

Wholesale Central Bank Digital Currency - A Survey of Countries Research

This research aims to analyze the use of Distributed Ledger Technology (DLT) for interbank payments by investigating the research that central banks are doing to propose DLT-based wholesale Central Bank Digital Currency (W-CBDC). The findings reveal that countries are researching W-CBDC using mostly experiment research methods publishing their research through study papers, experiment papers, and projects. The research is commonly focused on the technological dimension of W-CBDC implementation. This paper contributes to a better understanding of the trends in implementing W-CBDC and gives researchers, central banks, and IT developers more knowledge to further the research in their countries.

Keywords—*Distributed Ledger Technology, Central Bank Digital Currency, CBDC, DLT-based Wholesale, Wholesale CBDC.*

I. INTRODUCTION

Money is defined as a store of value (helpful in holding wealth), a unit of account (prices are set in it) and a medium of exchange (useful for payments), in this context, **Central Bank Digital Currency** (CBDC) is mentioned as digital money issued by a central bank that represents a legal claim on that central bank [1].

CBDC is defined as central bank-issued digital money denominated in the national unit of account, representing the central bank liability, different from cash, as it comes in a digital form, unlike cash physical coins and banknotes [2].

The Central Bank Digital Currency is defined by Bech and Garratt [3] as an electronic form of central bank money that can be exchanged in a decentralized manner, known as the peer-to-peer. These authors emphasize four types of digital central bank money: Two forms are token-based (retail and wholesale), and the other two are system-based account or account-based (retail and wholesale).

A wholesale payment system deals with inter-bank, inter-country large value, large volume real-time payments and related clearing and settlement systems governed by central banks integrating various globally accepted standards [4].

Central banks already provide digital money in the form of reserves or settlement account balances held by commercial banks and certain other financial institutions at the central bank. In this context, commercial banks' reserves or commercial banks' deposits are already digitalized in the account-based form of CBDC (Account-based wholesale), while token-based wholesale is a restricted-access digital settlement token for wholesale payment and settlement transactions [5].

The Wholesale Central Bank Digital Currency (W-CBDC) can be implemented on Distributed Ledger Technology (DLT) or Centralized Ledger.

The Real-Time Gross Settlement (RTGS) systems (In some jurisdictions, TARGET services) are typically used for high-value transactions requiring immediate settlement. Today most RTGS systems worldwide are operated on a centralized infrastructure, subject to risks such as a single point of failure [6].

The account-based form of CBDC or digital money issued by the central banks has long existed in reserves deposited in banks' current accounts under the central banks in the Real-Time Gross Settlement (RTGS). In this type of system, the money is held in an accounts-based system, and the central banks control the balances in the central systems; the digital money is thus managed under account balances basis [7].

Token-based Wholesale Central Bank Digital Currency (DLT-based W-CBDC) is a tokenized form of central bank money available to financial intermediaries that could offer safe and efficient settlement on a tokenized asset platform [8].

The Covid-19 pandemic motivated several central banks to accelerate research to implement their own Central Bank Digital Currency (CBDC). According to a survey published by the Bank for International Settlements (BIS)¹, 80% of central banks revealed that they was researching CBDC, where 40% of central banks had progressed from conceptual research to experiments (proofs-of-concept), and 10% had developed pilot projects [9].

Other institutions such as CBDC Tracker² and Atlantic Council³ are publishing statistics of CBDC research made by countries but they don't specify how countries are conducting their research. Otherwise, the BIS publish the name and reports of countries that are making experiment without detailing their results.

In this context, we understand that exploring the research that central banks are doing on Wholesale CBDC that central banks are doing is needed to help researchers and countries that didn't start their research project better understand the several paradigms and development strategies of CBDC research by others countries.

The main aim of this research paper is to survey the use of DLT for inter-bank payments by analyzing the strategies that central banks are made to research and experiment the Wholesale Central Bank Digital Currency (W-CBDC).

The paper is structured into four sections: Here, in section 1, we introduce the research context, the objective and the structure. Section 2 explains the research methodology. The results of the research question are presented in section 3. Finally, concluding remarks are made in section 4.

¹ BIS CBDC Report - <https://www.bis.org/publ/work880.htm>

² CBDC Tracker - <https://cbdctracker.org/>

³ Atlantic Council - <https://www.atlanticcouncil.org/cbdctracker/>

II. RESEARCH METHODOLOGY

In this section, we describe the research goal, the search strategy, the central banks reports identification, the reports selection, and the data extraction.

A. Research Goal and Question

This paper aims to survey the use of DLT for inter-bank payments by analyzing the research that central banks are made to propose wholesale Central Bank Digital Currency (W-CBDC).

- **RQ1:** How countries are publishing their researching?
- **RQ2:** What are the countries research strategies?

With these research questions, we explore how countries are researching W-CBDC, analysing the published type of documents, the year of publication, the research methods, and the research dimension. This question is motivated by the need to understand the research maturity by analysing the strategy used to research W-CBDC.

B. Search Strategy and Reports Selection

We choose BIS dataset of the central banks' wholesale research reports. The strategy used to discover all reports of countries that are researching wholesale CBDC for screening, was the excel dataset published by the Bank for International Settlements (BIS).

Our research started in February of 2022, we used the BIS dataset published in 1st January 2022⁴, next we update our research with dataset upgraded on 1st of July 2023 and we finally updated our results with the last dataset upgraded on 23 January 2023.

The BIS dataset, published in January and July of 2022 listed 28 countries researching CBDC. This number was increased in 2023 by 35 countries.

To find all reports for screening, we visited each listed central bank website to search and download all published reports and related documents of CBDC research. We identified 45 reports from the BIS dataset link from central banks' websites and more additional 11 papers by complementary research. The selection process is reported as recommended by the PRISMA guideline [10], a methodology used to remove all irrelevant documents for the study (see Figure 1).

To make the screening of the all documents imported from our database, we removed 7 duplicated reports that were duplicated in the retail and wholesale list, and 10 reports not written in English.

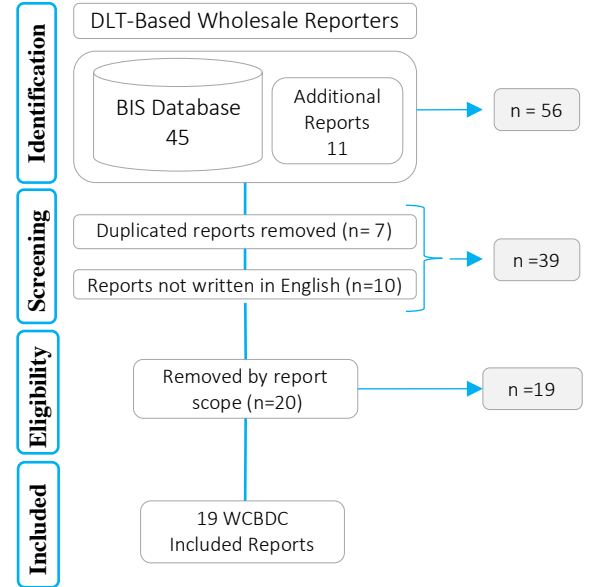


Figure 1 - Selection Process, based on the PRISMA guideline [10]

To select eligible reports for our study, we analysed the type of reports and we removed press releases that announce the results of research on W-CBDC, and news published on the Central Bank's site that announces the research on CBDC. Then, we read the executive summary of all reports to analyse the scope of the research.

For eligibility process, we defined that the reports to be included are reports focused on W-CBDC research, reports with clear research method and contribution, reports with clear research scope and focused on a technical proposal for W-CBDC implementation. We removed 20 focused on CBDC research study and cross-border, remaining 19 reports focused exclusively on W-CBDC focus.

C. Data Extraction

The extraction was done before a full reading of selected reports. To answer the defined research question, we developed a data extraction sheet in accordance with [11][12], (see TABLE. I).

TABLE. I DATA EXTRACTION FORM

Data Item	Value	RQ
Year of publication	Integer	RQ1
Country	String	
Type of document	Study paper; experiment paper, project report	
Strategy	W-CBDC Design; W-CBDC Use Case; W-CBDC implementation;	RQ2
Research method	Literature review; case study; experiment; other	
Research scope	Financial, Legal, Operational; Technological	

⁴ Rise of the CBDC: Drivers, approaches and technologies - <https://www.bis.org/publ/work880.htm>

To analyze how countries are researching W-CBDC, we extracted information about the year of publication, acceptance criteria, country, type of document, research method, and research scope.

In terms of research method, we defined the following research methods:

- **Literature Review:** research the CBDC and W-CBDC to better understand the issuance with CBDC, risks and opportunities.
- **Case Study:** Investigates a W-CBDC phenomenon within its real-life context, analysing a specific use case evolving wholesale requirement.
- **Experiment:** Investigates how W-CBDC settlement might be adapted if DLT.
- **Other**

III. RESULTS

In this section, we present the results of our research question.

A. RQ1: How countries are publishing their researching?

To analyse how countries are researching W-CBDC, we selected 19 reports focused on central bank's W-CBDC research and written in English covering 11 countries.

TABLE. II lists the title, year of publication and country of selected reports, ordered by country.

TABLE. II SELECTED REPORTS

Title	Year	Country	Ref.
Project Atom: Exploring a Wholesale CBDC for Syndicated Lending	2021	Australia	[13]
Distributed ledger technical research in Central Bank of Brazil	2017	Brazil	[14]
Project Jasper: A Canadian Experiment with Distributed Ledger Technology for Domestic Interbank Payments Settlement	2017	Canada	[15]
Project Jasper: Are distributed wholesale payment systems feasible yet?	2017	Canada	[16]
Jasper: Phase 3 - Securities Settlement Using Distributed Ledger Technology	2018	Canada	[17]
Progress of Research & Development of E-CNY in China	2021	China	[18]
Wholesale Central Bank Digital Currency experiments with the Banque de France	2021	France	[19]
Experimenting settlement of French government bonds in Central Bank Digital Currency with blockchain technology	2021	France	[20]
STELLA - Payment systems: liquidity saving mechanisms in a distributed ledger environment	2017	Japan	[21]
STELLA - Securities settlement systems: delivery-versus-payment in a distributed ledger environment – Stella project report phase 2	2018	Japan	[22]
The Future of Money – Central Bank Digital Currency Te Moni Anamata – Aparangi ā Te Pūtea Matua - Issues paper	2021	New Zealand	[1]
Project Ubin Phase 2: Re-imagining interbank real-time gross settlement system using distributed ledger technologies	2017	Singapore	[6]
Ubin Phase 1: SGD on Distributed Ledger	2017	Singapore	[23]
Delivery versus Payment on Distributed Ledger Technologies: Project Ubin	2018	Singapore	[24]

Title	Year	Country	Ref.
Project Khokha	2018	South Africa	[25]
Project Helvetia: Settling tokenised assets in central bank money	2020	Sweden	[8]
Project Helvetia Phase II: settling tokenised assets in wholesale CBDC	2022	Sweden	[26]
Inthanon Phase I: An application of Distributed Ledger Technology for a Decentralised Real Time Gross Settlement system using Wholesale Central Bank Digital Currency	2018	Thailand	[7]
Inthanon Phase 2: Enhancing Bond Lifecycle Functionalities & Programmable Compliance Using Distributed Ledger Technology	2019	Thailand	[27]

We observed that Brazil, Canada, Japan, and Singapore started their research in 2017 (see Figure 2).



Figure 2 - Countries Reports per Year

Central Banks are adopting different research strategies using research paper, experiment paper and project report to share their W-CBDC research (see Figure 3).

France published the experiment paper, Brazil, China, and New Zealand published the study paper, while Australia, Canada, Japan, Singapore, South Africa, Sweden and Thailand published their research projects.



Figure 3 –Type of Document per Countries

We observed that the research projects first focused on using DLT for interbank payment to create a safe and efficient Financial Market Infrastructure (FMI) for digital innovations and then experiment W-CBDC use cases.

Figure 4 shows the number of selected reports by type of documents which we observed that the majority of countries choose report of their project to publish their research.



Figure 4 – List of projects

Project Ubin is a collaborative project of the Monetary Authority of Singapore (MAS), the Association of Banks in Singapore (ABS), Singapore Exchange (SGX) and Singapore Government Securities (SGS). The Ubin Phases 1 provide an understanding of the prototype developed in Project Ubin for inter-bank payments using DLT, researched the DLT application re-imagining Interbank Real-Time Gross Settlement System using DLT [6], and the used DLT to develop Delivery versus Payment (DvP) for the settlement of tokenised assets [24].

Project Atom is a collaborative research project undertaken in 2020-21 between the Reserve Bank of Australia (RBA), Commonwealth Bank of Australia (CBA), National Australia Bank (NAB), Perpetual and ConsenSys, with additional input from King & Wood Mallesons (KWM). The project examined the potential use and implications of a wholesale form of CBDC, with a focus on how access to a tokenised CBDC could be extended to a wider range of wholesale market participants than just commercial banks and the potential benefits of integrating tokenised CBDC with a digital asset in the form of a tokenised syndicated loan on interoperable DLT platforms [13].

Project Helvetia is a joint experiment by the BIS Innovation Hub (BISIH) Swiss Centre, SIX Group AG (SIX) and the Swiss National Bank (SNB). This project investigates how central bank money can be used for settlement in a world where securities and other financial assets migrate from today's centralised financial market infrastructures to new so-called decentralised or tokenised platforms for trading and post-trading activities. In the first phase, started in 2020 project Helvetia experiment investigates how the provision of central bank money for wholesale settlement might be adapted if distributed ledger technology (DLT) and tokenisation are adopted by financial markets [26].

The second phase of this experiment, published in 2022, focused on W-CBDC, expanded on the work carried out in phase I by adding commercial banks to the investigation, integrating W-CBDC into the core banking systems of the central bank and commercial banks. Running transactions from end to end which settlement instructions for financial transactions were entered by the commercial banks or the SNB, instructions were matched and subsequently settled in W-CBDC with finality on the SDX platform and booked and reconciled in core banking systems [8].

Project Inthanon represents the collaborative effort between the Bank of Thailand and key industry players to explore the potential and applications of Distributed Ledger Technology (DLT) in financial infrastructure. Inthanon aims to develop a collaborative network among Thai financial institutions for learning DLT and its applications for financial infrastructure enhancement to explore the decentralised Real Time Gross Settlement system (RTGS) [7], and examine the lifecycle for bond tokens, bond DvP and interbank repurchase agreement and compliance/data reconciliation [27].

Project Jasper: Is a collaborative research initiative by Payments Canada, the Bank of Canada, financial innovation consortium R3 and several Canadian financial institutions to understand how distributed ledger technology (DLT) could transform the future of payments in Canada, exploring the use of DLT for wholesale interbank payments settlement [16]. The project was launched in March 2016 with the exploration

into the use of DLT for wholesale interbank payments settlement has been completed [15]. Jasper investigated this hypothesis by exploring DLT-based interactions between the wholesale interbank payment infrastructure and the Canadian securities settlement infrastructure [17].

Project Khokha is a collaborative project led by the South African Reserve Bank to research the application and use cases of distributed ledger technology (DLT) through a collaborative effort with the national banking community, the goal of the project was to build a proof-of-concept (PoC) wholesale payment system for interbank settlement using a tokenised South African rand on distributed ledger technology (DLT).

Project Stella is a collaborative research project between the Bank of Japan (BOJ) and the European Central Bank (ECB) entitled "Stella" created to assess the applicability of DLT solutions in the area of FMI [21]. This project research the specific functionalities of existing payment systems that could be safely and efficiently run in a DLT application and explore how the settlement of two linked obligations, such as the delivery of securities against the payment of cash, could be conceptually designed and operated in an environment based on DLT.

B. RQ2: What are the countries research strategies?

Based on our defined countries strategies selection criteria, we selected 14 reports focused on W-CBDC implementation, 4 on W-CBDC Use Case and 1 on W-CBDC design (see Figure 5).

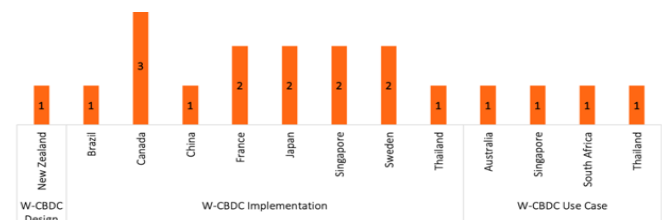


Figure 5 – Countries Research Strategies

The W-CBDC design explores the definition of CBDC, opportunities, challenges and risks, and design principles for developing the W-CBDC [1].

The 4 reporters focused on the W-CBDC use cases to explore the potential benefits of integrating tokenised CBDC with a digital asset in the form of a tokenised syndicated loan on interoperable DLT platforms [13], the wholesale interbank settlement using DLT [25][23], the tokenisation of bonds [27].

The remaining 14 reporters explores W-CBDC implementation of Liquidity-Saving Mechanism (LSM) [15] [16][21], the tokenization of assets [26][8][18], CBDC securities settlement [20][17], Delivery versus Payment (DvP) [22], [19] [24] and Decentralised Real Time Gross Settlement system (D - RTGS) [7], [6] [14].

Figure 6 shows the research method used by selected reports revealing that countries are using experiments, case studies, test-and-learn and literature review to research CBDC.



Figure 6 – Research Method per Type of Document

The research method most used is experiment with 14 reports where 11 of these reports are related to W-CBDC projects. This research method experiments with the key payment functionalities such as cash tokenisation, decentralised fund transfers, payment queue management, and gridlock resolution. The test-to learn research method uses the agile methodology for collaborative design and shared development. The solution design process is carried out through a joint exercise involving all key stakeholders (central bank and financial participants) to facilitate learning.

Figure 7 list the research dimensions of the selected reports, where 5 reports assumed that their research scope is essentially technological, confirming the relevance of the technological dimension of research and its integration with other dimensions namely financial, legal and operational.

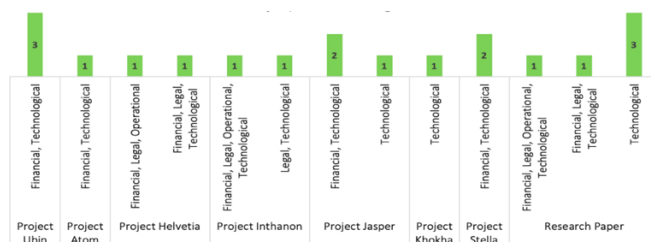


Figure 7 – Research dimensions

The technological dimension tests public and private DLT platforms such as Ethereum, Hyperledger Fabric, Corda, Quorum, R3 and others. The financial dimension explores implementing a safe and efficient payment system and the monetary policy through CBDC. The legal dimension explores the use of smart contracts to implement the regulated rules of payment system and monetary policy, the data protection and the security of information, and the operational dimension study the risks related to the use of CBDC.

IV. CONCLUSION

This research paper presents how countries are researching W-CBDC, describing the results found, especially the countries that are analysing W-CBDC and their research study, experiments and projects, the most used research method, and the research dimensions of W-CBDC.

Central banks are publishing their research on DLT-based W-CBDC through study paper, experiment paper and project. The option to create a project to conduct the research involving financial participants with and without direct access to central banks is the option mostly used to publish the research

We conclude that countries are publishing their research on DLT-based W-CBDC via experiment paper, study paper, and CBDC project report using mostly experiment research method, focused on the technological dimension and its integration with financial, legal and operational to understand the implementation of the DLT-based wholesale uses cases.

The countries research strategy is to focused on experiment the DLT for interbank payment then first, then they test the DLT-based W-CBDC use cases such as DLT-based Wholesale, tokenised syndicated loan on interoperable DLT platforms, and the tokenisation of bonds.

Digital currency regulation requires digital implementation of currency and the integration of technological scope of the digital representation of money with required financial, legal, operational and technological regulation.

For future work, we plan to conduct a systematic literature review of W-CBDC and propose metamodel in ArchiMate for W-CBDC implementation to promote digital innovation, safe and efficient payment system.

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