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# ISLAMIC CENTRAL BANK DIGITAL CURRENCY (CBDC) DESIGN

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## Abstract

*We aim to propose central bank digital currency (CBDC) design that aligned with Islamic principles, as well as strengths, weaknesses, opportunities, and threats of its design. An integrative review will be used to construct the CBDC design, while benefits and drawbacks are assessed by SWOT analysis. Our result shows that CBDC design should be both retail and wholesale interlinkages, account and token based payment authentication, hybrid architecture, non-interest bearing remuneration, and managed anonymity. This design is done through integrative review within relevant hadith, Quran verse, and other works of literature, so it could be achieving maslahah and mitigate mudharat. In adding relevancy, fostering digital financial inclusion, better resiliency towards power outage, and mitigating bank disintermediation are the main strengths. However, consequences such as system complexity, underdeveloped legal framework, and high cost of new technology investment should be faced by the central bank. As for external aspects, this study identifies major opportunities such as growing Islamic finance, cashless society, and accelerated network effect. Last but not least, cybercrime, low level of digital financial literacy, and attractive conventional alternatives are substantial threats to CBDC development.*

**Keywords:** *CBDC, Islamic finance, Integrative review, SWOT*
**JEL Classification:** *E58, G21, O31*

## 1. INTRODUCTION

Practicality, efficiency, and security within payment instruments could be attained through CBDC. In short, CBDC is a direct central bank liability in the form of digital currency (BIS, 2020). Its technology allows CBDC to escalate interoperability between central banks, payment service providers, and other financial institutions to arrange digital payment (Morales-Resendiz *et al*., 2021). Furthermore, CBDC is also able to have a significant positive impact on macroeconomics such as lowering inflation and promoting economic growth (Barrdear & Kumhof, 2017; Bordo & Levin, 2017; Dyson & Hodgson, 2016; Engert & Fung, 2017; Mancini-Griffoli *et al*., 2018). To that end, around 90 percent of central banks (Kalfon *et al*., 2021; Kosse & Mattei, 2022) and international institutions (Didenko & Buckley, 2021) worldwide have enthusiasm for CBDC development to reveal the benefit and consequences of its implementation (Kalfon *et al*., 2021), be it on research stage or launching stage (Boar & Wehrli, 2021).

However, given by the nature of CBDC, several Islamic principles could be violated if its not carefully implemented. Even though CBDC is principally different from cryptocurrency, its shares some similarities on its technology. For instance, anonymity could violate the *ushl fiqh* principle and *Ibnu Majah* number 2340 *hadith* about transparency in avoiding illicit activities such as money laundering. Furthermore,

Lukonga (2023) argues that CBDC is associated with several complicated design issues with Islamic principles such as how CBDC should be remunerated and how CBDC should be treated in the tokenized financial market. However, from different perspective, a study from Firdiansyah & Samsuri (2021) shows that CBDC implementation will provide more *maslahah* than *masdafah* because it's eliminating some *haram* elements from cryptocurrency.

Despite the inconclusive discussion on Islamic CBDC implementation, studies discussing CBDC from Islamic perspective are still limited. Jaffar (2020) argues that CBDC should be introduced to be anchored with commodities such as gold. Furthermore, it should not be implemented as interest-bearing. Following the same spirit, Aysan & Al-Ansari (2022) suggest that CBDC should rid agency cost and moral hazard in transaction cost to be aligned with Islamic principles. Blockchain and other DLT-based technologies could serve CBDC with Islamic principles by helping to apply *maqasid sharia* controlling its operation (Al-Ayubi & Halawatuddu'a, 2021; Unal & Aysan, 2022). In addition, as long as CBDC doesn't carry *maysir*, *usury*, and vulnerability to illicit activities, it will be accepted as an allowed instrument (Firdiansyah & Samsuri, 2021). However, given by the discussion above, no study explicitly proposes an optimal CBDC design that follows Islamic principles. Several studies such as Agur, Ari, & Ariccia ( 2019), Allen *et al*. (2020), and Zams *et al*. (2020) proposed how CBDC should be designed, but not from Islamic perspective.

Given the gaps above, this study aims to determine the optimal Islamic CBDC design, followed by its benefits and drawbacks. Integrative review and SWOT analysis will be used to achieve these objectives. Islamic principle is chosen due to several considerations. Islamic principle is expected to bring social welfare such as poverty and inequality alleviation (Aggarwal & Yousef, 2000; Ali *et al*., 2013; Boukhatem & Ben Moussa, 2018; Caporale & Helmi, 2018; Gheeraert & Weill, 2015; Imam & Kpodar, 2016; F. Khan, 2010; Mensi *et al*., 2020). Although Islamic finance is less than 2 percent of global finance (Lukonga, 2023), its assets grow radically from 1,975 billion USD to 3,374 billion USD from 2014 to 2020, respectively. It is also predicted that Islamic finance could reach 4,940 billion USD in 2025 (S. Mohamed & Ahmed, 2021). In terms of stability, many studies document that Islamic finance is better than conventional (Abedifar *et al*., 2013; Čihák & Hesse, 2010; Hasan & Dridi, 2010).

Briefly stated, our result reveals that optimal Islamic CBDC design properties are both retail and wholesale interlinkages, account and token-based payment authentication, hybrid architecture, non-interest-bearing remuneration, and managed anonymity. However, this design is also carrying several benefits and drawbacks, be it internal or external aspects.

This study will be divided into five chapters. This chapter mainly explains the supporting background of this study. The second chapter discusses relevant literature review, especially about CBDC development and CBDC from Islamic perspective. The data and methods that will be used will be explained in the third chapter. Meanwhile, the fourth chapter will define optimal CBDC design, followed by its SWOT analysis. The remainder will be the conclusion of this research, followed by recommendation.

## 2. LITERATURE REVIEW

This section will be divided into two main strands. The first strand will focus on lesson learned drawn from CBDC development. The remainder will focus on perspective of CBDC from an Islamic view. Starting from the development of CBDC, result from

Sweden central bank pilot testing shows that its CBDC still lacks of offline technology and legal framework robustness, one of them is privacy (Riksbank, 2021; Ulmi & Devi, 2023). Another example comes from Uruguay central bank, with a similar concern about offline technology (Bergara & Ponce, 2018). To fix these problems, several actions are taken by them such as offline technology using unstructured supplementary service data (USSD), balance capping to limit illicit activities, and embedding interest rates to directly impose policy rates in CBDC (Agur *et al*., 2018). Further assessments of financial stability and cyberattack are also important. These factors make The Fed takes a "wait and see" stance on CBDC development until these assessment are finished (Shapoval, 2020). One successful CBDC pilot stage come from China, who able to conduct pilot testing in several big cities (Jiang & Lucero, 2021). Another example comes from Bahamas, which was able to become the first country that fully implement CBDC (Morales-Resendiz *et al*., 2021).

However, despite these enthusiasms, several central banks choose to defer their CBDC development. One example comes from Denmark central bank. This is because its central bank doesn't found any significant improvement in CBDC implementation to its existing payment system (Margulies, 2021). Consumer demand also influences the development of CBDC, which makes Poland central bank to postpone its CBDC development. Careless decision of CBDC implementation would lead to the Ecuador use case. Ecuador failed to implement CBDC because it's less attractive than private electronic money. This case leads Ecuador central bank to disband its CBDC development (Arauz *et al*., 2021). Meanwhile, in Chile, CBDC development should be postponed until its central bank is done assessing the offline technology for CBDC (Chen *et al*., 2022). In Nigeria, people protesting the introduction of CBDC due to the loss of freedom in its transaction (Anthony, 2023). To that end, Nigeria central bank chooses to postpone its CBDC development and further assess its traceability.

Turning to Islamic perspective, CBDC issuance emerges from various matters. Fundamentally, Islamic principle prohibit interest rates (Berg & Kim, 2014), which implies that remunerated CBDC is not allowed within its implementation. One idea is to incorporate profit-sharing mechanism as the substitution to interest payment. Aside from that, the tokenized financial market should also be further assessed as the Islamic principle prohibits foreign exchange derivative transactions (Dau-Schmidt, 2012). In analyzing the impact on financial stability, bank disintermediation issue is worth mentioning. As CBDC is considered a perfect substitute for demand deposits, especially the unremunerated ones, people tend to convert their demand deposits into CBDC and foster bank disintermediation (Bitter, 2020).

However, these concerns could be mitigated by the predominance of retail deposits in bank funding. Islamic banks in GCC countries rely on a high share of low-cost customer deposits, which implies a low reliance on wholesale funding (Lukonga, 2023). This kind of situation supports the stability of their funding base due to the ideal proportion of liquid assets to the base of customer deposit (Huang & Ratnovski, 2011). Nevertheless, since it still has risk of bank disintermediation, implementing balance capacity on CBDC is intended to minimize its risk (Agur *et al*., 2018). Although Islamic finance brings stability as mentioned above, it still continues to develop slowly due to unsupportive regulations, sharia-compliance complexities, limited standardization, the small number of Islamic banks and the underdeveloped financial sectors in many countries (Natoor *et al*., 2022). Most development lies on sukuk issuance but is still concentrated in Malaysia and GCC countries (Puri-Mirza, 2023). Underdeveloped

Islamic finance, be it sharia-compliant money market instrument for liquidity management (Puneri *et al*., 2019) or sukuk market (Boukhatem, 2022) will limit Islamic bank liquidity management and reduce central bank ability as the lender of the last resort, respectively.

All in all, despite the CBDC pros and cons, followed by Islamic principles alignment, central banks need to further assess whether they need to further develop CBDC or postpone it until the right time. Nevertheless, CBDC design should promote interoperability (Kudrycki, 2021), resiliency (Morales-Resendiz *et al*., 2021), and reliability, and not disrupt monetary policy effectiveness (BIS, 2020). Last but not least, to promote greater *maslahah*, CBDC should follow Islamic principles (Firdiansyah & Samsuri, 2021).

## 3. METHODOLOGY

Firstly, to propose CBDC design that complies with Islamic principles, this study uses a literature-based methodology namely integrative review. Following Torraco (2005), this approach aims to assess, critique, and synthesize the literature on a research topic in a way that enables new theoretical frameworks and perspectives to emerge. After CBDC design is proposed, SWOT analysis will be used for further analysis to evaluate the possible strengths, weaknesses, opportunities, and threats of specific project. Its outcome could assist policymakers in decision-making through the maximization of strengths and opportunities, followed by threats and weaknesses minimization (Puyt *et al*., 2023).

Aside from the business model, this method could be used for policy formulation. For instance, SWOT analysis was used to evaluate the impact of world oil prices fluctuation (Wang & Li, 2016), infrastructure planning (Lu, 2010), management of organic waste (Paes *et al*., 2019), solar power (Lei *et al*., 2019), nuclear exploration (Ishola *et al*., 2019), and evaluation of specific industry (Wan-rong *et al*., 2013). Following Gurel & Tat (2017), several advantages and disadvantages could be mentioned in using SWOT analysis. Macro evaluation, general perspective, and interoperability with other strategic decision tools are the main advantages of this approach.

## 4. RESULT AND DISCUSSION

### 4.1. Proposed Islamic CBDC Design

In proposing CBDC design, we adopt several design choices from relevant literatures (Auer & Böhme, 2020b; BIS, 2020; CPMI, 2018). These design choices are summarized in the table below. Our choices refer to which possible design that in line with Islamic principles, which is to realize *maslahah* and mitigate *mudharat*.

**Table 1.** Several Choices of CBDC Design

| Function | Choices |
|---|---|
| Interlinkages | Retail, Wholesale |
| Payment Authenticator | Account, Token |
| Architecture | Direct, Indirect, Hybrid |
| Remuneration | Interest-Bearing, Non-Interest Bearing |
| Ledger System | Centralised, Decentralised |
| Anonymity | Full-traceable, Managed anonymity, Full-anonymity |

First, we propose that both retail and wholesale interlinkage designs should be implemented. As CBDC is intended to bring further *maslahah*, greater coverage should be achieved. Retail interlinkage allows central banks to promote financial inclusion due to accessibility towards households and businesses (Auer *et al*., 2022). Furthermore, it also offer new ways to convert unbanked into banked people, thus increasing their competition level and diversity in the global market (Tan, 2023). Inclusive financial ecosystem that could decrease the cost of transactions, eliminate barriers of financing, and increase microfinance power could also be attained through retail CBDC. At the same time, retail CBDC helps unbanked and underbanked individuals to have digital identitites (Lopez, 2022). This allows people to establish a financing track record and make them easier when they want to propose financing. Turning to wholesale interlinkage, its technology is also designed to reduce settlement risks and improves the efficiency of large-value financial transactions or so-called wholesale transactions (Greene, 2023). Although its alike from the existing digitized central bank liabilities associated with current payment and settlement systems, it could improve the experience in current Islamic financial transactions such as *sukuk*, while further deepening Islamic financial market (Kammer *et al*., 2015).

Aside from these, implementing both retail and wholesale CBDC implies our support toward wealth circulation to reduce inequality and poverty. Following QS. Al-Hasyr: 7,

... كَيْ لَا يَكُوْنَ دُوْلَةًۢ بَيْنَ الْاَغْنِيَاۤءِ مِنْكُمْۗ ...

…

*"...so that wealth will not be a perpetual distribution among the rich from among you..."*

To that end, increasing financial inclusion results in human welfare improvement in accordance with *maqasid sharia* in realizing *falah* and life of *thayyibah* in people's lives.

Second, both account and token payment authenticator should be implemented at the same time. Technically, it is possible to implement both technologies as illustrated by Bitcoin (Garatt *et al*., 2020). Account authenticator allows us to identify each CBDC user. To that end, central banks could prevent any illicit activities such as corruption, money laundering, terrorism financing, *haram* transaction, and tax evasion. At the same time, following BIS (2021b), token authenticator refers to a design where CBDC has one or more cash-like features such as representing a bearer instrument and supporting offline or anonymous payments. This will be important because CBDC represents national legal tender which should be accessible in every circumstance such as power outages (Chu *et al*., 2022). Nevertheless, communication line such as satellite for banking needs to be further developed to reduce digital divide (Prayudya & Firmansyah, 2022), thus fully optimize CBDC implementation.

By implementing these technologies, people could conduct *muamalah* such as transactions without any bad deeds due to the traceability from account authenticator, followed by convenience experience without worrying about downtime period. Traceability in CBDC is in line with *ushl fiqh* rule that "any illicit activities should be removed as much as possible". *Hadith* of Ibn Majah: 2340 also stated that

عَنْ أَبِي سَعِيْدٍ سَعَدْ بْنِ سِنَانِ الْخُدْرِي رَضِيَ اللهُ عَنْهُ أَنَّ رَسُوْلَ اللهِ صلعم قَالَ : لاَ ضَرَرَ وَلاَ ضِرَارَ

From Abu Sa'id, Sa'ad bin Sinan al-Khudri (RA), the Prophet (peace be upon him) said: *"It is not permissible to do actions that can harm oneself and harm others."*

Turning to architecture, we propose a hybrid architecture for Islamic CBDC due to several reasons. This architecture implies that CBDC is a claim on the central bank, intermediaries onboard and handle retail payment, while central bank also periodically records retail balances. Following Auer & Böhme (2020), hybrid CBDC would have both advantages and disadvantages vis-à-vis the indirect or direct CBDC architectures. As an intermediate solution, it might offer better resilience than indirect CBDC. the central bank retains a copy of all retail CBDC holdings, allowing it to transfer holdings from one payment service provider to another in the event of a technical failure. However, it will add more complexity to central bank operations. On the other hand, the hybrid CBDC is still simpler to operate than a direct CBDC. As the central bank does not directly interact with retail users, it can concentrate on a limited number of core processes, while intermediaries handle other services including instant payment confirmation.

Furthermore, hybrid architecture is also consistent with one of the *maqasid sharia* elements namely *hidzfu maal* (Firdiansyah & Samsuri, 2021). This element implies how Islam does solemnly about asset protection. Compared with other architectures, the hybrid offers better resilience. Aside from that, its simplicity allows central bank to concentrate on a specific concern, such as cyber security and illicit activities within a transaction (Auer & Böhme, 2020b). Again, this is consistent with Hadith of Ibn Majah: 2340 that we, in this context central banks, should provide solutions to mitigate cyber-attacks and any illicit activities such as money laundering, terrorism financing, and so on.

In term of remuneration, despite the obvious Islamic law that prohibit interest, there are several concerns that non-interest bearing offers a better *maslahah*. Implementing interest-bearing CBDC creates a "deposit-like" experience for the user (Chiu & Davoodalhosseini, 2021). In case of a positive interest rate, the interest payment will be delivered to each account. This kind of situation could drive bank disintermediation since people prefer to use CBDC rather than place their money on bank deposits (Wenker, 2022). The negative drawback could also happen in a negative interest rate situation. In case central bank plans to surpass zero lower bounds to trigger consumption, people's CBDC will be drained out according to the interest rate. This could potentially trigger people's anger over CBDC's negative interest rate as people also have their plan to manage their expenditure (Nelson, 2021).

Islamic principle strictly prohibits interest rates as mentioned in QS. Al-Baqarah: 278-279 about the prohibition of usury, which also contains elements of exploitation. Furthermore, it also denies the predetermined rate concept and only accepts profit rate of return (M. S. Khan, 1986). Likewise, the *hadith* narrated by Ibn Mas'ud that "There is no-one who deals in usury a great deal (to increase his wealth) but he will end up with little (his wealth will be decreased)." Similarly, Hadith by Abu Hurairah stated that "There will come a time when there will be no one left who does not consume interest, and whoever does not consume it will nevertheless be affected by it.".

Due to several reasons, the ledger system in this CBDC will be decentralized. First, this ledger system offers a better solution in facing power outages (Debe *et al*., 2019). This is because all of the nodes will be provided by copy of transaction, thus it will easily

be recovered once the outage is over. Second, decentralized wins over public trust (Lemieux & Feng, 2021). Verification that relies on a single point has more possibilities of fraud. Conversely, decentralized split the verification into several transparent verificator, which reduces the loopholes of fraud (Hansen & Delak, 2022). However, to maintain the central bank's sovereignty, a permissioned decentralized ledger system is chosen (Auer *et al*., 2021b). By doing so, the central bank could maintain an access control layer to allow certain actions to be performed only by certain verified participants.

Using the same hadith that was narrated by Ibn Majah: 2340, this ledger system is consistent with how we combat illicit activities to maintain *maslahah* within the system. Similarly, Imam Thabrani *hadith* stated:

عَنْ عَائِشَةَ، أَنَّ رَسُولَ اللَّهِ صَلَّى اللهُ عَلَيْهِ وَسَلَّمَ قَالَ: إن اللَّهَ عَزَّ وَجَلَّ يُحِبُّ إِذَا عَمِلَ

أَحَدُكُمْ عَمَلًا أَنْ يُتْقِنَهُ

"*Truly, Allah loves those who, if they do a job, is done itqan (precise, directed, and complete)*". This hadith implies by verifying participants within the ledger, the central bank is ensuring financial system to be worked without out from Islamic boundaries.

**Table 2**. Proposed CBDC Design

| Function | Choices |
|---|---|
| Interlinkages | Both retail and wholesale |
| Payment authenticator | Both account and token |
| Architecture | Hybrid |
| Remuneration | Non-interest bearing |
| Ledger system | Decentralised |
| Anonymity | Managed anonymity |

Lastly, the anonymity design is managed anonymity. This choice is considered a sweet spot as it is satisfying both public and central bank concerns (Mu, 2022). From public transaction, some of their privacies are maintained because only high amount of transaction is traced by the central bank, while the remainder is still anonymous. Meanwhile, central bank still has control over any illicit transactions, especially within high amount transactions. A study by Ren *et al*. (2022), using the Chinese economy as calibration, shows that managed anonymity drives tax revenue, followed by aggregate welfare. This implies that central banks could calibrate the anonymity level of CBDC toward desired work plans and economic situations.

### 4.2. SWOT Analysis of Proposed Design

This section presents a further analysis of the proposed Islamic CBDC design in previous section. The framework is illustrated in a quadrant form as indicated in the table below. Detailed discussion will be organized in the subsequent sections.

**Table 3.** SWOT Analysis of Proposed CBDC Design

| | |
|---|---|
| **Strengths:**<br>1. Fostering digital financial inclusion<br>2. Better resiliency towards power outage<br>3. Mitigating bank disintermediation | **Weaknesses:**<br>1. System complexity<br>2. Underdeveloped legal framework<br>3. High cost of new technology investment |
| **Opportunities**:<br>1. Growing Islamic finance<br>2. Cashless society<br>3. Accelerated network effect | **Threats:**<br>1. Cybercrime<br>2. Low level of digital financial literacy<br>3. Attractive conventional alternative |

### 4.3. Strengths Analysis

**Fostering Digital Financial Inclusion**

Fostering financial inclusion is highlighted as one of the main objectives for retail CBDC, especially for emerging and low-income economies (Kosse & Mattei, 2022), as well as to achieve greater *maslahah*. Choice of token-based CBDC allows central bank to access offline technology, which furthers the impact of financial inclusion. Offline capability drives simple conversion between cash and CBDC, incentivized and simplified account creation, two-tiered distribution system, and propagation of CBDC merchant (Mohammed *et al*., 2022). To that end, CDBC could offers an opportunity to become a panacea for some obstacles in overcoming the unbanked (Cartens & Máxima, 2022). Furthermore, lower transaction cost, simplicity, practicality, and risk-free attributes are compelling factors for people to convert CBDC (Mersch, 2020).

Financial inclusion is also in line with Islamic principles as Islam governs us to circulate the wealth to be distributed for all people. Following the same previous verse, QS. Al-Hasyr 7, stated that:

... كَيْ لَا يَكُونَ دُولَةً بَيْنَ الْأَغْنِيَاءِ مِنكُمْ ...

*"...so that wealth will not be a perpetual distribution among the rich from among you..."*

To that end, increasing financial inclusion results in human welfare improvement as it accordance with *maqasid sharia* in realizing *falah* and life of *thayyibah* in people's lives.

Tan (2023) develops a model incorporating CBDC impacts on financial inclusion. His model documents that CBDC could promote financial inclusion by giving incentives of bank account creation as access to CBDC wallet. China pilot project tested NFC technology to further assess the accessibility of CBDC to people that live in remote areas (Chow & Eckert, 2021). Using the same technology, Bahamas and Easter Caribbean are able to reach remote people within their archipelago (Turner, 2020). Following the same spirit, Hungary central bank tries to collaborate CBDC development with its existing program, which is the Digital Student Safe pilot project. Its main objectives are to further develop financial literacy and financial inclusion (Fáykiss *et al*., 2022).

**Better Resiliency Towards Power Outage**

To this day, energy become a vital component for almost every aspect of life, especially electrical energy (Küfeoğlu, 2015). The outage could bring a severe impact on the economy. For instance, Lerner (2014) reported that the average losses of internet outages are around 5,600 USD per minute and 300,000 USD per hour. Meanwhile, heavy blackouts caused traffic jams, stagnation of tourists, financial transaction disturbance, and

losses of up to a billion dollars (Shuai *et al*., 2018). This calamity could occurred due to several reasons, such as natural disasters and human error (Campbell, 2012; Lawrence, 2021). To that end, implementing both account and token based CBDC should be a right decision. Specifically, token-based authenticator allows CBDC to be conducted in offline manner which could become an alternative payment method during power outage.

Adding relevancy to this matter, following Stewart (2022), several examples of payment system downtime are (1) an eight-hour failure in Europe's TARGET2 large-value payment system, (2) Canada's massive outage on two telecommunication networks, (3) knock-on effects of AWS interruption, and (4) one-week downtime of Easter Caribbean CBDC. Given the examples above, the preventative measure is important for CBDC resiliency towards electrical downtime. One idea is to frequently copy the entire CBDC data as a backup file when downtime happened (Auer & Böhme, 2020b). Last but not least, CBDC should always be complementary to cash, not fully replace or substitute (BIS, 2020), so it will be such a backup payment when downtime happened.

**Mitigating Bank Disintermediation**

In general, bank disintermediation occurs when there is a crowding-out effect in bank deposits because people bypass the necessity of banking services (Choulete & Shulyatyeva, 2016). In case of interest-bearing design, CBDC could give a competing yield but with lower risk. This is because CBDC is directly issued from the central bank, which is a lender of the last resort. 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 happened (Bitter, 2020). To mitigate bank disintermediation, implementing non-interest bearing remuneration will be relevant. Non-interest bearing CBDC makes people consider CBDC same properties as cash, except it is digitalized. Moreover, it is also in line with Islamic principles, specifically QS. Al-Baqarah: 278-279 about the prohibition of usury. Aside from these, hybrid architecture allows banks to become intermediaries that handle public transactions (Auer & Böhme, 2020b). This maintains the necessity of banking services, which prevent bank disintermediation.

Though there is no empirical evidence of bank disintermediation within CBDC implementation, several studies conduct simulations of this occurrence. Wenker (2022), on his interest-bearing CBDC scenario, revealed that CBDC carries bank disintermediation risk due to the assumption that individuals or businesses tend to invest their assets in CBDC rather than in old-fashioned term deposits, bonds, or other longer-term debt instruments. Similarly, Bian *et al*. (2021) reported that under certain conditions, the convenient CBDC with better efficiency comes at the cost of commercial bank deposit base disruption.

### 4.4. Weaknesses Analysis

**System Complexity**

Despite the fact that hybrid architecture is better than other architecture, it comes with a price of system complexity (Auer & Böhme, 2020b). This architecture split the role between the central bank and intermediaries. Fundamental core processes such as CBDC direct claims will be handled by the central bank, while other services such as payment services will be handled by intermediaries. The central bank does not operate retail payments, but maintains a backup copy of balances which allows it to restart payment should intermediaries run into insolvency or technical outages. Furthermore, with managed anonymity, it will add more complexity to CBDC design, be it in the form

of technology or regulation (Darbha & Arora, 2020). Central bank as designers should build a system with hybrid privacy levels. In specific, anonymous transactions, which offer privacy to people, should be allowed within limits. Meanwhile, traceable transactions such as wholesale could surpass the limitation. Adding relevancy, Morgan & Fullerton (2022) reported that managed anonymity adds more levels of KYC, which is into four levels of KYC. Altogether, the complexity of CBDC is inevitable so central banks in the digital era should develop substantial technological expertise (Auer & Böhme, 2020a).

When it comes to empirical evidence, Morales-Resendiz *et al*. (2021) summarize the development of several CBDC projects carried out by central banks. A complex balance of cooperation within intermediaries, in this context hybrid architecture, should be embraced by central banks to establish risk management framework. Moreover, referring to Bank Indonesia (2022) white paper, proposing both retail and wholesale CBDC adds more complexity since retail CBDC itself requires more complex treatment than wholesale one. Meanwhile, during its assessment, Digital Euro project is also aware that complexity within hybrid architecture lies on intermediaries management on accounts that are not on their balance sheet (Bechtel & Otto-Schleicher, 2020). Turning to managed anonymity use case, Chinese CBDC pilot project shows that managed anonymity adds complexity to their system (Jiang & Lucero, 2021; Mu, 2022). Adopting two-tier system, Chinese central bank supplies CBDC to the authorized operators for public transactions. Subsequently, necessary information will be collected by authorized operators. Legitimate and normal transaction privacy remains protected, while suspicious transactions will be further identified.

**Underdeveloped Legal Framework**

Following the current traction within central banks, CBDC implementation would likely to has an issue with legal aspects (Shirai, 2019). In specific, this issue is related to the CBDC supervision, ownership, privacy, and legitimacy (Bossu *et al*., 2020). This issue becomes concerning because CBDC collects critical public information (Jiang & Lucero, 2021; Riksbank, 2021). Moreover, Islamic finance legal framework is less established than conventional one, which makes it more concerning. During practice, the development of Islamic monetary framework is still influenced by the conventional system because it tends to develop side-by-side with the conventional one (Khatat, 2016). In terms of Islamic finance market, most of them are still considered underdeveloped (Fauzi & Hapsari, 2019). As for illustration, Islamic finance accounts for less than 2 percent of global finance (Lukonga, 2023).

For instance, China still has a concern about the law when there is information fraud or misuse in CBDC. (Jiang & Lucero, 2021). Following the same spirit, Sweden still needs to ensure the guarantor of CBDC. Furthermore, data protection should also be accommodated (Riksbank, 2021). The same goes with BIS *et al*. (2020), central banks should highlight the legal concerns of issuance, transfer, and redemption. Despite of these concerns, CBDC issuance should be clear, transparent, and legally acknowledged (CPMI, 2017).

**High Cost of New Technology Investment**

CBDC that aims for improvement to existing payment systems may entail new technology of payment systems (World Economic Forum, 2021). However, this renewal has a consequence of high-cost investment (CPMI, 2018). The authorities, in this case,

central banks, will have to endure all of the costs associated with CBDC implementation (H. Mohamed, 2020). Following Camara *et al*. (2018), the cost of technology and human resources training is the main implementation cost on brand new CBDC infrastructure. In particular, the cost associated with CBDC implementation is IT consultation, UI/UX expert, software development, cloud and server management, software lisence, cyber security system, and helpdesk support (Kiff *et al*., 2020). Moreover, the proposed design demands to implement both account and token payment authentication, which further increase investment cost. Managed anonymity is also responsible for investment cost increment due to the complexity of CBDC encryption (Darbha & Arora, 2020).

To reduce the burden of the central bank in implementing CBDC, a public-private partnership (PPP) scheme could be organized. Following Adrian (2020), to have authorities, in this case, central banks, handle new technology would be futile. This is because private sector already reaches an advanced stage of technology, and keeps innovating. Therefore, it will be wiser if central banks could arrange a partnership with relevant private companies. Looking at other central banks practices, China organized a partnership with commercial banks, fintech companies, and other telecommunication companies (Jiang & Lucero, 2021). Meanwhile, Sweden also declares a partnership with prominent IT consultants namely Accenture and R3 Corda (Riksbank, 2021). A group of six is also invited to collaborate with the Swiss central bank in their Helvetia Project (Bank for International Settlements *et al*., 2020).

### 4.5. Opportunities Analysis

#### Growing Islamic Finance

Expanding the fintech industry means that CBDC development is benefited from its expansion as The Financial Stability Board (FSB) describes that fintech is a technology-enabled innovation in financial services. Several fintech adoptions from current technology such as artificial intelligence (AI), blockchain, cloud computing, and data security could be implemented in CBDC design (Swain & Gochhait, 2022). For instance, CBDC could be benefited from advanced technology in AML/CTF (PwC, 2020), data security (Ozdayi *et al*., 2020), data analytics (Matsui & Perez, 2023), and lower transaction cost (Auer *et al*., 2021a). However, following IMF (2017), this expansion is not limited to conventional, but also within Islamic finance. Growing Islamic finance could support policy advice, capability development, and development of its financial market. Furthermore, important areas in Islamic finance such as banking regulation, macroprudential policy, safety nets, monetary policy, and security could also be improved. Altogether, these phenomena could support the development of Islamic CBDC.

Reserve Bank of Australia has benefitted from its fintech growing technology namely the new payment platform (NPP) (Emery, 2019). In short, NPP is a centralized platform that facilitates real-time clearing and settlements of payments between participating Australian financial institutions. NPP technology offers ubiquitous, electronic, account-to-account transfer with real-time receipt of funds by the payee, backed with a capped government guarantee. In China, its central bank adopts fintech technology to improve interoperability within CBDC, IC card, mobile phones, wearable objects, and the Internet of Things devices (People's Bank of China, 2021). These combinations could enrich the CBDC ecosystem and meet the demand of different groups of people.

**Cashless Society**

Due to the convenience of digital payment, most countries are experiencing cash decline (Auer *et al*., 2020; Barret, 2021; Coyle *et al*., 2021; Riksbank, 2020; Skingsley, 2016; Wolf, 2021). Cash has several cons to be considered such as risk of theft, high maintenance cost, and inefficient distribution (Brugge *et al*., 2018). Furthermore, cash is considered for lack of practicality, convenience, and efficiency. Moreover, the Covid-19 pandemic also hastens the declining usage of cash due to its physical distancing protocol (Syarifuddin & Setiawan, 2022; Torry, 2021).

These phenomena could become an opportunity for the central bank to provide a solution through CBDC (ING Group, 2020). For instance, Sweden develops its CBDC due to the impracticality of using cash (Riksbank, 2020). Aside from that, Shekhar *et al*. (2020) reported that younger generations, which are Y and Z generations, are dominating the usage of digital payment. This could be inferred that CBDC implementation is considered a forward-looking move and will be relevant for future occasions.

**Accelerated Network Effect**

Islam, as the fastest-growing religion, is expected to account from 24.1 percent in 2017 to 26.4 percent of the total world population in 2030 (Hackett & McLendon, 2017; Pew Research Center, 2011). To that end, with almost everything becoming digitalized, the impact of the network effect tends to be accelerated (Bartels & Schmitt, 2022). Digitalized technology allows us to connect with people across the world without boundaries, thus amplifying the network effect. The same goes with CBDC, as in the form of digital payment, with the national scale of user, the network effect will has a significant impact towards society. In short, network effect refers to the augmentation of of goods/services value when the participant is increasing (Parente *et al*., 2018). To that end, the benefit of CBDC will be determined by the amount of users that are connected with CBDC (Forner, 2020).

As the CBDC implementation will gain a significant network effect, policy implementation will be affected. Following BIS (2021a), in connection with the network effect, increasing CBDC users will enhance monetary policy effectiveness due. Not only for central banks, but also for governments. When there is a charity program, the aid will be directly transmitted to the users effectively and efficiently (Natarajan & Bossone, 2020). However, despite these benefits, central banks should be aware of several cons. For example, in Sweden, the network effect in digital payment drives people to convert their cash to electronic payment, leading to cash disappearance and outdated ATMs (Riksbank, 2020). Due to this network effect, specific payment instruments may disappear when their use falls below a critical threshold, and the successful CBDC implementation could risk tipping the balance (Agur *et al*., 2021).

### 4.6. Threats Analysis

**Cybercrime**

Despite design choices, CBDC is still prone to cybercrime. Even though the technology is always evolving, the risk of cybercrime will follow (Australian Computer Society, 2016). In brief explanation, a cyberattack is an attack to compromise the confidentiality, integrity, and availability of data through the internet (Bendovschi, 2015). This should be concerning because CBDC contains data on transactions, identity, and other important aspects (Minwalla, 2020). For regulators, failure in cybercrime prevention could lead to people's trust reduction (Armantier *et al*., 2021). Moreover, the payment sector is the most

frequent target of cybercrime which become concerning (Aldasoro *et al*., 2021).

Following Auer & Böhme (2020), CBDC is vulnerable to massive Distributed Denial of Service (DDoS) attacks, which could disrupt transactions. Generally speaking, DDoS is a deliberate attack that makes both the network and system unavailable for an authorized user, which opens an opportunity for the hacker (Tripathi & Mehtre, 2013). Adding relevancy, CBDC carries public information which becomes a feasible target for hackers (Minwalla, 2020), especially for retail CBDC due to many participants and points of strikes (CPMI, 2018). To that end, DDoS brings consequences such as payment, settlement, and clearing disruption. This impact could be worsened into financial instability due to the huge amount of users. (Collet *et al*., 2020).

**Low Level of Digital Financial Literacy**

Despite our payment authenticator design that enables CBDC to be both online and offline, it will not automatically support financial inclusion since unfamiliar CBDC interface could discourage adoption when digital financial literacy is still at a low level. The latest international survey by OECD (2020) shows we still on low levels of financial literacy with high levels of financial stress, followed by low financial resilience within certain groups. These certain groups could lead to intensifying the digital divide (Morgan & Fullerton, 2022). Furthermore, with a low digital financial literacy level, risks of cybercrime such as fraud, phishing, and hacking are inevitable. Accumulating low digital financial literacy could forms a lack of trust toward CBDC, such as questioning data security, issue on accessing account, feeling discomfort without physical cash, and excess fear of glitches and bugs (Raghuveera & Bray, 2020; Ali *et al*., 2020). However, this skepticism is normal since any issue, be it minor or major, could poses a substantial risk to their existence.

Several efforts are also encouraged in their CBDC project. For instance, the central bank of Bahamas reintroduces its financial literacy program on April 2019. Furthermore, an essay competition with financial literacy theme for students was also hosted in 2020 and 2021. Sand Dollar website that allows public to deepen their understanding is also launched in 2021 (Wright *et al*., 2022). Meanwhile, the CBDC whitepaper is also launched by Bank Indonesia (2022) as an introduction to its CBDC. Last but not least, Chinese central bank encourages private entities to actively promote Digital Yuan to raise people's awareness (He, 2023). The full potential of CBDC will not be attained if digital financial literacy is not evenly distributed (Pantuliano & Tyson, 2021). Implementing CBDC is not a panacea for any financial issue, instead, it should be followed by adequate digital financial literacy (IMF, 2022).

**Attractive Conventional Alternatives**

As a faithful Muslim, prohibitions such as usury, *maysir*, and *gharar* should be avoided. Hence, we propose CBDC without interest-bearing remuneration. Yet, it's still tempting for unfaithful Muslim to commit such these prohibitions for their self-interest (Saleh, 1986), which is usually rooted from greedy behavior. Moreover, following the enthusiasm of crypto-asset, private companies develop their cryptocurrency, such as Bitcoin, which is full of these prohibitions. However, despite Islamic principles, these cryptocurrencies are very alarming for regulators because the legal basis of the crypto-asset is not yet mature enough to govern (Morales-Resendiz *et al*., 2021). Moreover, CPMI (2015) remains vigilant because cryptocurrencies are peer-to-peer basis, and not as central bank liabilities. Moreover, anonymity within private cryptocurrency prevents central banks to

monitor money circulation, which could weaken AML/CFT (Gross & Schiller, 2020). Furthermore, private cryptocurrency domination could reduce monetary policy credibility, which leads to financial instability (Woodford, 2000). To that end, several countries consider banning cryptocurrency (Houben & Snyers, 2018).

However, despite of Islamic principles prohibitions and central banks concern, cryptocurrency is tempting due to several reasons. Firstly, cryptocurrency allows people to have anonymous transactions, which has more privacy for the user (Agur, 2018; Goodell & Aste, 2019). Second, in terms of data protection, several best practices show that private companies are better than regulators (Gasbeke, 2021). Lastly, high fluctuation within the cryptocurrency market attracts people to speculate with high risk.

## 5. CONCLUSION AND RECOMMENDATION

Using an integrative review, followed by SWOT analysis, we propose the optimal design of CBDC based on Islamic principles. Our result shows that CBDC design should implement (1) both retail and wholesale interlinkages, (2) both account and token payment authentication, (3) hybrid architecture, (4) non-interest bearing remuneration, (5) decentralized ledger system, and (6) managed anonymity. In analyzing strength aspects, this proposed design could be fostering digital financial inclusion, better resiliency towards power outages, and mitigate bank disintermediation. Meanwhile, system complexity, an underdeveloped legal framework, followed by the high cost of new technology investment will be the weaknesses. In current circumstances, growing Islamic finance, cashless society, and accelerated network effect will become opportunities to optimize this CBDC design. However, threat aspects such as cybercrime, low level of digital financial literacy, and attractive conventional alternatives should be important to note.

Our results have several policy implications and recommendations as an action plan. Complexity in the CBDC system could create uncertainty, hard to understand, unforeseeable, unclear consequences, and longer construction time. To that end, continuous improvement is a must for central banks to simplify their system. Legal concerns, be it privacy or data protection, are currently developed to cater CBDC implementation. Furthermore, it is also challenging for central banks to fully align it with Islamic principles since the conventional framework leads the domination. Cooperation between OIC countries or between Islamic-related authority is needed to further assess and stand up for proposing proper Islamic legal framework. Proposing such design could lead to high investment costs. A cooperation scheme such as PPP between the central bank and private companies should be a suitable idea. Aside from the cost-saving motive, cooperation with private companies triggers further innovation for CBDC refinement. As CBDC become a high-valued target for cybercrime, central banks should be serious in allocating their cyber security. Otherwise, whole transactions could be collapsed and start to lose public trust. CBDC is closely influenced by digital financial literacy and it could determine the effectiveness of CBDC. To that end, central banks could take an example of other successful CBDC introductions, such as the Bahamas, to propose innovative programs to raise people's awareness. Maintaining people's faith to gradually stay away from attractive conventional alternatives are difficult. However, the central bank should maintain its integrity within Islamic principles, security, and other concern, so it could draw people attraction towards Islamic CBDC.

Regarding the caveats, limited literatures become the main concern. To the best of our knowledge, few literatures further assess CBDC through Islamic perspective. Even

so, only a few countries fully implement CBDC throughout their country, the rest are still working on their pilot projects. We expect that in the future time, CBDC will be implemented in more countries, thus could add the use case of CBDC implementation. To that end, this topic could be further assessed and refined the Islamic CBDC design.

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