

# OPTIMAL CENTRAL BANK DIGITAL CURRENCY DESIGN FOR EMERGING ECONOMIES

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## Abstract

The growth of digitalisation presents the possibility for Central Bank Digital Currency (CBDC) to emerge as a secure and efficient payment method. However, despite the benefits, CBDC implementation needs to be adapted to the capabilities and needs of each country. This study uses meta-strength, weakness, opportunity, and threat (meta-SWOT) analysis to assess the internal strengths and weaknesses, as well as the external opportunities and threats, to determine the most optimal CBDC design for emerging economies. In analysing internal aspects, CBDC allows for an efficient payment system, followed by a more effective monetary policy. Furthermore, the technology creates the possibility to boost financial inclusion and trace many illicit activities. However, to achieve that, high investment costs and privacy issues must be accommodated, followed by technological risks such as the digital divide and electrical outages. Turning to external aspects, growing technology, the network effect, enthusiasm for CBDC, and the impracticality of cash usage have become catalysts for CBDC development. Despite these opportunities, central banks should be wary of the threat of cyberattacks, quickening bank disintermediation, legal issues within their respective countries, and competition with private crypto companies. Altogether, the most optimal CBDC design in emerging economies is retail and wholesale coverage, interest-bearing (wholesale) and non-interest-bearing (retail) remuneration, account-based and token-based payment systems, a traceable degree of anonymity, hybrid architecture, a Decentralised Ledger Technology (DLT) ledger system, and domestic and cross-border scope. These results are supported by rigorous examination of global CBDC research and development.

**Keywords:** *CBDC, optimal design, SWOT analysis*

## I. INTRODUCTION

Ubiquitous digitalisation provides an opportunity for CBDC to become a secure and efficient payment instrument. Broadly speaking, CBDC can encourage cooperation between central banks, private sector participations (PSPs), and other institutions to implement digital payments.<sup>1</sup> On a broader

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<sup>1</sup> Raúl Morales-Resendiz et al., “Implementing a Retail CBDC: Lessons Learned and Key Insights,” *Latin American Journal of Central Banking* 2, no. 1 (2021): 100022, <https://doi.org/10.1016/j.lateb.2022.100058>.

scale, the implementation of CBDC can also benefit the macroeconomy.<sup>2</sup> In brief terminology, CBDC is a direct central bank liability in the form of digital currency.<sup>3</sup> More than 60 central banks have a keen interest in CBDC development to unleash its potential and impose constraints, from the research stage to the launch stage.<sup>4</sup> Aside from the central banks themselves, the Bank for International Settlements (BIS), International Monetary Fund (IMF), the World Economic Forum (WEF), World Bank, and other institutions are also involved in CBDC development, allowing it to reach a larger ecosystem.<sup>5</sup>

Several lessons can be learned by countries considering implementing CBDC by observing the development of CBDC, including Indonesia, which has only released a conceptual design for CBDC implementation. For example, during the pilot stage, the central bank of Sweden encountered the lack of adequate technology, privacy concerns, and robustness of a legal basis for CBDC implementation.<sup>6</sup> To that end, they have developed CBDC that is offline, incorporating balance capping and interest rate properties.<sup>7</sup> With regard to offline payment possibilities, the central bank of Uruguay has proposed Unstructured Supplementary Service Data (USSD) from phone SIM cards as the medium of offline payment.<sup>8</sup>

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<sup>2</sup> John Barrdear and Michael Kumhof, “The Macroeconomics of Central Bank Issued Digital Currencies,” *SSRN Electronic Journal*, no. 605 (2017), <https://doi.org/10.2139/ssrn.2811208>; Michael D Bordo and Andrew T Levin, “Central Bank Digital Currency and the Future of Monetary Policy,” 2017; Ben Dyson and Graham Hodgson, “Digital Cash: Why Central Banks Should Start Issuing Electronic Money,” *Positive Money*, 2016, 1–36, [https://positivemoney.org/wp-content/uploads/2016/01/Digital\\_Cash\\_WebPrintReady\\_20160113.pdf](https://positivemoney.org/wp-content/uploads/2016/01/Digital_Cash_WebPrintReady_20160113.pdf); Walter Engert and Ben S C Fung, “Central Bank Digital Currency: Motivations and Implications,” no. January (2017), [https://www.researchgate.net/publication/322274275\\_Central\\_Bank\\_Digital\\_Currency\\_Motivations\\_and\\_Implications](https://www.researchgate.net/publication/322274275_Central_Bank_Digital_Currency_Motivations_and_Implications); Tommaso Mancini-Griffoli et al., “Casting Light on Central Bank Digital Currency,” *Cryptoassets*, 2019, 307–40, <https://doi.org/10.1093/oso/9780190077310.003.0012>.

<sup>3</sup> BIS, “Central Bank Digital Currencies: Foundational Principles and Core Features,” *Bank of International Settlements*, 2020, <https://www.bis.org/publ/othp33.pdf>.

<sup>4</sup> Pauline Adam-Kalfon et al., “PwC Global CBDC Index 2021,” *PwC*, no. April (2021), <https://www.pwc.com/gx/en/industries/financial-services/assets/pwc-cbdc-global-index-1st-edition-april-2021.pdf>; Codruta Boar and Andreas Wehrli, “Ready, Steady, Go? – Results of the Third BIS Survey on Central Bank Digital Currency,” *BIS Papers*, no. 114 (2021): 77–82.

<sup>5</sup> Anton N. Didenko and Ross P. Buckley, “Central Bank Digital Currencies: A Potential Response to the Financial Inclusion Challenges of the Pacific,” *SSRN Electronic Journal*, no. 3 (2021), <https://doi.org/10.2139/ssrn.3937698>.

<sup>6</sup> Riksbank, “E-Krona Pilot Phase 1,” *Sveriges Riksbank*, 2021, 1–21, <https://www.riksbank.se/globalassets/media/rapporter/e-krona/2021/e-krona-pilot-phase-1.pdf>.

<sup>7</sup> Itai Agur et al., “Do We Need Central Bank Digital Currency? Economics, Technology and Institutions,” in *SUERF - The European Money and Finance Forum 2018/2*, ed. Ernest Gnan and Donato Masciandro (Milan: SUERF/BAFFI CAREFIN Centre Conference, 2018), [https://www.suerf.org/docx/s\\_cf0d02ec99e61a64137b8a2c3b03e030\\_7025\\_suerf.pdf](https://www.suerf.org/docx/s_cf0d02ec99e61a64137b8a2c3b03e030_7025_suerf.pdf).

<sup>8</sup> Agur et al.

However, some central banks are postponing their CBDC projects. For instance, the central bank of Denmark concluded that CBDC did not offer significant facilities that their existing payment infrastructure lacked.<sup>9</sup> The same goes for Poland. Its central bank could not identify the consumer demand to justify CBDC development. In the same spirit, Ecuador, which already launched CBDC, is abandoning its development due to competition with private companies.<sup>10</sup> Meanwhile, The Federal Reserve System in the United States is also taking a wait-and-see approach until the assessment of financial stability and cyber-attack risk is completed.<sup>11</sup>

The phenomenon above shows that despite the benefits of CBDC implementation, central banks can not merely place CBDC on their priority agenda. The Centro de Estudios Monetarios Latinoamericanos (CEMLA) argues that there is no “one-size-fits-all” CBDC design, which implies that it needs to be adjusted to the capabilities and needs of each country.<sup>12</sup> The role of central banks in CBDC must be clear, whether as operators or supervisors.<sup>13</sup> Interoperability is a must, so it could be integrated with other entities, such as financial institutions.<sup>14</sup> The implementation must also be reliable and resilient, with protection of user data.<sup>15</sup> To that end, CBDC development is not a race or about careless implementation but rather about solving the current problem.<sup>16</sup> Last but not least, CBDC should not denigrate monetary policy and financial stability, as well as be able to coexist with any means of payment, and promote broader innovation and efficiency.<sup>17</sup>

<sup>9</sup> Ben Margulies, “CBDC: The Case for ‘Wait and See,’” *Central Banking*, 2021, <https://www.centralbanking.com/fintech/cbdc/7844751/cbdc-the-case-for-wait-and-see>.

<sup>10</sup> Andrés Arauz, Rodney Garratt, and Diego F. Ramos F., “Dinero Electrónico: The Rise and Fall of Ecuador’s Central Bank Digital Currency,” *Latin American Journal of Central Banking* 2, no. 2 (2021): 100030, <https://doi.org/10.1016/j.latchb.2021.100030>.

<sup>11</sup> Yuliia Shapoval, “Central Bank Digital Currencies: Experience of Pilot Projects and Conclusions for the NBU,” *Economy and Forecasting* 2020, no. 4 (2020): 103–21, <https://doi.org/10.15407/eip2020.04.103>.

<sup>12</sup> CEMLA, “Key Aspects around Central Bank Digital Currencies Policy Report,” 2019, <https://www.cemla.org/fintech/docs/2019-06-KeyAspectsAroundBankDigitalCurrencies.pdf>.

<sup>13</sup> BIS, “III. CBDCs: An Opportunity for the Monetary System,” *BIS Annual Economic Report 2021*, 2021, <https://www.bis.org/publ/arpdf/ar2021e3.pdf>.

<sup>14</sup> Thomas Kudrycki, “Central Bank Digital Currency (CBDC) as a Tool for E-Money Interoperability,” *eCurrency*, 2019, <https://www.ecurrency.net/post/central-bank-digital-currency-cbdc-as-a-tool-for-e-money-interoperability>.

<sup>15</sup> Morales-Resendiz et al., “Implementing a Retail CBDC: Lessons Learned and Key Insights.”

<sup>16</sup> Central Banking Newdesk, “No UK Central Bank Digital Currency before 2025, BoE Says,” *Central Banking*, 2021, <https://www.centralbanking.com/fintech/cbdc/7896726/no-uk-central-bank-digital-currency-before-2025-boe-says>; Rachael King, “CBDC Issuance Should Not Be Rushed, Say Central Bank Experts,” *Central Banking*, 2021, <https://www.centralbanking.com/fintech/cbdc/7897181/cbdc-issuance-should-not-be-rushed-say-central-bank-experts>.

<sup>17</sup> BIS, “Central Bank Digital Currencies: Foundational Principles and Core Features.”

Despite the importance of CBDC, as mentioned in prior paragraphs, studies related to CBDC design are still few and have limited scope. For instance, Agur found that CBDC should fall between interest-bearing and noninterest-bearing depending on its network effect,<sup>18</sup> whereas Zams et al. found that non-interest-bearing CBDC is the most optimal design.<sup>19</sup> Both studies, however, only addressed the scope, remuneration, and possible characteristics of the CBDC design. Along the same lines, studies that used ledger systems and anonymity perspectives include those conducted by Allen et al. and Darbha and Arora.<sup>20</sup> Meanwhile, the structural aspect of CBDC has been reported in Auer and Böhme.<sup>21</sup> Later on, Kudrycki argues that CBDC must be properly designed so it can unify the distinction between the two.<sup>22</sup> Given the gaps above, this study determines the optimal CBDC design in emerging economies using meta-SWOT analysis with a purposive sampling approach.

Emerging economies, including China, India, Indonesia, Malaysia, the Philippines, Thailand, and Vietnam, are included in the sample based on several considerations. First, emerging economies are expected to play an important role in international trade and finance, including global economic growth.<sup>23</sup> Second, despite their potential, emerging economies' payment systems still have limited financial inclusion and high transaction costs, especially for cross-border payments.<sup>24</sup> The implementation of CBDC may be able to address these limitations. To that end, further discussion of CBDC implementation is appropriate since its technology has the possibility to solve many problems that occur in emerging economies.<sup>25</sup>

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<sup>18</sup> Itai Agur, Anil Ari, and Giovanni Dell'Ariccia, "Designing Central Bank Digital Currencies," Working Paper No. 2019/252, 2019, <https://www.imf.org/en/Publications/WP/Issues/2019/11/18/Designing-Central-Bank-Digital-Currencies-48739>.

<sup>19</sup> Bastian Muzbar Zams et al., "Designing Central Bank Digital Currency for Indonesia: The Delphi-Analytic Network Process," *Bulletin of Monetary Economics and Banking* 23, no. 3 (2020): 411–38, <https://doi.org/https://doi.org/10.21098/bemp.v23i3.1351>.

<sup>20</sup> Sarah Allen et al., "Design Choices for Central Bank Digital Currency: Policy and Technical Considerations," 2020, <https://doi.org/10.3386/w27634>; Sriram Darbha and Rakesh Arora, "Privacy in CBDC Technology," Bank of Canada, 2020, <https://doi.org/https://doi.org/10.34989/san-2020-9>.

<sup>21</sup> Raphael Auer and Rainer Böhme, "The Technology of Retail Central Bank Digital Currency," *Ssrn*, no. March (2020): 85–100.

<sup>22</sup> Kudrycki, "Central Bank Digital Currency (CBDC) as a Tool for E-Money Interoperability."

<sup>23</sup> Mohamed Aroui, Sabri Boubaker, and Duc Nguyen, *Emerging Markets and the Global Economy* (Academic Press, 2014), <https://doi.org/https://doi.org/10.1016/C2012-0-03535-1>.

<sup>24</sup> Erik Feyen et al., "What Does Digital Money Mean for Emerging Market and Developing Economies?," *The Palgrave Handbook of Technological Finance*, no. 97 (2021): 217–42, [https://doi.org/10.1007/978-3-030-65117-6\\_9](https://doi.org/10.1007/978-3-030-65117-6_9).

<sup>25</sup> Didenko and Buckley, "Central Bank Digital Currencies: A Potential Response to the Financial Inclusion Challenges of the Pacific."

In short, the result of this study shows that optimal CBDC design properties for emerging economies are retail and wholesale coverage, interest and non-interest-bearing remuneration, account and token-based payment systems, a traceable degree of anonymity, hybrid architecture, a DLT ledger system, and both domestic and cross-border coverage. This study is divided into four chapters. The first chapter explains the foundational concept of this research. The second chapter consists of the data and methodology employed. The third chapter defines optimal CBDC design. Lastly, the fourth chapter presents the research conclusion, followed by policy implications and recommendations.

## **II. RESEARCH METHODOLOGY**

### **II. A. Data**

This research examines the optimal CBDC design using meta-SWOT analysis. Purposive sampling is used to extract certain CBDC development literature that discusses, including but is not limited to, motivation, design characteristics, macroeconomic implications, and lessons learned. To maintain their quality, the sample literature used in this study is indexed in Scopus. For the working paper, information is only extracted from credible institutions such as BIS, CEMLA, the Asian Development Bank (ADB), the European Central Bank (ECB), the World Bank, the Financial Stability Board (FSB), PricewaterhouseCoopers (PwC), Deloitte, and Ernst & Young (EY). To enrich the observation, several official webinars organised by prominent institutions (e.g., BIS) are used in this study. Though this study also uses news platforms as references, it will be limited to credible news outlets such as the Wall Street Journal and the Central Bank. Based on the availability of relevant information, the countries used in this study are limited to 23 nations, China, Canada, Sweden, the Bahamas, the USA, Switzerland, France, Canada, the Eastern Caribbean, Singapore, Thailand, Hong Kong, Japan, Uruguay, Denmark, Ecuador, Poland, England, Japan, Nigeria, Jamaica, Ghana, and Russia.

### **II. B. Methods**

This study uses a meta-SWOT analysis to discern the research objectives. In general, a SWOT analysis divides information into internal aspects, e.g., strengths and weaknesses, and external aspects, such as opportunities and threats. For further observation, it is necessary to make an assessment to measure the contribution or influence of each criterion on each model. A standard SWOT, however, analysis cannot be used to measure the impact

of each aspect.<sup>26</sup> Therefore, other studies or expert opinions can be used to determine the magnitude of the impact of internal and external aspects. With the formulation of the impact size, this research will adapt and modify the meta-SWOT analysis of Agarwal, as shown in Table 1 below.<sup>27</sup>

**Table 1.**  
**Scoring for SWOT Analysis**

	Internal Factors		External Factors	
	Strengths	Weaknesses	Opportunities	Threats
Yes	+1	-1	+1	-1
Quasi Yes	+0.75	-0.75	+0.75	-0.75
Dependant	+0.5	-0.5	+0.5	-0.5
Quasi No	+0.25	-0.25	+0.25	-0.25
No	0	0	0	0

At the initial stage, the SWOT aspects of each CBDC design is outlined first. Then, each SWOT aspect is assessed as described in Table 1 above. If the characteristics of the CBDC model have absolute attributes that do not depend on other characteristics, in other words, strengthen the SWOT aspects, then the CBDC design will obtain a “Yes” attribute. For instance, despite the other chosen attributes, retail CBDC clearly supports financial inclusion. The “Quasi Yes” attribute is obtained if the CBDC characteristics support SWOT aspects but still have deficiencies in other aspects. For example, although traceable has a lower investment cost than anonymous, it is still inevitable that implementing CBDC can be considered a high-cost investment. The “Dependant” attribute will be assigned if the CBDC characteristics support SWOT aspects but are highly dependent on other aspects. To illustrate, the investment cost of retail CBDC depends on its anonymity because traceable CBDC has a lower cost than anonymous CBDC. The “Quasi No” attribute will be assigned if the CBDC characteristics do not really support the SWOT aspect in question but still have a slight impact on it. One example is the interaction between account-based CBDC and financial inclusion. Compared with token-based CBDC, which allows for implementing offline modes, account-based CBDC relies on the Internet and limits coverage in remote areas. However, despite that disadvantage, it still contributes to financial inclusion, though it loses

<sup>26</sup> E. Gurel and M. Tat, “SWOT Analysis: A Theoretical Review,” *The Journal of International Social Research* 10 (2017): 994–1006, [https://www.scirp.org/\(S\(czeh2ftqw2orz553k1w0r45\)\)/reference/referencespapers.aspx?referenceid=3040380](https://www.scirp.org/(S(czeh2ftqw2orz553k1w0r45))/reference/referencespapers.aspx?referenceid=3040380).

<sup>27</sup> Ravi Agarwal, Wolfgang Grassl, and Joy Pahl, “Meta-SWOT: Introducing a New Strategic Planning Tool,” *Journal of Business Strategy* 33, no. 2 (2012): 12–21, <https://doi.org/10.1108/02756661211206708>.

out to token-based coverage. Lastly, “No” attributes will be assigned if the characteristic does not support the respective SWOT aspect. Suppose that anonymous CBDC was compared with privacy loss, the score would be “No” because anonymous CBDC does not expose any transaction information, thus leading to no privacy loss.

**Table 2.**  
**General SWOT Matrix**

		CHARACTERISTICS														
		A		B		C		D		E			F		G	
		A1	A2	B1	B2	C1	C2	D1	D2	E1	E2	E3	F1	F2	G1	G2
<b>SWOT ASPECTS</b>	<b>S<sub>1</sub></b>	X <sub>S1A1</sub>	X <sub>S1A2</sub>	...												X <sub>S1G2</sub>
	...	X <sub>S2A1</sub>	X <sub>S2A2</sub>	...												X <sub>S2G2</sub>
	...	...	...													
	<b>S<sub>n</sub></b>															
	<b>W<sub>1</sub></b>															
	...															
	...															
	<b>W<sub>n</sub></b>															
	<b>O<sub>1</sub></b>															
	...															
	...															
	<b>O<sub>n</sub></b>															
	<b>T<sub>1</sub></b>															
	...															
	...															
	<b>T<sub>n</sub></b>	X <sub>TnA1</sub>	X <sub>TnA2</sub>													
<b>Total</b>	X1A	X2A	X1B	X2B	X1C	X2C	X1D	X2D	X1E	X2E	X3E	X1F	X2F	X1G	X2G	
<b>Coverage:</b>		<b>Remuneration:</b>				<b>Payment System:</b>				<b>Degree of Anonymity:</b>						
A1: Retail		B1: Interest-bearing				C1: Account-based				D1: Anonymous						
A2: Wholesale		B2: Non-interest bearing				C2: Token-based				D2: Traceable						
<b>Architecture:</b>		<b>Ledger System:</b>				<b>Scope:</b>										
E1: Indirect		F1: Centralized Ledger Technology (CLT)				G1: Domestic										
E2: Direct		F2: Decentralised Ledger Technology (DLT)				G2: Cross-border										
E3: Hybrid																

Source: Constructed by author



After analysing each SWOT aspect of each CBDC characteristic, the scores are accumulated vertically for each characteristic. This aims to determine the most optimal CBDC design for developing countries. For example, in terms of CBDC coverage, the score for the retail aspect is higher than the score for the wholesale aspect. Thus, it can be concluded that a CBDC design with a focus on retail coverage is the most optimal choice. However, if there is an equal score between retail and wholesale CBDC designs, then both should be implemented simultaneously.

### III. RESULTS AND ANALYSIS

#### III. A. SWOT Analysis of CBDC

##### III. A.1. Strengths Aspect

###### III. A.1.i. Payment Efficiency

CBDC is endorsed largely due to its payment efficiency.<sup>28</sup> He et al. argue that CBDC technology allows rapid and secure cross-border settlement.<sup>29</sup> A transaction costs encourages greater household consumption.<sup>30</sup> Due to CBDC's peer-to-peer nature, settlements can become nearly-instant and be continuously available.<sup>31</sup> Also, CBDC definitely facilitates quicker, cheaper, transparent, and more inclusive cross-border transactions.<sup>32</sup> Compared with cash, CBDC likely offers reduced handling costs and lower transaction fees, thus benefitting both households and businesses.<sup>33</sup> To illustrate this, the cost of cash handling is estimated to be reduced by up to 0.5 percent of the GDP of the European Union.<sup>34</sup> The same goes for taxation. CBDC implementation would be identical to the reduction of substantial distortionary taxes.<sup>35</sup> In

<sup>28</sup> Bordo and Levin, "Central Bank Digital Currency and the Future of Monetary Policy."

<sup>29</sup> Dong He et al., "Fintech and Financial Services: Initial Considerations," *International Monetary Fund*, 2017, 49, <https://www.imf.org/en/Publications/Staff-Discussion-Notes/Issues/2017/06/16/Fintech-and-Financial-Services-Initial-Considerations-44985>.

<sup>30</sup> Ferry Syarifuddin and Toni Bakhtiar, "The Macroeconomic Effects of an Interest-Bearing CBDC: A DSGE Model," *Mathematics* 10, no. 10 (2022): 1–33, <https://doi.org/10.3390/math10101671>.

<sup>31</sup> CPMI, *Central Bank Digital Currencies*, 2018, [http://file://localhost\(null\)%0Apapers3://publication/uuid/B47B3FF7-D88A-4403-9BD5-9E22746EAB8C](http://file://localhost(null)%0Apapers3://publication/uuid/B47B3FF7-D88A-4403-9BD5-9E22746EAB8C); PwC, "The Rise of Central Bank Digital Currencies (CBDCs)," *PwC*, 2019, <https://www.pwc.com/gx/en/financial-services/pdf/the-rise-of-central-bank-digital-currencies.pdf>.

<sup>32</sup> BIS et al., *Central Bank Digital Currencies for Cross-Border Payments: Report to the G20, Bank for International Settlements 2021*, 2021, <https://www.bis.org/publ/othp38.pdf>.

<sup>33</sup> Bordo and Levin, "Central Bank Digital Currency and the Future of Monetary Policy"; Nikhil Raghuvеera, "Central Bank Digital Currency Can Contribute to Financial Inclusion but Cannot Solve Its Root Causes," Atlantic Council, 2020, <https://www.atlanticcouncil.org/blogs/geotech-cues/central-bank-digital-currency-can-contribute-to-financial-inclusion-but-cannot-solve-its-root-causes/>.

<sup>34</sup> Agur et al., "Do We Need Central Bank Digital Currency? Economics, Technology and Institutions."

<sup>35</sup> Barrdear and Kumhof, "The Macroeconomics of Central Bank Issued Digital Currencies."



terms of transmission, a central bank could directly apply monetary policy to the CBDC wallet, thus reducing the number of transmissions and increasing the effectiveness of monetary policy.<sup>36</sup>

### III.A.1.ii. Monetary Policy Effectiveness

Monetary policy could be more effective employing CBDC because of the faster transmission by adjusting the CBDC rate directly through a central bank's wallet.<sup>37</sup> Aside from transmission, CBDC enables a central bank to supervise economies in a real-time manner, increasing the responsiveness of a central bank in monetary policy implementation.<sup>38</sup> With regard to the possibility of a negative policy rate, assuming the absence of cash, CBDC is able to penetrate the zero lower bound and provide a stimulus to public consumption in the event of an economic downturn.<sup>39</sup> In terms of bureaucracy reduction, CBDC enables regulators to transfer financial aid directly to individual wallets.<sup>40</sup>

### III.A.1.iii. Increasing Financial Inclusion

Financial inclusion is one of the important factors driving CBDC development.<sup>41</sup> The practicality of CBDC can boost financial inclusion by transforming the unbanked community into a banked one, thus empowering that community to harness financial services such as payments, transfers, savings, credit, insurance, and other vital services.<sup>42</sup> Moreover, CBDC is considered a risk-free asset, along with lower transaction costs and better practicality, making an attractive case for CBDC conversion.<sup>43</sup> Nevertheless, most of the benefits of financial inclusion tend to be perceived by emerging economies.<sup>44</sup>

<sup>36</sup> Sumei Luo, Guangyou Zhou, and Jinpeng Zhou, "The Impact of Electronic Money on Monetary Policy: Based on Dsge Model Simulations," *Mathematics* 9, no. 20 (2021): 1–26, <https://doi.org/10.3390/math9202614>.

<sup>37</sup> Agur et al., "Do We Need Central Bank Digital Currency? Economics, Technology and Institutions"; Ajay S. Mookerjee, "What If Central Banks Issued Digital Currency?," *Harvard Business Review*, 2021, <https://hbr.org/2021/10/what-if-central-banks-issued-digital-currency>; Bill Nelson, "The Benefits and Costs of a Central Bank Digital Currency for Monetary Policy," Bank Policy Institute (BPI), 2021, <https://bpi.com/the-benefits-and-costs-of-a-central-bank-digital-currency-for-monetary-policy/>.

<sup>38</sup> Aldenio Burgos and Bruno Batavia, "Currency in the Digital Era," 2018, <https://www.bcb.gov.br/htms/public/inovtec/Currency-in-the-Digital-Era.pdf>.

<sup>39</sup> Mohammad Davoodalhosseini, Fransisco Rivadeneyra, and Yu Zhu, "CBDC and Monetary Policy," Bank of Canada, 2020, <https://doi.org/https://doi.org/10.34989/san-2020-4>.

<sup>40</sup> BIS, "Central Bank Digital Currencies: Foundational Principles and Core Features."

<sup>41</sup> John Kiff et al., "A Survey of Research on Retail Central Bank Digital Currency," *IMF Working Papers* 20, no. 104 (2020), <https://doi.org/10.5089/9781513547787.001>.

<sup>42</sup> James Wallis, "Unlocking Financial Inclusion with CBDCs," *ripple*, 2021, <https://ripple.com/insights/unlocking-financial-inclusion-with-cbdc/>.

<sup>43</sup> Yves Mersch, "An ECB Digital Currency – a Flight of Fancy?," European Central Bank, 2020, <https://www.ecb.europa.eu/press/key/date/2020/html/ecb.sp200511~01209cb324.en.html>.

<sup>44</sup> Adam-Kalfon et al., "PwC Global CBDC Index 2021."

### III.A.1.iv. Traceability

The metaphor that data is more valuable than oil becomes relevant if we realise the potential of traceable data.<sup>45</sup> Without considering permissions, CBDC allows access to real-time data on each transaction conducted.<sup>46</sup> Using the Internet of things (IoT), CBDC data could be imported and used to observe current economic activities. This also creates the possibility of accurately calculating GDP in real-time.<sup>47</sup> Aside from that, traceability enables central banks to respond quickly when there is an unusual occurrence, for instance, the anomaly in price levels.<sup>48</sup> The same goes for Anti-Money Laundering (AML), Countering the Financing of Terrorism (CFT) and tax evasion concerns; any illicit activities could be easily detected.<sup>49</sup> Essentially, traceability within CBDC enables us to conduct better data analysis, thus improving the decision-making process for regulators.<sup>50</sup>

### III.A.2. Weaknesses Aspect

#### III.A.2.i. High Investment Cost

Implementing new technology, in this case CBDC, faces the consequence of high investment costs due to infrastructure renewal.<sup>51</sup> To that end, a central bank needs to develop a customer interface, front-end wallet, choose and maintain technology, supervise transactions, promote AML, and prevent CFT.<sup>52</sup> Aside from that, Kiff et al. also found that the costs associated with CBDC include IT expertise for the development of user interfaces (UI)/user experiences (UX) specialists, and software developers, as well as infrastructure (cloud and server), software (licence and service fees), cyber security (threat modelling, response management, penetration test, identification, and support

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<sup>45</sup> Kiran Bhageshpur, "Data Is The New Oil -- And That's A Good Thing," *Forbes*, 2019, <https://www.forbes.com/sites/forbestechcouncil/2019/11/15/data-is-the-new-oil-and-thats-a-good-thing/?sh=267eef507304>.

<sup>46</sup> CPMI, *Central Bank Digital Currencies*; Mookerjee, "What If Central Banks Issued Digital Currency?"

<sup>47</sup> PwC, "The Rise of Central Bank Digital Currencies (CBDCs)."

<sup>48</sup> Agur et al., "Do We Need Central Bank Digital Currency? Economics, Technology and Institutions?"; Kiff et al., "A Survey of Research on Retail Central Bank Digital Currency."

<sup>49</sup> European Central Bank, "Exploring Anonymity in Central Bank Digital Currencies," *In Focus*, no. 4 (2019): 1–11, <https://www.ecb.europa.eu/paym/intro/publications/pdf/ecb.mipinfocus191217.en.pdf>; Zijian Wang, "Tax Compliance, Payment Choice, and Central Bank Digital Currency," no. June (2022): 1–52.

<sup>50</sup> OECD, "Well-Being in the Digital Age" (Paris, 2019), <https://www.oecd.org/digital/well-being-in-the-digital-age.pdf>.

<sup>51</sup> CPMI, *Central Bank Digital Currencies*.

<sup>52</sup> Tobias Adrian and Tommaso Mancini-Griffoli, "Central Bank Digital Currencies: 4 Questions and Answers," *IMF Blog*, 2019, <https://www.imf.org/en/Blogs/Articles/2019/12/12/central-bank-digital-currencies-4-questions-and-answers>.

(helpdesk). However, this consequence is likely to be felt in the short term due to the high upfront costs of investment.<sup>53</sup>

### III.A.2.ii. Privacy Protection

When traceability is implemented in CBDC, the potential for invasion of privacy is presumed. Despite the benefits that can be obtained by allowing the traceability feature, people tend to want their privacy maintained.<sup>54</sup> During the pilot stage, Sweden is still evaluating the legal aspects of limiting the information that could be contained within CBDC.<sup>55</sup> Similarly, Jiang & Lucero reported that China is still evaluating its privacy protection concerns, especially the reporting of fraud or misused information.<sup>56</sup> Still, most central banks would likely disagree with allowing fully anonymous CBDC.<sup>57</sup> For instance, during its pilot stage, China implemented managed anonymity in its CBDC, which implies that transactions would be traceable if exceeding a certain huge value.<sup>58</sup> The same goes for Russia, which sacrifices anonymity by putting a unique identifier within CBDC to track each transaction.<sup>59</sup> Aside from the consequences of being anonymous, one argument explains that full anonymity in CBDC would have higher operational costs due to the complexity of the technology.<sup>60</sup>

### III.A.2.iii. Internet Coverage Limitation

To build a feasible environment for CBDC, related infrastructure such as internet coverage, electricity, and digital ID systems should be fortified.<sup>61</sup> Roller & Waverman emphasised that the critical mass of telecommunication

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<sup>53</sup> Kiff et al., “A Survey of Research on Retail Central Bank Digital Currency.”

<sup>54</sup> Giovanni Rabitti et al., “Central Bank Digital Currencies, Cryptocurrencies, and Privacy: What Experiments Tell Us,” Centre for Economic Policy Research, 2021, <https://cepr.org/voxeu/columns/central-bank-digital-currencies-cryptocurrencies-and-privacy-what-experiments-tell-us>.

<sup>55</sup> Riksbank, “E-Krona Pilot Phase 1.”

<sup>56</sup> Jiaying Jiang and Karman Lucero, “Background and Implications of China’s Central Bank Digital Currency: E-CNY,” *SSRN Electronic Journal*, no. 23 (2021): 1–26, [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3774479](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3774479).

<sup>57</sup> David G. W. Birch, “No Government Will Allow Anonymous Digital Currency,” *Forbes*, 2021, <https://www.forbes.com/sites/davidbirch/2021/04/06/no-government-will-allow-anonymous-digital-currency/?sh=8086a8110d56>.

<sup>58</sup> People’s Bank of China, “Progress of Research & Development of E-CNY in China,” 2021, 16.

<sup>59</sup> Bank of Russia, “A Digital Ruble” (Moscow, 2020), [https://www.cbr.ru/StaticHtml/File/113008/Consultation\\_Paper\\_201013\\_eng.pdf](https://www.cbr.ru/StaticHtml/File/113008/Consultation_Paper_201013_eng.pdf).

<sup>60</sup> Darbha and Arora, “Privacy in CBDC Technology.”

<sup>61</sup> Didenko and Buckley, “Central Bank Digital Currencies: A Potential Response to the Financial Inclusion Challenges of the Pacific.”

infrastructure is important for economic activities.<sup>62</sup> Even though a common transaction has the possibility of being conducted offline, interest-bearing CBDC implementation can only be executed online.<sup>63</sup> Furthermore, limited internet coverage could reduce the effectiveness of monetary policy due to limited policy coverage areas.<sup>64</sup>

#### III.A.2.iv. System Failure: Outages

To this day, energy has become a vital component for almost every aspect of life, especially electrical power.<sup>65</sup> To that end, electrical outages have a severe impact on the economy. For instance, Lerner reported that the average losses from internet outages are around 5,600 USD per minute and 300,000 USD per hour.<sup>66</sup> Meanwhile, heavy blackouts have caused traffic jams, stagnation among users, financial transaction disturbances, and losses of up to a billion dollars.<sup>67</sup> These calamities occur for several reasons, such as natural disasters and human error.<sup>68</sup> In such cases, CBDCs are vulnerable to outages and become unreliable in emergencies, so backup plans are needed to maintain the reliability of CBDCs in the event of outages, such as rapid resource assignment, advance action plans, and well-prepared recovery procedures.<sup>69</sup>

#### III.A.3. Opportunities Aspect

##### III.A.3.i. Developing Technology

As time passes, the development of financial technology keeps growing, making our lives easier.<sup>70</sup> For instance, artificial intelligence (AI) has the potential

<sup>62</sup> Lars-Hendrik Roller and Leonard Waverman, “Telecommunications Infrastructure and Economic Development: A Simultaneous Approach,” *American Economic Review* 91, no. 4 (2001): 909–23, <https://doi.org/10.1257/aer.91.4.909>.

<sup>63</sup> Dinesh Shah et al., “Technology Approach for a CBDC,” Bank of Canada, 2020, <https://doi.org/https://doi.org/10.34989/san-2020-6>.

<sup>64</sup> CPMI, *Central Bank Digital Currencies*.

<sup>65</sup> Sinan Küfeoğlu, *Economic Impacts of Electric Power Outages and Evaluation of Customer Interruption Costs* (Aalto University publication series, 2015), <https://core.ac.uk/download/pdf/301131449.pdf>.

<sup>66</sup> A Lerner, “What’s the Real Cost of IT Downtime?,” 2014, [https://www.the20.com/wp-content/uploads/2018/07/The\\_20\\_IT\\_Downtime\\_Infographic.pdf](https://www.the20.com/wp-content/uploads/2018/07/The_20_IT_Downtime_Infographic.pdf).

<sup>67</sup> Mao Shuai et al., “Review on Economic Loss Assessment of Power Outages,” *Procedia Computer Science* 130 (2018): 1158–63, <https://doi.org/10.1016/j.procs.2018.04.151>.

<sup>68</sup> Richard J Campbell, “Weather-Related Power Outages and Electric System Resiliency,” *Congressional Research Service*, 2012, [www.crs.gov](http://www.crs.gov); Andy Lawrence, “Annual Outage Analysis 2021: The Causes and Impacts of Data Center Outages,” 2021, 1–21, <https://www.velir.com/-/media/files/pdfs/uptime-annualoutageanalysis2021.pdf>.

<sup>69</sup> Amber Wadsworth, “The Pros and Cons of Issuing a Central Bank Digital Currency,” *Reserve Bank of New Zealand Bulletin* 81, no. 7 (2018): 1–21; Jeremy Spivey, “Minimizing the Cost of Downtime,” Wingswept, 2023, <https://www.wingswept.com/cost-of-downtime/>.

<sup>70</sup> Raphael Auer, Giulio Cornelli, and Jon Frost, “Covid-19, Cash, and the Future of Payments,” no. 3 (2020), <https://www.bis.org/publ/bisbull03.pdf>.

to improve the current workflow by learning from the existing patterns and creating efficient solutions from them.<sup>71</sup> In terms of CBDC, AI could be utilised for asset management, banking, or another lending platforms.<sup>72</sup> Furthermore, AI could be used in data analytics to supervise and validate portfolio risk assessments.<sup>73</sup> Turning to ledger system innovation, blockchain is one of the DLT technologies allowing storage of any digital asset with a high level of security and transparency.<sup>74</sup> Its immutability attributes could be implemented in CBDC to increase resiliency against cyberattack tampering.<sup>75</sup> Aside from that, blockchain also enables CBDC to conduct seamless Delivery vs Payment transactions (Adrian, 2019).<sup>76</sup> Thus, emerging technology can be a considerable opportunity for the development of CBDCs in the future.

### III.A.3.ii. Network Effect

Technology that relies on a large number of people will naturally have a network effect.<sup>77</sup> A network effect is an improvement in the value of goods or services as there is a critical mass in the number of participants.<sup>78</sup> The scale of the ecosystem and transaction volume could be determined by the network effect.<sup>79</sup> For instance, the benefits of a social network are higher depending on the number of connected people. Positive and sustainable network effects play

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<sup>71</sup> Ahmed Suliman et al., “Monetization of IoT Data Using Smart Contracts,” *IET Networks* 8, no. 1 (2019): 32–37, <https://doi.org/10.1049/iet-net.2018.5026>.

<sup>72</sup> Paul Moon Sub Choi and Seth H. Huang, “Fintech with Artificial Intelligence, Big Data, and Blockchain,” *Springer Singapore*, no. 1 (2021): VI, 304, <https://doi.org/https://doi.org/10.1007/978-981-33-6137-9>.

<sup>73</sup> BIS Innovation Hub, “Work Programme FY 2021/22,” 2021, <https://www.bis.org/press/p210122.htm>.

<sup>74</sup> Henning Diedrich, *Ethereum: Blockchains, Digital Assets, Smart Contracts, Decentralized Autonomous Organizations*, 1st ed. (CreateSpace Independent Publishing Platform, 2016), <https://www.amazon.com/Ethereum-Blockchains-Decentralized-Autonomous-Organizations/dp/1523930470>.

<sup>75</sup> Mustafa Safa Ozdayi, Murat Kantarcioglu, and Bradley Malin, “Leveraging Blockchain for Immutable Logging and Querying across Multiple Sites,” *BMC Medical Genomics* 13, no. Suppl 7 (2020): 1–7, <https://doi.org/10.1186/s12920-020-0721-2>.

<sup>76</sup> Tobias Adrian, “Stablecoins, Central Bank Digital Currencies, and Cross-Border Payments: A New Look at the International Monetary System,” International Monetary Fund, 2019, <https://www.imf.org/en/News/Articles/2019/05/13/sp051419-stablecoins-central-bank-digital-currencies-and-cross-border-payments>.

<sup>77</sup> David Easley and Jon Kleinberg, “Network Effects,” in *Networks, Crowds, and Markets: Reasoning about a Highly Connected World*, vol. 398 (Cambridge University Press, 2010), 509–42, <https://doi.org/10.4018/978-1-59904-885-7.ch132>.

<sup>78</sup> Caroline Banton, “Network Effect: What It Is, How It Works, Pros and Cons,” Investopedia, 2023, <https://www.investopedia.com/terms/n/network-effect.asp>.

<sup>79</sup> David P. McIntyre, Arati Srinivasan, and Asda Chintakananda, “The Persistence of Platforms: The Role of Network, Platform, and Complementor Attributes,” *Long Range Planning* 54, no. 5 (2020): 101987, <https://doi.org/10.1016/j.lrp.2020.101987>.

a remarkable role in retaining stakeholders.<sup>80</sup> Similarly with CBDC, the benefits themselves will increase when there are more participants in CBDC.<sup>81</sup>

### III.A.3.iii. CBDC Enthusiasm

Central banks have explored and developed CBDC for to its potential.<sup>82</sup> Furthermore, CBDC has become the hot topic within the central banking forum and thus gained traction.<sup>83</sup> In the same spirit, not only central banks but also private companies, especially fintech, are building enthusiasm for this kind of electronic payment. To that end, due to the similar motivation, it creates a possibility for collaboration between central banks and fintech companies.<sup>84</sup> Not only for cost sharing, but for collaboration to broaden CBDC coverage.

### III.A.3.iv. Cash Inefficiency

Due to the convenience of digital payment, most countries are experiencing a cash decline.<sup>85</sup> Cash has several negative aspects to be considered, such as the risk of theft, high maintenance costs, and inefficient distribution.<sup>86</sup> Furthermore, cash lacks practicality, convenience, and efficiency. The COVID-19 pandemic shined a spotlight on these problems and hastened the declining usage of cash

<sup>80</sup> Erol Kazan et al., “Disentangling Digital Platform Competition: The Case of UK Mobile Payment Platforms,” *Journal of Management Information Systems* 35, no. 1 (2018): 180–219, <https://doi.org/https://doi.org/10.1080/07421222.2018.1440772>.

<sup>81</sup> Gianluca Forner, “Network Effects on Central Bank Digital Currencies and Blockchain Protocol Based Ledgers,” Università Ca’ Foscari Venezia, 2020, <http://dspace.unive.it/handle/10579/17133>.

<sup>82</sup> Boar and Wehrli, “Ready, Steady, Go? – Results of the Third BIS Survey on Central Bank Digital Currency”; Adam-Kalfon et al., “PwC Global CBDC Index 2021.”

<sup>83</sup> Raphael Auer, Giulio Cornelli, and Jon Frost, “Rise of the Central Bank Digital Currencies: Drivers, Approaches and Technologies,” *SSRN Electronic Journal*, no. 880 (2021), <https://doi.org/10.2139/ssrn.3724070>.

<sup>84</sup> Yogesh Chauhan and Vijaya B. Marisetty, “Do Public-Private Partnerships Benefit Private Sector Evidence from an Emerging Market,” *Research in International Business and Finance* 47 (2019): 563–79, <https://doi.org/10.1016/j.ribaf.2018.10.002>.

<sup>85</sup> Auer, Cornelli, and Frost, “Covid-19, Cash, and the Future of Payments”; Claer Barrett, “Cash Use Plunges During Pandemic,” *Financial Times*, 2021, <https://www.ft.com/content/c4c39abc-93b2-46f5-a731-9dd95840b841>; Kelsey Coyle, Laura Kim, and Shaun O’Brien, “2021 Findings from the Diary of Consumer Payment Choice,” Federal Reserve Bank of San Francisco, 2021, <https://www.frbsf.org/cash/publications/fed-notes/2021/may/2021-findings-from-the-diary-of-consumer-payment-choice/>; Riksbank, “Cash Is Losing Ground,” Sveriges Riksbank, 2020, <https://www.riksbank.se/en-gb/payments--cash/payments-in-sweden/payments-in-sweden-2020/1.-the-payment-market-is-being-digitalised/cash-is-losing-ground/>; Cecilia Skingsley, “Should the Riksbank Issue E-Krona?,” *Sveriges Riksbank*, no. November (2016): 1–10, <https://www.bis.org/review/r161128a.pdf>; Martin Wolf, “The Time to Embrace Central Bank Digital Currencies Is Now,” *Financial Times*, 2021, <https://www.ft.com/content/7a93fb0a-ae95-44fc-a3d2-1398ef0ce1af>.

<sup>86</sup> Jonathan Brugge et al., “Attacking the Cost of Cash,” McKinsey & Company, 2018, <https://www.mckinsey.com/industries/financial-services/our-insights/attacking-the-cost-of-cash#/>.



due to its physical distancing protocols.<sup>87</sup> These phenomena could become an opportunity for central banks to provide a solution through CBDC.<sup>88</sup>

### III.A.4. Threats Aspect

#### III.A.4.i. Cyber Attacks

Technology is always evolving, the risk of cyberattacks evolves in kind.<sup>89</sup> In brief, a cyberattack is an attack intended to compromise the confidentiality, integrity, and availability of data through the internet.<sup>90</sup> This should be concerning because CBDC contains data on transactions, identity, and other important information.<sup>91</sup> According to Auer & Böhme, CBDC is vulnerable to massive Distributed Denial of Service (DDoS) attacks, which could disrupt transactions.<sup>92</sup> Generally speaking, a DDoS attack deliberately renders both the network and system unavailable for an authorised user, which opens an opportunity for hackers.<sup>93</sup> Adding relevance, CBDC carries public information, which becomes a feasible target for hackers.<sup>94</sup> To that end, DDoS brings consequences such as payment, settlement, and clearing disruption.<sup>95</sup> This impact could deepen financial instability due to the huge number of users.<sup>96</sup>

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<sup>87</sup> Ferry Syarifuddin and Maman Setiawan, “The Relationship between COVID-19 Pandemic, Foreign Direct Investment, and Gross Domestic Product in Indonesia,” *Sustainability (Switzerland)* 14, no. 5 (2022), <https://doi.org/10.3390/su14052786>; Harriet Torry, “Don’t Bank on Covid-19 Killing Off Cash Just Yet,” *The Wall Street Journal*, 2021, <https://www.wsj.com/articles/dont-bank-on-covid-19-killing-off-cash-just-yet-11612105200>.

<sup>88</sup> ING Group, “Central Bank Digital Currency in a European Context,” *ING Viewpoint*, 2020, <https://www.ing.com/About-us/Regulatory-international-affairs/Viewpoints/Central-bank-digital-currency-in-a-European-context.htm>.

<sup>89</sup> Australian Computer Society, “Threats Challenges Opportunities Preview” (Sydney, 2016), <https://www.acs.org.au/insightsandpublications/reports-publications/cybersecurity-threats-challenges-opportunities.html>.

<sup>90</sup> Andreea Bendovschi, “Cyber-Attacks – Trends, Patterns and Security Countermeasures,” *Procedia Economics and Finance* 28, no. April (2015): 24–31, [https://doi.org/10.1016/s2212-5671\(15\)01077-1](https://doi.org/10.1016/s2212-5671(15)01077-1).

<sup>91</sup> Cyrus Minwalla, “Security of a CBDC,” Bank of Canada, 2020, <https://www.bankofcanada.ca/2020/06/staff-analytical-note-2020-11/>.

<sup>92</sup> Auer and Böhme, “The Technology of Retail Central Bank Digital Currency.”

<sup>93</sup> Nikhil Tripathi and Babu Mehre, “DoS and DDos Attacks: Impact, Analysis and Countermeasures,” *Proceedings of National Conference on Advances in Computing, Networking and Security*, no. July (2013): 1–6, [https://www.researchgate.net/publication/259941506\\_DoS\\_and\\_DDos\\_Attacks\\_Impact\\_Analysis\\_and\\_Countermeasures](https://www.researchgate.net/publication/259941506_DoS_and_DDos_Attacks_Impact_Analysis_and_Countermeasures).

<sup>94</sup> Minwalla, “Security of a CBDC.”

<sup>95</sup> CPMI, *Central Bank Digital Currencies*.

<sup>96</sup> Laurent Collet et al., “Are Central Bank Digital Currencies the Money of Tomorrow?,” *Deloitte*, 2020, 1–25, <https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/financial-services/Banking/lu-are-central-bank-digital-currencies.pdf>.



### III.A.4.ii. Bank Disintermediation

In general, bank disintermediation occurs when there is a crowding-out effect on bank deposits.<sup>97</sup> CBDC can foster bank disintermediation for several reasons. First, in the case of an interest-bearing design, CBDC offers a comparable yield but with lower risk. This is because CBDC is directly issued by the central bank, which is a lender of last resort. Second, even when not an interest-bearing design, CBDC is more convenient and practical in terms of transaction.<sup>98</sup> Despite these reasons, this could be worse due to the fact that CBDC has near-instant settlement time, which could become a catalyst when bank disintermediation happens.<sup>99</sup>

### III.A.4.iii. Prepared Legal Framework

Following the current traction within central banks, CBDC implementation would likely implicate many legal issues.<sup>100</sup> Specifically, this issue is related to CBDC supervision, ownership, privacy, and legitimacy.<sup>101</sup> These issues are concerning because CBDC collects critical public information.<sup>102</sup> For instance, China still has concerns about the law when there is information fraud or misuse of CBDC.<sup>103</sup> In the same spirit, Sweden still needs to be the guarantor of CBDC. Furthermore, data protection should also be accommodated.<sup>104</sup> BIS et al., espoused that central banks should highlight the legal concerns of issuance, transfer, and redemption.<sup>105</sup> Despite these concerns, CBDC issuance should be clear, transparent, and legally legitimate.<sup>106</sup>

<sup>97</sup> Celine Choulet and Yelena Shulyatyeva, "History And Major Causes Of US Banking Disintermediation," BNP Paribas, 2016, <https://www.investing.com/analysis/history-and-major-causes-of-us-banking-disintermediation-383881>.

<sup>98</sup> Agur, Ari, and Dell'Ariccia, "Designing Central Bank Digital Currencies."

<sup>99</sup> Lea Bitter, "Banking Crises under a Central Bank Digital Currency (CBDC)," *Beiträge Zur Jahrestagung Des Vereins Für Socialpolitik 2020: Gender Economics*, 2020, 1–46, <http://hdl.handle.net/10419/224600>.

<sup>100</sup> Sayuri Shirai, "Central Bank Digital Currency: Concepts and Trends," VOXEU - The Centre for Economic Policy Research, 2019, <https://cepr.org/voxeu/columns/central-bank-digital-currency-concepts-and-trends>.

<sup>101</sup> Wouter Bossu et al., "Legal Aspects of Central Bank Digital Currency: Central Bank and Monetary Law Considerations," *IMF Working Papers* 20, no. 254 (2020), <https://doi.org/10.5089/9781513561622.001>.

<sup>102</sup> Janet Hua Jiang and Yu Zhu, "Monetary Policy Pass-Through with Central Bank Digital Currency," Bank of Canada, 2021, <https://www.bankofcanada.ca/2021/03/staff-working-paper-2021-10/>; Riksbank, "E-Krona Pilot Phase 1."

<sup>103</sup> Jiang and Lucero, "Background and Implications of China's Central Bank Digital Currency: E-CNY?"

<sup>104</sup> Riksbank, "E-Krona Pilot Phase 1."

<sup>105</sup> BIS, SIX Group AG, and Swiss National Bank, *Project Helvetia: Settling Tokenised Assets in Central Bank Money*, 2020, <https://www.bis.org/publ/othp35.pdf>.

<sup>106</sup> CPMI, "Distributed Ledger Technology in Payment, Clearing and Settlement," *Bank for International Settlements*, no. February (2017): 1–29, [http://file:///localhost\(null\)%0Apapers3://publication/uuid/BBE832E3-BE53-4CA4-BE33-725585FB91BC](http://file:///localhost(null)%0Apapers3://publication/uuid/BBE832E3-BE53-4CA4-BE33-725585FB91BC).

#### III.A.4.iv. Private Crypto-asset Competition

Following the enthusiasm for crypto-assets, private companies have tried to jump on this opportunity by developing their own cryptocurrency and Non-Fungible Token (NFT). However, this is very alarming for regulators because the legal basis of crypto-assets is not yet mature enough to govern.<sup>107</sup> Moreover, the Bank for International Settlements' Committee on Payments and Market Infrastructures (CPMI) is still alarmed because cryptocurrencies are distributed on a peer-to-peer basis and not as central bank liabilities.<sup>108</sup> Moreover, anonymity within private cryptocurrency prevents central banks from monitoring money circulation, which could weaken AML/CFT.<sup>109</sup> Furthermore, private cryptocurrency dominance can reduce monetary policy credibility, leading to financial instability.<sup>110</sup> To that end, several countries have considered banning cryptocurrency.<sup>111</sup>

### III. B. Optimal CBDC Design

Based on previous analysis of the SWOT aspects of each CBDC characteristic, the most optimal CBDC design in emerging economies can be determined by calculating the scores for each characteristic vertically as in Table 3. In analysing CBDC coverage, both retail and wholesale score the same (0.5), which means that either or both can be implemented. Turning to numeration design, both interest-bearing and non-interest-bearing remuneration also achieve the same score (1), which means both are feasible. The same goes for payment systems. Account-based and token-based payment systems achieve the same score (0.5), so it would be feasible for both options. However, in terms of anonymity, this study found that the score for traceable CBDC (1.25) is higher than anonymous CBDC (1). The architecture choices should therefore be a hybrid CBDC (2.5), and the ledger system would be DLT (2). Lastly, the scope could be both domestic and cross-border (0.75).

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<sup>107</sup> Morales-Resendiz et al., "Implementing a Retail CBDC: Lessons Learned and Key Insights."

<sup>108</sup> CPMI, "Digital Currencies," *Bank for International Settlements*, no. November (2015): 227–55, <https://doi.org/10.4324/9781003343776-11>.

<sup>109</sup> Gross Jonas and Jonathan Schiller, "A Model for Central Bank Digital Currencies: Implications for Bank Funding and Monetary Policy," *SSRN Electronic Journal*, 2021, 1–46, [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3721965](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3721965).

<sup>110</sup> Michael Woodford, "Monetary Policy in a World Without Money," *National Bureau of Economic Research* (Cambridge, 2000), <https://doi.org/10.3386/w7853>.

<sup>111</sup> Robby Houben and Alexander Snyers, "Cryptocurrencies and Blockchains: Legal Context and Implications for Financial Crime, Money Laundering and Tax Evasion," *IPOL | Policy Department for Economic, Scientific and Quality of Life Policies*, 2018, <https://doi.org/10.37282/991819.16.38>.

Table 3.  
SWOT Matrix Calculation

SWOT ASPECTS	CHARACTERISTICS														
	A		B		C		D		E		F		G		
	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2	E3	F1	F2	G1	G2
S <sub>1</sub>	0.75	0.25	1	0.25	0.5	0.75	0.25	0.75	1	0.75	1	1	0.75	0.5	0.75
S <sub>2</sub>	0.75	0.25	1	0.25	0.75	0.25	0.5	0.75	0.25	0.75	0.75	0.75	0.25	0.5	0.75
S <sub>3</sub>	1	0	0.75	0.75	0.75	1	0.75	0.5	0.75	0.5	0.75	0.5	0.75	0.5	0.75
S <sub>4</sub>	0.75	1	0.75	0.5	1	0.75	0	1	0.25	0.75	0.5	0.5	0.75	0.5	1
W <sub>1</sub>	-0.75	-0.5	-0.75	-0.5	-0.25	-1	-1	-0.25	-0.5	-0.75	-0.5	-0.75	-0.25	-0.5	-0.75
W <sub>2</sub>	-0.75	-1	-0.75	-0.5	-1	-0.75	0	-0.75	-0.25	-0.75	-0.5	-0.5	-0.5	-0.25	-0.75
W <sub>3</sub>	-1	-0.25	-1	-0.25	-1	-0.75	-0.5	-0.75	-0.5	-0.75	-0.5	-1	-0.75	-0.75	-1
W <sub>4</sub>	-0.75	-1	-1	-0.75	-1	-0.75	-0.5	-0.75	-0.5	-0.75	-0.5	-1	-0.75	-0.5	-0.75
O <sub>1</sub>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
O <sub>2</sub>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
O <sub>3</sub>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
O <sub>4</sub>	1	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
T <sub>1</sub>	-1	-0.75	-0.75	-0.5	-0.5	-0.5	-0.5	-0.75	-0.75	-1	-0.75	-1	-0.25	-0.5	-0.75
T <sub>2</sub>	-0.5	0	-0.5	-0.25	-0.75	-1	-0.75	-0.5	-0.5	-0.25	-0.5	-0.5	-0.75	-0.5	-0.75
T <sub>3</sub>	-1	-1	-1	-0.75	-0.75	-0.5	-0.5	-0.75	-0.5	-0.75	-0.5	-0.5	-0.75	-0.5	-0.75
T <sub>4</sub>	-1	0	-0.25	-0.75	-0.75	-0.5	-0.25	-0.75	-0.25	-0.5	-0.25	-0.5	-0.25	-0.75	-0.25
Total	0.5	0.5	1	1	0.5	0.5	1	1.25	2	0.75	2.5	0.5	2	0.75	0.75

Source: Constructed by author

Notes:

- A (Coverage); A1 (Retail); A2 (Wholesale)
- B (Remuneration); B1 (Interest-bearing); B2 (Non-interest bearing)
- C (Payment system); C1 (Account-based); C2 (Token-based)
- D (Anonymity); D1 (Anonymous); D2 (Traceable)
- E (Architecture); E1 (Indirect); E2 (Direct); E3 (Hybrid)
- F (Ledger system); F1 (Centralised Ledger Technology/CLT); F2 (Decentralised Ledger Technology. DLT)
- G (Scope); G1 (Domestic); G2 (Cross-border)
- S<sub>1</sub> (Payment efficiency); S<sub>2</sub> (Monetary policy effectiveness); S<sub>3</sub> (Increasing financial inclusion); S<sub>4</sub> (Traceability)
- W<sub>1</sub> (High cost of CBDC infrastructure); W<sub>2</sub> (Privacy loss); W<sub>3</sub> (Internet coverage limitation); W<sub>4</sub> (System failure: outage)
- O<sub>1</sub> (Growing technology); O<sub>2</sub> (Network effect); O<sub>3</sub> (CBDC enthusiasm); O<sub>4</sub> (Cash inefficiency)
- T<sub>1</sub> (Cyberattack); T<sub>2</sub> (Bank disintermediation); T<sub>3</sub> (Ill-prepared legal framework); T<sub>4</sub> (Private crypto-asset competition)

In terms of the most optimal CBDC design for emerging economies, especially coverage, this study suggests implementing both retail and wholesale CBDC. By doing so, central banks could achieve two significant things, which are financial inclusion and efficient interbank transactions.<sup>112</sup> However, in terms of implementation strategy, it would be appropriate if wholesale CBDC is developed before retail CBDC. This is because in emerging countries, internet coverage tends to be limited, inhibiting the effectiveness of retail CBDC implementation. Implementing both retail and wholesale is also the same as utilising potential coverage, thus making monetary policy more effective.<sup>113</sup>

With regard to remuneration, the design should be both interest-bearing and non-interest bearing but applied differently for retail and wholesale CBDC. For interest-bearing remuneration, wholesale CBDC would be more appropriate. Wholesale CBDC covers interbank transactions such as wholesale payments, reserves, and interbank loans, which are suitable for interest-bearing CBDC. Meanwhile, non-interest-bearing remuneration fits retail CBDC. Non-interest-bearing remuneration allows CBDC to be implemented with offline transaction technology, which could have broader coverage, especially in remote areas.<sup>114</sup> Nevertheless, both remunerations have the same score, which could infer that both remunerations are feasible.

Both account-based and token-based payment systems could be implemented simultaneously within the CBDC design. From the perspective of security, cyberattacks could be mitigated by applying an account-based payment system. Its multiple factor verification structure would allow CBDC to impose multiple security measures for cyberattack prevention. One example is using OTP technology. Furthermore, account-based CBDC could support AML/CFT concerns due to its account traceability.<sup>115</sup> However, since account-based CBDC depends on internet connectivity, token-based CBDC should also be implemented. Technology in token-based CBDC allows for offline operation, which could be an alternative when outages happens.<sup>116</sup> In the same spirit, by allowing offline transactions, CBDC can be used to conduct transactions in remote areas, which could promote financial inclusion. Furthermore, monetary policy could be more effective through broad CBDC coverage.

<sup>112</sup>BIS, SIX Group AG, and Swiss National Bank, *Project Helvetia: Settling Tokenised Assets in Central Bank Money*; Kiff et al., “A Survey of Research on Retail Central Bank Digital Currency.”

<sup>113</sup>CPMI, *Central Bank Digital Currencies*.

<sup>114</sup>Hanna Armelius, Carl Andreas Claussen, and Isaiah Hull, “On the Possibility of a Cash-like CBDC,” 2021, <https://www.riksbank.se/globalassets/media/rapporter/staff-memo/engelska/2021/on-the-possibility-of-a-cash-like-cbdc.pdf>.

<sup>115</sup>PwC, “Central Bank Digital Currency: PwC Overview,” 2020, <https://www.pwc.com/it/it/publications/assets/docs/central-bank-digital-currency.pdf>.

<sup>116</sup>BIS, “Central Bank Digital Currencies: Foundational Principles and Core Features”; Charles M. Kahn, Francisco Rivadeneyra, and Russell Wong, “Should the Central Bank Issue E-Money?,” *JSRN Electronic Journal*, 2018, <https://doi.org/10.2139/ssrn.3271654>.

Despite the SWOT result that traceability is an important feature for the most favourable CBDC design, traceability is important for regulators. It is inevitable that traceability could prevent illicit activities such as money laundering and terrorism financing. In terms of investment cost, traceable CBDC is cheaper than anonymous CBDC because complex encryption of CBDC is needed to build an anonymous system.<sup>117</sup> Furthermore, traceable CBDC allows the central bank to extract real-time data for policymaking purposes.<sup>118</sup>

With regard to the currency's architecture, this study suggests implementing hybrid CBDC. Generally speaking, this architecture separates the roles of the central bank and third parties. In this case, the distribution and "know your client" (KYC) of CBDC are managed by third parties, while the central bank takes on a supervisory role.<sup>119</sup> This scheme also allows the central bank to share its investment burden with third parties. Furthermore, it creates the possibility of having broader coverage since third parties already cover most regions. This scheme can also help avoid a single point of failure due to its distributed nature.<sup>120</sup>

The ledger system should use DLT. First, it is more resilient to an outage due to the lower risk of single-point failure.<sup>121</sup> Consider CBDC, where one server runs a single system. The underlying server hardware could present a single point of failure for the system's availability. When the server has an outage, the system becomes unstable. Second, DLT allows the use of blockchain technology.<sup>122</sup> Generally speaking, blockchain technology uses blocks that are chained to each other by hashes, where each block is validated through consensus, thus becoming immutable and able to withstand cyberattacks.

Lastly, given the similar score of both designs, the scope should be both domestic and cross-border. By doing so, monetary policy could be more effective since it allows CBDC to have broader coverage and support financial inclusion. With regard to the transaction costs, cross-border CBDC reduces remittance costs and improves settlement speed. Greater interoperability is

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<sup>117</sup> CPSS, *Principles for Financial Market Infrastructures, Bank for International Settlements and International Organization of Securities Commissions 2012*, 2012, [https://www.bis.org/cpmi/info\\_pfmi.htm](https://www.bis.org/cpmi/info_pfmi.htm); Darbha and Arora, "Privacy in CBDC Technology?"

<sup>118</sup> CPMI, *Central Bank Digital Currencies*; Mookerjee, "What If Central Banks Issued Digital Currency?"

<sup>119</sup> Auer and Böhme, "The Technology of Retail Central Bank Digital Currency."

<sup>120</sup> Mazin Debe et al., "IoT Public Fog Nodes Reputation System: A Decentralized Solution Using Ethereum Blockchain," *IEEE Access* 7 (2019): 178082–93, <https://doi.org/10.1109/ACCESS.2019.2958355>.

<sup>121</sup> Debe et al.

<sup>122</sup> World Bank, "Distributed Ledger Technology (DLT) and Blockchain," *FinTech Note* (Washington, DC: International Bank for Reconstruction and Development, 2017), <http://hdl.handle.net/10986/29053%0Ahttp://documents.worldbank.org/curated/en/177911513714062215/pdf/122140-WP-PUBLIC-Distributed-Ledger-Technology-and-Blockchain-Fintech-Notes.pdf>.

also achieved since it creates integration for a greater payment ecosystem and optimises network effects.<sup>123</sup> Furthermore, implementing both domestic and cross-border CBDC is aligned with the Principles for Financial Market Infrastructures (PFMI), specific to communications procedures and standards.

#### IV. CONCLUDING REMARKS

Based on the analysis using the meta-SWOT method, it can be concluded that the optimal CBDC design for emerging economies is both retail and wholesale coverage, both interest-bearing and non-interest-bearing remuneration, both account-based and token-based payment systems, traceable anonymity, hybrid architecture, a DLT ledger system, and both domestic and cross-border scope.

As a self-critical caveat, this study is supported by limited empirical literature on CBDC implementation. Most central banks are still in the development stage, including Indonesia, which has only released a conceptual design for CBDC implementation, called the Digital Rupiah. Currently, the Bahamas and Eastern Caribbean are the only countries that are rolling out CBDC. To that end, it is still possible that there will be many implementations of CBDC in the future. Given the current circumstances, future scholars could extend this study by adding relevant CBDC implementations to create a more comprehensive CBDC design proposal.

The findings of this study have several policy implications, followed by recommendations. CBDC comes at a high investment cost for the central bank. For this reason, this study propose that the central bank initiate a scheme like Private Public Partnership (PPP) with private companies. Not only is it cost-saving, but having a partnership with private companies could support innovation in CBDC development. Turning to money withdrawal, CBDC has the potential to mitigate the crisis impact due to its near-instant withdrawal capability. As a prevention measure, the central bank should apply balance capacity in CBDC so it would not worsen financial stability when a crisis happens. Since this study proposes both account- and token-based CBDC are appropriate designs, people should raise their awareness about their own CBDC key access, otherwise, they will lose all of their money. One idea is to implement a low-balance CBDC wallet to prevent any further losses when neglect occurs. With regard to anonymity, this study proposes traceable CBDC.

<sup>123</sup>Raphael Auer, Philipp Haene, and Henry Holden, "Multi-CBDC Arrangements and the Future of Cross-Border Payments," *BIS Papers*, no. 115 (2021): 17; BIS, "Central Bank Digital Currencies: System Design and Interoperability," *Bank for International Settlements 2021*, 2021, [https://www.bis.org/publ/othp42\\_system\\_design.pdf](https://www.bis.org/publ/othp42_system_design.pdf); Gongpil Choi, Meeyoung Park, and NaEun Park, "The Use of Virtual Currencies in Small-Value Cross-Border Remittances and Its Implication," *Remittances Review* 2, no. 2 (2017): 89–119, <https://doi.org/10.33182/rr.v2i2.430>.

However, the central bank should ensure legal compliance in their respective countries.

On the subject of technology, there is a possibility for outages in CBDC operation, hence, prevention measures such as a backup power plan should be concerned, otherwise, it could disrupt financial stability. Turning to the ledger system, DLT is the most viable option for CBDC design. However, due to their decentralised nature, the validators are considered third parties. Hence, the central bank must maintain its sovereignty and ensure the credibility of the validator. Last but not least, this study agrees that CBDC should inherit both domestic and cross-border scope. Implementing both would be a good sign since it would improve CBDC interoperability. However, since each country has its own policy, central banks should ensure that CBDC system integration does not weaken any nation's sovereignty.

### **Competing Interests**

The author declares that there are no conflicts of interest to disclose.

### **Data Availability Statement**

The data supporting the findings in this study are available from the corresponding author upon reasonable request.

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