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The Efficiency of the Brazilian Payment System as per the Deployment of the Digital Currency based on DLT: Challenges and Opportunities

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ABSTRACT

This article aims to identify and discuss the challenges and opportunities involved in the deployment of the digital currency based on Distributed Ledger Technology (DLT) in the Brazilian Payment System (BPS), regulated by the Central Bank (CB) of Brazil. To do so we consider the following two steps. First, a theoretical study is made concerning learned lessons from the digital-currency deployment projects in the Bahamas, the Eastern Caribbean, and China. These countries are herein explored due to the maturity stage already reached in their respective projects. Second, an interview is conducted with specialists in the Brazilian financial market. This interview is carried out with the goal of capturing the perception of the Brazilian market in the face of the challenges and opportunities that lie ahead. The final results obtained in this work lead to the main conclusion that the adoption of a digital currency in Brazil cannot result successfully without considering proper government actions related to motivation for its adoption by the population and financial institutions, besides the existence of investment in cybersecurity technology. Furthermore, this deployment is likely to bear opportunities regarding the use of technology to boost the resilience, interoperability, programmability, and security of the BPS. In this context, as a main contribution, this article provides indicators and theoretical subsidies that may help assess the efficiency of the BPS in the face of the deployment of digital currency. At last, final conclusions and future works close this article.

CCS Concepts

•Information systems → Web services; •Networks → Network services; Network services; Application layer protocols; •Security and privacy → Database activity monitoring; Database activity monitoring; Software and application security;

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Keywords

Digital Currency; DLT; Central Bank; Brazilian Payment System; Efficiency

1. INTRODUCTION

Digital Real is the denomination of the Brazilian digital currency. It is based on Distributed Ledger Technologies (DLTs) and is a direct extension of the FIAT currency called Real [1]. Around the world, digital currency is commonly denoted as Central Bank Digital Currency (CDBC). The deployment of Digital Real is supposed to be very beneficial for Brazil. In addition to promoting greater efficiency in the Brazilian Payment System (BPS), it will provide social inclusion of unbanked people through new digital experiences.

The Central Bank (CB) of Brazil raised the above subject matter in August 2020 through its Ordinance 108.092/20, with the goal of carrying out studies on the issuance of a digital currency. Since then, CB has sought information from other markets and specialists. Particularly, in May 2021, CB formally launched the Digital Real's Guidelines [2] and, in November 2021, the Financial and Technological Innovations Laboratory (FTIL) launched a challenge to validate ideas on the rollout of Digital Real, which has been running since September 2022 [3].

In this context, to contribute to the process of deploying the Digital Real in the BPS, this article aims to identify and raise the main challenges and opportunities. To this end, we consider the two steps that follow. First, we carry out a survey on learned lessons in the Bahamas, the Eastern Caribbean, and China. Second, we conduct an interview with specialists in the Brazilian financial market. The main motivation of this research is to evaluate topics that are sensitive to maintaining the stability of the BPS, once there will be interoperability issues between the current system and the new system based on tokenized assets through the use of DLT [10]. It is worth noting that CBDCs and other forms of money are not mutually exclusive, implying that various means of payment will all coexist [4, 5].

The remainder of this article is organized as follows. Section 2 explores the fundamental concepts regarding DLT and CBDC, as well as presents a glossary of acronyms. In Section 3, learned lessons from the CBDC deployment in the Bahamas, the Eastern Caribbean, and China are explored. Section 4 contains a structured interview with professionals in the Brazilian financial market. Finally, Section 5 presents

the general conclusions and suggestions for future works.

2. FUNDAMENTAL CONCEPTS

This section brings fundamental concepts related to DLTs and CBDCs. In addition, for the purpose of facilitating the reading of this article, it presents a glossary of the main acronyms used within this text as well.

2.1 Distributed Ledger Technology - DLT

A DLT consists of five main components: database to record the ledger, cryptographic hash function, public-key cryptography, peer-to-peer (P2P) network, and consensus algorithm [6, 7]. There are two general implementation approaches. The first is the public one like the Bitcoin Blockchain. Under this approach, one cannot prevent malicious participants from acting. The second approach follows the consortium or private concept, in which you can have reliable participants (under the consortium concept) or a single entity (under the private concept). We can enumerate the advantages below that result from the use of DLTs in favor of the financial system [7, 8].

- Fast propagation of information: a network is updated almost in real-time by the network nodes.
- Complete traceability: the regulator can track the information flows throughout the node chain, enabling audit. The entries on the chain are added by the participants, but cannot be modified. This guarantees information immutability.
- Simplified reconciliation: all participants log into the network in real-time. This process currently requires a lot of effort and cost. It can be optimized.
- Reliable system: the participants guarantee the authenticity of the data in the ledger, implying information integrity.
- High resiliency: if any participant has a failure, others can operate to ensure continuity.

The Digital Real pilot project is a private DLT of permissioned type, compatible with the Ethereum Virtual Machine (EVM - Ethereum Virtual Machine), called Hyperledger Besu. It is an open-source Ethereum client that is developed under the Apache 2.0 license and written in Java. Its execution can take place on the Ethereum public network or on permissioned networks. Hyperledger Besu includes several consensus algorithms and has comprehensive permission schemes. According to the CB's guidelines of February 2023, the benefits mentioned right below are expected with the tokenization of assets [25].

- Programmability, with the possibility of creating smart contracts.
- Atomic settlement, enabling the reduction of counterparty risks.
- True single sources, replacing records of informational silos.
- Multiassets, enabling assets of different natures to be used in the same technological environment.

Moreover, we add that DLT has been envisioned in many prototypes of CBDCs lately [9], particularly because they can mitigate issues coming from illicit activities as they allow validation exclusively originated by a network of verified or authorized validators.

2.2 Central Bank Digital Currency - CBDC

Countries' currencies and payment systems have historically evolved in important ways due to the recent advancements of existing technologies. CBs around the world have increasingly sought a real-time settlement approach supported by digital technologies, leading to better experiences for customers at the edge with less cost.

Conceptually, CBDC is a fiduciary digital currency issued by a CB. Technically, it is made available through a DLT platform to facilitate the processing and settlement of financial transactions between institutions and customers [11]. The Bank for International Settlements (BIS) reported that 60% of CBs are making use of the DLT concept to implement CBDCs. As the use of digital currencies grows, DLTs bring strategic opportunities for CBs to expand their fiscal arsenal, modernize payment systems, support economic stability, and promote financial social inclusion [11].

The Brazilian CBDC, i.e., the Digital Real, has been tested at the Laboratory of Technological Financial Innovations (LIFT Lab), where nine companies have been chosen according to the topics mentioned right below [3].

- Delivery versus Payment (DvP), which focuses on the settlement of transactions with digital assets (Figure 1).
- Pay versus Pay (PvP), which explores currency exchange.
- Internet of Things (IoT), which aims at algorithmic settlement or between machines directly.
- Decentralized finance (DeFi), which spans protocols with settlement based on a CBDC, as well as compliance and supervision requirements established in the norm.

Within the above context, the potential for interoperability, scalability, information privacy, and programmability needs to be evaluated. The pivot of this challenge is programmability through smart contracts, with the aim of exploring how much this can solve real problems or improve experiences under an infrastructure focused on digital assets. Additionally, during the year 2023, a workshop devoted to discussions on Digital Real will be held [24], so that, in the following December, the basic tests will be concluded. Hence, in February 2024, the test of the selected use case on Federal Public Securities (FPS) is expected to be entirely finalized.

Furthermore, one of the guidelines for the development of Digital Real is the interoperability guarantee between this new form of currency and the means of payment currently available to the population. The preoccupation is to maintain the stability of the financial system. With this in mind, the Brazilian CB will create a Digital Payment System (DPS), which will be integrated with the Brazilian Payment System (BPS) [10]. Under the DPS, everything will be tokenized, namely stocks, debt securities, consortium bonds, and other financial assets [18].

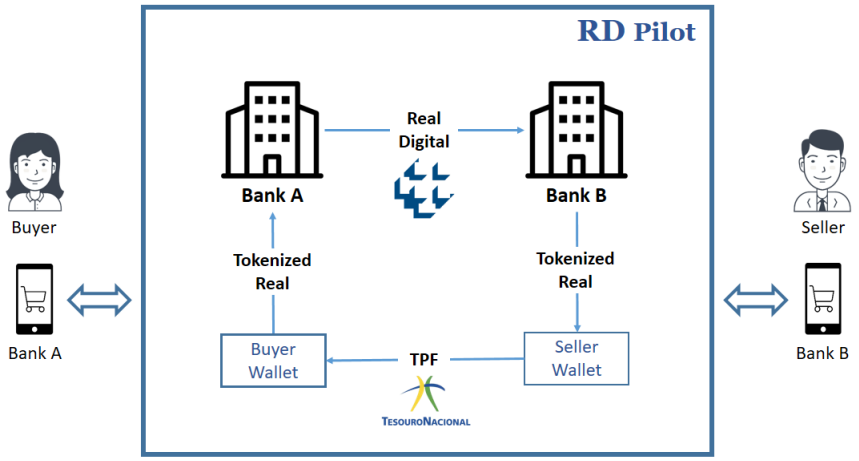

Figure 1: Delivery versus Payment (DvP).

The aforementioned tokens will use Digital Real as a reference to perform a kind of ballast for their activities. In other words, the banks and institutions that are part of the Digital Real system will tokenize their balance of financial assets into Digital Real, thus allowing the issuance of their own tokenized currencies. Another interesting point is that both the Reserve Transfer System (RTS) and the change in ownership of the asset that occurs at B3 (https://www.b3.com.br) will be done via smart contracts. This entire digital system will be integrated into the current payment system.

There are 119 countries that are evaluating or have already evaluated the use of CBDC [12]. Among these countries, eleven have already launched their respective digital currencies, such as the Bahamas (Sand Dollar), Jamaica (JAM-DEX), Nigeria (eNaira), and eight Eastern Caribbean countries (DCash). Within these eleven countries, we have then chosen three ones to explore their respective learned lessons in this research work, namely the Bahamas, the Eastern Caribbean, and China.

2.3 Acronyms

For the sake of readability, Table 1 provides a glossary of the main acronyms used within this text.

Table 1: Acronyms

Acronym	Meaning
AML	Anti Money Laundering
CB	Central Bank
BCB	Brazilian Central Bank
CBDC	Central Bank Digital Currency
DCEP	Digital Currency Electronic Payments
DLT	Distributed Ledger Technology
DSand	Dollar Sand
DvP	Delivery versus Payments
EVM	Ethereum Virtual Machine
IoT	Internet of Things
KYC	Know Your Customer
PII	Personal Identifiable Information
PvP	Payments versus Payments
P2P	Peer-to-Peer
RMB	Renminbi
BPS	Brazilian Payment System
DPS	Digital Payment System
IPS	Instantaneous Payment System
RTS	Reserve Transfer System
FPT	Federal Public Titles

3. LEARNED LESSONS

3.1 Bahamas

On October 20, year 2020, the CB of Bahamas launched the Sand Dollar. It was the first CBDC issued in the world [12]. This currency became available to all citizens of the country as soon as it was launched, whereas integration with the banking system was carried out gradually. It is worth emphasizing that the main motivations of the Bahamas for the creation of this currency were the following ones [13].

- Improvement in the efficiency of the payment system through a secure and fast settlement system.
- Increased financial inclusion, with reduced cost and improved access to financial services in the country.
- Providing non-discriminatory access to the payment system regardless of age, immigration, or region of residence.
- Strengthening national security against money laundering, counterfeiting, and other illicit activities.

After two years of launching the Bahamas CBDC [14], the following points were then raised as learned lessons.

- Build a network of merchants who accept and encourage the use of CBDC.
- Achieve interoperability with the traditional banking system.
- Enlist the participation of the traditional banking sector and credit unions.
- Educate the user to promote confidence in the system through various public campaigns.

- Create interoperability among digital currency wallets authorized by the Central Bank [16].

In this context, Richard Douglas, co-founder of Island Pay stated that an important and necessary strategy is to prioritize adoption by commercial establishments, which will leverage adoption by the population [16]. Another important point, raised in the World Monetary Fund - IMF report [15], is that the Central Bank of the Bahamas must continue to strengthen internal capacity, which includes cybersecurity and the resilience of systems associated with the Sand Dollar, maintaining careful oversight of the CBDC project to safeguard financial integrity. Furthermore, the IMF strengthens the point that the country must accelerate education through public campaigns, as the CBDC represents less than 0.1% of the currency in circulation, and there are restricted avenues for the use of the Sand Dollar. One of the culprits for the slowdown in population education was the COVID-19 pandemic.

3.2 Eastern Caribbean

On March 31, year 2021, the DCash digital currency was officially launched and made publicly available to four out of the eight Eastern Caribbean members (later on, it was expanded to the remaining members) [12]. DCash may currently be used by citizens either through the government's own application (i.e., the DCash App) or through a participating financial institution.

It is interesting to note that, in terms of security, there is an adoption scheme by the CB of the Eastern Caribbean [20], in which all transaction data is stored in the DLT. Other than that, Know Your Customer (KYC) / Anti Money Laundering (AML) data is collected by a third-party tool and stored separately. Third parties offering such a service have strict Personally Identifiable Information (PII) guidelines to protect this data. All third-party providers are assessed for compliance with applicable international standards for information security (i.e., cybersecurity), data privacy, and quality assurance. Applicable standards include ISO 27001, SOC 2, GDPR, and ISO 9001.

Nevertheless, it is worth mentioning that from January to March, the year 2022, some technical problems, unfortunately, appeared, leaving the system inoperative, which required an evolution in the security system [12]. The Director of Risk at the Central Bank of the Eastern Caribbean, Sharmyn Powell, stated that the main motivations for the creation of the digital currency were the ones mentioned in the following [16].

- Financial social inclusion.
- Access to a unique and reliable payment system between islands and different territories.
- Improvement of the system against money laundering besides the fight against terrorism.
- Cost reduction plus increased efficiency of the payment system.
- Promotion of innovation.

Nevertheless, during this journey of implementing the digital currency, Sharmyn said that some challenges have been encountered and worked on. Among them, the particular lessons mentioned below were detected [16].

- Difficulty in collaboration between intermediaries to leverage digital currency adoption. With that in mind, they are creating public campaigns to educate the population and encourage traders to use Dollar Sand.
- Authentication can exclude some segments of the population. It was then detected the need to create an authentication adapted for financial social inclusion focused on people with less accessibility. For that, they created the strategy of different levels of authentication linked to different transaction limits.
- People are overwhelmed with news about cryptocurrencies and digital assets. They do not know what to do or how to use it. Hence, public education is essential to the success of the project.
- Banking correspondents are not engaged. Action will be needed to increase correspondent banking engagement, and thereby increase digital currency adoption.

3.3 China

In 2017, as part of a broader effort to develop its high-tech sectors, China launched a project called Digital Currency Electronic Payments (DCEP), later named e-CNY [12]. The pilot program expanded to 28 major cities in 10 regions. In June 2021, the PBOC (People's Bank of China) announced that more than 20.87 million personal and 3.51 million corporate yuan digital wallets were opened, with a total transaction value of about 5.39 billion dollars. As per figures of October 2021, 123 million individual wallets and 9.2 million corporate wallets were opened with a transaction volume of 142 million plus a transaction value of 56.0 billion Renminbi (RMB) (approximately 8.8 billion dollars). Reports from early 2022 indicate that over two hundred and sixty million wallets have been opened.

The numbers above indicate that China is a country that has been successful in this subject matter due to its early adoption of regulated digital currency. One of China's excellent strategies was to use the digital currency, in February 2022 [12], as a payment method for visitors to the Olympic Games venues in Beijing and Zhangjiakou, where they could use the e-CNY software application and hardware e-CNY card. Daily transactions during the events amounted to over US$ 300,000.

China's main motivation for creating this digital currency was to increase the resilience of the payments ecosystem in case of disruption in its domestic markets, which are dominated by Alipay and Tenpay [21]. This is capable of inducing greater competition in the market, besides providing an alternative solution in case payment systems are shut down due to cyber-attacks or network issues. Alipay and TenPay (which own the QQ and WEPAY payment apps) have more than 900 million monthly active users each. E-CNY works as a FIAT currency, just like physical money, and its adoption is essential to create more competition in China's payments market. During this period, the main learned lessons are mentioned right below [22].

- Integration of the digital currency with the pre-existing payment ecosystem should be promoted. A CBDC is just one type of payment instrument available to citizens. Unless it works as any other form of payment, adoption will be limited. In countries that already

have well-established payment systems (like in the case of Brazil with PIX payment), consumers may have little motivation to switch to another payment tool.

- Public-private sector integration can be a win-win approach, as the CBDC was designed to complement current forms of money, not to replace them. Implementing a CBDC without proper integration into the established private payment infrastructure makes it difficult to increase adoption and usage rates.

- Another measure by China to drive adoption involves providing a variety of offline payment methods around the CBDC. Although the digital transformation has allowed a large proportion of the population to access money via mobile phones, there is still an unmet demand from people who do not own smartphones or lack knowledge or even access to the Internet.

- Government incentives must be created and carefully targeted. Financial incentives offered by the government are perhaps the most effective way to drive CBDC adoption. It is important to carefully incentivize users to continuously use CBDC rather than just requesting a one-time transaction. In China, 321.2 million RMB (the official currency of the Popular Republic of China) in total were distributed as gifts. The launch went through 17 rounds in eight cities, generating around 620 million e-CNY transactions.

In addition to the above, it is worth mentioning that world experts raised five important lessons learned in three countries (including China), which are listed right below [23].

- A very big barrier is digital exclusion when it comes to connectivity and digital knowledge in some communities. Central banks need to improve their initial CBDC model in response to these challenges. For example, to address digital literacy issues. The CB of Bahamas incorporated SunCash's PopPay, a mobile app that enables digital payments via facial recognition without the need for a smartphone.

- Early pilot projects may require trade-offs between financial inclusion and scale in adoption. Initial scaling is critical to successful and sustainable adoption. For instance, in China, 23 of the most developed cities in the country were selected for the first phase of launching the digital currency.

- The success of CBDCs depends on multi-stakeholder buy-in to raise awareness and ensure meaningful implementation. In 2022, this adoption proved difficult in Nigeria once the CB observed apathy among commercial banks in promoting eNaira (Nigeria's digital currency) due to lost revenue on transaction fees. In China, where this early adoption has been successful, partnering with digital platforms (such as Alipay and WeChat Pay) has played an important role in demonstrating the power of trusted brands to create acceptance of this financial innovation. The Popular Bank of China realized this early in its CBDC trials and has used several private sector partners during their pilot iterations to encourage adoption, including Webank and MyBank in 2021.

- Constant iteration is necessary since unexpected challenges will arise and they will be different in each country. In Nigeria, for example, problems with the registration process have left some customers unhappy with eNaira. In the Bahamas, the CB discovered structural barriers due to the geographic reach of existing telecommunications networks, in addition to their ability to apply local redundancies during power outages. This meant that offline payments could only be partially facilitated and, as a result, this stage of the project had to be put on hold for further refinements. Being able to proactively identify deficiencies in a CBDC solution and, in the sequence, work with partners to address or mitigate these areas is critical to the success of a CBDC.

4. INTERVIEWS

Delving into the analysis carried out in Section 3, one can note many common hurdles faced by the respective countries' CBs scrutinized in this research work. These hurdles were then used as a baseline for the interview made herein.

A form was created in Google Forms (see online form at: https://tinyurl.com/msy9dpar) containing 15 items grouped by section, which are presented in Table 2. Compared to the current Brazilian payment system, each interviewee was then asked to assess at what level the item would represent an opportunity and a risk (i.e., challenge). The level assignment is graded as *Low*, *Moderate*, *Medium*, or *High*.

Even though Digital Real is going to formally start with a limited scope in wholesale institutions, we have asked the interviewees to conjecture the evolution of the implementation of digital currency in retail, considering the principles already explained herein and contained in Vote 31/2023–BCB, of February 14th, 2023, by the Brazilian CB. For data collection on the 15-item form, electronic mail or a messaging system was used, according to the interviewee's preference.

The survey was carried out in March 2023, considering a sample of 15 professionals, specialists in the digital financial market, distributed as follows: 53% from a public institution, and 47% from a private institution. They were all from different institutions and with great participation in the development and research on the Brazilian financial system. Explicit personnel identifications are not made herein for reasons of privacy and secrecy. This reduced set was due to the limited number of specialists with adequate expertise in digital currencies.

The results are summarized in percentages in Table 3 (for details see: https://github.com/vladiuf/dsfe). For mere exemplification, Figures 2, 3, and 4 depict the computed percentages specifically for social inclusion, cyber-attacks, and scalability, respectively. From all results, the general observations that follow in the sequence are made.

- Under the aspect of social impact, the perception is very favorable, demonstrating a feeling of great optimism.

- Under the more technical aspect of security and cybersecurity, although there is an overall optimistic thinking, the specific item on cyber attacks reveals some concern, leading to the conjecture that people still feel vulnerable.

- Finally, from the point of view of the technological solution, there is not clearly a unique general perception,

Table 2: Items for interview

Section	Items	Understanding
Social Impact	Social Inclusion Public Security Adoption by Society	More general perceptions of the deployment of Digital Real.
Security and Cybersecurity	Illicit Activities Cyberattacks Data Privacy Identification/KYC	More technical perception of the deployment of Digital Real, focusing on citizens' life and society.
Technology	Scalability Performance Resilience Programmability Interoperability Solution Security Audit	More technical perception of the deployment of Digital Real, focusing on the use of DLT and the entire BPS.

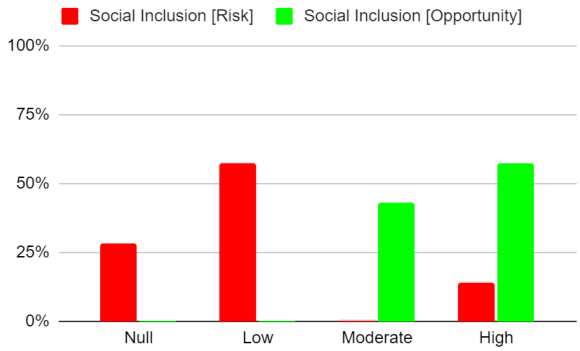

Figure 2: Results for social inclusion.

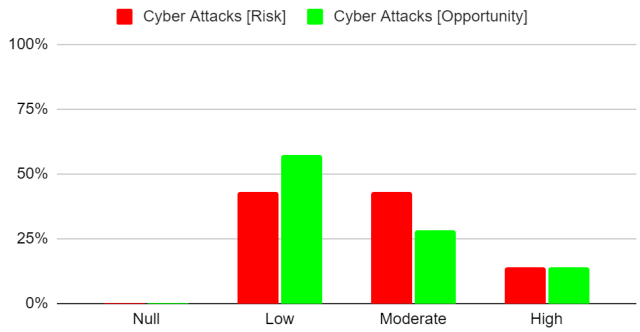

Figure 3: Results for cyber-attacks.

that is, although there is an optimistic view, there is also a significant uncertainty about the final effectiveness of the solution.

In view of what was exposed and discussed in this section, we may globally infer what follows.

- There are mostly more opportunities to be explored than risks (challenges) to be mitigated (faced) as for the current BPS.
- There is a relevant concern about cyber-attacks. Risks related to data privacy must be monitored as well.
- There is a great opportunity for social inclusion and improvement of the population's sense of security.
- Most people believe that Digital Real will positively impact both the control of illegal activities and the BPS audit.
- The technology provides opportunities for improvements related to performance, resiliency, programmability, interoperability, and security of the BPS. It is though mandatory to look into the scalability that may be achieved by the deployment of DLT.

5. CONCLUSIONS AND FUTURE WORKS

This article aimed to identify and discuss the challenges and opportunities involved in the implementation of the digital currency based on Distributed Ledger Technology in the Brazilian Payment System (BPS), regulated by the Central Bank of Brazil. To this end, a theoretical study of the learned lesson in the Bahamas, the Eastern Caribbean, and China was first carried out. Then, an interview was conducted with experts from the Brazilian financial market.

From the final results, it was possible to verify that the implementation of Digital Real mostly brings a number of valuable opportunities to be explored when compared to the risks. For instance, we may outline a technological improvement of the entire BPS in terms of resilience, interoperability, and scalability, as well as the possibility of social inclusion and reduction of the number of stockholders and players. Nonetheless, some essential points, related to risks, were also raised and must be considered for the successful implementation of Digital Real. In particular, cybersecurity and scalability issues were identified, such as cyber-attacks and serious concerns related to the lack of adoption and engagement by both retail and wholesale.

The learned lessons by the countries herein studied had an interesting intersection with the risks analyzed by the interviewees. From this, we noted possible strategies that could be proactively worked on, namely: a) engagement

Table 3: Results

Items	Risk	Opportunity
Social Inclusion	87.5% (None or Low)	99.9% (Moderate or High)
Public Security	56.5% (None or Low)	62.5% (Moderate or High)
Adoption by Society	61.5% (None or Low)	87.5% (Moderate or High)
Illicit Activities	71.5% (None or Low)	57.5% (Moderate or High)
Cyberattacks	87.5% (Low or Moderate)	87.5% (Moderate or High)
Data Privacy	68.5% (None or Low)	75.5% (Moderate or High)
Identification/KYC	56.3% (None or Low)	87.5% (Moderate or High)
Scalability	99.9% (Low or Moderate)	99.9% (Moderate or High)
Performance	99.9% (Low or Moderate)	99.9% (Moderate or High)
Resilience	99.9% (Low or Moderate)	99.9% (Moderate or High)
Programmability	87.5% (None or Low)	87.5% (Moderate or High)
Interoperability	54.5% (None or Low)	99.9% (Moderate or High)
Solution Security	99.9% (Low or Moderate)	99.9% (Moderate or High)
Audit	73.9% (Low or Moderate)	99.9% (Moderate or High)

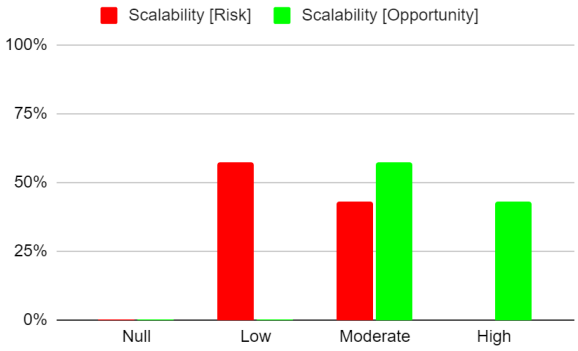

Figure 4: Results for scalability.

with the private market from the beginning of the deployment process; b) creation of advertisements focused on education and motivation regarding the population and merchants; c) strategical government incentives, such as financial incentives to accelerate initial adoption; d) selection of more structured geographical regions for the launching pilot projects, aiming at a quicker initial adoption curve; e) creation of different authentication levels (KYC) and offline payment possibilities for social inclusion; f) interoperability with the current payment system; g) creation of a network of merchants who accept and use digital currency; and h) attracting participation from the traditional banking sector and credit unions.

Finally, as an extension of this research, we may suggest the following: i) Competitively analyze different types of DLTs to identify alternatives to the current Brazilian pilot project (Hyperledger Besu); ii) Conduct field surveys to estimate the CBDC's adoption extent in different communities; iii) Use the current Brazilian pilot project (Hyperledger Besu) to assess scalability, resiliency, interoperability, and security. The results derived from these three works may provide solid insights or even solutions to eventual obstacles that may impact the SPB's stability within the novel digital ecosystem in the near future.

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