents/oib2018_web_signets.pdf
- [24] Libra Association, 'The libra Block chain'. Libra Association, Geneva, 2019. [Online]. Available: https://libra.org/en-US/wp-content/uploads/sites/23/2019/06/LibraWhitePaper_en_US.pdf
- [25] B. Mouline and H. Sadok, 'Corporate Cash Holdings and Agency Conflicts: Evidence from Moroccan Developing Market', *ujaf*, vol. 9, no. 1, pp. 24–32, Feb. 2021, doi: 10.13189/ujaf.2021.090103.
- [26] H. Mahboub and H. Sadok, 'Towards a Better Digital Transformation: Learning from the Experience of a Digital Transformation Project', in *Digital Economy. Emerging Technologies and Business Innovation*, vol. 461, in *Lecture Notes in Business Information Processing*, vol. 461, Cham: Springer International Publishing, 2022, pp. 203–214. doi: 10.1007/978-3-031-17037-9_15.
- [27] A. Berentsen and F. Schar, 'The Case for Central Bank Electronic Money and the Non-case for Central Bank Cryptocurrencies', *r*, vol. 100, no. 2, pp. 97–106, 2018, doi: 10.20955/r.2018.97-106.
- [28] W. &Fung Engert and S.C., 'Motivations and Implications of a Central Bank Digital Currency', in *Do We Need Central Bank Digital Currency? Economics, Technology and Institutions*, E. Gnan and D. Masciandaro, Eds., Vienna: SUEF, 2019, pp. 56–71. [Online]. Available: <https://www.suerf.org/studies/7025/do-we-need-centralbank-digital-currency-economics-technology-and-institutions>
- [29] H. Sadok, 'How can inclusive growth be enabled from financial technology', *IJBPM*, vol. 22, no. 2/3, p. 159, 2021, doi: 10.1504/IJBPM.2021.116410.