4-19-2024

Framing Central Bank Digital Currency: Design and Diffusion for Cross-Border Payments

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FRAMING CENTRAL BANK DIGITAL CURRENCY: DESIGN AND DIFFUSION FOR CROSS-BORDER PAYMENTS

BY

ANDREW C. HASKELL

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree

Of

Doctor of Business Administration

In the Robinson College of Business

Of

Georgia State University

GEORGIA STATE UNIVERSITY
ROBINSON COLLEGE OF BUSINESS
2024

ACCEPTANCE

This dissertation was prepared under the direction of the *ANDREW C. HASKELL* Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctor of Business Administration in the J. Mack Robinson College of Business of Georgia State University.

Dr. Richard Phillips, Dean

DISSERTATION COMMITTEE

Dr. Qian (Cecilia) Gu (Chair)

Dr. Lars Mathiassen

Dr. Vikas Agarwal

DEDICATION

This dissertation is dedicated to those who have influenced my journey throughout life and are sadly no longer alive to witness the publication of this document.

My Grandparents, who provided a warm and loving home for me each summer as a child. Throughout these annual retreats, they taught me the values of hard work, skills of farming and carpentry, strength of familial bonds, and power of community.

Uncle Andy, from whom I am blessed to be given an opportunity to help carry on his legacy. A kind soul whose journey in life concluded far too early, everlasting in our hearts.

Aunt Susan, whom I am fortunate to have known and spent the best years of my childhood with. Her laughter and love exist eternally, forever radiating from the cosmos.

Yesterday is history.

Tomorrow is a mystery.

Today is a gift.

That's why we call it the present.

-Anonymous

ACKNOWLEDGEMENTS

This dissertation is the culmination of a multi-year journey, far extending beyond the doctorate program requiring its development and defense, during which time I have had the benefit of receiving guidance and support from countless individuals and organizations. The following is an earnest attempt to recognize and appreciate those who have been most influential and encouraging along the way.

Georgia State University has held a special place in my life and heart since I was a child and attended the Saturday School Program during my elementary years, learning about architecture, chess, and origami. Subsequently, the J. Mack Robinson College of Business has repeatedly satiated my hunger for knowledge throughout my undergraduate, graduate, and doctorate programs. Accordingly, thank you to Georgia State University, the J. Mack Robinson College of Business, University Presidents, College Deans, Faculty (particularly those in the Department of Finance), Professors, the Career Advancement Center, the Panthers Immersion Program (notably Panthers on Wall Street), and Staff. Special appreciation to my doctorate program classmates who shared this journey with me and endured my many questions, especially Mike and Prince who served as my teammates, confidants, and masterful co-presenters.

Thank you to Dr. Qian (Cecilia) Gu, who served as my primary advisor, committee chair, confidant, guiding light, and friend. Your attention to detail, precise feedback, and tough love have been instrumental in my development as a researcher. Thank you to Dr. Lars Mathiassen, who first provided guidance years before the doctorate program, later welcoming me with open arms, faithfully fulfilling his role as committee member, and consistently challenging me to consider different perspectives in pursuit of becoming a better researcher. Thank you to Dr. Vikas Agarwal, having served as a professor during my degree in Finance and again as a

member of my committee, whose experience, knowledge, and methodology have contributed greatly to my continued academic maturation. Thank you to Dr. Charles Dhanaraj for your vision and leadership of the DBA program, and your personal guidance and support as I navigate my future within academia and industry. Thank you to those who volunteered to be interviewed for the purpose of this study – your insights and feedback helped more than I can express.

My sincere appreciation to medical Drs. Lief, Riina, Torres, and Anbarasan for saving my life in more ways than one. Without your individual and combined efforts, I would not be here today, and this document would not exist. It is because of you that I can feel the warmth of the sun on my face, the crisp air I breathe in my lungs, and the pulse emanating from my heart. Thank you to Reverend Andrew Frearson for your compassion and counsel for many decades.

Thank you to my mentors Orlando, Nick, and Casey for their unwavering support; friends Marcus, Steven, Brad, and Connie for the motivation; Bob and Marie for their kindness since day one; Jason, Sharry, Barry, and Elizabeth in affording me countless unique opportunities; and those industry contacts and colleagues globally who took a genuine interest in my research.

Thank you to my family for the continued encouragement along this journey, notably Claire, Scott, Peter, Susie, and Jeff. Your love, support, phone calls, text messages, cards, and letters have helped tremendously.

Most importantly, I am forever indebted to my loving Mother and Father. They have been the most dedicated, selfless, and vocal supporters throughout my entire academic journey, beginning as a child and continuing today. Without their kindness, encouragement, and countless sacrifices along the way, near and far, this document and degree would not have been possible. Thank you, Mom and Dad. I love you.

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GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND INITIALISMS

ABA	American Bankers Association
ACH	Automated Clearing House
AFP	Association for Financial Professionals
ATM	Automated Teller Machine
BAFT	Bankers Association for Finance and Trade
BIS	Bank for International Settlements
CBDC	Central Bank Digital Currency
CBPR+	Cross-Border Payments and Reporting Plus
CPMI	Committee on Payments and Market Infrastructures
DBA	Doctor of Business Administration
DLT	Distributed Ledger Technology
DOI	Diffusion of Innovation
EBA	Euro Banking Association
ECB	European Central Bank
ERC	Ethereum Request for Comments
EVF	Extended Valence Framework
FinTech	Financial Technology
FSB	Financial Stability Board
FX	Foreign Exchange
G20	Group of Twenty
GPI	Global Payments Innovation

G-SIFI	Global Systemically Important Financial Institution
IDT	Innovation Diffusion Theory
IIF	Institute of International Finance
IMF	International Monetary Fund
IRB	Institutional Review Board
ISO	International Organization for Standardization
ITT	Institutional Trust Theory
JPM	JPMorgan Chase
KYC	Know Your Customer
mCBDC	Multi-CBDC
MRP	Material Requirements Planning
MSLR	Multivocal Systematic Literature Review
Nacha (also NACHA)	National Automated Clearinghouse Association
PPM	Push-Pull-Mooring Framework
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
PSP	Payment Service Provider
RMB	Renminbi
Sibos	SWIFT International Banking Operations Seminar
SIFMA	Securities Industry and Financial Markets Association
SLR	Systematic Literature Review
SME	Subject Matter Expert
Swift (also SWIFT)	Society for Worldwide Interbank Financial Telecommunication
TAM	Technological Acceptance Model

TAM2	Technological Acceptance Model Two
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
TTF	Task-Technology Fit
USD	United States Dollar
USD₮ (also USDT)	Tether
USDC	USD Coin
UTAUT	Unified Theory of Acceptance and Use of Technology

ABSTRACT

FRAMING CENTRAL BANK DIGITAL CURRENCY:
DESIGN AND DIFFUSION FOR CROSS-BORDER PAYMENTS

BY

ANDREW C. HASKELL

April 2024

Committee Chair: *Dr. Qian (Cecilia) Gu*

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We are undergoing a period of change whereby analog structures are yielding to their electronic successors, known as digitization. This change envelops much of society, including the currency we use to transact, as it lacks the immunity to resist this evolution underway. In response, Central Banks around the globe are exploring digital versions of currency – known as Central Bank Digital Currencies (CBDCs) – with many in research and development, and some that have launched and are live in production. In parallel, we are also undergoing change through globalization as commerce and communications span international boundaries to bring people and organizations closer together. To effectively operate in this rapidly changing environment, financial system participants are seeking improvements for orchestrating cross-border payments which suffer from undesirable characteristics of being slow, expensive, lacking transparency, and exclusiveness. As digitization and globalization forces converge, CBDCs are positioned to provide cross-border payment solutions that are faster, cheaper, more transparent, and more inclusive, thus remedying existing limitations insofar as Central Banks make appropriate decisions during the CBDC design process. These design choices include Architecture, Interoperability, and Technology, all of which contribute to currency adoption outcomes.

However, failure through limited adoption is expensive, time-consuming, and reputationally detrimental to a Central Bank, warranting careful consideration of these CBDC design choices. This challenge presents an opportunity to contribute guidance for practitioners by leveraging theory and practical considerations together in creating unified solutions. Accordingly, this study builds upon and extends the Diffusion of Innovation Theory by adapting it to CBDC diffusion and introduces a complementary model expressing how CBDC innovations are designed for diffusion. These theoretical advances follow a multivocal systematic literature review and provide scholars with new foundations for future research. The result is a set of intellectual tools, validated through semi-structured interviews with subject matter experts – the Model of CBDC Diffusion, the Model of CBDC Innovation, the CBDC Design Framework, and Initial CBDC Design Typology – that can aid Central Banks when considering their design choices in pursuit of CBDC innovations for cross-border payments.

Keywords: Central Bank Digital Currency (Currencies), CBDC, Diffusion of Innovation Theory, Cross-Border Payments, Architecture, Interoperability, Technology, Design, Choice, Framework

I. RESEARCH MOTIVATION AND OVERVIEW

The world is undergoing a transitional shift from analog instruments, applications, communication channels, and solutions to their digital counterparts – commonly referred to as digitization (Luo, 2022). Currency, specifically its analog variants of metal coins and paper notes, is one example of a physical instrument used for financial transactions that is undergoing transformation to its digital alternate, known as Digital Currency (Peneder, 2022). These Digital Currencies are issued by Central Banks rather than financial institutions, commercial banks, or retail banks, and are referred to as CBDCs (Agur, Ari, & Dell'Ariccia, 2021). As of December 2022, 120 countries are exploring CBDCs, representing over 95 percent of global GDP, with all G7 countries under development of a CBDC and 18 of the G20 countries in advanced development.[1] A common objective of these Central Banks is to design their respective CBDC so that it results in diffusion amongst the populace it supports (Fernández-Villaverde, Sanches, Schilling, & Uhlig, 2021); however, a common or recognized set of optimal design choices for Central Banks to consider when seeking to improve diffusion has not yet been defined (Balvers & McDonald, 2021).

Just as digitization is on the rise, so is globalization. Roughly defined, globalization is an "accelerating set of processes involving flows that encompass ever-greater numbers of the world's spaces and that lead to increasing integration and interconnectivity among those spaces" (Robertson & White, 2007), albeit with much conjecture and debate on a singular definition (Al-Rodhan & Stoudmann, 2006). Globalization requires the transference of funds internationally, historically accomplished through the use of correspondent banking for cross-border payments

[1] CBDC Tracker, the Atlantic Council Geoeconomics Center, https://www.atlanticcouncil.org/cbdctracker/, website accessed May 15, 2023, at 3:59 PM ET.

(Casu & Wandhöfer, 2018). The intersection of digitization and globalization – expressed through the convergence of CBDCs and cross-border payments – has culminated in a topic of significant and increasing interest by prominent financial system participants including the European Central Bank (European Central Bank, 2022), thus providing the practical foundation for this research effort. Specifically, the application of CBDCs for cross-border payments is currently being explored and researched by various entities including the Bank for International Settlements (Auer, Haene, & Holden, 2021), the World Bank (The World Bank, 2021), industry groups (Kosse & Mattei, 2022), and scholars (Prasad, 2023; van der Linden & Łasak, 2023).

Focusing on Central Banks' goals of improving CBDC diffusion, the Diffusion of Innovation (DOI) Theory introduced by Rogers (1962) provides support for examining how innovations are diffused amongst a population. First, this theory identifies the categories of individuals involved in the innovation adoption process through categorization based on speed, and second, it explores the independent variables which serve as antecedents to the dependent variable of Information System Implementation Success (i.e., adoption, infusion) as the consequent in a variance model. Further harnessing the variance model proposed by the DOI Theory, these independent variables include Technical Compatibility, Technical Complexity, Relative Advantage, Trialability, and Observability, with the latter two excluded from more recent models due to weaker support following a factor analysis (Agarwal & Prasad, 1998). While publications exist examining the adopter categories in detail (Valente, 1996; Williams, Dhoest, & Saunderson, 2019), the variance model offers fewer results, with many examining the antecedents independently of each other or in an explanatory perspective (M. Ali, Syed Ali, Chin Hong, & Amin, 2019; Oyewo, 2021; Parthasarathy, Rangarajan, & Garfield, 2021). As a result, an opportunity exists to make a theoretical contribution through examination of the variance

model in further detail with an exploratory perspective, specifically regarding the relationships amongst the antecedents and the relationship of these variables collectively to the consequent of diffusion. Despite the topic of CBDCs gaining attention, most publications have focused on their non-technical aspects (e.g., monetary policy, stability, and economic implications), rather than the theoretical or technical aspects.

First, focusing on the theoretical aspects of CBDCs – specifically, the diffusion of CBDCs as an innovation – existing research is sparse, save for the work by Ma et al. (2022) which examines alternative theories to the Diffusion of Innovation including the Theory of Reasoned Action (Ajzen & Fishbein, 1973; Fishbein, 1967; Fishbein & Ajzen, 1975), Extended Valence Framework (D. J. Kim, Ferrin, & Rao, 2009; Peter & Tarpey, 1975), the Theory of Planned Behavior (Ajzen, 1985, 1991), the Technology Acceptance Model (Davis, 1986, 1989; Davis, Bagozzi, & Warshaw, 1989), and the Unified Theory of Acceptance and Use of Technology (Venkatesh, Morris, Davis, & Davis, 2003). Existing research efforts have examined how the Diffusion of Innovation theory has played a role with respect to innovations in the global payments landscape, thus establishing a precedent as exemplified with an investigation into Electronic Data Interchange adoption (Premkumar, Ramamurthy, & Nilakanta, 1994); however, a focus solely on CBDCs remains largely unaddressed. Specifically, while existing literature examines global banking phenomena (specifically cross-border payments), CBDCs, or the DOI Theory separately, combining these three components within one research effort and to a detailed degree remains unaddressed. Meanwhile, the goal of Central Banks to improve diffusion of their respective CBDC persists. Accordingly, this gap in literature results in an opportunity to address the primary research question of, *how can Central Banks improve CBDC diffusion?*

Second, focusing on the technical aspects of CBDCs – specifically, the design choices of Architecture, Interoperability, and Technology – these exact choices have yet to be examined together and in the context of facilitating cross-border payments. While these elements of Architecture (Auer & Böhme, 2020), Interoperability (Araujo, 2022), and Technology (Elsayed & Nasir, 2022) have received attention with respect to CBDCs through prior research efforts, they are limited within existing literature independently, and when present, do not coexist in detail within the same research effort and neglect to include the component of cross-border payments. The previously mentioned gaps converge in an opportunity to examine how these three design choices coexist, thereby influencing the design of CBDCs as an innovation and for the purpose of supporting cross-border payments, ultimately impacting the diffusion of CBDCs. Subsequently, this research effort aims to address the secondary research question of, *how do the design choices of Architecture, Interoperability, and Technology jointly affect CBDC diffusion?*

With these two research questions providing the foundation of this research effort, a Multivocal Systematic Literature Review followed by literature analysis was conducted to explore existing published materials, both within the scholar and practitioner realms, with the objective of understanding what gaps and opportunities for contribution exist, if any. The analysis which followed the literature review identified a gap at the intersection of technical CBDC design choices (i.e., Architecture, Interoperability, and Technology), Diffusion of Innovation Theory considerations, and cross-border payments, thereby exposing opportunities for contribution. The first finding pertains to theory, in that while models of innovation diffusion are present in literature, a model of the innovation being diffused is absent. The second finding is that a standard model for CBDC classification is also non-existent, forcing central banks to independently design their CBDC and preventing multiple central banks from referencing one

common typology, hindering efficient collaboration and harmonization. Additionally, a third finding is that the lack of a common CBDC typology and classification framework presents challenges to researchers in aligning on a common instrument which can be measured via quantitative data collection and analysis. These findings are addressed within this research effort with the intellectual tools proposed for use by practitioners and researchers for benefit and contribution to industry and theory.

This set of tools includes a collection of two models (presented individually and conjoined) with the **Model of CBDC Diffusion** and **Model of CBDC Innovation**, a three-dimensional classification matrix known as the **CBDC Design Framework**, and an initial typology introducing three of the possible 27 CBDC types proposed within the framework. This collection of tools provides rigorous and relevant instruments which can be utilized in future exploratory efforts as CBDCs continue to launch in production around the world and further used to measure the influence of CBDC design choices during the act of diffusion in support of cross-border payments. These tools also address the gap at the intersection of technical CBDC design choices, Diffusion of Innovation Theory considerations, and cross-border payments. Noting that this research effort is exploratory in nature, the proposed toolset requires installation by practitioners and testing by researchers to confirm their applicability and validity as CBDCs become more common and data is available and accessible.

In practice, these tools provide decision makers at Central Banks with a common model of how to design a CBDC given a subset of design choices and options, applicable to individual Central Banks in their own design and the collective of Central Banks globally as to aid in standardizing discussions and collaboration given the lack of an internationally accepted CBDC reference model. In research, these tools provide scholars with a set of models based on

theoretical precedent that can be leveraged to measure the phenomenon of CBDCs being created and diffused once quantifiable data becomes accessible, and a typology which warrants maturation as to explore the feasibility and legitimacy of all 27 possible types given the design choices and options proposed as in scope for this study in writing. To aid in ensuring validity of these proposed tools, semi-structured interviews with CBDC subject matter experts were conducted, thereby providing unique feedback, support, considerations, and applicability of the toolset. The combination of the literature review and analysis, proposed toolset, and interview data is intended to yield a comprehensive and valuable research effort to extend theory and aid practitioners, in pursuit of bridging theoretical and practical realms via engaged research.

II. RESEARCH METHODOLOGY

Given the nascency of CBDCs and limited quantifiable data available with respect to CBDCs live in production, this research effort is being approached in a multi-stage format comprised of four stages for this study, with a fifth proposed for future research, summarized in ***Table 1***. The first stage is a Multivocal Systematic Literature Review (MSLR) to produce the initial collection of published materials appropriate for analyzing data from the realms of both theory and practice. The second stage is the identification of any gaps in theory or practice from said collection of literature via document analysis with respect to CBDCs and their diffusion in the context of cross-border payments, thus yielding opportunities for contributions to theory or practice or both. Stage three is the development, introduction, and explanation of extended or novel arguments, propositions, and tools (i.e., new visual depictions to convey the information, e.g., table, figure, model, framework, typology, etc.) which can subsequently be utilized by researchers and practitioners alike. Stage four is the collection and analysis of qualitative data obtained through semi-structured interviews with CBDC subject matter experts to obtain their feedback on the accuracy, applicability, and validity regarding the outputs from stage three (i.e., arguments, propositions, and tools), thereby adding relevant perspectives and new information to augment the data collected via the MSLR.

Table 1. Research Methodology Stages and Descriptions

Stage	Method	Purpose
One	Multivocal Systematic Literature Review	Construct a collection of rigorous and relevant literature (i.e., published data)
Two	Literature Analysis	Identify gaps in existing literature (theory, practice, or both)
Three	Contribution Development	Create contributions to address theoretical and practical gaps, with visual depictions and explanations
Four	Semi-Structured Interviews (execution and analysis)	Obtain qualitative data in response to the proposed contributions by interviewing relevant subject matter experts
Five *(Future Research)*	Quantitative Data Collection	Obtain quantitative data regarding the three CBDC design choices to measure their influence on diffusion

The expected results of this research effort are multifaceted and intended to provide researchers with theoretical foundations by which to build upon with the collection and application of quantitative data in the future once available, and offer practitioners intuitive, comprehendible, and actionable tools that can be used in the decision-making process when designing a CBDC in the pursuit of increased diffusion and in the context of cross-border payments. Given the nascency of CBDCs, both from practical and theoretical perspectives, this area of research is relevant to current market developments and is anticipated to provide a unique opportunity to make valuable contributions to practice and theory alike.

Following completion of the MSLR, this research effort expects to identify gaps where: (1) the Diffusion of Innovation Theory has not yet been applied to the concept of CBDCs to yield a model of CBDC diffusion, (2) the Diffusion of Innovation Theory has not yet been examined from the perspective of the innovation that is being diffused as opposed to the diffusion of said innovation, or in the context of CBDCs, by producing a model of CBDC innovation, (3) CBDC design choices have not received attention or identification of which choices are most influential

to diffusion by examining the relationship between models of innovation and diffusion, and (4) the most influential CBDC design choices are consolidated into a singular framework which Central Banks can utilize during the research and development phases prior to launching a CBDC live in production. Accordingly, these gaps are then expected to present opportunities to make contributions which are both relevant and rigorous and applicable to scholars and practitioners.

Beginning with stage one, data is initially collected through a MSLR, adopted from the format developed by Themistocleous, Rupino da Cunha, Tabakis, and Papadaki (2023). The intent of this approach is to identify gaps in published literature regarding both the technical aspects of CBDCs and their relationship to innovation diffusion and adjacent theories, and in pursuit of opportunities for contribution to industry and theory alike. Building off the Systematic Literature Review (SLR) guidelines from Webster and Watson (2002) and Kitchenham (2004) which lay the search process foundation to include peer-reviewed academic journals (i.e., white literature), the Multivocal element pertains to the inclusion of additionally relevant publications found online (Kitchenham & Charters, 2007), such as those by Central Banks and industry consortiums (i.e., grey literature), thus yielding a MSLR (Themistocleous et al., 2023). The inclusion of grey literature is especially relevant in this context given their high frequency of reference within white literature on the topic of CBDCs, an approach validated by prior researchers (Fedorova & Skobleva, 2020).

For the purposes of this research effort, white literature has been primarily sourced from three databases, specifically ABI/INFORM Collection, Business Source Complete, and Web of Science. Similarly, grey literature has been sourced from four main categories: Central Bank Reports, Industry Consortium Documents, News Articles, and Private Companies. ***Table 2***

specifies the white and grey literature classifications, literature databases (white) and types (grey), and provider (white) or author (grey). Considering the vastness of available grey literature from which to source from, a bounding condition of only including documents classified as high-credibility Tier 1 (e.g., central bank reports, industry coalition documents, etc.) and medium-credibility Tier 2 (e.g., news articles, private company documents, etc.), while excluding low-credibility Tier 3 (e.g., social media posts, website entries, etc.) has been applied, as proposed by R. J. Adams, Smart, and Huff (2017).

Table 2. MSLR Document Sources

Literature Classification	Literature Database or Type	Provider or Author
White	ABI/INFORM Collection	ProQuest
	Business Source Complete	EBSCO
	Web of Science	Clarivate
Grey	Central Bank Reports (Tier 1)	Bank of England (2022) Bank of Japan (2019) Board of Governors (2012, 2022) European Central Bank (2022) Reserve Bank of Australia (2015)
	Industry Consortium Documents (Tier 1)	BIS (2018, 2020, 2022a, 2022b, 2023) CPMI (2020) FSB (2020a, 2020b) IMF (2023) The World Bank (2014, 2017, 2021) World Economic Forum (2023)
	News Articles (Tier 2)	Financial Times (2020)
	Private Companies (Tier 2)	Icon Solutions (2019) Oliver Wyman (2021) SIFMA (2023) The Clearing House (2020)

The utilization of both white and grey literature subsequently produced a comprehensive collection of data by which to consult in the development of this paper, acknowledging the varying degrees of rigor given such a wide spectrum of publications on the emergent and quickly

evolving topic of CBDCs. Following the identification of article databases for white literature, the literature selection process was then adapted from Tuunanen, Rossi, Saarinen, and Mathiassen (2007) and their Table 1 which explains the multiple selection steps, relevant details, and corresponding search results. ***Table 3*** (ABI/INFORM Collection), ***Table 4*** (Business Source Complete), and ***Table 5*** (Web of Science) detail the literature selection process steps with corresponding descriptions and search result counts for each of the three databases in scope for this research effort. Important to note is the search string used for all three databases was constructed and refined, ultimately arriving at “("Central Bank Digital Currenc*" OR CBDC) AND (Architecture OR Interoperability OR Technology)”, utilizing both Boolean operators and truncation to yield a more exhaustive set of results. Equally important to note is that while the original literature selection process steps, keywords utilized, and corresponding article counts are detailed and replicable, future search results will differ to reflect newly published literature as this topic and area of research matures.

Table 3. Record Selection Process: ABI/INFORM

Selection Step	Description	Results
Step 1: Broad search in the ProQuest: ABI/INFORM Collection database. (March 2, 2024)	Initial search using the following string: ("Central Bank Digital Currenc*" OR CBDC) AND (Architecture OR Interoperability OR Technology)	**12,083**
Step 2: Filtered for Full Text documents.	Checked the "Full text" box within the "Limit to" section of the search results page.	**11,922**
Step 3: Filtered for Peer Reviewed documents.	Checked the "Peer reviewed" box within the "Limit to" section of the search results page.	**363**
Step 4: Filtered for Scholarly Journals as the Source Type.	Using the "Source type" filter on the search results page, the following sections were made: 1. Scholarly Journals (347): Include 2. Trade Journals (11): Exclude 3. Conference Papers & Proceedings (5): Exclude	**347**
Step 5: Filtered for English language documents.	Using the "Language" filter on the search results page, the box for "English" was checked.	**314** (Initial set of articles identified for screening)

Table 4. Record Selection Process: Business Source Complete

Selection Step	Description	Results
Step 1: Broad search in the EBSCO: Business Source Complete database. (March 2, 2024)	Initial search using the following string: ("Central Bank Digital Currenc*" OR CBDC) AND (Architecture OR Interoperability OR Technology)	**263**
Step 2: Filtered for Full Text documents.	Checked the "Full text" box within the "Limit To" section of the search results page.	**138**
Step 3: Filtered for Peer Reviewed documents.	Checked the "Peer reviewed" box within the "Limit To" section of the search results page.	**70**
Step 4: Filtered for Scholarly Journals as the Source Type.	Using the "Source Types" filter on the search results page, the box for "Academic Journals (65)" was checked.	**65**
Step 5: Filtered for English language documents.	Using the "Language" filter on the Search Options popup page (accessed by clicking the "Show More" hyperlink on the Search Results page), the option for "English" was selected from the drop-down menu.	**60**
Step 6: Filtered for Academic Journals as the Source Type.	Using the "Source Types" filter on the search results page, the box for "Academic Journals (55)" was checked.	**55** (Initial set of articles identified for screening)

Table 5. Record Selection Process: Web of Science

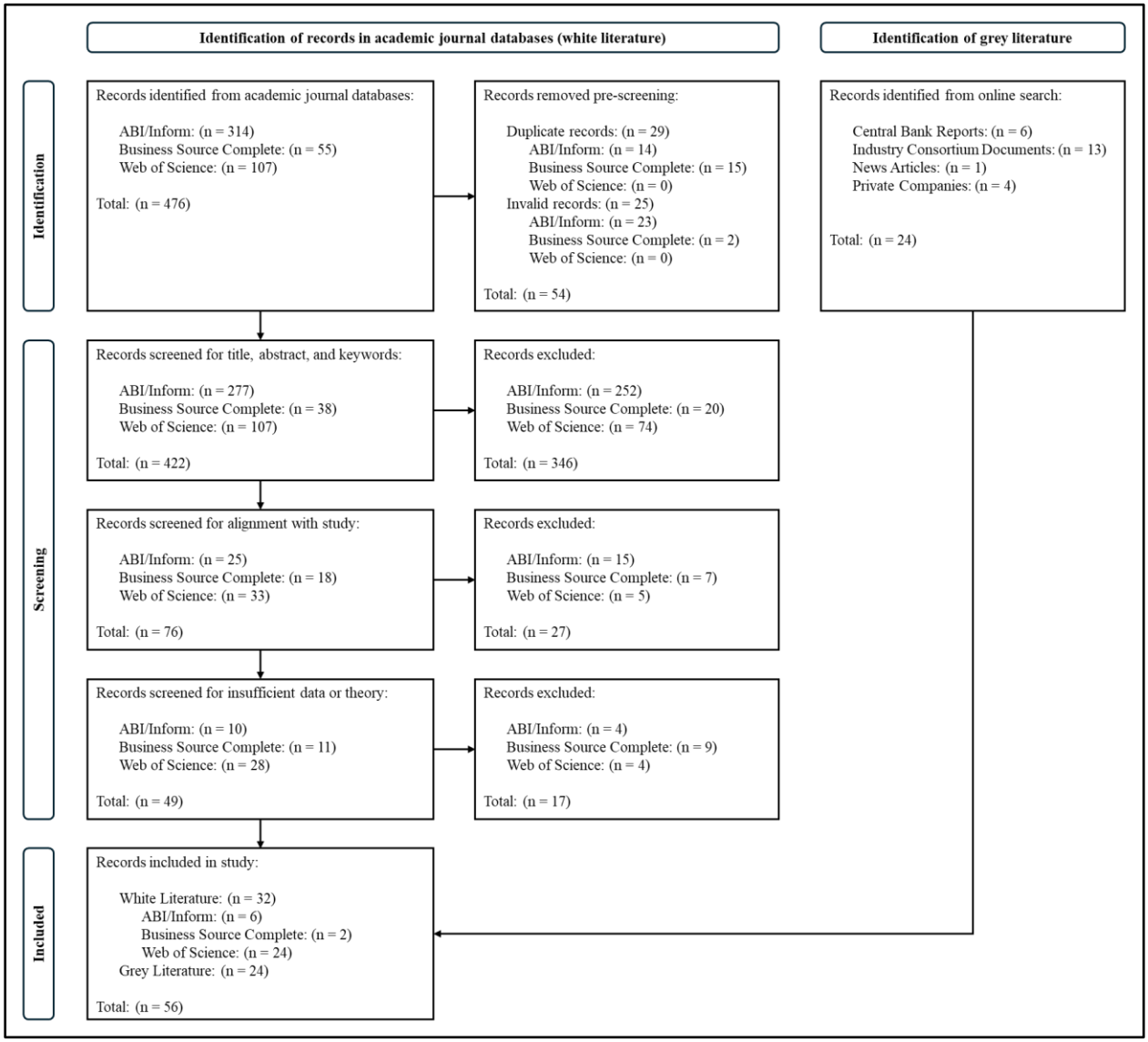
Selection Step	Description	Results
Step 1: Broad search in the Clarivate: Web of Science database. (February 19, 2024)	Initial search using the following string: ("Central Bank Digital Currenc*" OR CBDC) AND (Architecture OR Interoperability OR Technology)	**206**
Step 2: Filtered for Article documents.	Checked the "Article" box within the "Document Types" section of the search results page.	**140**
Step 3: Filtered for English language documents.	Checked the "English" box within the "Languages" section of the search results page.	**108**
Step 4: Filtered for Retracted Publication documents.	Checked the "Retracted Publications" box within the "Editorial Notices" section of the search results page.	**107** (Initial set of articles identified for screening)

Once the initial set of white literature articles identified for screening were obtained from all three databases, the screening process commenced and was conducted in alignment with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines, noting both the original variant (Moher, Liberati, Tetzlaff, Altman, & PRISMA Group*, 2009) and updated version (Page et al., 2021). Prior to the screening of the articles (i.e., records), the initial set was reviewed to remove duplicate records (using the results from the Web of Science database as the basis for comparison) and invalid records such as book reviews and non-peer reviewed publications. The remaining set of records were then screened to determine their appropriateness and applicability to this study, consisting of three levels of screening, each more detailed than the previous.

The first level of screening included a review of the record's title, abstract, and keywords; the second level to determine if the record was in alignment with this study; and the third level to confirm if the data and theory included in the record were sufficient for further analysis. These

levels of screening reduced the set of records from 422 (excluding duplicate and invalid records) down to 32 for inclusion in this study. In parallel, the grey literature search online yielded 24 records, which combined with the white literature totaled 56 records to be included in this research effort. This MSLR process, as expressed in a PRISMA flow diagram, is shown with ***Figure 1***. Lastly, during the process of reviewing the final set of records individually, both backward snowballing (i.e., utilizing a paper's reference list to source new papers) and forward snowballing (i.e., sourcing new papers which reference the record under investigation) techniques were employed to identify additional white and grey documents and included the use of journal publishers (e.g., JSTOR, ScienceDirect [Elsevier], Wiley Online Library) and Google Scholar if the article was not available within the aforementioned three databases (Wohlin, 2014; Wohlin & Prikladniki, 2013).

Figure 1. PRISMA Flow Diagram of Multivocal Systematic Literature Review

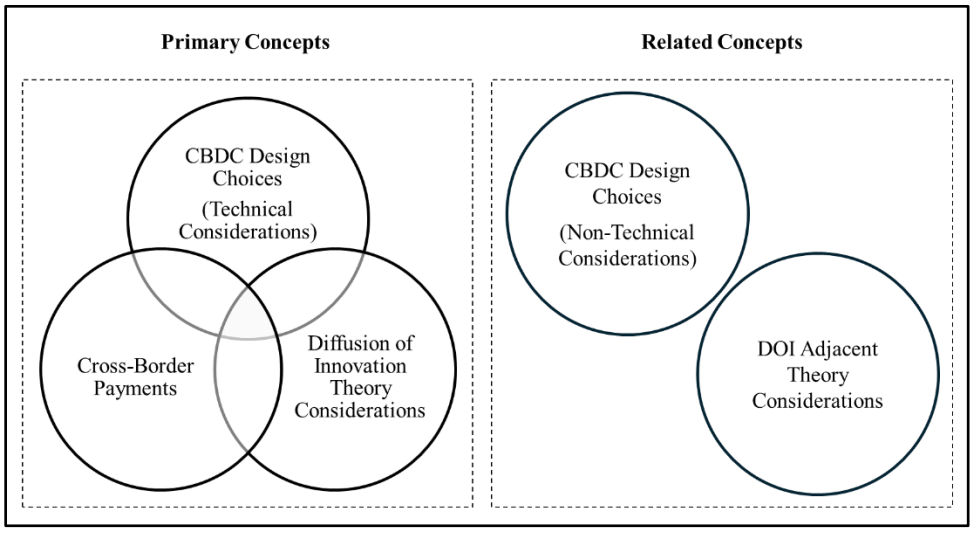


Source: Author, adapted from Moher et al. (2009)

The second stage of this research effort is focused on identifying gaps in existing literature by conducting a comprehensive record analysis, with the output detailed within the subsequent sections, beginning with the practical realm in sections ***III. Digitization of Currencies and Payments*** and ***IV. Design of Central Bank Digital Currency*** and continuing with the theoretical realm in section ***V. Diffusion of Central Bank Digital Currency***. Adhering to

the literature review procedure proposed by Snyder (2019) as a guideline, analysis of the literature sourced during the MSLR was conducted by reading each record to identify connections to the three areas of focus for this study as depicted in ***Figure 2*** (i.e., technical CBDC design choices, Diffusion of Innovation Theory considerations, and cross-border payments) and in pursuit of answering the two research questions posed in section ***I. Research Motivation and Overview***. Data was abstracted from a combination of findings which were predominately associated with the practical aspects of non-technical and technical considerations (i.e., CBDC design) and conceptualizations of theoretical considerations (i.e., CBDC diffusion). During the process of analyzing each record independently, commonalities and themes spanning different records emerged with respect to the convergence of multiple areas of focus for this study, expressed as the overlap of two circles in ***Figure 2***. Simultaneously, the identification of focus area convergence also uncovered focus area omission – where one or more areas of focus were absent from the record – and the discovery of related concepts, also shown in ***Figure 2***.

Figure 2. Research Study Areas of Focus



Source: Author

As stage two progressed through the identification of commonalities both present and absent, it served as the catalyst for the third stage which includes the formulation and introduction of arguments and propositions in the subsequent three sections. In other words, the literature was first sampled, then analyzed, and finally utilized for conceptual development across stages one through three, respectively. To aid the reader in following this research effort, the first point of clarification is that this study is a framing exercise, given the nascency of CBDCs and the lack of quantifiable data, and the second being an intentional bifurcation into CBDC design (section ***IV. Design of Central Bank Digital Currency***) and CBDC diffusion (section ***V. Diffusion of Central Bank Digital Currency***). This bifurcation allows both framing themes of CBDC design and diffusion to be explored in detail by serving as the mechanism to express the output of the literature analysis and introduce contributions within each section that are relevant to the framing theme in question. These contributions are then revisited in section ***VI. Discussion***, as are the research limitations of this study and future research opportunities.

The set of contributions developed in stage three and collectively positioned as the intellectual toolset for the purpose of this study, is then introduced to industry professionals as a means to collect qualitative data obtained through interviews. Specifically, this additional data in stage four is gathered in the form of feedback and perspectives by conducting interviews with industry professionals having associations with both central and commercial banks. The interviews were conducted in a semi-structured format with open-ended questions to allow for the collection of "rich data" (Schwenk, 1985) whereby the qualitative data provided via interviewee responses is used to enrich this research effort and highlight statements which corroborate or contradict the contributions proposed. To augment the MSLR, literature analysis, and conceptual development noted above, opinions and commentary from subject matter experts

are obtained through interviews with the objective of validating the applicability and appropriateness of the contributions proposed. The interviews were conducted after the contributions in this study were developed and in a near-final state in order to obtain the most relevant data prior to publication. The interview research protocol, informed consent form, and questions are found in ***Appendix A: Interview Research Protocol***, ***Appendix B: Interview Informed Consent Form***, and ***Appendix C: Interview Questions***, respectively, with approval by the Georgia State University Institutional Review Board (IRB) as an Exempt Category 2 submission as defined in 45 CFR 46 (IRB Number: H24432, Reference Number: 378668, Determination Date: 02/21/2024).

This study then culminates with section ***VII. Conclusion***, followed by the appendices and references utilized in the development of the document in writing. Please note that these first four stages serve as the foundation for my individual dissertation to satisfy the Doctorate of Business Administration (DBA) program requirements. A fifth stage is proposed for future researchers to build upon the first four by incorporating quantitative data regarding the three CBDC design choices (i.e., Architecture, Interoperability, and Technology) and how they independently and jointly affect the diffusion of CBDCs. This fifth stage is proposed to be conducted using a quantitative survey with multiple central banks globally to understand the design choices made and obtaining quantifiable data of the CBDC under review as to measure the influence of the CBDC design choices to the diffusion of said CBDC. Noting the complexity and geographic distribution of these CBDCs and their associated data, this fifth stage is anticipated to require significant time and effort to obtain approvals internationally by the IRB of the country or region under investigation, conduct and analyze the survey, and obtain the CBDC data from systems publicly available and live in production.

III. DIGITIZATION OF CURRENCIES AND PAYMENTS

III.A. Physical Currency

Central Banks have long supported their respective country's financial system through the issuance and management of currency. Historically, Central Bank currency has been a physical instrument, produced as metal coins and paper banknotes. While these paper and metal instruments have benefitted society by supporting the storage of wealth and purchasing of goods and services, they create problems within the global financial system including significant expenses to produce and maintain, risk of counterfeiting, and negative environmental impacts, amongst others. Physical currency introduces increased costs across the financial system and are incurred by Central Banks, commercial banks, consumers, and other system participants.

Beginning with Central Banks, the U.S. Federal Reserve incurs costs through the Treasury's Bureau of Engraving and Printing with respect to currency (i.e., banknote) production. These costs include quality assurance, security feature design and implementation to prevent counterfeiting, movement (i.e., shipment) of currency, training, and currency destruction. To support these activities, the U.S. Federal Reserve incurred expenses of $979.9MM in 2022 (Board of Governors, 2022, p. 168), a 36% increase over expenses a decade prior of $721.1MM in 2012 (Board of Governors, 2012, p. 340), and representing 16% of the total operating expenses of the Federal Reserve System that year (Board of Governors, 2022, p. 150), with transportation and associated costs totaling $26.5MM. Similarly, the Bank of England incurred a total of £75MM (USD equivalent of $94.96MM[2]) in banknote costs pertaining to production, issuance, custody, and payment in 2022 (Bank of England, 2022, p. 200). Continuing with other financial system participants, costs are incurred with the storage, processing, and movement of

[2] GBP/USD exchange rate of 1.2662 on December 21, 2023, at 11:44 AM (4:44:00 PM UTC).

physical currency. As examined by Geismar, Sriskandarajah, and Zhu (2017), these costs extend to commercial banks, consumers due their reliance upon ATMs, armored cash-in-transit vehicles (e.g., Brink's and Loomis armored transport).

Additionally, the continued use of physical currency fosters the environment for counterfeit banknotes. Currency counterfeiting, despite the continued innovation and development of deterrence technologies including security features and designs, has been "democratized" due to advancements in consumer-accessible tools such as computers, printers, and copiers (Morris, Copes, & Perry-Mullis, 2009). While currency counterfeiting is neither a novel concept nor reserved for one country or geography (Garner, 1930), easily accessible technological advancements have further accelerated counterfeit currency production and distribution globally, resulting in the seizing of $41.5MM[3] by the U.S. Secret Service in 2022.

The prevalence of currency counterfeiting has broader impact to the global financial system as well, including potential exchange rate implications (Gomis-Porqueras, Kam, & Waller, 2017), a continuous need to thwart fraudsters by improving anti-counterfeiting measures through costly currency redesign and production (Quercioli & Smith, 2015), and social costs such as reduced consumer confidence and corresponding reduced use (Viles, Rush, & Rohling, 2015), noting that even the possibility of counterfeiting can affect the currency's "value, velocity, output, and welfare" (Li & Rocheteau, 2011). The aforementioned implications and costs associated with the continued use and maintenance of physical currency have contributed to Central Banks' exploration of alternative currency options, notably digital currencies.

[3] FY 2022 by the Numbers, Investigative Operations, FY 2022 Annual Report, U.S. Department of Homeland Security United States Secret Service, https://www.secretservice.gov/annual-reports/fy-2022-annual-report, website accessed December 21, 2023, at 3:01 PM ET.

III.B. Digital Currency

As the world continues to evolve through the replacement of physical or analog devices with their digital or electronic counterparts, components of the global financial system are undergoing analysis to determine which are appropriate for digitization. Recognizing the challenges above pertaining to the continued use of physical currency instruments, the desire to identify a suitable replacement arose and led to the introduction of the first cryptocurrency, Bitcoin (Nakamoto, 2008). This introduction paved the way for a new market to form, with the global cryptocurrency market cap currently at $1.73T[4] 15 years later, although relatively small in comparison to the $106.0T global equity market cap (SIFMA, 2023). In addition to creating a new market, the inception of Bitcoin and associated technologies (e.g., cryptography and distributed ledgers) have given rise to three digital alternatives to physical currency (Fernández-Villaverde et al., 2021) – cryptocurrencies, stablecoins, and CBDCs – as explained in the subsequent paragraphs.

Beginning with Cryptocurrencies, these digital alternatives to physical currency (e.g., Bitcoin and Ethereum) allow for direct entity-to-entity (e.g., person-to-person, business-to-business) transactions to be conducted within a decentralized digital ecosystem leveraging the internet. This ecosystem avoids the use of intermediaries (e.g., Central Banks or Commercial Banks), thus shifting reliance upon banks to technology (G.-J. Wang, Ma, & Wu, 2020). Adopted from Wattenhofer (2016), cryptocurrencies can be further explained as technologies of asymmetric cryptography and a consensus mechanism distributed database that are combined within a decentralized and secure register blockchain utilizing Distributed Ledger Technology

[4] "Digital Assets: Cryptocurrency Prices Today By Market Cap", Forbes, Forbes Media LLC., https://www.forbes.com/digital-assets/crypto-prices/, website accessed December 30, 2023 at 2:28 PM ET.

(DLT), yielding a novel instrument to orchestrate authenticated payments instantly between entities and without reliance upon government or banking entities (Wątorek et al., 2021).

While cryptocurrencies have benefits for the entities involved in the payment such as the freedom of operating in an unregulated environment, anonymity (a similar attribute to physical currency), protection against fiat currency fluctuation, and convenience due to the purely digital nature, they also have limitations. Examples such as Bitcoin are ripe with speculative bubble-creating volatility and questionable value, argued by some researchers to have a price of zero (Cheah & Fry, 2015). Bitcoin also requires "mining" as facilitated through computers performing complicated mathematical equations which lead to a massive carbon footprint due to the substantial amounts of energy required, with estimates ranging from the needs of a small power plant to the total consumption of "small to medium-sized countries such as Denmark, Ireland or Bangladesh" (Vranken, 2017).

From the perspective of central authorities (e.g., government and banking entities), cryptocurrency characteristics – including the aforementioned volatility, artificial value, anonymity, lack of issuance by a central authority, and non-adherence to Know Your Customer (KYC) procedures to identify entities engaging in transactions (Pieters & Vivanco, 2017) – prevent their use as a digital alternative that is fit for purpose in an official capacity. These characteristics, coupled with the lack of a global regulatory framework that has led to the use of cryptocurrencies for nefarious purposes such as illicit activities by terrorists and criminals leading to terrorist financing and money laundering (Fletcher, Larkin, & Corbet, 2021), further prevent its adoption and support by central authorities as an alternative form of currency. Despite these barriers to entry, if Bitcoin were used in the creation of a new banking system, there are multiple and significant challenges presented with the exclusion of a Central Bank as posited by

R. Ali, Barrdear, Clews, and Southgate (2014), including the risk of uncontrolled inflation following an over issuance of instruments (e.g., loans) that are not fully backed, and an inability to convert or trade “at par”.

Continuing with stablecoins (e.g., Tether, USD Coin [USDC], TerraUSD), these digital currency alternatives carry similar characteristics to cryptocurrencies including their existence as blockchain-based tokens which facilitate direct, near-instant, and immutable entity-to-entity transaction orchestration within a digital ecosystem. Unlike cryptocurrencies, price volatility does not act as a hinderance to adoption; rather, stablecoins are commonly pegged to “less volatile assets or currencies” and result in more widespread usage, often within cryptocurrency exchanges (Ante, Fiedler, & Strehle, 2021). Importantly, not all stablecoins are pegged to a currency, leading to different levels of associated valuation risk.

While many stablecoins are pegged to a currency, including Tether with a 1-to-1 fiat currency match (e.g., 1 USD₮ = 1 USD[5]) and USDC which is “backed 100% by highly liquid cash and cash-equivalent assets and is always redeemable 1:1 for US dollars” using a reserve fund[6], others are classified as algorithmic stablecoins (e.g., TerraUSD) relying upon a secondary mechanism (e.g., Luna) to maintain value, and crypto-backed stablecoins (e.g., Dai) using cryptocurrency as collateral. Noting that currency-pegged stablecoins aid in confidence building through reduced volatility, Dai is considered to be a superior variant due to reliance upon autonomous smart contracts in the decentralized Ethereum blockchain (Kozhan & Viswanath-

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[5] “Why use Tether: 100% backed by Tether’s reserves” dialog box, Tether Operations Limited, https://tether.to/en/why-tether, website accessed December 29, 2023, at 2:51 PM ET.
[6] “FAQs: How does Circle guarantee that USDC is fully backed and always redeemable 1:1 with US dollars?” dialog box, Circle Internet Financial Limited, https://www.circle.com/en/usdc, website accessed December 29, 2023, at 3:07 PM ET.

Natraj, 2021), TerraUSD has been deemed inferior, as evidenced with its crash in May 2022 due to devaluation following under-collateralization and the Luna price plummeting (Lyons & Viswanath-Natraj, 2023). Furthermore, the TerraUSD crash resulted in a loss of $40B and spillover to adjacent cryptocurrency markets, reducing confidence in currency alternatives by investors and overall market sentiment (S. Lee, Lee, & Lee, 2023).

These hybrid attributes of cryptocurrency-like convenience and national currency-pegged value (e.g., the U.S. Dollar) yield a currency alternative favored by end users with potential global support by notable market participants as evidenced with the launch of Diem by Meta (formerly Libra by Facebook) and JPM Coin by JPMorgan Chase & Co (Ante et al., 2021). However, administration that is performed outside of government and banking entities (i.e., decentralized administration) prevents the supervision and regulation required by central authorities to utilize stablecoins as an officially designated form of currency. Accordingly, many central authorities are looking to the third option of CBDCs as the most viable alternative to physical cash, while representing the safety and stability of Central Bank-issued currency (Morales-Resendiz et al., 2021). That said, there are Central Bank representatives who have not fully dismissed the use of stablecoins pegged to a sovereign currency (Waller, 2022).

Concluding with the third digital alternative, CBDCs are issued by a central authority – that being the Central Bank – and can be regulated. Although not backed by a physical commodity (e.g., gold, silver), their value is fixed by the Central Bank, thus representing a direct liability of the Central Bank (BIS, 2023). Accordingly, CBDCs and their ability to provide immediate finality while using central bank money yield a safe alternative for Central Banks to consider when complementing or replacing their traditional, physical currency (Carstens, 2021). The pursuit of CBDCs has now been undertaken by more than 70 countries which have launched

and piloted or are under research and development, with 11 live in production[7]. These pursuits are prompted by the potential for CBDCs to improve many facets of banking (e.g., medium of exchange, store of value, unit of accounting, method of financial inclusion) and align with the digital migration underway across society (S. Allen et al., 2020). Acknowledging that CBDCs offer many potential benefits, applications, and opportunities, this paper is concerned with the medium of exchange feature, specifically to support the function of cross-border payments by end-users (i.e., retail and wholesale entities).

III.C. Digital Payments

Retail entities (i.e., consumers and businesses) and wholesale entities (i.e., banks and financial institutions) are similar in two ways: (1) they both have the need to send and receive funds internationally through the use of cross-border payment schemes across multiple use cases (e.g., payments, securities, treasury, trade), commonly using wire transfers via Swift messaging and services (11.2B transactions in 2022[8]) and International ACH (112.6M transactions in 2022[9]), and (2) they both have a relationship with their country's Central Bank (e.g., the U.S. Federal Reserve, Bank of England, European Central Bank). The FSB found that these end-users are burdened with existing methods for conducting cross-border payments given four undesirable characteristics of being slow, expensive, lacking transparency, and exclusionary (FSB, 2020a).

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[7] CBDC Tracker, the Atlantic Council Geoeconomics Center, https://www.atlanticcouncil.org/cbdctracker/, website accessed May 15, 2023, at 3:59 PM ET.
[8] "Swift IN FIGURES: December 2022 YTD" Report, SWIFTNet FIN Total FIN Messages (December 2022 YTD), Swift, https://www.swift.com/swift-resource/251971/download, website accessed January 15, 2024, at 12:31 PM ET.
[9] "International ACH Payments a Valued Option: 2022 Key Metrics", International Payments by Volume: 2022, Nacha, https://www.nacha.org/content/ach-network-volume-and-value-statistics, website accessed January 15, 2024, at 12:35 PM ET.

For perspective, the value of cross-border payments is estimated to have increased from almost $150T in 2017 to over $250T by 2027 (Cunliffe, 2020), equating to a rise of over $100T within a single decade. Beginning with the first characteristic of being slow, this increase in global payments value is accompanied by transactional delays of two to three days on average (Oliver Wyman, 2021) and up to 10 days or more in some instances (Cunliffe, 2020) to clear and settle a cross-border payment, slow in comparison to existing methods of payment including domestic real-time payment schemes which clear and settle in seconds such as the RTP® System[10] in the U.S. (The Clearing House, 2020). In addition to payment delays, the expense to facilitate cross-border payments is estimated at $120B in 2020 excluding Foreign Exchange (FX) costs (Oliver Wyman, 2021), incurred through per-transaction fees borne by the payment originator, hence the second undesirable characteristic of being expensive. These costs are the result of multiple factors in the existing cross-border payment landscape, including utilization of legacy structures (i.e., antiquated architecture), coexistence of incompatible message formats (i.e., lack of interoperability), technology differences amongst scheme participants, country-specific processes, and reliance upon multiple intermediaries and the incorporation of correspondent banks (FSB, 2020b).

Diminishing the appeal of existing cross-border payments further, these payments lack transparency, specifically the ability to have access to information in real time as to the location of the payment, the extent to which the payment instruction (e.g., payment message) has been altered, tracking information unique to the payment, and associated delays in processing or deductions taken from the principal amount of the payment for processing by intermediaries. To combat this third undesirable characteristic of deficient transparency, solutions have been

[10] RTP® is a registered service mark of The Clearing House Payments Company, LLC.

introduced by the private sector, such as Swift GPI (Global Payments Innovation) for payment tracking (Casu & Wandhöfer, 2018), thereby providing a mechanism similar to that of UPS or DHL package tracking. However, Swift GPI is optional and not all banks, such as those in the correspondent banking arena, enable this functionality for tracking which reduces transparency and yields an inconsistent experience. Concluding with the fourth characteristic of exclusivity (i.e., lacking financial inclusion), underbanked and unbanked individuals have limited access to cross-border payments, adding challenges for those in emerging markets and developing economies (FSB, 2020b). Financial inclusion via cross-border payments is exemplified with international remittances, notably money that is transmitted by migrant workers to their household while working in a separate country (R. H. Adams, 2009, 2011), further compounded by the second characteristic of high costs.

These undesirable characteristics led to the Financial Stability Board (FSB) being tasked with creating a roadmap to enhance cross-border payments by the G20 in February 2020 at its Finance Ministers and Central Bank Governors meeting. This task to the FSB included a three-stage process, complete with corresponding reports to detail the following: (1) assess the existing landscape and its challenges, (2) develop building blocks to address said challenges as facilitated by the Committee on Payments and Market Infrastructures (CPMI), and (3) develop a roadmap for go-forward activities (Quarles, 2020). Within the Stage 2 report, the CPMI (2020) introduced a concept consisting of multiple building blocks (19 in total) which detail the elements recommended for enhancing cross-border payments. Aligning with this research effort, Building Block 19 pertains to the cross-border element of CBDCs by addressing the potential of Central Banks to facilitate efficient cross-border transactions via interoperability as performed through

international infrastructure interfaces following analysis, guidance, oversight, and legislative changes.

Accordingly, CBDCs have been identified as having the potential to satisfy the FSB's objective of improving cross-border payments by making them faster, cheaper, more transparent, and more inclusive. This position by the CPMI, coupled with the aforementioned increase in cross-border payments, provides legitimacy and support for this research effort to explore the phenomenon in greater detail. In the time since roadmap publication, the CPMI and other industry partners have further explored interoperability as it pertains to CBDCs and their ability to facilitate cross-border payments, as evidenced by multiple reports on CBDC applicability and utilization (BIS, 2022a; International Monetary Fund, 2023; World Economic Forum, 2023). In addition to interoperability, other elements of CBDCs applicable to cross-border transactions have been identified and researched, notably Architecture and Technology which are covered in the subsequent section.

However, the potential of CBDCs facilitating cross-border payments and satisfying the FSB's objective is only realized if they are successfully diffused amongst the respective country's populace, followed by adoption, and ultimately, infusion. Therefore, success of diffusion in this context is measured by the ability of CBDCs to resolve the four undesirable cross-border payment characteristics, which is itself contingent upon the design of the CBDC by the Central Bank, thereby providing validity to the importance of design choices and the options selected. Central Banks are faced with numerous choices when developing a CBDC including their support of retail and/or wholesale entities, whether they are account- or token-based, different levels of anonymity and privacy, and varying degrees of support for financial intermediaries. This research effort focuses on three fundamental design choices which are all

technical in nature – Architecture, Interoperability, and Technology. These three design choices were intentionally selected as they form the most fundamental elements of CBDCs and are posited to explain the most variance in the process of diffusion, thus outweighing other design choices. Additionally, these three choices are quantifiable, contain distinct options for each, and have not yet been examined jointly for the purpose of contributing to improved diffusion in support of facilitating cross-border payments.

IV. DESIGN OF CENTRAL BANK DIGITAL CURRENCY

IV.A. Cross-Border Payments

Transitioning from Digitization, this research effort highlights two fundamental elements of CBDCs in the context of Globalization, specifically how they are used and by whom. In this context, CBDCs are able to support end-users (i.e., wholesale and retail entities) and for the purpose of facilitating cross-border transactions. These two complementary elements are captured in existing literature to varying degrees, with information on payment transactions outpacing payment users. Beginning with end-user support, the two primary categorizations of CBDC users in literature include retail and wholesale entities, with distinctions made between the two. This categorization within the context of CBDCs is noted by BIS (2018) and summarized by T. Zhang and Huang (2022) whereby retail is classified as payments among individuals and businesses facilitated by CBDCs which act as a replacement for cash, while wholesale is applicable to payments between banks, often referred to as inter-bank settlements, noting that each entity must have a direct relationship with the corresponding Central Bank in that country or region.

Existing literature includes further analysis into the applications of CBDCs by wholesale and retail entities, and the benefits provided to each type of end-user. Ma et al. (2022) is one example of this approach, noting that the application of CBDCs for retail entities is to provide users (i.e., consumers and businesses) with a universal payment type that has high liquidity, low risk, and easily used, versus wholesale entities that apply their use of CBDCs for cross-border payments that are faster, safer, and cheaper, addressing two of the FSB's undesirable characteristics from above. Similarly, Lloyd (2022) adds to this distinction, providing insight into retail and wholesale projects underway, proposed models and benefits of each, regional

initiatives for the two categories, and forward-looking propositions regarding the future of both retail and wholesale CBDC applications.

The second fundamental element of this research effort is the ability of CBDCs to facilitate cross-border payment transactions, in pursuit of the "holy grail of cross border payments…through interlinked CBDC with FX conversion layer" (European Central Bank, 2022). Unlike the element of end-users with limited publications to source from, the function of cross-border transaction enablement is prevalent in existing literature. T. Zhang and Huang (2022) note that wholesale CBDCs can reduce the risks and costs of cross-border payments, while also improving inter-bank payment settlement. In parallel, F. Allen, Gu, and Jagtiani (2022) conducted a robust investigation into the cross-border functionality of CBDCs, explaining their ability to improve efficiency in cross-border payments, facilitate interoperability across jurisdictions, promote internationalization of currencies such as China's Renminbi (RMB), and increase the level of interoperability across platforms. Furthermore, Lloyd (2022) provides an extensive review of CBDCs and their ability to support and improve cross-border transactions including an overview of existing cross-border projects underway (e.g., m-Bridge, Jura, Dunbar, and Helvetia). This review also examines the reduced costs, increased transfer speeds of cross-border transactions, and usage of fiat money via wholesale CBDC issuance to "ensure control and financial stability over large-scale financial transfers" in both trade and investment areas.

Extant literature in this space further includes the proposition that Central Banks may allow its national currency via means of a CBDC, to "become a medium" of cross-border payments, noting that existing transactions are facilitated through traditional corresponding banking networks (Belke & Beretta, 2020); the use of a CBDC as a means of international transaction settlement which can support an open economy (Fantacci & Gobbi, 2021); the ability

of CBDCs to improve cross-border payments given that existing systems are costly, inefficient, and lack transparency (Yanagawa & Yamaoka, 2019); and the proposition that a universal currency based on CBDCs have the most promise and potential for "eliminating the main problems of cross-border payments" (Kochergin, 2021). However, the design choices made by Central Banks with respect to CBDCs will impact the viability of their use for cross-border payments, with Kuehnlenz, Orsi, and Kaltenbrunner (2023) calling attention to the importance of interoperability via common models and standards, and continued asymmetries amongst international financial system participants.

The quantity and depth of articles pertaining to cross-border payment functionality provide validation for this research effort as an important topic warranting further analysis, and expressed by subject matter experts calling for greater analysis into complex questions such as the "cross-border implications of CBDCs" (Auer et al., 2022). Having explored the literature for the two cross-border payment elements of users and transactions with respect to CBDCs, attention is now placed on the many considerations faced by Central Banks, bifurcated into technical and non-technical categories. Similar to the imbalance of literature between the two cross-border payment elements above, extensive research has been devoted to non-technical factors such as monetary policy, stability, and economic implications; however, existing literature is lacking in the area of CBDC technical requirements. This imbalance is explained in the following sections, highlighting the gaps between the two consideration categories. Furthermore, this gap in published material provides an opportunity for contribution, specifically addressing the point of technical considerations of CBDCs for the purpose of cross-border payment transactions.

IV.B. CBDC Non-Technical Considerations

The first non-technical consideration for CBDCs pertains to monetary policy, often positioned in comparison to existing policy for physical (i.e., analog) cash (e.g., metal coin and paper currency), and accompanied by the debate of whether or not to replace physical cash with CBDCs or allow for coexistence. As explored by Davoodalhosseini (2022) through extensive modeling, the decision between cash and CBDCs is dependent upon the carrying cost (i.e., operational expenditure) of each, with CBDCs being favored due to their potential to bear interest and welfare implications. Keister and Sanches (2022) further investigate the monetary policy implications of CBDC issuance, again with the foci of tradeoff between the initial investment with continued costs to offer a CBDC and the benefits to financial system participants (e.g., consumers and businesses). This second article expands the monetary policy topic beyond domestic transactions to encompass international applications (i.e., cross-border payment transactions), noting that this area is “a promising area of ongoing research”, in alignment with the purpose of this research paper.

The second non-technical consideration for the issuance of a CBDC is related to stability (i.e., resilience) with respect to the level of fragility of the banking system to support currency as a liquid asset while acknowledging the risk of runs on banks (Popescu, 2022). Specifically, in times of financial distress when financial institutions and other banking system participants encounter challenges meeting obligations, consumers and businesses are likely to withdraw funds from their demand deposit (i.e., checking) accounts as physical cash to ensure its safety and security. The ease and speed at which these funds are withdrawn is referred to as liquidity, where financial instruments (e.g., cash, coin, bonds, etc.) can be moved from one account to another expeditiously (i.e., having a high degree of liquidity) or slowly (i.e., lacking liquidity).

However, Keister and Monnet (2022) found that the same high level of liquidity inherent in CBDCs is less of a threat to supporting run on banks; rather, when consumers and businesses know that their funds can be moved quickly, they are less likely to do so, thus benefiting the financial institution where the funds are kept. Similar findings exist in China as facilitated by the People's Bank of China and examined by Qian (2019) whereby the incorporation of CBDCs into the financial system increase stability, as well as transparency while simultaneously lowering costs of currency issuance. The concept of stability can take multiple forms; in addition to the aforementioned form of stability pertaining to deposits and cash reserves, stability can apply to the value of said currency. Balvers and McDonald (2021) explore the latter variant of stability, finding that the characteristics of a CBDC – notably a global CBDC – has the potential to surpass existing levels of currency stability by means of being pegged (i.e., tied or associated) to multiple currencies internationally rather than one single currency (e.g., USD).

The third non-technical consideration for CBDCs is concerned with the economic implications of digital currency issuance. Economic implications can take multiple forms, including the aspect of "run on banks" as explained above, to interest rate preservation or manipulation, currency convertibility, guarantees, and the delineation between currency availability in the private sector and currency reserved for central banks. An expansive analysis of these economic implications is captured by Kumhof and Noone (2018), in partnership with the Bank of England, providing a wide breadth of topics for practitioners and scholars to consider; however, without significant depth given the report's purpose of serving as "useful background material for research in the field of CBDC."

Agur et al. (2021) further explore many of these economic implications, including the ability of a CBDC to bear interest and the transference of a CBDC from Central Banks to the

private market, but differs by also elaborating upon CBDCs' ability increase transactional anonymity (i.e., obfuscation of the parties involved in the transaction) and the topic of disintermediating intermediary financial institutions (i.e., retail and commercial banks, e.g., JPMorgan Chase & Co., Wells Fargo, Bank of America) in the event Central Banks (e.g., the U.S. Federal Reserve) provide access to CBDCs directly to the end users (i.e., consumers and businesses). The topic of disintermediation, which is a significant consideration given its ability to reduce the effectiveness of retail and commercial banks while simultaneously transforming Central Banks into monopolistic entities, is one of many areas researched by Fernández-Villaverde et al. (2021).

IV.C. CBDC Technical Considerations

The previous section of non-technical considerations highlights the information available pertaining to CBDCs with respect to monetary policy, stability, and similar economic implications. In comparison to the depth of knowledge regarding non-technical considerations in publication today, existing literature pertaining to the technical considerations of CBDCs is shallower and lacks applicability to the design of the CBDC, which can be forgiven noting the nascency of this research topic. One example includes the research conducted by Mohammed, De-Pablos-Heredero, and Montes Botella (2023) wherein the authors explore multiple aspects affecting the CBDC adoption by country including technological factors; however, it is done in the context of network readiness of the country upon which the CBDC is issued, not the technology of the CBDC itself. Within published literature, while depth (i.e., the extent of a single subtopic) may be limited regarding technical considerations, breadth (i.e., the spectrum of subtopics) does not suffer this same limitation. Rather, technical considerations in print include the ledger's structure, payment authentication, functionality, and access (BIS, 2020);

architecture, infrastructure, access technology, wholesale and retail interlinkages (Auer & Böhme, 2020); cross-border system interlinking and interoperability (Boar, Claessens, Kosse, Leckow, & Rice, 2021); and many more.

A primary example is that of the work by Cunha, Melo, and Sebastião (2021) which includes a robust listing of CBDC "main characteristics/design goals" and draws parallels to this study in writing with regards to Architecture, Interoperability ("Interlinkages"), and Technology ("Authority"), thus signifying the alignment of interests amongst fellow researchers in this field. The authors then expand the list with other options including Application Area (e.g., Wholesale or Retail), Access Technology (e.g., Account-based or Token-based access), Availability and Limitations (e.g., Unlimited usage, Geographical or Value limits), concluding that not only are the choices to Central Banks numerous, so are the associated benefits and risks which warrant further exploration (Cunha et al., 2021). Previous attempts to synthesize and consolidate these technical design choices include that of Genc and Takagi (2024) which arrived at three main choices of Distribution mechanism (e.g., Wholesale or Retail), Operating mechanism (e.g., Direct, Indirect/Synthetic, Hybrid, or Intermediated), and Access mechanism (e.g., Account-based or Token-based) following a literature review; a note published by Laband (2022) which introduces a closely related design choice framework of Architecture (e.g., Direct or Indirect), Infrastructure (e.g., Centralized or Distributed), and Access (e.g., Tokens or Accounts), while also referencing Interest and Quantitative Limits, and Interoperability; and the study by Goodell, Al-Nakib, and Tasca (2021) proposing a DLT-based settlement system operated by private, independent actors and overseen by state actors, focusing on privacy considerations following a detailed comparison of retail CBDC systems.

For the purposes of this research effort, three technical considerations were chosen amongst all currently known and proposed options, specifically Architecture, Interoperability, and Technology. These three considerations were selected for the following reasons: (1) Audience applicability – Decision makers at Central Banks have the ability to choose amongst the options presented in the forthcoming sections for each technical consideration, (2) Most prolific – Amongst the available technical considerations, these benefit from multiple perspectives and examinations from academics and practitioners alike, (3) Technically appropriate – In the context of utilizing CBDCs to facilitate cross-border payment transactions, each option within the three considerations positively or negatively affects the outcome of diffusion, (4) Unique combination – From the research conducted, these three technical considerations and the three options for each have not been researched comprehensively within a single study, (5) Parsimony – This growing and evolving area of research can benefit from robust and comprehensive analyses inclusive of all available options; however, in the spirit of simplicity, only three considerations were chosen, and (6) Theoretically appropriate – Noting the intention of this study to bridge academia and industry (i.e., boundary span), this author posits that these three technical considerations are most suitable when exploring the intersection of practice and the Diffusion of Innovation Theory as explained in later sections.

Expounding upon the third reason of being technically appropriate, each of the three options within each technical consideration will improve or worsen diffusion of the CBDC as evidenced in each option's ability to facilitate or impede cross-border transactions. The first technical consideration, Architecture, identifies each country's financial system participants, specifically Central Banks and end-users at a minimum, potentially including Commercial/Retail Banks or financial intermediaries, their relationship, and the flow of data and funds amongst

those identified. Noting that cross-border payments require action by all participants, the role of each – specifically that of the Central Bank and Commercial/Retail Bank – varies by Architecture option. The option selected and corresponding relationship then influences the attractiveness, convenience, servicing, and administration of CBDCs (Auer & Böhme, 2020).

The second technical consideration, Interoperability, represents the extent to which each country's CBDC network connects to, and is compatible with, CBDC networks representing other countries or foreign jurisdictions. This technical consideration is concerned with the extent to which two CBDC networks align on technical, operational, and regulatory levels, resulting in an inter-country CBDC network which can promote or obstruct the facilitation of cross-border payment transactions due to the amount of friction introduced by the option selected (Auer et al., 2021; Boar et al., 2021). The European Central Bank (2022) extends this concept further in the context of supporting cross-border payments, noting that the interlinking of central banks inherently reduces one layer of complexity as payments are transitioned from Commercial Bank money to Central Bank money, while continuing to recognize "there is still considerable work ahead."

The third technical consideration, Technology, is reflective of the underlying storage and access of data necessary to facilitate cross-border payment transactions via CBDCs. Emphasizing the digital element of Central Bank *Digital* Currency, the reading, writing, storing, and accessing of payment-related data are critical for correct and timely transactions. Accordingly, the choice selected as to where this data resides, who can access it, and how it is read and written will impact the expansion of CBDCs noting the responsibilities of each financial system participant for their share of the infrastructure (Auer & Böhme, 2020). Noting the importance of each choice made for all three technical considerations in pursuit of diffusion, their inclusion is validated

while ensuring this research effort provides a necessary contribution to Central Bank practitioners. The subsequent subsections explain each consideration and associated options in greater detail, preserving the context of cross-border payment transactions via CBDCs and for the benefit of Central Bank practitioners.

IV.C.1. CBDC Architecture

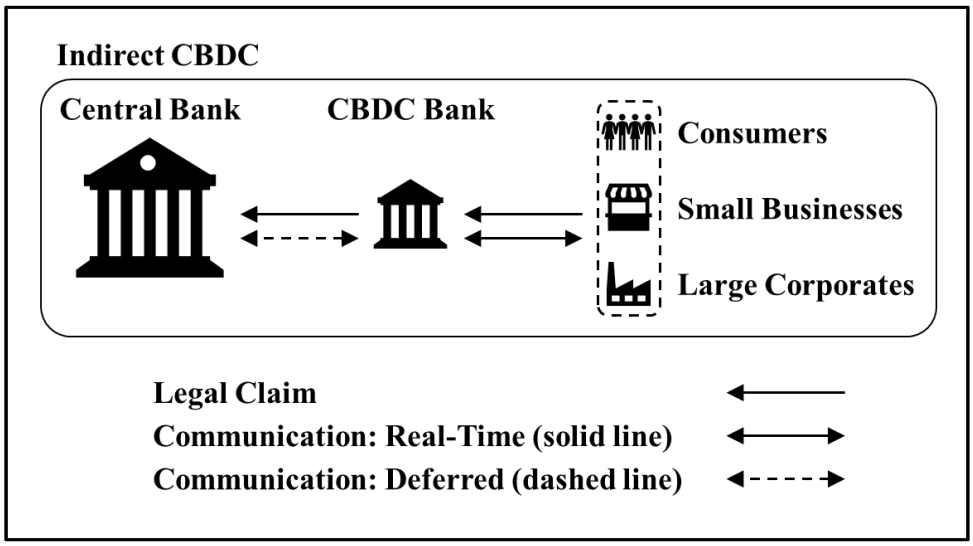
The first technical consideration pertains to CBDC Architecture, which for the purposes of this study are categorized into direct, intermediated (i.e., hybrid), and indirect, aligning with the research performed by Auer and Böhme (2020) on potential retail CBDC architectures. This association of architecture to the relationships amongst Central Banks, institutions, and end-users (e.g., two-tier and three-tier architectures) is further researched by Jin and Xia (2022). Noting the lack of standardized and globally-recognized terms with respect to CBDCs, other research efforts equate architecture with blockchain and examine traditional and modular variants (J. N. Zhang et al., 2021). However, while not applicable to architecture, this blockchain association is reserved for the third technical consideration below, Technology.

These three variants of CBDC Architecture detail the relationships between Central Banks, Commercial/Retail Banks (if applicable), and end-users (e.g., consumers, small businesses, and large corporates), while identifying the flow of information and legal claims amongst the multiple entities. For display purposes, each CBDC Architecture option is shown individually, adapted from Auer and Böhme (2020, p. 89), with a comprehensive collection of all three options displayed in ***Figure 31*** within ***Appendix D: CBDC Architecture Options*** for ease of comparison. While all three variants require the Central Bank to issue the CBDC, the differences exist within the inclusion/exclusion of Commercial/Retail Banks or financial intermediaries. Beginning with the Indirect architecture variant shown in ***Figure 3***, this two-

tiered system includes one tiered relationship between the Central Bank and Commercial/Retail Banks, and a second tiered relationship between the Commercial/Retail Banks and end-users, with no direct relationship between the Central Bank and end-users. The term Indirect was proposed by Kumhof and Noone (2018) as a means to capture the relationship between the Central Bank and end-users, which is intermediated by Commercial/Retail Banks, thus resulting in an indirect connection between the two end points.

This first variant is akin to our existing banking system with analog currency, whereby end-users engage with Commercial/Retail Banks for the opening and management of accounts, execution of retail payments (domestic and cross-border), and storage of funds, adhering to the "narrow bank" designation within existing literature whereby a waterfall of claims exists from the end-user to the Commercial/Retail Bank, and subsequently from the Commercial/Retail Bank to the Central Bank (Bindseil, 2019; Mancini-Griffoli et al., 2018). In parallel, the Commercial/Retail Banks maintain a relationship with the Central Bank for the facilitation of wholesale payments. From the perspective of the Central Bank, the audience for this research effort, this model is beneficial for its ability to place responsibility upon the Commercial/Retail Bank to perform KYC procedures and account administration activities for end-users, with the limitation that this shift in responsibilities is accompanied by reduced transparency into payment and account-related activities of the end-users.

Figure 3. CBDC Architecture Option: Indirect CBDC



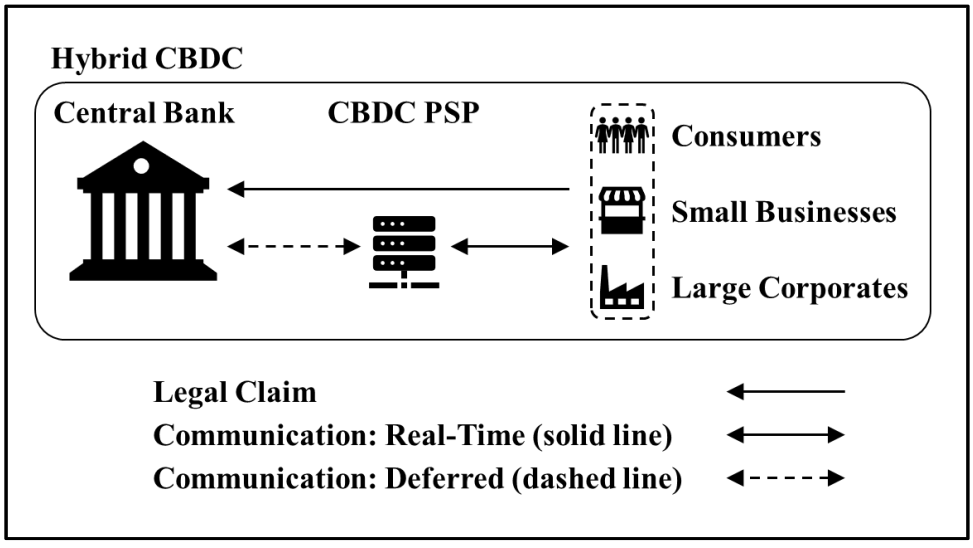
Source: Adapted from Auer and Böhme (2020)

Next, the Hybrid variant is similar to Indirect, save for the Commercial/Retail Banks which are replaced with a private sector layer in the form of Payment Service Providers (PSPs) and the legal claim circumventing the PSP and instead existing directly between the Central Bank and end-users, as shown in ***Figure 4***. From the perspective of the Central Bank, this second architecture variant is beneficial due to the increased resiliency provided by PSPs, requiring amicability towards PSPs to participate in the global financial system, which also yields an attractive market for end-user services and healthy industry competition within the market. The tradeoff for these benefits is the increased cost borne by the Central Bank to establish the network with PSPs and navigating varying degrees of regulatory sophistication amongst PSPs, contrasting with Commercial/Retail Banks which traditionally have robust regulatory regimes and uniform policies and procedures.

Similar to the Indirect model, the existence of an intermediary between the Central Bank and end-user shifts responsibility for KYC procedures and account administration efforts, while

introducing the possibility of reduced transparency to the Central Bank. Specifically, while existing constructs limit the transparency between PSPs and their partner banks (e.g., Central Banks and Commercial/Retail Banks), the possibility exists for future constructs to include new PSP transparency requirements, thereby reducing end-user privacy (i.e., user anonymity and payment obfuscation) and increasing visibility for Central Banks. Lastly, Auer and Böhme (2020) posit that this Hybrid variant should provide Central Banks with the ability to orchestrate PSPs by transitioning activity from one PSP to another in the event of inoperability due to technological, operational, or similar challenges, yielding a more robust and resilient network while reducing risk and the potential of failed transactions.

Figure 4. CBDC Architecture Option: Hybrid CBDC

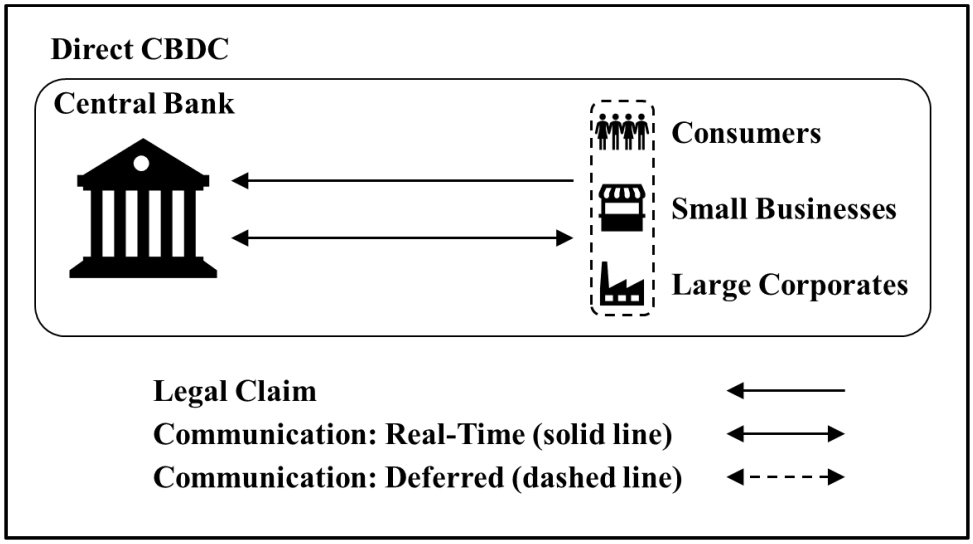


Source: Adapted from Auer and Böhme (2020)

Concluding with the third variant, the Direct architecture removes the layer between the Central Bank and end-users, providing direct connectivity between the two entities, while extending the legal claim to the Central Bank. This variant provides the Central Bank with the

control and transparency into end-user accounts and activity, it does so at the expense of absorbing KYC processes (unless allowed and supported by third parties specializing in this discipline), retail payment execution, resiliency requirements, and the technological and operational debt which accompany these functions. A transition from the Indirect variant today to Direct in the future for the purposes of CBDCs will lead to a tradeoff by Central Banks with respect to Commercial/Retail Banks, thus reducing their reliance upon this middle layer while simultaneously losing the core competencies (e.g., adherence to rapidly changing global messaging standards via technological development) and economies of scale (e.g., execution of payments at reduced costs per item due to increased volume). Refer to ***Figure 5*** for a visual depiction of the Direct CBDC Architecture Option.

Figure 5. CBDC Architecture Option: Direct CBDC



Source: Adapted from Auer and Böhme (2020)

IV.C.2. CBDC Interoperability

The second technical consideration is the Interoperability of a CBDC, specifically the extent to which Central Bank systems will interoperate and the structure which supports this activity. Emphasizing the focus of this research effort on CBDCs and their ability to facilitate cross-border payments, interoperability is a critical means to that end. Within the context of this research effort, interoperability represents the alignment between Central Banks on three distinct levels: (1) technically, as evidenced by the use of common messaging formats and standards to seamlessly exchange payment-related information digitally via automated systems, (2) operationally, as facilitated through standardization of administrating and applying payments between banks, and (3) regulatory, as indicated with a common set of rules, regulations, and requirements, applied to all payment participants (i.e., Central Banks, Commercial/Retail Banks, private sector entities, and end-users). Note that the description of interoperability within this research effort shares some attributes with the proposal by Boar et al. (2021), aligning on the technical layer given its foundational importance for connecting disparate systems, while differing on the remaining layers which they positioned as semantic (uniform system language for interpretation consistency) and business (system alignment on rights and obligations).

To provide context, the existing financial system for cross-border transactions is heavily reliant upon correspondent banking, whereby relationships amongst banking partners are utilized during the processing of a payment transaction, requiring multiple banks between the originator and beneficiary, each of which can introduce delays and additional costs (Naughton & Leslie Soon-Lim, 1998). This continued usage of correspondent banking (i.e., multiple hub-and-spoke) is currently necessary due to the lack of direct connectivity amongst all banks (i.e., point-to-point). Transitioning from a traditional correspondent banking model to direct connectivity via

Central Bank interoperability has the potential to reduce processing times and fees while improving transparency and inclusiveness, thus addressing all four of the FSB's undesirable characteristics of existing cross-border payments (Boar et al., 2021). The importance of interoperability is further recognized as an outcome of analyzing existing CBDC ventures and technical experiments, including Project Dunbar in collaboration with the Bank for International Settlements (BIS, 2022b), noting that "the ability for these systems to communicate with each other easily and seamlessly, will be crucial for global connectivity."

Failing to ensure interoperability amongst Central Banks when implementing CBDC programs can result in perpetuating the undesirable characteristics of existing cross-border payments. Examples of issues resulting from a lack of interoperability include higher fees due to reliance upon third parties to provide translation and processing services, slow processing caused by prolonged reliance upon manual processing, and impede integration of foreign exchange components (He, 2021). Similarly, the pursuit of interoperability is not without its own challenges, such as increased costs due to complexities across the multiple integration layers, tradeoffs to consider due to said costs, differing priorities amongst Central Banks, alignment between Central Banks and the private sector, agreement on the interoperability specifications and corresponding sequencing and timing, and others which may not yet be known due to the nascency of CBDC interoperability (Araujo, 2022; Auer et al., 2021; Themistocleous et al., 2023).

The view that interoperability is a means for Central Banks to facilitate cross-border transactions via CBDCs is shared by Auer et al. (2021) with the introduction of a Multi-CBDC (mCBDC) arrangement, identifying Globalization as a contributing factor and highlighting the importance of collaboration amongst Central Banks in pursuit of improved currency conversion

efficiency and convenience. Auer et al. (2021) also notes that while focus is placed on cross-border interoperability to connect Central Banks internationally, there are potential benefits domestically with connectivity to existing clearing and settlement systems. For the purpose of their research and this effort in writing, domestic interoperability is out of scope and serves as a recommended topic of future research endeavors. This perspective that interoperability is a critical factor in enabling cross-border payments via CBDCs served as the focus of a multivocal systematic literature review, concluding that demand exists amongst financial system participants to explore this topic further, while also acknowledging that CBDC interoperability itself and the associated literature are both in their infancy (Themistocleous et al., 2023).

Other research efforts instead view CBDCs as the means which will aid the march towards interoperability (Kóczián, Kollarik, Kiss, & Simon, 2022), noting the benefits for service providers and users during the process of connecting and transacting between different financial intermediaries (e.g., financial institutions, technical integrators, payment processors) and closed financial platforms. In contrast, Araujo (2022) provides a more detailed account of the interoperability technical consideration, including regional and international interoperability, the regulatory impacts of interoperability, challenges encountered when a lack of interoperability exists, the importance of interoperability for scalability, and live examples of varying levels of interoperability in production. Throughout the survey responses from the Central Bank of Brazil, Central Bank of Peru, Hong Kong Monetary Authority, and other Central Banks, interoperability is a recurring and uniform theme as an element critical for success of a CBDC, noting an equal level of inconsistency regarding the specific type of interoperability desired (Araujo, 2022).

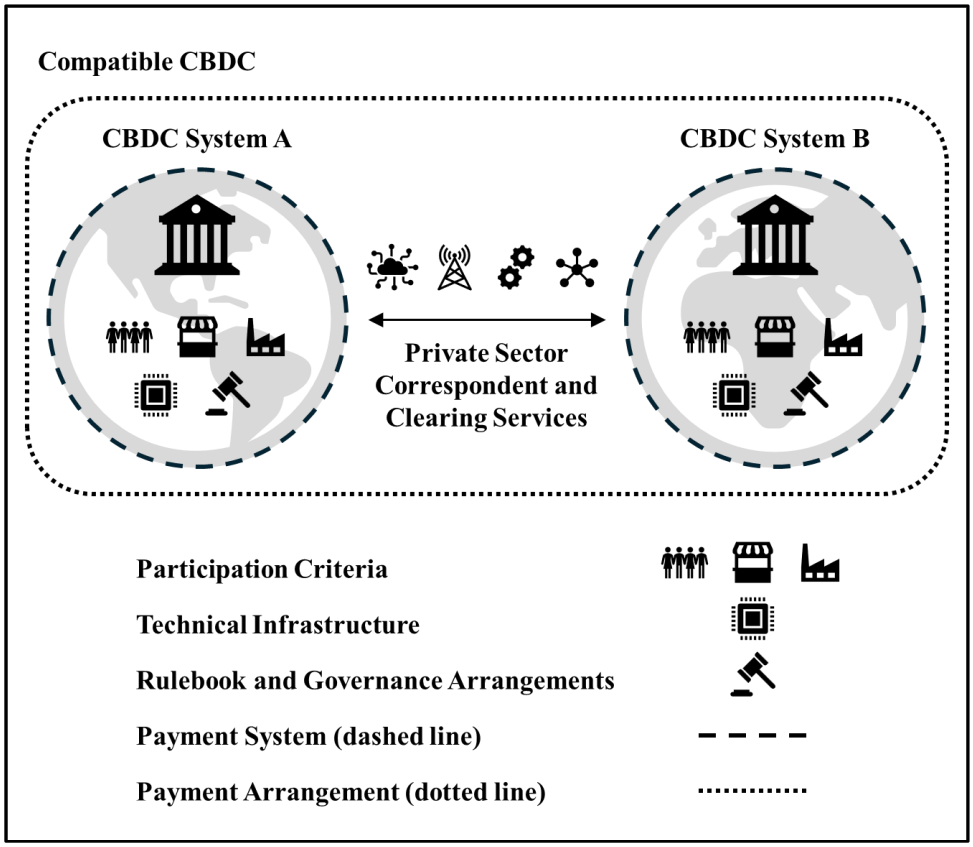
Existing research and industry reports have yielded multiple variants of interoperability models between Central Banks, including those reviewed and proposed by Jung (2021), and

synthesized in the work by Themistocleous et al. (2023) which analyzes models proposed by Auer et al. (2021), Deloitte (2020), and Icon Solutions (2019). Aligning with Themistocleous et al. (2023), this research effort in writing references the three models from Auer et al. (2021), as extended from the research performed by Bech, Faruqui, and Shirakami (2020), given their specificity and adjacency to the work by Auer and Böhme (2020) on architecture variants in the prior section above. Each Interoperability option, adapted from Auer et al. (2021, pp. 4-9), is explained and depicted below in the following order: (1) mCBDC arrangements based on compatible CBDC systems, (2) mCBDC arrangements based on linking multiple CBDC systems, and (3) mCBDC arrangements based on a single multi-currency system, all using "mCBDC" to represent multi-CBDC arrangement that consist of interoperating multiple CBDCs. Similar to the preceding section on Architecture options, all three Interoperability options are shown together in ***Appendix E: CBDC Interoperability Options*** with ***Figure 32***.

Beginning with the first model shown below in ***Figure 6***, mCBDC arrangements based on compatible CBDC systems, hereafter referred to as the "Compatible" model, this most closely resembles today's domestic payment schemes whereby cross-border transactions require the use of correspondent banks and private sector entities to perform necessary payment message translation and clearing between the originator and beneficiary. Although there exists a low level of interoperability stemming from the lack of unified and global standards, both technical and non-technical as discussed above, the similarity of this model to existing correspondent banking has the potential to yield a less complex option for financial system participants with lower short-term costs. However, these benefits come at the expense of further perpetuating many of the undesirable characteristics of today's cross-border payments (e.g., slow, inclusive) which

carry higher long-term costs and fail to provide significant differentiation and improvement from the current environment.

Figure 6. CBDC Interoperability Option: Compatible CBDC

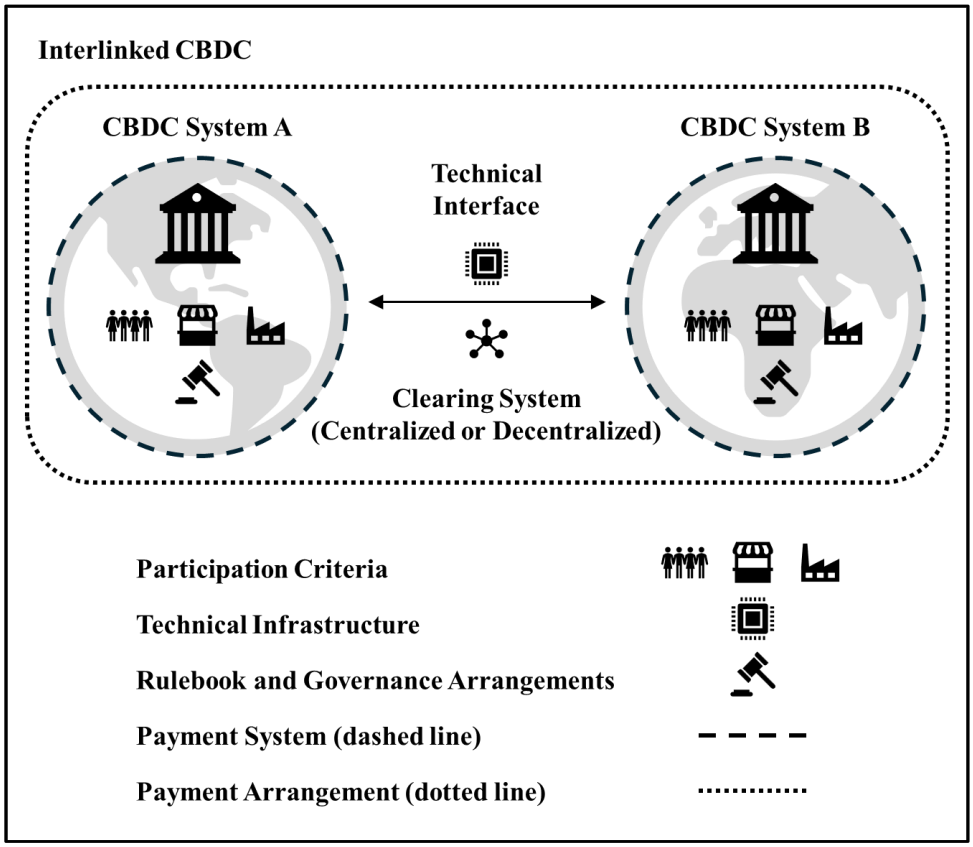


Source: Adapted from Auer et al. (2021)

Continuing with the second model depicted in ***Figure 7***, mCBDC arrangements based on linking multiple CBDC systems, hereafter referred to as the "Interlinked" model, which itself has three sub-variants. This Interlinked model benefits from a shared linkage directly between two CBDC systems, thus yielding a higher level of interoperability than the Compatible model, complete with improved scalability, security, and resiliency, which translate into greater progress made towards addressing existing cross-border payment undesirable characteristics. These

benefits also come at the price of increased complexity, significant financial investment, a suboptimal benefit-cost ratio (The World Bank, 2014), and greater coordination corresponding with each new CBDC system added. The sub-variants noted are in reference to the connectivity between the CBDC systems and include: (1) technical interface, whereby inter-system payments are facilitated via shared technical interface; (2) centralized clearing system leveraging settlement accounts in a common and joint platform; and (3) a decentralized clearing system also leveraging settlement accounts, with said accounts existing within counterparties' respective platforms. Regardless of sub-variant selection, the aforementioned benefits and limitations persist.

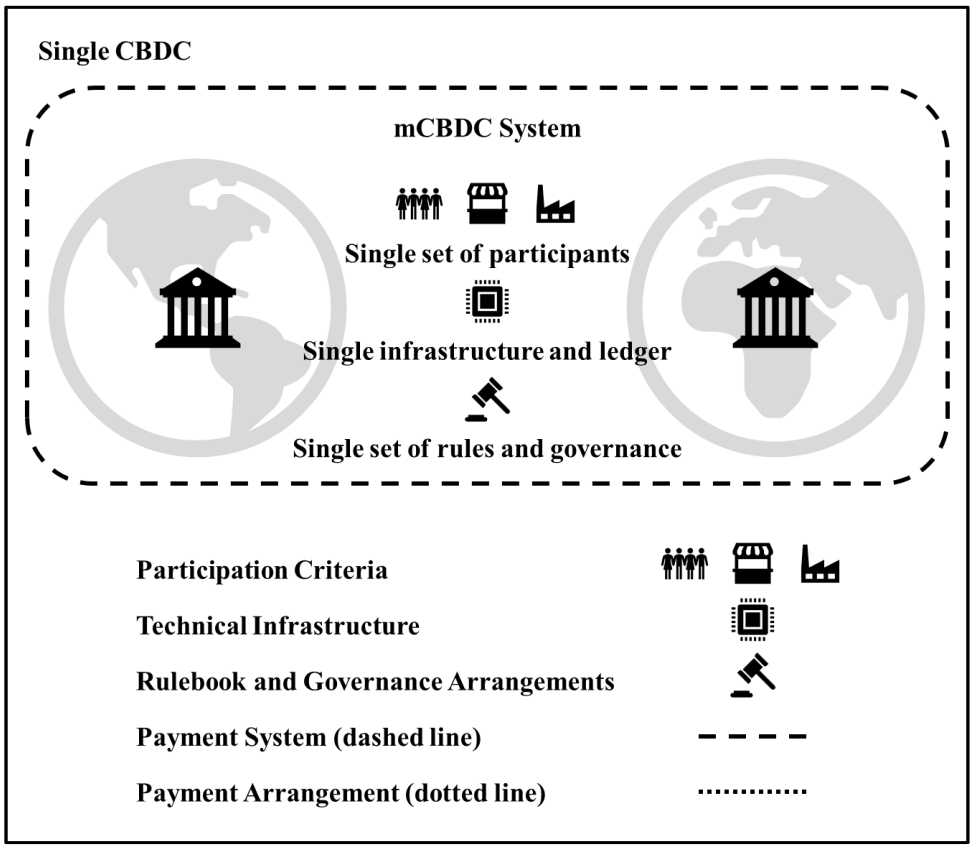
Figure 7. CBDC Interoperability Option: Interlinked CBDC



Source: Adapted from Auer et al. (2021)

Concluding with the third model (***Figure 8***), mCBDC arrangements based on a single multi-currency system, hereafter referred to as the "Single" model, produce the highest level of interoperability amongst the three models, and the most complex. Within this model, all CBDC systems are connected through a single system, yielding uniformity amongst all participants with increased efficiency, transparency, and consistency following adherence by members to a common set of rules and requirements both technical and non-technical in nature. This uniformity also requires the largest financial burden by participants and the greatest conviction in the system as to ensure a positive return on investment, evidenced by appropriate volumes and utilization across system members; incomplete implementation or limited adoption introduce the risk of the resulting system becoming an also-ran and bypassed by a newer or superior system for cross-border payments. Unlike the first two models, this Single model includes an alignment of rules amongst participants, which introduces policy implications for Central Banks active in the system and calls attention to the time required for discussion and elaboration to align on a common rulebook and governance framework.

Figure 8. CBDC Interoperability Option: Single CBDC



Source: Adapted from Auer et al. (2021)

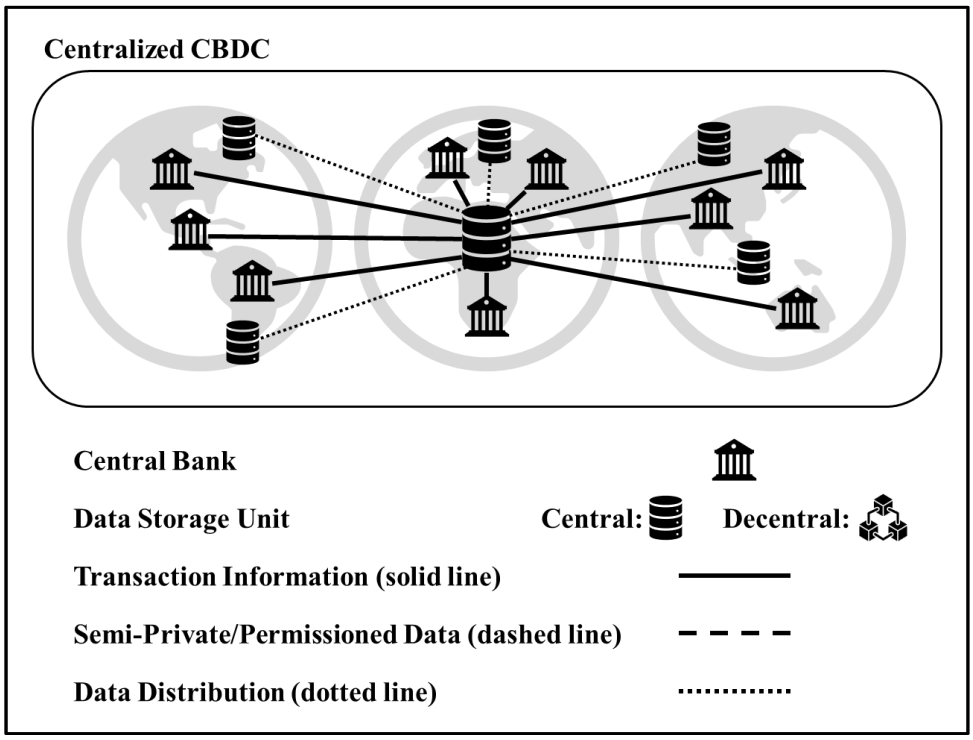
IV.C.3. CBDC Technology

The third technical consideration is Technology, alternatively referred to as "technical platform" in existing literature (Sethaput & Innet, 2023), and occasionally referenced as infrastructure (Auer, Cornelli, & Frost, 2020; Elsayed & Nasir, 2022; Morales-Resendiz et al., 2021), again highlighting the lack of consistent industry terminology given the nascency of CBDCs. Despite inconsistent nomenclature, commonalities exist across existing literature regarding the underlying technology options to support CBDCs, notably Centralized (i.e., Conventional) and Decentralized (i.e., Distributed). Acknowledging that the majority of extant literature identifies Centralized and Decentralized as the two de facto options for CBDC

technology, additional options exist currently or are proposed for the future, specifically hybrid and proprietary options, respectively, hereafter referred to as “Tertiary” technology options. The subsequent paragraphs cover each of these three technology options individually, visually depicted together with ***Figure 33*** in ***Appendix F: CBDC Technology Options***. As CBDCs mature and their usage increases, demands upon the underlying technology will further increase in importance, warranting careful consideration amongst Central Banks as to the option chosen.

Starting with the Centralized option displayed in ***Figure 9***, the primary attribute is that the transactional data is retained within a single storage unit (i.e., database) which financial system participants read from and write to during the process of executing transactions. Expounding further, the database is controlled by one authoritative entity (i.e., the parent node) with resilience provided through the use of data being stored across many lesser (i.e., child) nodes and expressed with the use of multiple backups (Auer & Böhme, 2020). The authoritative entity entrusted with administrating the Centralized database (e.g., Central Bank) is required to ensure data consensus as the golden source of record for participants to confidently rely upon, with the understanding that concentration risk is introduced given the single point of failure, thus representing a fundamental difference between it and the Decentralized option (Sethaput & Innet, 2023). Importantly, the Centralized option has the benefit of being known and reputable for supporting substantial transactional data processing demands due to its centralization of data storage and read/write capabilities, thus avoiding the burden of establishing harmonization of data amongst all participants (i.e., obtaining consensus).

Figure 9. CBDC Technology Option: Centralized CBDC



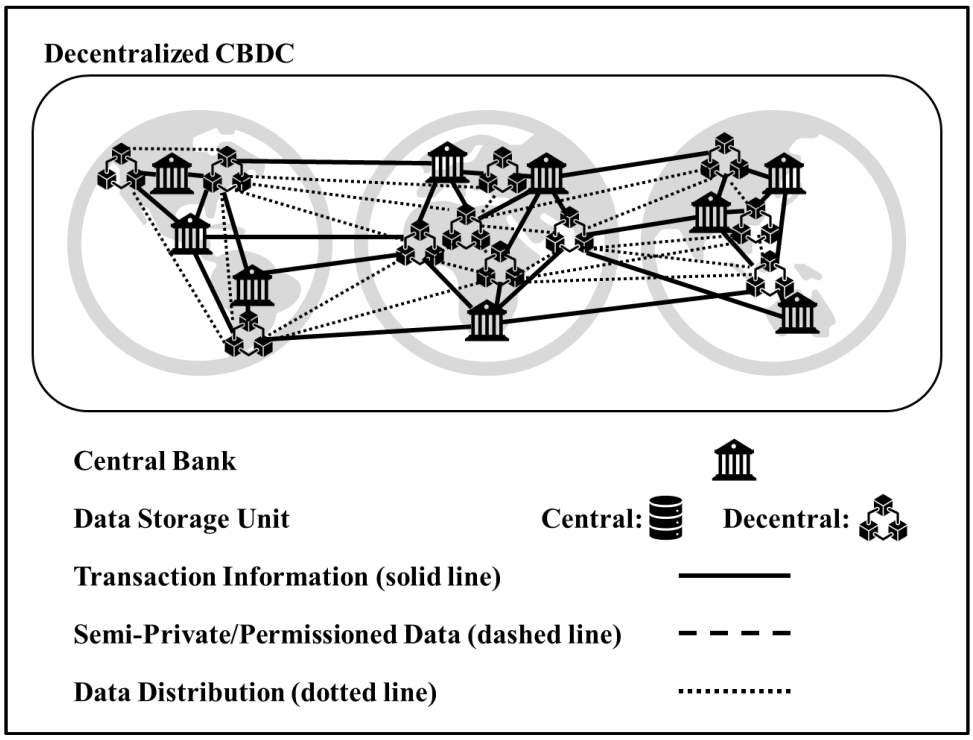
Source: Author

Next, the Decentralized option shown in ***Figure 10*** is fundamentally opposite from the Centralized structure, in that data is widely distributed amongst multiple entities (i.e., nodes), with no authoritative node (i.e., parent), yielding a non-hierarchical framework as expressed by a common ledger (Auer & Böhme, 2020). This lack of centralization is beneficial as concentration risk is prevented and resiliency obtained by eliminating a single point of failure, albeit at the burden of requiring consensus which itself introduces technological complexity and data processing delays (Sethaput & Innet, 2023). The Decentralized option can be further segmented into two sub-options: (1) Private (i.e., Permissioned), and (2) Public (i.e., Permissionless), denoting the ability to join the network and actively participate. A Private Decentralized structure requires participants (i.e., nodes) to be permissioned before they can engage in activity within the

network, whereas a Public Decentralized structure exists without said permission requirement (Sethaput & Innet, 2023). Alternatively, Guo, Kreitem, and Moser (2024) propose DLT can be subcategorized into three types of implementation structures including private, public, and permissioned, a hybrid of the two former options.

Existing literature commonly uses Decentralized and DLT interchangeably and within the same context (Auer & Böhme, 2020; Morales-Resendiz et al., 2021; Sethaput & Innet, 2023); acknowledging that these terms are analogous, subsequent references in this research effort will use Decentralized as the common term. Blockchain, a specific type of DLT, is explored by T. Zhang and Huang (2022) who conclude that certain elements of blockchain are "suitable for requirements of CBDC design" through its ability to support improved performance, scalability, interoperability, and a range of transactional scenarios. For the purposes of this research effort, blockchain and its parent technology, DLT, are encapsulated within the Decentralized option, with subsequent references of blockchain and DLT being that of referenced works as to preserve consistency within this research effort and author's contributions.

Figure 10. CBDC Technology Option: Decentralized CBDC

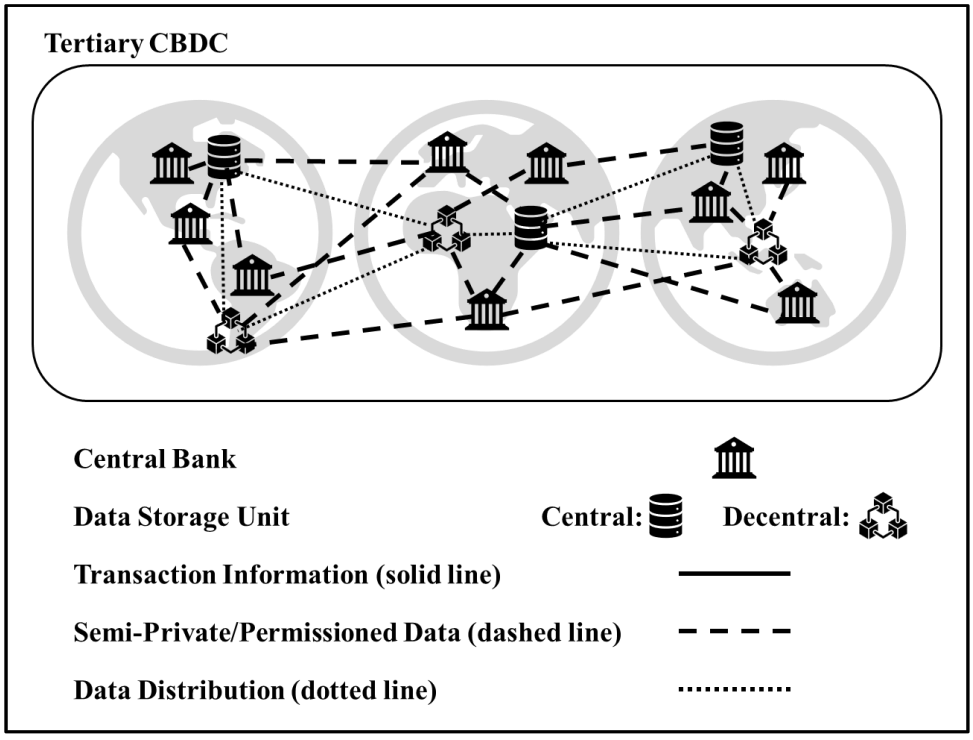


Source: Author

While Centralized and Decentralized options dominate existing literature, additional options include the hybrid structure (***Figure 11***) which is in limited use today and the proprietary structure which is envisaged for networks yet to come. These Tertiary options share some characteristics with the prior two options noted above, while introducing novel and unique attributes. The hybrid structure is a concatenation of Centralized and Decentralized structures, not to be conflated with the hybrid architecture model noted above, represented through multiple proposed structures, including those by J. N. Zhang et al. (2021) consisting of multiple nodes dividing the blockchain ledger, the consortium blockchain which is "semi-private and can be accessed by various organizational groupings, including banks, energy dealers, and hospitals" (Mandapuram, 2016), permissioned networks built on public blockchain infrastructure providing

open access with restricted roles in a Decentralized system (Natarajan, Krause, & Gradstein, 2017), and permissioned blockchains requiring initial authorization for participation and having public identity visibility or existing on permissionless systems (Romano & Schmid, 2021). As a result, this hybrid subtype of the Tertiary Technology option consists of transaction records existing in a combination of central and decentral storage units with varying ratios and methods to access. In contrast to hybrid structures, proprietary structures are hypothetical and serve as a placeholder for currently undiscovered networks or those which are beginning to enter the periphery as evidenced with the research by the U.S. Federal Reserve Bank of Boston and the Massachusetts Institute of Technology Digital Currency Initiative known as Project Hamilton (Sethaput & Innet, 2023).

Figure 11. CBDC Technology Option: Tertiary CBDC



Source: Author

These three technical considerations explained above – Architecture, Interoperability, and Technology – form the practical foundation of this research effort's contributions given multiple gaps in existing material: (1) the unique mixture of these three considerations and each of their underlying options, which constitute design choices for decision makers at Central Banks, and (2) the ability of these three design choices and the options selected to be combined into an innovation, that being a CBDC, for the purpose of cross-border payments. The intersection of these two gaps and their collective role in the process of diffusion are revisited later in this study following an analysis of related theories. Although industry publications explain and examine these technical considerations across a variety of combinations and informational depth, the bridge between industry and theory with respect to CBDCs and diffusion is underrepresented, thus providing an opportunity for contribution to both practitioners and theorists. This perspective is shared by Bhaskar, Hunjra, Bansal, and Pandey (2022) who conducted an analysis of 174 documents since 2018, calling out room for "theoretical development, contextual coverage, and methodology contributions."

This research effort is not the first to investigate the intersection of industry and theory, noting Ben Dhaou and Rohman (2018) who explored the overlap between CBDCs and diffusion as measured within the innovation adoption timeline (Rogers, 1962), focusing on the area between early adopters and early majority, denoted as "the chasm." J. J. Kim, Radic, Chua, Koo, and Han (2022) have also explored the intersection of theory and practice with the adoption of CBDCs in the context of the hospitality and tourism industry, thus moving research forward with respect to the entrance of CBDCs into the global financial system. Joining these research efforts in carving new paths for researchers and practitioners, this study is the first to examine CBDCs for the purpose of cross-border payments in detail within the context of the Diffusion of

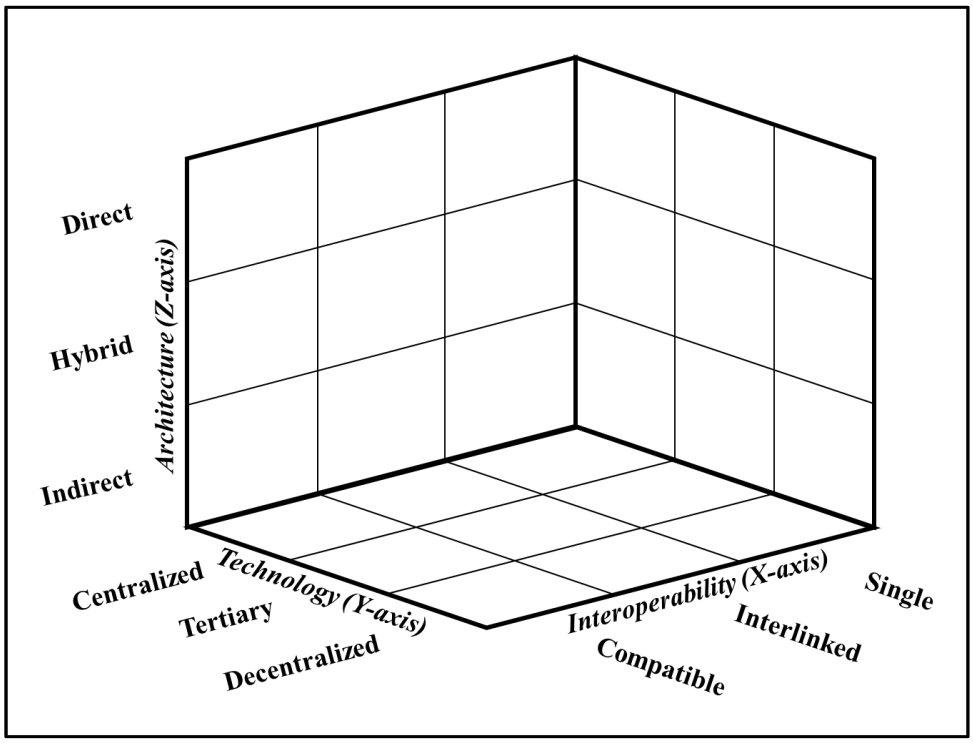
Innovation Theory, thus providing a unique contribution to this nascent topic and a foundation for subsequent researchers to build upon. Accordingly, performing the industry literature analysis above and the scholarly literature analysis below introduces an opportunity for multiple contributions with the development of two models, a framework, and associated typology to serve as tools while benefitting practitioners and researchers alike. Before these models are introduced, a comprehensive analysis of diffusion and diffusion-adjacent research is warranted, as performed in section ***V. Diffusion of Central Bank Digital Currency***.

IV.D. CBDC Design Framework and Typology

Recognizing that there are 27 possible combinations of the three technical CBDC design choices explained above, each of which has three options to choose from, a three-dimensional structure, the **CBDC Design Framework**, shown below by ***Figure 12***, is proposed and accompanied by three initial types within a novel typology classification scheme (***Table 6***) for decision-makers at Central Banks to consider while designing a CBDC. Specifically, the design choices (and options) include Architecture (Direct, Hybrid, and Indirect), Interoperability (Single, Interlinked, and Compatible), and Technology (Decentralized, Tertiary, and Centralized), whereby Central Banks will select one option from each of the three choices, resulting in one CBDC type. The three design choices establish the three axes of the CBDC Design Framework with Architecture occupying the Z-axis, Interoperability on the X-axis, and Technology on the Y-axis. The options within each of the three design choices are in ascending order of complexity from the matrix origin (intersection point of the three axes) outward within the positive space for each axis (i.e., occupying the positive octant for all three axes). Noting that this specific set of CBDC design choices, while commonly referenced individually, and used in combination with

other choices as evidenced in industry publications and referenced in peer-reviewed literature, the resulting distinct combinations are unique to this research effort in writing.

Figure 12. CBDC Design Framework



Source: Author

Table 6. Initial CBDC Design Typology

	CBDC Design Choices		
CBDC Type	**Architecture**	**Interoperability**	**Technology**
Basic (Fastest/Simplest)	Indirect	Compatible	Centralized
• Benefits: Reduced time to market by utilizing existing financial system elements. • Limitations: High amount of fragmentation, low level of compatibility and effectiveness. • Resolves (Degree*): Speed (M), Cost (L), Transparency (M), and Inclusiveness (L). • Expected Result: Minimal improvement over existing systems due to low conformity.			
Intermediate (Balanced/Moderate)	Hybrid	Interlinked	Tertiary
• Benefits: Provides opportunities for intermediaries and payment service providers. • Limitations: Inability to realize full potential with points of friction and variability. • Resolves (Degree*): Speed (M), Cost (M), Transparency (H), and Inclusiveness (M). • Expected Result: Transitory and inconsistent solution with material benefit over status quo.			
Advanced (Optimal/Complex)	Direct	Single	Decentralized
• Benefits: High degrees of consistency, efficiency, and effectiveness; avoids legacy issues. • Limitations: Slow to launch, considerably resource intensive, requires mass alignment. • Resolves (Degree*): Speed (H), Cost (H), Transparency (H), and Inclusiveness (H). • Expected Result: Unlocks full potential of CBDCs via new network and total uniformity.			

** L-Low, M-Medium, H-High*

To collect and restate earlier declarations, these three choices embedded within the **CBDC Design Framework** are not exhaustive, are purely technical in nature, do not account for socioeconomic, political, country development stage, or other external factors which can influence the final CBDC design; exclude limitations which may inhibit or prevent their use, assumes necessary resources are available; and under the pretense that a shared understanding of design choice options exists amongst all global financial system participants. This study also assumes that while there may be conceptual overlap between the three design choices, they are treated as mutually exclusive for the purposes of this exercise. As the **CBDC Design Framework** and associated typology permutations are refined following the maturation of CBDCs, any technical incompatibilities warrant identification as to invalidate the type in

question. Additionally, this research effort is exploratory in nature given the nascency of CBDCs, the limited number of live CBDCs in production and used by the respective populace, and rapidly changing elements of digitization and globalization which influence the development and production of CBDCs. Future researchers are encouraged to utilize the **CBDC Design Framework** and typology in an explanatory manner to quantitatively validate the efficacy of these contributions and confirm if statistical significance exists.

While future research efforts are encouraged to quantitatively measure all possible design choice and option permutations in pursuit of validating the role of each in the final CBDC Innovation design, this study introduces an initial typology which subsequent efforts in practice and research can build upon. To that extent, current research efforts are challenged due to four primary limitations: (1) there are few CBDCs which have been successfully launched into production and are operating at scale, 11 as of May 2023[11], (2) the design choices of the CBDCs which have been launched lack full transparency via publicly available information as to the options selected, (3) the partial transparency available today via public information shows a trend of little variance in design choice option selection, and (4) quantitative data on the amount of diffusion of each launched CBDC is not yet publicly accessible. As more CBDCs are launched and become live in production around the world, this researcher is optimistic that more data on both design choices and the resulting amount of diffusion will become publicly accessible to researchers and practitioners alike. Once the diffusion resulting from these design choices (i.e., CBDC type) can be measured with quantitative data, the effectiveness of each type in improving diffusion can be understood and utilized by Central Banks to compute return on investment more

[11] CBDC Tracker, the Atlantic Council Geoeconomics Center, https://www.atlanticcouncil.org/cbdctracker/, website accessed May 15, 2023, at 3:59 PM ET.

accurately, perform cost-benefit analyses, and calculate similar financial and performance equations to compare and weigh each design choice. In other words, measuring how each design choice influences diffusion provides Central Banks with quantitative data to aid in deciding which of the 27 possible CBDC types is best for their respective country or region; the answer may be found with one of the following three initial CBDC types or a type from the remaining 24 which are not explored in detail within this research effort, reinforcing the importance of the **CBDC Design Framework** as a basis for both CBDC classification and measurement. This research effort positions all 27 CBDC types as possible combinations, given that the literature analysis identified a lack of all three design choices in a singular framework, thereby not examining this typology structure in detail, and no explicit conflicts were identified in instances where two design choices were present in the same literature record, thereby also not flagging any combinations as implausible or impossible.

The three initial CBDC design types proposed to support cross-border payments as shown in ***Table 6*** are: **Basic**, **Intermediate**, and **Advanced**. These initial CBDC types represent the collection of options selected within the three CBDC design choices available to decision-makers at Central Banks, denoting a summary of benefits and limitations, and the degree to which the four undesirable characteristics of cross-border payments are resolved. Importantly, the expected result if said typology were introduced into the market is included and representative of the relative level of success of each collection of design choices. Accordingly, these four points for each typology – benefits, limitations, undesirable characteristic resolution degree, and expected result – are predictions based on the combination of data obtained from peer-reviewed and industry publications while conducting the multivocal systematic literature review. The options selected are intentional to provide representation of each design choice

option and in ascending degree of complexity. These three types are then depicted within the **CBDC Design Framework** as shown in ***Figure 13*** with markers placed to align with the three design choice options. For the purpose of this study, the size of the marker is not representative and all types are considered equal from the perspective of performance or ability to improve diffusion; however, future researchers are encouraged to utilize marker size as a means to depict the resulting diffusion of each typology (e.g., larger marker represents improved diffusion, smaller marker represents reduced diffusion), which can also be leveraged for recommendations.

Important to note are the names for each of the three initial CBDC types of **Basic**, **Intermediate**, and **Advanced** within ***Table 6***, in that they are intentional and meaningful. Given that each design choice has three options, there are varying levels of complexity for each design choice option, with the assumption that more complexity equates to more time and resources needed to implement said option. Using Architecture as an example, the Indirect option is most similar to existing relationships amongst financial system participants in place today, whereas the Hybrid option increases in complexity, time, and resources needed to make the transition. The Direct option further increases the complexity, time, and resources required to transition from the Hybrid option. Accordingly, Indirect is the **Basic** option, Hybrid as the **Intermediate** option, and Direct as the **Advanced** option. This ranking logic is then applied to the design choices of Interoperability and Technology for similar representation with **Basic** (Compatible, Centralized), **Intermediate** (Interlinked, Tertiary), and **Advanced** (Single, Decentralized), respectively. These three initial types proposed also assume common characteristics, specifically **Basic** being representative of a type that is fastest to market and simplest (in relation to the other design choice options), **Intermediate** is the most balanced option of the three given its average benefits and moderate amount of complexity, and **Advanced** acting as the most optimal option given its

ability to harness the full functionality of each design choice option for benefit of improving cross-border payments while also the most complex. Each initial type (i.e., **Basic**, **Intermediate**, and **Advanced**) is further explained in detail in the following pages.

Beginning with the **Basic** type, a CBDC designed with this unique set of options is expected to be available for use in market within a short period of time due to the indirect architecture which most closely resembles the current financial system, a high degree of fragmentation due to the low level of interoperability offered in a compatible arrangement, and with limited compatibility resulting from the centralized technology option whereby the CBDC is challenged in transversing between networks administered by other entities. While this typology improves speed and transparency for cross-border payments, the expense and exclusiveness remain relatively unchanged. This type is expected to provide incremental benefit over existing options available today given its reliance on legacy concepts and systems, continued usage of mapping and translation services to resolve system variations, and reduced scalability due to power concentration by administrative entities which further fragment the global financial system.

Continuing with the **Intermediate** type, benefits are realized through increased macro alignment amongst Central Banks and administrative entities leading to more economical and transparent clearing and settlement across borders. However, the possibility of (or potential reliance upon) third parties and financial intermediaries preserves points of friction inherent in the current global financial system and prevents uniformity due to inconsistent processes, thus hindering the full potential of CBDCs from being realized. To that extent, this type has the potential to serve as a transitory system, serving as a temporary solution to introduce CBDCs to market while financial system participants continue the journey towards an optimal CBDC

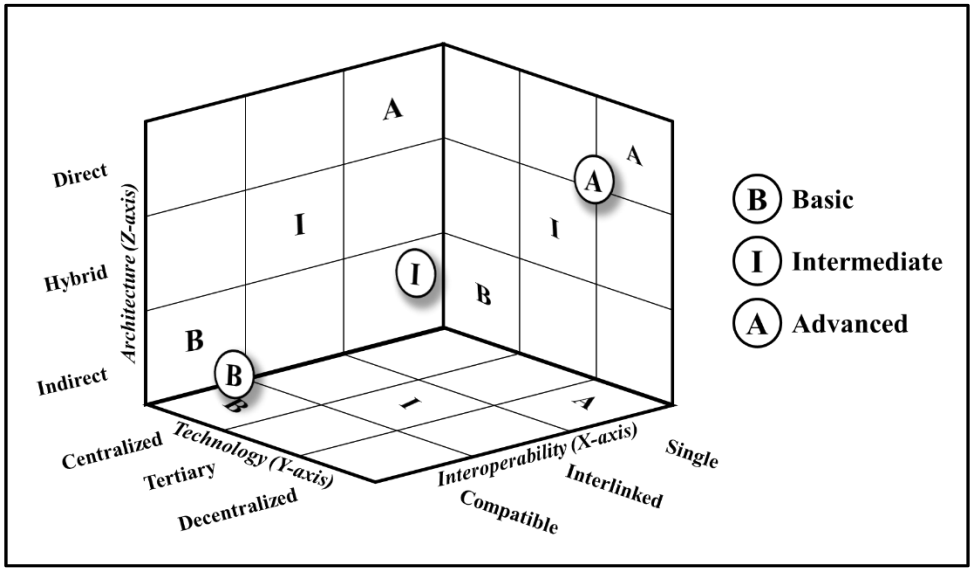
solution through resource allocation, prioritization, and discussions required for rule and governance alignment. Furthermore, as more organizations evolve from the waterfall methodology of project management to agile by means of incremental product development and launch, this iterative approach as evidenced by the **Intermediate** type may be an appropriate decision.

Concluding with the **Advanced** type, the high level of benefits resulting from the development and introduction of this CBDC design into market are also challenged by the correspondingly high level of resources and global market coordination required to align and promote said CBDC. This type, utilizing the most complex option of each of the three design choices, offers the greatest improvement over the current global financial system and is closest to finding the coveted "Holy Grail of Cross-Border Payments" as proposed by the European Central Bank (2022). This type is also positioned to address all four of the existing cross-border payment undesirable characteristics, notably speed and cost which are accomplished through the reduction of entities involved in the transaction via point-to-point streamlining and utilizing a singular specification agreed to collectively and globally. Also inherent in this type is the exclusion of Commercial/Retail Banks wherein the end-user is interacting directly with their respective Central Bank, introducing concern amongst said Commercial/Retail Banks regarding disintermediation, potentially adding further delays.

In summary, in measuring the success of each collection of design choices as the degree to which it is diffused in the global banking system, represented as the expected result of each CBDC type in ***Figure 13***, a correlation exists in increased success in relation to increased complexity, wherein **Intermediate** is both more complex and more successful than **Basic**, and **Advanced** is both more complex and more successful than **Intermediate**. Reiterating the points

above, these three types are but an initial set of the 27 total permutations, introduced for the purposes of depicting how the **CBDC Design Framework** can be harnessed to visually map where each type resides with respect to their design choice options and provide a basis for future researchers to build upon. Future research efforts are also encouraged to explore the legitimacy of all 27 types, noting the potential for one or more types to be implausible or impossible due to incompatible design choices. Additionally, future research efforts are encouraged to quantitatively measure how each CBDC type impacts its diffusion, thus providing guidance to practitioners as to what design choice options make it easier to diffuse or for more adopters to want it. Assumptions above notwithstanding, such as the political landscape or socio-economic status of a given market, this proposed **CBDC Design Framework** encapsulates the three CBDC design choices into a three-dimensional framework to visually depict all possible permutations of CBDCs, providing a singular device for practitioners and researchers to utilize when classifying and designing CBDCs for cross-border payments in pursuit of improved diffusion.

Figure 13. CBDC Design Framework with Three Initial CBDC Types



Source: Author

V. DIFFUSION OF CENTRAL BANK DIGITAL CURRENCY

V.A. Overview

Following the MSLR above which is focused on practical (i.e., non-theoretical) elements and perspectives, the attention of this research effort now pivots to the theoretical applications, implications, and integrations of CBDCs within the context of a new innovation as it is diffused amongst the populace. Despite the literature review above pertaining to the practical aspects of CBDCs containing hundreds of articles, this field of study is still in its infancy as validated by Bhaskar et al. (2022), concluding that CBDC research in general "still has a long way to go", with brief mention by the opportunity for theoretical development is even greater.

Important to note is the existence of research conducted by Liu, Wang, Wu, and Zhang (2022) which examines the role of adoption and diffusion theories as examined in the context of China's CBDC and measured via quantitative analysis, and the work by Windawi (2022) that explores the role of diffusion in the context of blockchain as the innovation, one of the potential technical design choice options of CBDCs this paper in writing considers, amongst others. Additionally, the work by Roussou, Stiakakis, and Sifaleras (2019) investigates the role of theory, specifically the Innovation Decision Process Model (Rogers, 1995) and Technological Acceptance Model (Davis, 1986), as it pertains to the adoption of digital currencies broadly (including cryptocurrencies such as Bitcoin) as opposed to CBDCs only. While this study in writing and those by Liu et al. (2022), Windawi (2022), and Roussou et al. (2019) are located on the same spectrum, this study is focused on identifying the relationship between CBDC design choices which constitute the innovation being diffused and the subsequent act of diffusion, whereas the other studies examine the CBDC as a whole, not the individual parts driven by design choices.

Accordingly, this study addresses the gap caused by a lack of exploration into the role of theory as CBDCs are diffused amongst their respective markets and importantly, an examination into the options available to Central Banks by means of design choices and their respective influence on said diffusion. Noting the current gap with respect to the intersection of CBDC design choices and theory on diffusion, a related study exists with the research conducted by Ma et al. (2022) which applies and modifies the theories of Technological Acceptance Model (TAM), Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), Unified Theory of Acceptance and Use of Technology (UTAUT), and Extended Valence Framework (EVF) through the lens of perceived privacy, security, system quality, and benefits of CBDCs from the perspective of consumers. Within their research, the authors develop a hypothetical model depicting the intersection of theory and practice that is closely related to innovation diffusion; however, while the Diffusion of Innovation theory is referenced within the related work, it is not one of the chosen theories explored further in the study, thus preserving the gap that this study in writing resolves.

Recognizing that these five theories do not constitute an exhaustive group of all potentially relevant and neighboring theories, these five were chosen to align with existing literature on CBDCs (Ma et al., 2022). Similar theories and models identified by Venkatesh et al. (2003) which future research efforts are encouraged to explore in the context of CBDCs include, but are not limited to: Motivational Model (Davis, Bagozzi, & Warshaw, 1992), Model of PC Utilization (Thompson, Higgins, & Howell, 1991; Triandis, 1977), Social Cognitive Theory (Bandura, 1986; Compeau & Higgins, 1995), and new permutations when two or more are combined including the TAM and TPB hybrid (Taylor & Todd, 1995). Additional theories pertaining to adoption and investigated in the context of CBDCs include the Push-Pull-Mooring

Framework (PPM) and Task-Technology Fit (TTF) as evidenced by Xia, Gao, and Zhang (2023), both of which future research efforts are also encouraged to explore further by comparing the gamut of applicable theories to identify which best explain how CBDC design choices ultimately influence its adoption or diffusion.

While this study in writing focuses on the DOI Theory (Rogers, 1962) given the aforementioned gap in literature, the five proximal theories of TRA, EVF, TPB, TAM, and UTAUT warrant review as to properly establish relative context to the original DOI model and its related iterations. Furthermore, the following sections covering these DOI-adjacent theories serve the purpose of justifying their exclusion from consideration during the development of the forthcoming pair of proposed models and framework on the basis that all have an embedded level of analysis at the individual level, thus incompatible with the theme of this study at the societal level of analysis represented as the global financial banking system by which CBDCs will be diffused through.

Similar research efforts explore the application of these user acceptance and innovation related theories in banking more broadly beyond CBDCs including a comparative analysis of TRA, TPB, and TAM to explain internet banking behavior (Yousafzai, Foxall, & Pallister, 2010); consumer surveys investigating the role of TAM in online banking acceptance (Pikkarainen, Pikkarainen, Karjaluoto, & Pahnila, 2004); examination of TAM and TPB pertaining to mobile banking adoption (Aboelmaged & Gebba, 2013); and the application of UTAUT to predict individual intentions and behaviors of mobile banking (Yu, 2012). This limited exploration into the interaction between Diffusion of Innovation theory and CBDCs serves as a primary catalyst for this research effort, noting that a primary objective of Central Banks as they launch Digital

Currencies to their respective markets is that of successful diffusion, culminating in adoption by end-users and utilization for the purpose of facilitating cross-border payments.

Prefacing this analysis, an important distinction is necessary to frame perspectives and relationships in this context. Specifically, new innovations (e.g., CBDCs) that are introduced into the market have two opposing perspectives as evidenced with the concepts of (A) adoption, and (B) diffusion, as experienced through the perspectives of the adopter and diffuser independently, and the resulting relationship between these two entities. Recognizing that the two perspectives are both interrelated and opposing forces, clear differentiation is a prerequisite to the forthcoming theoretical analysis. To this extent, these two concepts of adoption and diffusion are intrinsically linked, with differing units of analyses as adoption is focused on the firm making the decision to adopt the innovation being pushed to the field (e.g., TRA, EVF, TPB, TAM, and UTAUT) and diffusion is concerned with the organizational field containing multiple participants (e.g., DOI).

Expounding further, adoption is the act of selecting (i.e., pulling) an innovation available in the market and utilizing its features and functions by end-users, exemplified in the international banking system as retail consumers and wholesale businesses who are the originators and beneficiaries of cross-border payments, selecting from available options. Conversely, diffusion is the act of disseminating (i.e., pushing) an innovation into the market comprised of end-users so that they may take advantage of its features and functions, exemplified in the international banking system as the cross-border payment options offered by Commercial/Retail banks and utilized by retail consumers and wholesale businesses. An alternative synopsis in the context of economics positions adoption and adopters as satisfying the demand bisection, and diffusion and diffusers as occupying the supply bisection, noting a

delicate balance and relationship between the two elements. Analogized, adoption and diffusion are opposing sides of the same coin (e.g., heads and tails). Therefore, proper bifurcation of these two related perspectives is essential in framing this research effort for its intended practitioner audience, decision makers at Central Banks responsible for CBDC design choice selection.

Another important distinction is that of diffusion and infusion as explored by Eder and Igbaria (2001), in which the former pertains to spreading the use of an innovation (i.e., outward movement), and the latter with integrating the innovation into business processes (i.e., inward movement), noting that diffusion can occur without a corresponding or equal amount of infusion (Cooper & Zmud, 1990). Combining all three concepts within an example, diffusion is the concept by which the new innovation is introduced and distributed amongst the intended market as in an electronics manufacturer designing, marketing, and disseminating a new computer within the countries it conducts business; adoption is the process by which an individual progresses from innovation awareness to obtaining the innovation as with a retail consumer seeking out a new computer for personal use; and infusion is the process of an individual integrating the innovation into their respective ecosystem as with the retail consumer using their new computer by leveraging its features and functions with daily use. When an entity has decided to adopt an innovation, the entity must also infuse the innovation to make it work; the act of adopting (i.e., deciding) without infusion is insufficient. In summary, diffusion is the production and distribution of an innovation, adoption is the decision to use an innovation, and infusion is integrating and utilizing the innovation, thereby harnessing its potential.

Recognizing the existence of an opportunity for contribution by preliminarily addressing the complexities inherent within the act of infusion and the closely-associated process of routinization, Zmud and Apple (1992) answered this call to action by examining the difference

between these two concepts of innovation incorporation through analysis and measurement. The authors define routinization as “the adjustment of an organization’s governance systems to account for the innovation” and infusion as “the extent to which the full potential of the innovation has been embedded within an organization’s operational or managerial work systems”, concluding that the two aspects are both distinct and measurable (Zmud & Apple, 1992). Furthermore, Zmud and Apple (1992) draw attention to considerations regarding infusion including the importance of not only those entrusted with infusing having an understanding of the innovation, but the organization at large as to provide legitimacy; the increased complexity when multiple work units are in scope for incorporating the innovation; a high degree of routinization does not guarantee an equally high level of infusion; and the rate of routinization can outpace infusion and thus require different approaches. Returning to the focus of theoretical analysis, the subsequent sections first review DOI-adjacent theories (e.g., TRA, EVF, TPB, TAM, and UTAUT), followed by reviewing the DOI model originally proposed by Rogers (1962) and its adaptations which this study further builds upon.

V.B. Diffusion of Innovation Adjacent Theories

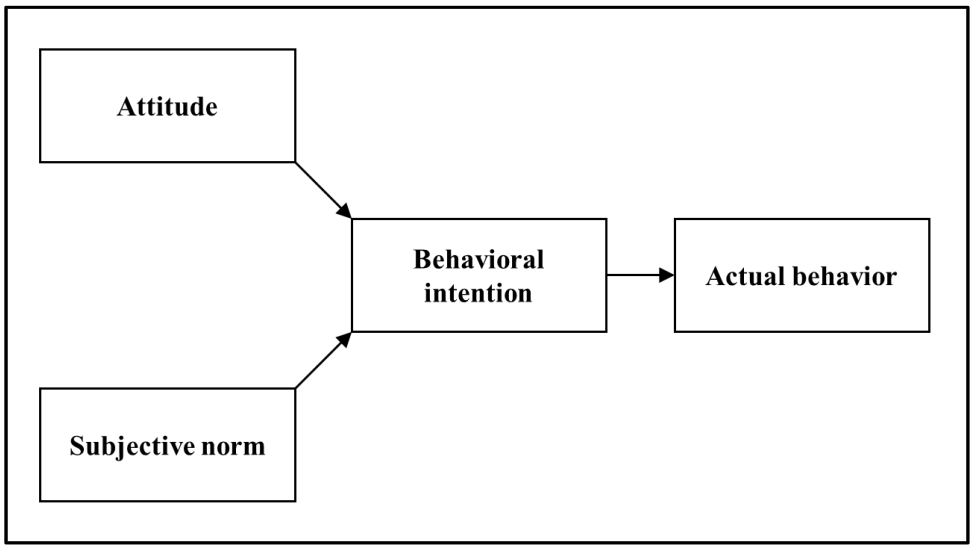
V.B.1. Theory of Reasoned Action

Examining these theories in chronological sequence, Fishbein (1967) is credited with developing the foundation of TRA, itself an extension of the Theory of Propositional Control (Dulany, 1968) via adjustments to variable naming and measuring, which was subsequently extended by Ajzen and Fishbein (1973) and serves as the reference point for this research effort in writing. TRA is concerned with deriving the behavior of an individual from two independent variables: (1) their attitude toward the behavior, and (2) subjective norms of the behavior, through the variable of behavioral intention, itself a function of both independent variables.

Fishbein and Ajzen (1975) describe attitude as the favorable or unfavorable response towards a given object and subjective norms as the normative pressures the individual references which may or may not create motivation to comply. The function of the individual's attitude and subjective norms is expressed as their behavioral intention, the antecedent variable to the behavior consequent variable as shown in ***Figure 14***.

Although this model is parsimonious and generalizable, it fails to fully consider and incorporate elements which are out of the individual's control, an important consideration which was later remedied by TPB (Ajzen, 1991). Relating to this study by means of contextualizing a new innovation introduced to the market, TRA assumes the perspective of the adopter (i.e., end-user, e.g., retail consumer or wholesale business) and attempts to explain their actual behavior towards the use of CBDCs for cross-border payments by measuring their attitude towards the innovation and corresponding subjective norms. Reflecting upon the dueling perspectives above with respect to the introduction of new innovations, TRA is more appropriately aligned with adoption and utilizes an individual level of analysis, contrary to this study's foci of diffusion and with a global level of analysis. Although TRA remains adjacent to this explorative study, the level of analysis and adoption perspective fails to surpass DOI as the theory of choice by which to extend.

Figure 14. Theory of Reasoned Action Model by Fishbein and Ajzen (1975)



Source: Fishbein and Ajzen (1975)

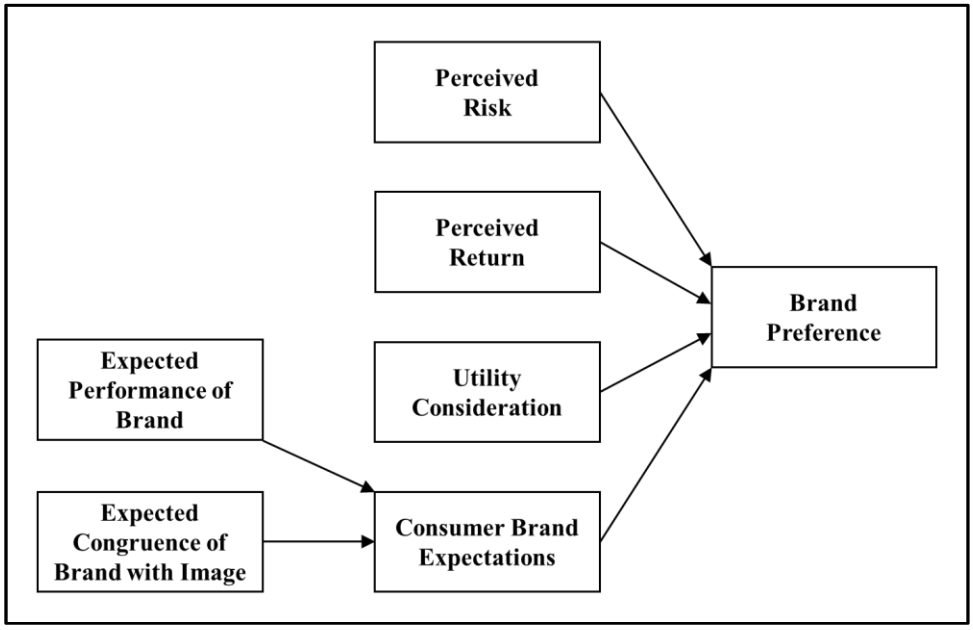
V.B.2. Extended Valence Framework

Following TRA is EVF, and while the research by D. J. Kim et al. (2009) is often referenced, its roots can be found in the work by Peter and Tarpey (1975) which investigates consumer decision-making strategies in relation to brand preference pertaining to expected loss, expected gain, and net expected gain (i.e., perceived risk, perceived return, net perceived return, respectively). Attempting to address the gap caused by a lack of consumer behavior studies into the aforementioned three strategies and the "various facets or dimensions of utility" under consideration by consumers during the decision-making process, the authors' study introduced representative models with subsequent measurement of each, resulting in support for the model and associated variables both conceptually and empirically (Peter & Tarpey, 1975). This study analyzed the following three strategies in pursuit of explaining which accounts for the most variance in consumer behavior: (1) minimization of perceived risk, (2) maximization of perceived return, and (3) maximization of net perceived return, finding that the latter accounted

for the most variance, respectively. This analysis also found that perceived risk carries a greater weight than perceived return with respect to explaining consumer brand preference. ***Figure 15*** below is this author's interpretation of a unified and simplified (i.e., non-extended) Valence Framework model for the purposes of illustrating these variables and their associated relationships.

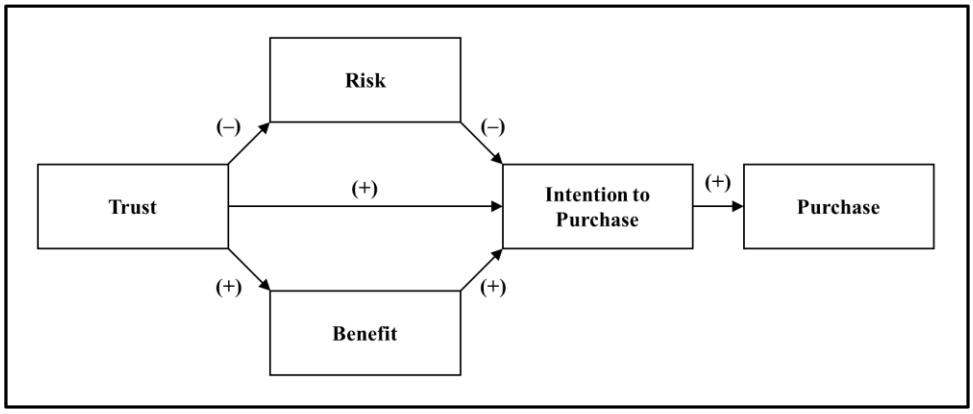
The authors further drew two additional conclusions, specifically that consumers consider both positive and negative utility when making decisions and the simultaneous dimensions of brand expected performance and congruence of the brand with the consumer's self-image and reference group image (Peter & Tarpey, 1975). This second conclusion of image alignment (self and group) draws parallels to the independent variable of subjective norms from TRA above. Noting that this analysis was conducted in the scope of consumers' automotive brand preference, the foundational concepts can be applied to other innovations introduced into the market (e.g., CBDCs). D. J. Kim et al. (2009) extends this concept of perceived value (i.e., the Valence Framework), derived from the net of perceived risk and return, through the integration of elements from TRA, thus yielding the Extended Valence Framework as shown in ***Figure 16***. Further drawing parallels with TRA, EVF is also aligned with the perspective of adoption as evidenced with the focus on consumers and their considerations during the decision-making process (i.e., an individual level of analysis), again failing to replace DOI as the foundational theory for this study.

Figure 15. Valence Framework Model by Peter and Tarpey (1975) Interpretation



Source: Interpretation of Peter and Tarpey (1975) by Author

Figure 16. Extended Valence Framework Model by D.J. Kim, et al. (2009)



Source: D. J. Kim et al. (2009)

V.B.3. Theory of Planned Behavior

Approximately a decade after the Valence Framework by Peter and Tarpey (1975) and before the Extended Valence Framework by D. J. Kim et al. (2009), TPB was introduced by

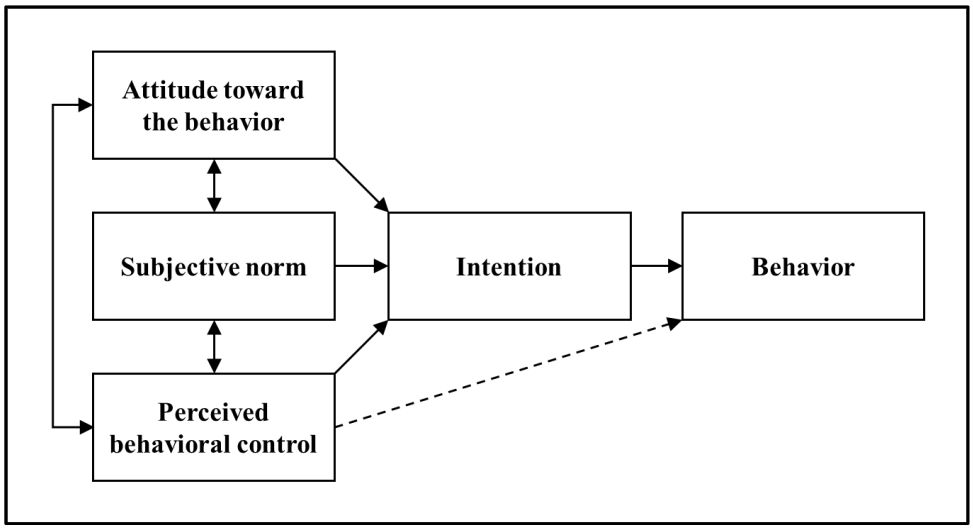
Ajzen (1985) and builds upon the TRA work by Fishbein and Ajzen (1975), seeking to address the aforementioned shortcoming of excluding elements which are out of the individual's control. Accordingly, the model created to support TRA was extended to include a third independent variable – perceived behavior control – and serves as an antecedent to both behavioral intention and behavior variables as shown in ***Figure 17***. An important distinction with this new variable is the use of "perceived" to properly differentiate it from "actual", in that while the behavior is a choice made by the individual so long as they can decide whether or not to perform the behavior (i.e., the individual has volitional control), external factors exist which influence said behavior control and are difficult to evaluate, hence the distinction (Ajzen, 1991).

Ajzen (1991) further explains that the three independent variables are similar in that higher values for each will lead to stronger intention by the individual, with the caveat that not all three will exist in every situation or always serve as predictors. Additionally, each of the three independent variables were denoted to have relationships with the other two rather than existing fully independent of one another, an attribute which was absent from the original TRA model (Fishbein & Ajzen, 1975); however, Ajzen (1991) further notes that "the exact form of the relations is still uncertain." Although TPB addresses the element of conditions which may influence the end-users' behavioral intention via the perceived behavioral control variable, it assumes that there exists a high correlation between behavioral intentions and behavior and therefore fails to remedy another shortcoming of the TRA model (Yousafzai et al., 2010). Similar to the stated position of TRA above, TPB remains aligned with the adoption perspective and individual level of analysis and is therefore not selected as the theory to build upon.

In addition to the research conducted by Ma et al. (2022), Radic et al. (2022) performed a quantitative analysis examining the role of TPB with respect to CBDC adoption in the context of

China's Digital Yuen and Korea's Digital Won, as did Muchran et al. (2024) with Indonesia. The measurements of TPB's variables of Attitude toward CBDC payment, Subjective norm, and Perceived behavioral control were found to be "robust and significant antecedents of international tourists' behavioral intention toward the adoption of CBDCs" and while this has both theoretical and practical implications, directionally aligning with this study in writing, DOI theory is not the primary focus and adoption is the unit of measurement, not diffusion (Radic et al., 2022).

Figure 17. Theory of Planned Behavior Model by Ajzen (1985)



Source: Ajzen (1985)

V.B.4. Technology Acceptance Model

The year following the introduction of TPB included the seminal work by Davis (1986) in which the proposed model to represent the acceptance of technology by an individual as a factor of their perceived usefulness and ease of use of said technology, more commonly known as TAM. Elements from previous theories continue to persist within TAM to varying degrees,

notably the consequent variable of Actual System Use and mediator variable of Attitude Toward Using, similar to that of (Actual) Behavior and Behavioral Intention from TRA, respectively. In contrast, the independent variables of Attitude and Subjective Norm from TRA have been replaced with Perceived Usefulness and Perceived Ease of Use within TAM, both of which serve as antecedent variables to the mediating variable of Attitude Toward Using (Davis, 1986). Differing from TRA, a unidirectional relationship exists between the two TAM independent variables, with Perceived Ease of Use influencing Perceived Usefulness.

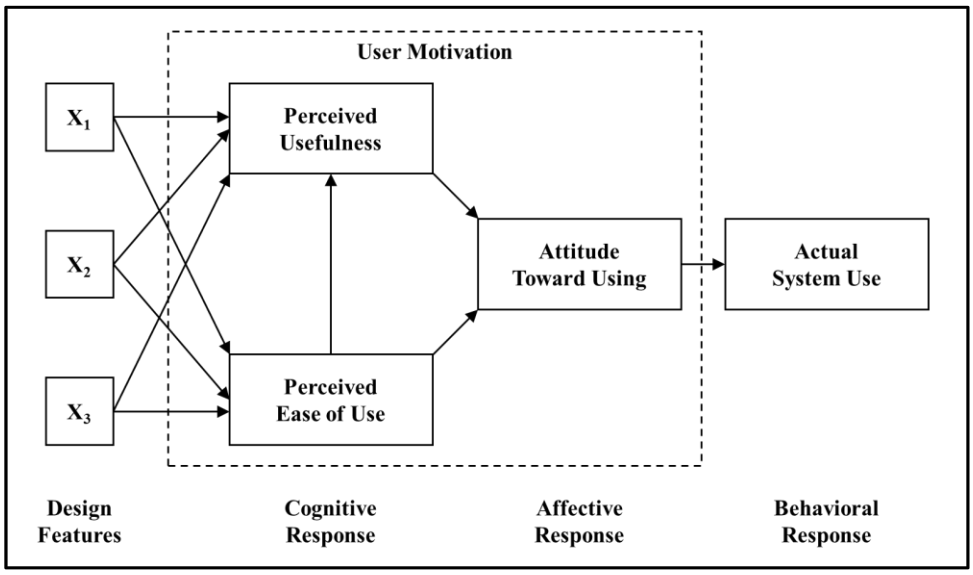
The proposed model shown in ***Figure 18*** was tested shortly thereafter with the intention of creating and validating new measurement scales for the two independent variables, Perceived Usefulness and Perceived Ease of Use, an effort which proved successful as evidenced with confirmed significant empirical relationships in the context of individuals' computer usage, serving as the study's innovation at the time (Davis, 1989). That same year, the original model (i.e., TAM) was revisited by Davis et al. (1989) and revised in pursuit of parsimony by retaining the three most powerful constructs: Behavioral Intention, Perceived Usefulness, and Perceived Ease of Use, thus removing External Variables and Attitude as conceptualized in ***Figure 19***. This more parsimonious TAM was revisited again and extended with additional theoretical constructs, some adopted from TRA, by incorporating "spanning social influence processes (subjective norm, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability, and perceived ease of use)" resulting in the creation of TAM2, evidenced in ***Figure 20*** (Venkatesh & Davis, 2000).

Sharing commonalities with the preceding theories, TAM represents the individual (i.e., adopter) as the level of analysis and offers and explanation to their acceptance of a new innovation, thus contrary to this study's focus on the global level of analysis and act of diffusion,

rejecting it as the theory to extend for the purposes of this study. Although not fully aligned to this study, TAM is being utilized by other researchers to explore consumer behavior with the adoption of CBDCs as evidenced in the work by J. J. Kim, Kim, Hailu, Ryu, and Han (2023) investigating tourism as an use case through purchases of travel-related products and services, and that of Ma, Wu, Sun, Zhou, and Sun (2023) which combines TAM with UTAUT to validate consumers' intention to use CBDCs by examining multiple variables including perceived usefulness, ease of use, attitude, security, and cost, amongst others. The latter referenced study explores CBDCs using the Digital Currency Electronic Payment (DCEP) project launched in the People's Republic of China as its focal point; understandable given China's advancement in this space, mirroring similar studies on CBDCs (D. K. C. Lee, Yan, & Wang, 2021; Liu et al., 2022; H. Wang, 2023; Xia et al., 2023; Xu, 2022).

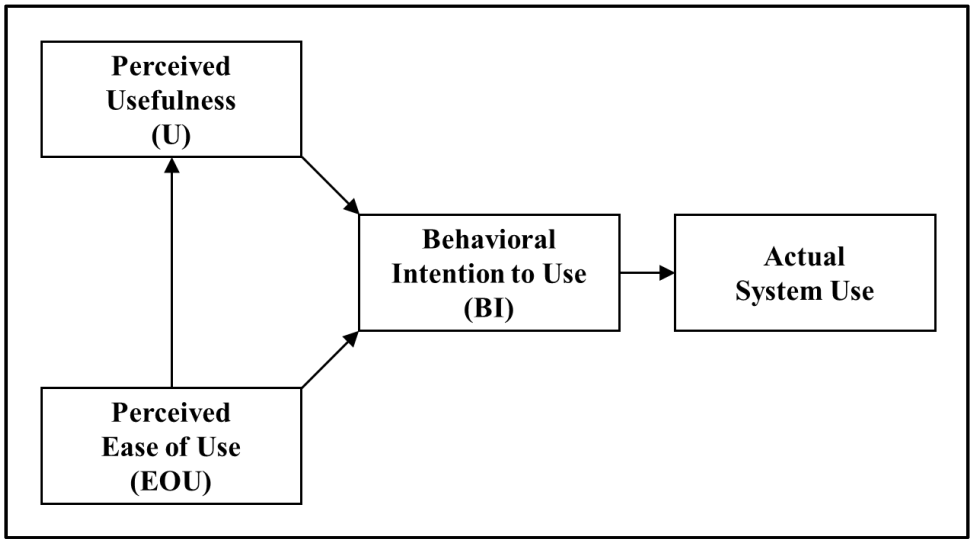
Similarly, the research conducted by Sun and Li (2024) utilized the TAM2 model variant given its heightened focus on external variables which influence Perceived Usefulness and Perceived Ease of Use while investigating individuals' intentions to use CBDCs. Leveraging quantitative analysis, these researchers found that credibility has a significant positive effect on Perceived Usefulness and Perceived Ease of Use, concluding that users' perception of CBDCs as credible results in an increased likelihood to find CBDCs useful and easy to use (Sun & Li, 2024).

Figure 18. Original Technology Acceptance Model by Davis (1986)



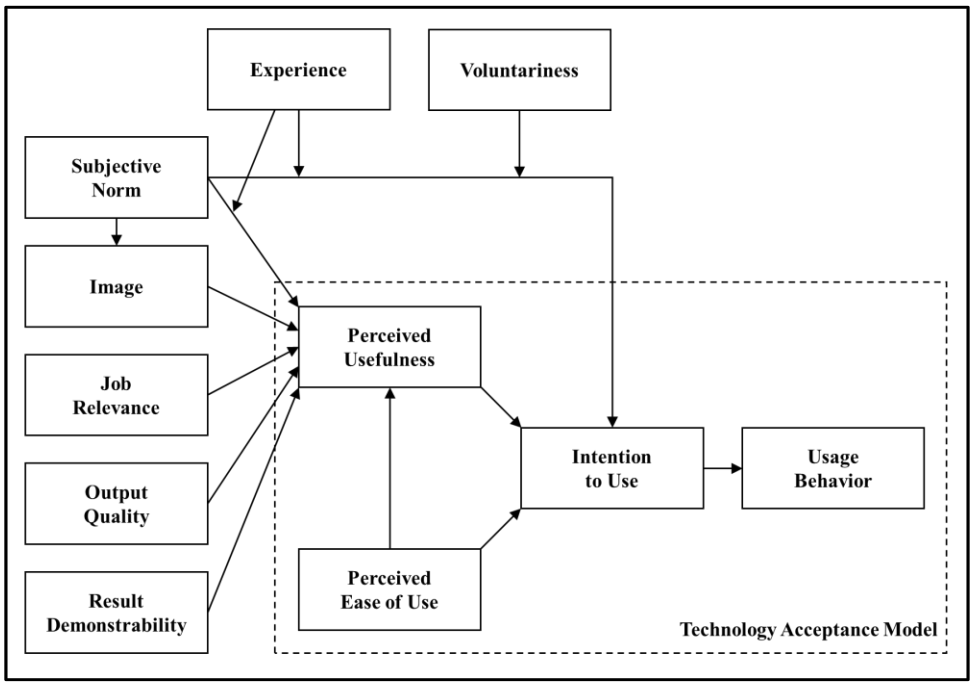
Source: (Davis, 1986)

Figure 19. Revised Technology Acceptance Model by Davis, Bagozzi, and Warshaw (1989)



Source: Davis et al. (1989)

Figure 20. Technology Acceptance Model Two (TAM2) by Venkatesh and Davis (2000)



Source: Venkatesh and Davis (2000)

V.B.5. Unified Theory of Acceptance and Use of Technology

Shortly after the introduction of the TAM2 model (Venkatesh & Davis, 2000), a similar cadre of researchers acknowledged the existence of multiple models proposed to explain acceptance of technology with similar attributes and shortcomings. This led to a comprehensive review and analysis of said models, followed by the introduction of a new proposed theory (UTAUT), a new model to depict the theory as shown in ***Figure 21***, and its corresponding empirical validation (Venkatesh et al., 2003). Having completed a robust analysis of existing models and associated comparative studies, identifying the models' core constructs, and performing their own measurement via quantitative analysis, Venkatesh et al. (2003) found seven constructs to be direct determinants of intention to use a technology and statistically significant.

Of these constructs, four were theorized as directly contributing to user acceptance, specifically Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions.

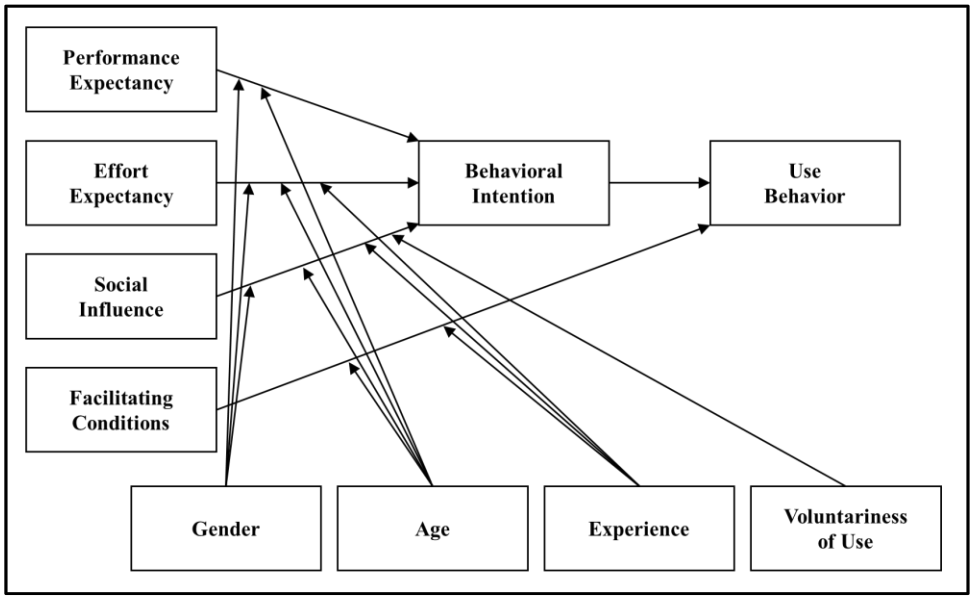
Diverging from prior models above, UTAUT excludes attitude towards using the technology, a common theme in TRA, TPB, and TAM (original 1986 variant). The authors then shifted their focus from the main effects and identified four key moderators, notably Gender, Age, Experience, and Voluntariness of Use, all of which are included in the UTAUT model (Venkatesh et al., 2003). Ultimately, the authors validated UTAUT to have an adjusted R^2 of 0.70 when explaining the variance in usage intention, far surpassing prior models with TRA (0.36), TAM (0.52), TAM2 (0.53), and TPB (0.36 including voluntariness, 0.46 including gender, and 0.47 including age) while reducing possible main effects from 32 to four in the process (Venkatesh et al., 2003).

Acknowledging the contributions made through the construction and validation of the UTAUT and model, it remains fixed from the perspective of the end-user, aligning with the adoption viewpoint and similar to the theories above with an individual level of analysis, and therefore excluded as this study's underlying theory. Similar to TAM, literature has been published recently exploring the adoption of CBDCs under a theoretical lens by measuring the strength of antecedent variables in relation to the dependent variable of user behavior. Recently, Söilen and Lamiae (2022) have investigated CBDC adoption using the UTAUT framework, and in combination with Institutional Trust Theory (ITT), whose research results indicate a desire amongst consumers to adopt CBDCs with trust being a critical element in this endeavor.

Recognizing complementary literature, Wong, Tenk, and Heong (2022) employed an extension of the UTAUT framework in measuring the influence from output quality, perceived accessibility, result demonstrability, and perceived security as antecedents to adoption behavior

in the context of cryptocurrency adoption in Malaysia. Similarly, Recskó and Aranyossy (2024) utilized the UTAUT framework to explore user behavior in the hypothesized scenario where a prominent social network company backed a cryptocurrency, finding the strongest influence by usefulness and ease of use, noting the study's limitation to Central-Eastern Europe.

Figure 21. Unified Theory of Acceptance and Use of Technology Model by Venkatesh, et al. (2003)



Source: Venkatesh et al. (2003)

V.C. Diffusion of Innovation Theory

The process of diffusion has scholastic precedent, originating from the DOI Theory, alternatively known as the Innovation Diffusion Theory (IDT), published by Rogers (1962). This seminal work contains two primary components: (1) the concept that adoption of an innovation occurs at different speeds through individuals categorized by their willingness to adopt, and (2) the rate of innovation adoption is impacted by a number of factors. Importantly, DOI examines user acceptance of a new innovation in the macro analytical level (i.e., industry or segment, e.g.,

the global banking ecosystem), thus marking a significant departure from the five theories and models above which pertain to the micro analytical level (i.e., individual, e.g., end-user), noting that both levels coexist within the same context. This distinction between the adopter perspective of the preceding theories and the diffuser perspective inherent in DOI validates the reasoning for the remainder of this research effort utilizing DOI as the foundational theory and associated models in support of the forthcoming arguments and proposals.

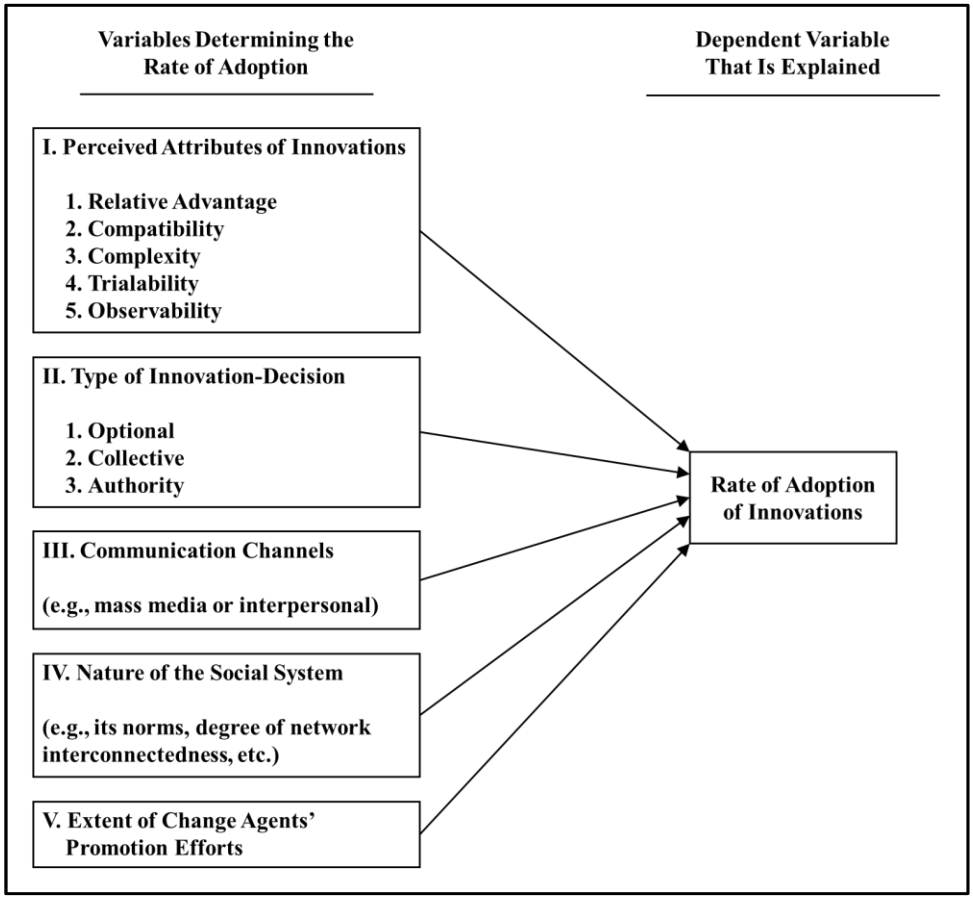
Summarizing DOI further, Rogers (1962) explores diffusion through multiple contexts, most notably from two directions: (1) the different types of individuals adopting the new innovation as categorized temporally based on when the innovation is adopted by the user, and (2) the factors which contribute to the diffusion of new innovations. Continuing a previous theme within this study, these two directions are intrinsically linked whereby those adopting (i.e., the former) consider the factors of the innovation (i.e., the latter), and vice versa, serving as a symbiotic relationship. This study in writing is concerned with the latter, to the extent that the CBDC design choices of Architecture, Interoperability, and Technology are factors (i.e., multiple independent, antecedent variables) which play a role in CBDC diffusion (i.e., a single dependent, consequent variable) by Central Banks within their respective regions, similar to the originally proposed factors by Rogers (1962) as explained below.

Beginning with the direction of adopters and their timing of adoption, DOI expresses the timeline for innovation adoption through a normal distribution curve, beginning with innovation introduction, and spanning through innovation termination. Adoption throughout this normal distribution is facilitated by various types of adopters, each of whom have different levels of willingness to adopt the innovation and are segmented into five categories: Innovators, Early Adopters, Early Majority, Late Majority, and Laggards. These ideal types of adopter categories

serve the purpose of encapsulating observations in reality, allow for comparisons to occur, guide research (current and future), and are based on abstractions given that there is not clear demarcation between each category and fluidity between categories exists (Rogers, 1962). In the context of CBDCs, each of these adopter segments will contribute to the cumulative total of diffusion in a given market; however, this research effort is instead focused on the factors which impact diffusion, upon which attention is shifted to the second direction of contributing diffusion factors.

Rogers (1962, 1983, 1995) proposes a model containing five variables identified to determine the rate of adoption as expressed in a variance model seen in ***Figure 22***, wherein the rate of adoption can be measured quantitatively using the number of individuals adopting the new innovation within a given timeframe (e.g., year). These five variables include: (1) Perceived Attributes of Innovations, (2) Innovation Decision, (3) Communication Channels, (4) Nature of the Social System, and (5) Extent of Change Agents' Promotion Efforts. Cognizant that all five variables are necessary to fully explain the dependent variable of "Rate of Adoption of Innovations" as originally intended, this study is concerned with the first variable containing the five perceived attributes of innovations: (1A) Relative Advantage, (1B) Compatibility, (1C) Complexity, (1D) Trialability, and (1E) Observability. These five perceived attributes were measured to account for 0.49-0.87 of variance in the rate of innovation adoption, thus validating their role as direct contributors in the DOI variance model (Rogers, 1962).

Figure 22. Model of Variables Determining Rate of Adoption of Innovations by Rogers (1983)



Source: Rogers (1983)

Rogers (1962) further notes that these five attributes were selected for "maximum generality and succinctness" and "as mutually exclusive and as universally relevant as possible." This focus on generalizability is a primary aspect of this research effort given that practitioners at Central Banks (i.e., those entrusted to diffuse) can benefit by receiving relevant guidance regarding design choices of their respective CBDCs in support of cross-border payments, which is not explicitly provided in the DOI's universally relevant model. More precisely, while the five perceived attributes of innovations within the DOI model are innovation agnostic and can applied broadly to CBDCs, the model has not yet been tailored or retrofitted for the benefit of

Central Bank decision makers, a gap which this study remedies. Accordingly, this research effort seeks to move the needle from generalizability to specificity by examining attributes specific to the design of CBDCs – namely Architecture, Interoperability, and Technology – and in the context of DOI, thus creating a bridge between theory and practice, more appropriately known as "boundary spanning" (Tushman, 1977).

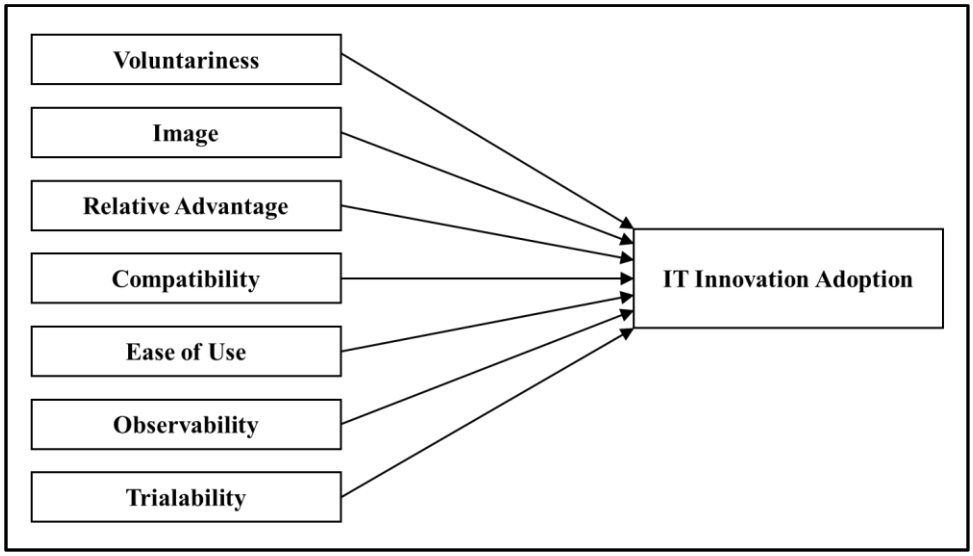
The theoretical relevance of DOI is further enforced in this study by applying one of the three research approaches identified by Rogers (1962) to predict the rate of innovation adoption into the future, specifically method three: Investigating the acceptability of an innovation in its pre-diffusion stages, such as when it is just being test marketed and evaluated in trials." This approach aligns with the current state of CBDCs where only 11 countries out of 120 being tracked have launched, with the majority of CBDC initiatives in states of Pilot (18), Development (32), and Research (40)[12]. Accordingly, this research effort is predictive and exploratory in nature, utilizing an extensive MSLR in combination with the adaptation of the DOI's "Model of Variables Determining Rate of Adoption" for CBDC design. The result of this effort is to provide Central Banks with a rigorous and relevant pair of models and accompanying framework with typology to aid practitioners as they seek to improve diffusion in the context of cross-border payments.

Focusing on the factors impacting adoption, the original five attributes proposed by Rogers (1962) and incorporated into the DOI Adoption of Innovation variance model (relative advantage, compatibility, complexity, trialability, and observability) have since been revisited by researchers, both through expansion and contraction. Moore and Benbasat (1991) took the route

[12] CBDC Tracker, the Atlantic Council Geoeconomics Center, https://www.atlanticcouncil.org/cbdctracker/, website accessed May 15, 2023, at 3:59 PM ET.

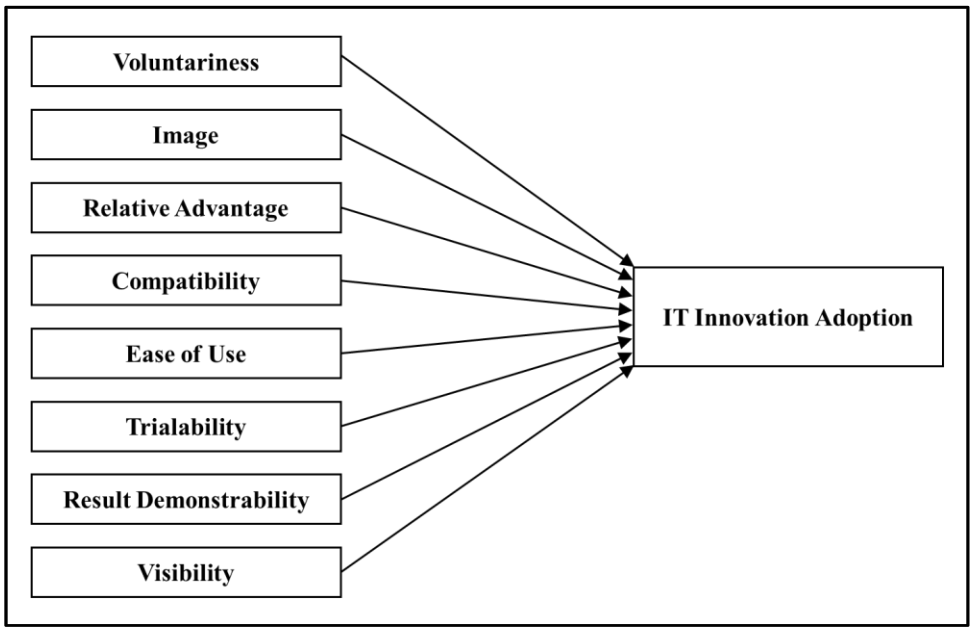
of expansion, increasing the attributes (i.e., Perceived Characteristics) from five to seven (adding Image and Voluntariness, see ***Figure 23***) and eight (adding Image, Result Demonstrability, and Visibility, see ***Figure 24***), while also incorporating elements from TAM (Davis, 1986) including Ease of Use. The authors found the seven-factor model to explain approximately 63% of the variance and noted that the eight-factor model was hindered by two factors (Relative Advantage and Compatibility) being correlated at the 0.99 level, thus considered a single factor (Moore & Benbasat, 1991). Reflecting on the intention of this study in writing to identify an appropriate innovation user adoption theory to reflect the three CBDC design choices, these two model variants confirm that DOI-related models can be expanded as necessary to reflect variables which impact an innovation's diffusion.

Figure 23. Seven-Factor Model by Moore and Benbasat (1991)



Source: Moore and Benbasat (1991)

Figure 24. Eight-Factor Model by Moore and Benbasat (1991)



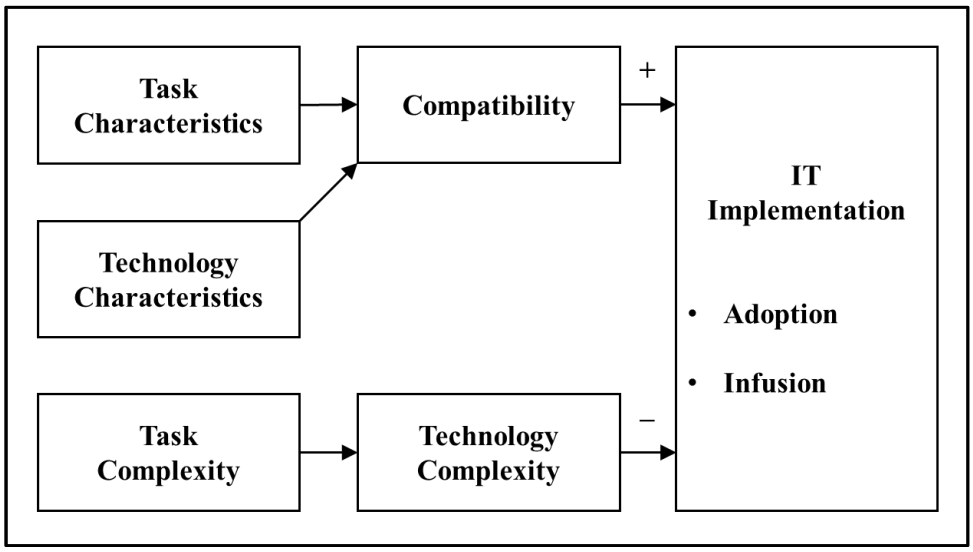
Source: Moore and Benbasat (1991)

Conversely, other research efforts have reduced the number of attributes, including from five to two within the work by Cooper and Zmud (1990) which preserved Compatibility and Complexity (referenced as Technology Complexity) as antecedent variables to the dependent variable of IT Implementation. Distinguishing itself from the original DOI model, the Compatibility attribute is bifurcated into Task Characteristics and Technology Characteristics, and Technology Complexity is extended with Task Complexity as a preceding variable shown in ***Figure 25***. This study is commendable for the fact that it examines both perspectives of innovation user acceptance via adoption (e.g., explaining behaviors leading to IT adoption) and infusion (e.g., incorporating IT within work systems). The authors went on to test their model through both perspectives, finding that the adoption model is statistically significant whereas the infusion model is insignificant, echoing extant literature positing that the act of infusing is

complex with wide-ranging implications across an organization and warrant a different type of model to measure (Laudon, 1985).

Regarding applicability of this model with respect to CBDC diffusion, the research conducted by Cooper and Zmud (1990) was narrowly focused on the implementation of a production and inventory control information system (i.e., Material Requirements Planning [MRP]), leading to reduced generalizability via specialization of a uniquely-complex solution (e.g., MRP) to a similarly-complex organizational need (e.g., the company and associated technological infrastructure incorporating said MRP). CBDCs by comparison are more generalizable to the extent that all entities in the global financial system serve as perspective candidates to interact with these digital currencies. Out of scope for the purposes of this research effort is a comparison between the technical complexity of an MRP system to a CBDC, an intriguing phenomenon which future researchers are encouraged to explore, specifically the extent to which differences in complexity between two fit-for-purpose innovations influence the rate of infusion within an organization. Noting the MRP specificity and the inclusion of infusion to represent user innovation acceptance, elements of this model are appropriate for consideration in extending the DOI theory.

Figure 25. Research Model by Cooper and Zmud (1990)

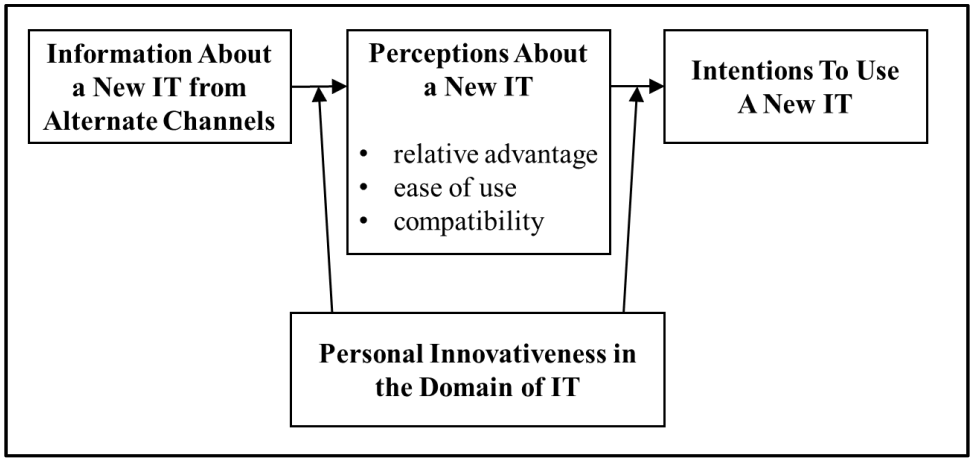


Source: Cooper and Zmud (1990)

Another research effort reducing the number of attributes to explain innovation adoption was conducted by Agarwal and Prasad (1998), during which three attributes were preserved: relative advantage (i.e., perceived need, usefulness), ease of use (i.e., technical complexity), and compatibility, depicted in the hypothesized model shown in ***Figure 26***. An important distinction in the model proposed by Agarwal and Prasad (1998) is the inclusion of Personal Innovativeness in the Domain of IT as a moderating variable which seeks to account for an individual's response to an innovation, further defined as "the willingness of an individual to try out any new information technology." The authors further detail this variable as having a temporal element (i.e., timeline for adoption), drawing parallels to the five category ideal types of adopters (Rogers, 1962), noting that statistically significant moderation was only confirmed with one perception (i.e., attribute). For the purposes of this research effort in writing, the focus remains on the attributes that influence the adoption of a new innovation, represented as the area enclosed in ***Figure 26***, thus excluding the Personal Innovativeness in the Domain of IT variable itself

from consideration as the DOI model is adapted for CBDCs. That said, the adaptation of the DOI model to incorporate a moderating variable warrants consideration in future adaptations of the DOI model, or that of the proposed models in this study.

Figure 26. Hypothesized Model by Agarwal and Prasad (1998)



Source: Agarwal and Prasad (1998)

V.D. Model of CBDC Diffusion

Concluding the comprehensive MSLR, literature analysis, and leveraging data across the various studies, an opportunity for contribution to theory has been identified in the form of a new model examining the relationship between diffusion and its antecedents. Reflecting upon the collection of DOI-related models analyzed, multiple commonalities exist and to varying degrees. First, the antecedents to user acceptance, referred to as “attributes” by Rogers (1962), “constructs” per Davis (1986), and “perfections” by Agarwal and Prasad (1998), serve the purpose of identifying the nuances of the innovation that explain variances during the process of a new innovation being accepted. Second, these antecedents have been subject to varying terms across the literature as evidenced with Relative Advantage being likened to Usefulness and Ease

of Use to Complexity as first introduced by Davis (1986) and supported by Moore and Benbasat (1991). Third, the consequent of user acceptance has largely remained consistent as adoption, save for Cooper and Zmud (1990) who incorporated infusion alongside adoption.

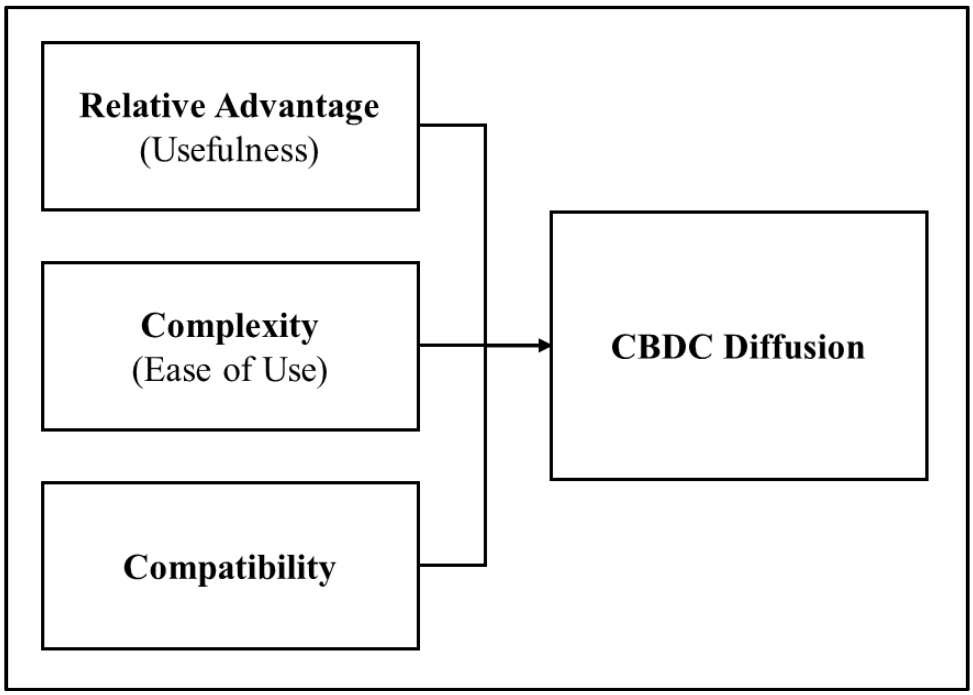
Additionally, the elements from the original DOI model and its variants which this study considers and seeks to incorporate in a new model adapted for CBDC diffusion include: (A) the foundation of innovation attributes which contribute to the variance in user acceptance of an innovation (Rogers, 1962), (B) the expansion of said attributes to represent other variables that contribute to innovation adoption (Moore & Benbasat, 1991), (C) the inclusion of infusion to accompany adoption to represent both perspectives of adoption and diffusion (Cooper & Zmud, 1990), and (D) the reduction of antecedent variables to three and the optionality for a moderating variable (Agarwal & Prasad, 1998). Ergo, with respect to theoretical placement, the model proposed in the next section is positioned to exist external to DOI-adjacent theories given their existing coverage in relation to CBDCs by Ma et al. (2022) and inappropriateness by their level of analysis at the individual level, and to build upon the DOI model by considering elements introduced in prior adaptations and its appropriateness noting its level of analysis at the societal level. This extension of the DOI model is therefore a custom-tailored variant for the explicit application of CBDC Diffusion by incorporating the most relevant iterative elements.

In response to this opportunity for contributions to theory by adapting innovation user acceptance via diffusion and practice with its application to CBDCs, the following **Model of CBDC Diffusion** is proposed as shown in ***Figure 27***. This new model finds its foundation rooted in the three aforementioned commonalities found during literature analysis amongst existing DOI-related models, then tailored appropriately for CBDCs and the act of their diffusion. Specifically, these antecedents were chosen based on their validated role as direct contributors to

user acceptance variance (Rogers, 1962), repeated variable reduction (Agarwal & Prasad, 1998; Cooper & Zmud, 1990), and in pursuit of a more parsimonious model. The consequent, commonly in the perspective of adoption or infusion, is intentionally and purposefully modified to diffusion as to properly reflect the level of analysis by pivoting from the former which is concerned with the individual (i.e., micro level, e.g., retail consumer or business) to the latter that represents the broader industry (i.e., macro level, e.g., global financial system). One element which is absent from the **Model of CBDC Diffusion** is that of a moderating variable as introduced by Agarwal and Prasad (1998); as this **Model of CBDC Diffusion** is validated and extended in future research efforts, external variables such as a country's socioeconomic status, political environment, or stage of development can be incorporated and measured to better understand its impact to CBDC diffusion.

Importantly, this new **Model of CBDC Diffusion** has been developed following a comprehensive MSLR and subsequent analysis of DOI-related theories and models. Future research efforts are encouraged to utilize this **Model of CBDC Diffusion** in quantitative and mixed-method studies to validate its power to explain variances in CBDC diffusion by examining these three innovation attributes inherent in CBDCs. A critical distinction is that attributes do not equate to design choices, meaning, a direct linkage between a CBDC design choice (e.g., Architecture) and CBDC attribute (e.g., Complexity) does not exist. To that extent, the role of CBDC design choices and a proposed indirect link is put forth in the following section. In closing for this first contribution, the introduction of this new **Model of CBDC Diffusion** results in not only a benefit to research and practice, but also serves as the mechanism to answer the primary research question of, *how can Central Banks improve CBDC diffusion?*

Figure 27. Model of CBDC Diffusion



Source: Author

V.E. Model of CBDC Innovation

In addition to the three commonalities described above following the comprehensive MSLR and literature analysis, a fourth discovery took place, presenting another opportunity for contribution. Expounding further, the existing models in print are positioned to explain user acceptance given an innovation released into the market (i.e., the effect), thereby neglecting the opposing force of the design choices of an innovation prior to market introduction which subsequently leads to user acceptance (i.e., the cause). Meaning, the preceding theories, both specific or adjacent to DOI, are concerned with adoption or diffusion given the existence of an innovation by which to adopt or diffuse. This positioning and repeated reinforcement and revision has created an unintentional gap in literature whereby a model explaining the innovation by means of its design (i.e., the choices made which culminate in the innovation's final form

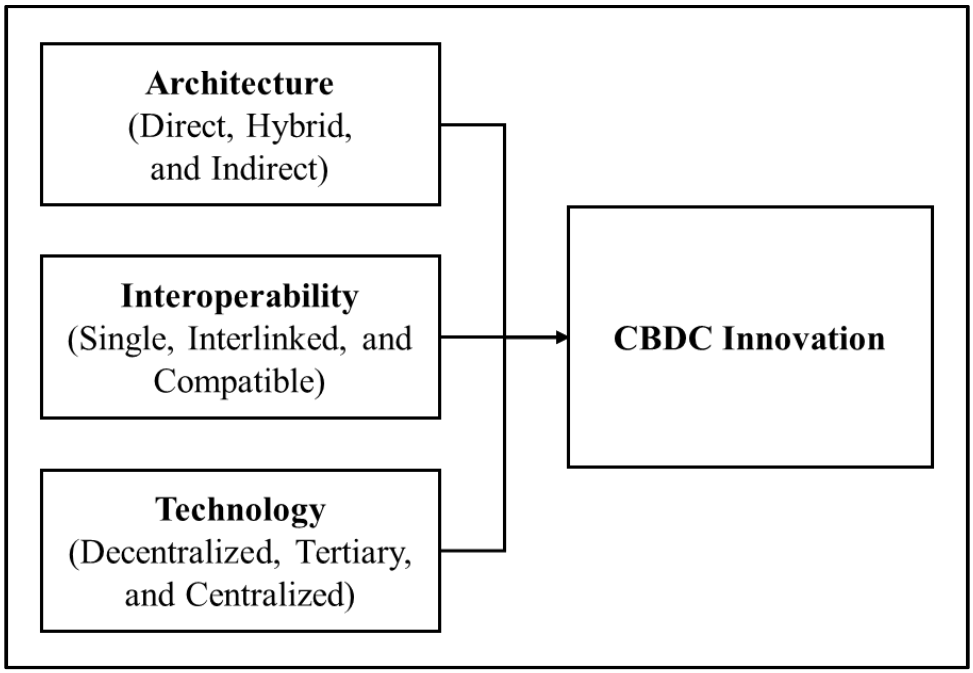
introduced into the market) has yet to be developed and proposed as a counterbalance to existing models on user acceptance.

Described differently, existing literature has been devoted to the variables (i.e., attributes, constructs, perceptions) which explain the variance in user acceptance of an innovation, not the variables which explain how the innovation is designed that result in a variance to user acceptance, regardless of the perspective of making it easier to diffuse or for more adopters to want it. Examining this idea further, the term "Diffusion of Innovation" can be deconstructed to its most fundamental and literal elements, noting that the diffusion of an innovation is supported by multiple models in extant literature; however, the innovation being diffused lacks proper representation in the same context, which this study seeks to rectify. Therefore, this research effort posits that existing user acceptance models lack this critical perspective and while often generalizable, they also fail to provide specificity for CBDC design choices which are the foci of this research. In response to this identified gap in theory created by only focusing on the acceptance of the innovation, not the innovation that is being accepted, and the gap in practice evidenced with an absence of CBDC-specific applications, this effort proposes a remedy with the **Model of CBDC Innovation** as depicted in ***Figure 28***.

Following the comprehensive review of technical considerations in practice and explained above, the three choices of Architecture, Interoperability, and Technology that form the foundation of this research are now called to action as expressed in the **Model of CBDC Innovation**, serving as the variables which collectively dictate the design of the innovation, that being the CBDC. These three design choices serve as the independent variables which precede the dependent variable of CBDC Innovation (i.e., the ultimate design of the CBDC), subsequently terming the combination of these four variables as the **Model of CBDC**

Innovation. Contrary to the antecedent variables in the **Model of CBDC Diffusion** which are elements that are implicit in the innovation and quantitatively measured ex post (Agarwal & Prasad, 1998), the three design choices shown in the **Model of CBDC Innovation** are elements explicit in the innovation selected from a finite set of options and devoid of a measurement function. In closing for this second contribution, the introduction of this new **Model of CBDC Innovation** results in a benefit to research and practice by articulating a critical aspect of innovations previously overlooked by expressing how an innovation is designed, thus complementing existing knowledge on the diffusion of an innovation.

Figure 28. Model of CBDC Innovation



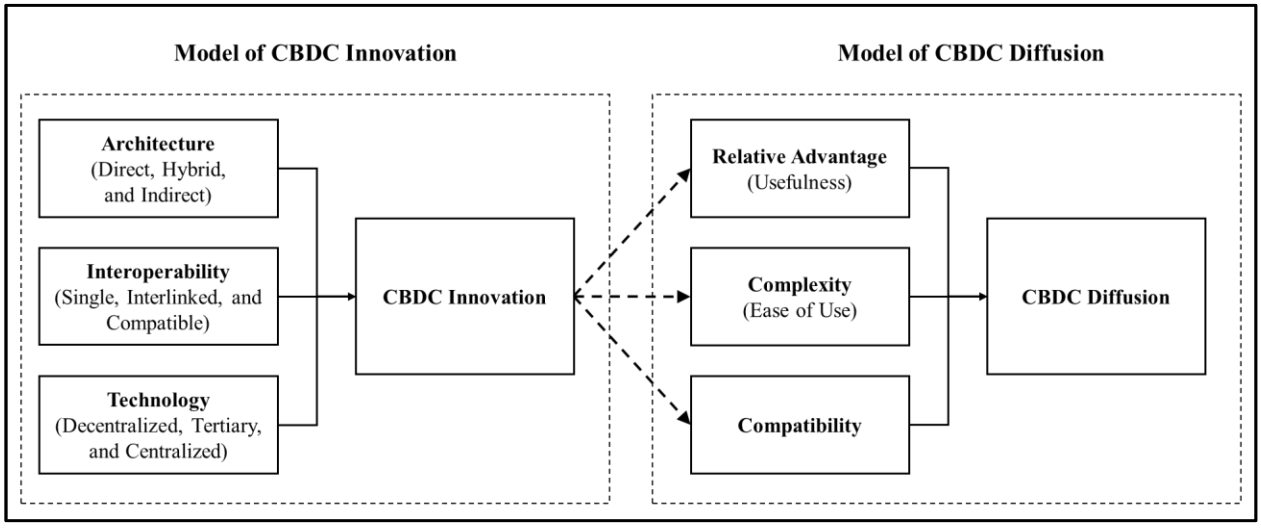
Source: Author

V.F. Combined Model of CBDC Diffusion and Innovation

Acknowledging the power of the **Model of CBDC Innovation** in articulating the design of the CBDC, its full potential is harnessed when combined with the **Model of CBDC Diffusion**

in a linear relationship as shown in ***Figure 29***. Importantly, the connection between the two models as depicted with dashed arrows represents the unidirectional relationship from the **Model of CBDC Innovation** to the **Model of CBDC Diffusion**. Jointly, the **Model of CBDC Diffusion** and the **Model of CBDC Innovation** provide a singular model available for use in practice and research to understand how a CBDC is designed, based on the design choices made, and the resulting variance to its diffusion within a specific market. Thus, this **Combined Model of CBDC Diffusion and Innovation** serves as the mechanism to answer the secondary research question of, *how do the design choices of Architecture, Interoperability, and Technology jointly affect CBDC diffusion?* In closing for this fourth contribution, the integration of the two newly introduced models – the **Model of CBDC Diffusion** and the **Model of CBDC Innovation** – their linear ordering, and the proposed relationships between them, adds to industry and theory by bridging both realms (i.e., boundary spanning) with an intellectual tool available to practitioners and scholars alike.

Figure 29. Combined Model of CBDC Diffusion and Innovation



Source: Author

VI. DISCUSSION

VI.A. Findings

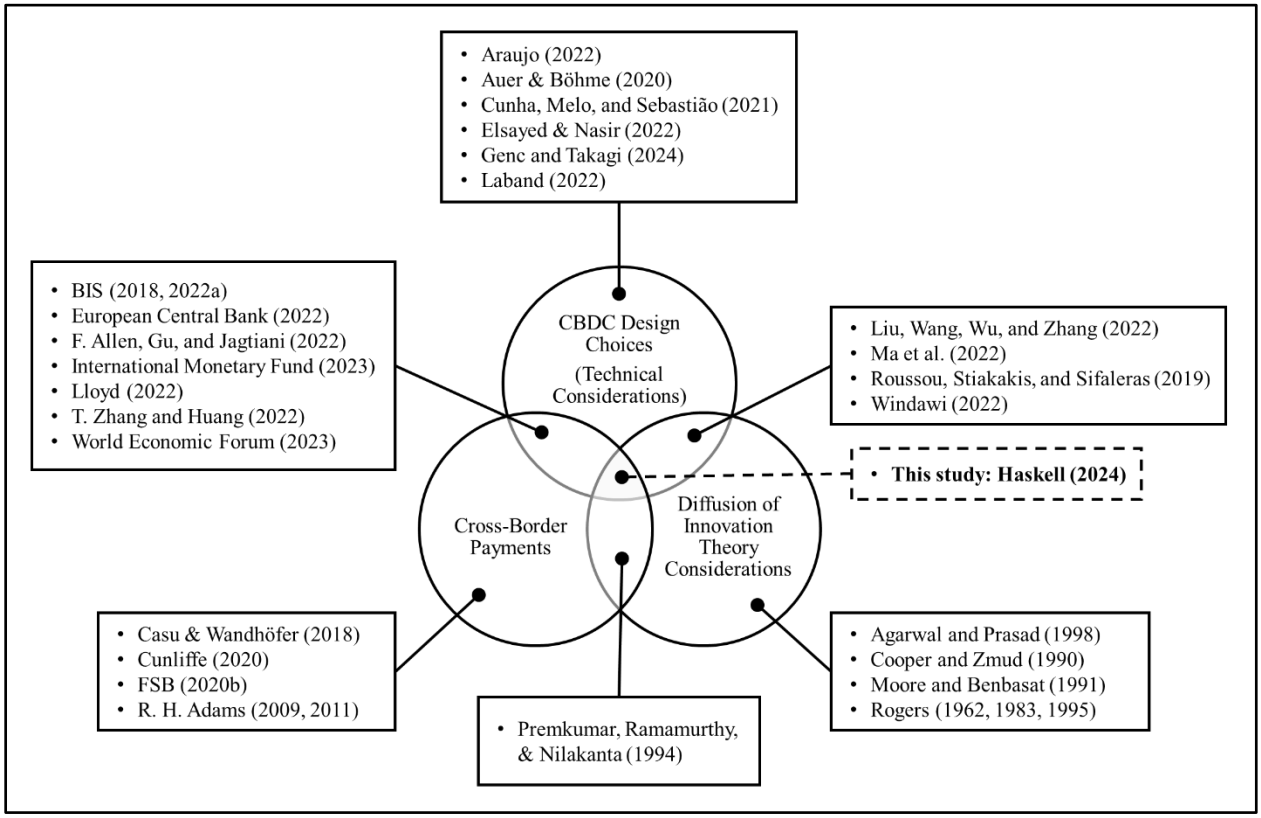
The MSLR and subsequent record analysis provided rigorous and relevant data across the three key areas of focus within this study, specifically (1) CBDC design choices (i.e., technical considerations of Architecture, Interoperability, and Technology), (2) cross-border payments, and (3) DOI theories and extensions. The data obtained was primarily sourced from white literature and unsurprisingly was more rigorous, while grey literature contributed less data, albeit more relevant. Noting that white literature is typically used for academic discourse, grey literature provides the content for said discourse, in which event there is a symbiotic relationship between the two data sources. Within this study in writing, both literature types were leveraged and were instrumental in the identification of contribution opportunities, and the subsequent contributions via the intellectual toolset. Specifically, the white literature was primarily utilized in developing and refining the research methodology via MSLR and theoretical precedent, both DOI and DOI adjacent theories, while the grey literature was leveraged for the research motivation and technical considerations. Accordingly, information was drawn from both literature types during the MSLR and data analysis that followed, providing the basis which subsequently led to the development and introduction of the concepts and corresponding contributions which serve as the output (i.e., synthesis) of the data analysis performed.

The three key areas of focus noted above are encapsulated in a three-set Venn diagram below as shown in ***Figure 30***, noting that each individual area of focus and intersections between all three instances of overlapping areas (i.e., three bi-areas) are supported with extant literature. Most critical to this study in writing is the lack of existing literature in the center of the diagram wherein the three areas of focus intersect (i.e., single tri-area), thereby presenting an opportunity

for practical and theoretical contributions by means of this study, tentatively designated as Haskell (2024). While the MSLR and ensuing literature analysis explained in section ***II. Research Methodology*** served as the mechanism to identify gaps within literature, more importantly, they informed the development of the intellectual tools as contributions within this study. Explained differently, the role of the methodology was to provide a model (i.e., input) of how to conduct literature analysis which led to the identification of the three domains and their collective intersection, with the result (i.e., output) being the four contributions which serve as the synthesis of these three domains and their intersection.

Also important to note is that the references within ***Figure 30*** are not exhaustive; rather, they serve as a representative subset of the full literature collection analyzed for visual display purposes. Additionally, the references within the figure consist of both white and grey literature, with a bias towards white documents in a similar ratio of 3:2 white to grey with the records included in this study as evidenced in ***Figure 1***. In response to this identified gap in literature, four contributions are proposed and serve as the synthesis of the literature analysis, with the intent to provide decision makers at Central Banks with a set of intellectual tools integrating theoretical and practical elements to aid in the CBDC design process, within the context of improving diffusion to support cross-border payments.

Figure 30. Multivocal Systematic Literature Review and Analysis



Source: Author

VI.B. Contributions

Revisiting the methodology of this research effort, a collection of relevant literature was sourced using the MSLR and analyzed to identify gaps and opportunities for contribution to practice and theory. Once identified, these gaps were remedied through conceptual development and a group of intellectual tools to be used in practice and research to advance the body of knowledge pertaining to CBDCs. This intellectual toolset is expressed with a collection of models, framework, and typology, resulting in instruments to frame CBDCs for the purposes of design and diffusion with respect to cross-border payments. Beginning with the design perspective, the **CBDC Design Framework** (***Figure 12***) introduced in section ***IV. Design of***

Central Bank Digital Currency provides a mechanism for CBDC representation based on the technical design choices of Architecture, Interoperability, and Technology, serving as a common point of reference for practitioners and researchers when discussing CBDC design. Complementing the **CBDC Design Framework** is the initial typology which serves as a classification mechanism to identify the technical design choice options selected for a given type and the associated benefits, limitations, ability to resolve each of the four undesirable characteristics of cross-border payments, and the expected result, beginning with three of the possible 27 unique combinations (i.e., CBDC types). The expectation is that Central Banks can leverage the **CBDC Design Framework** and typology to compile and classify each CBDC type and its associated properties, providing equal benefit to scholars with a foundation for comparison, aided by three types introduced as the catalyst for discussion (***Figure 13***).

Progressing to the diffusion perspective of framing CBDCs, two additional tools were introduced in section ***V. Diffusion of Central Bank Digital Currency*** – the **Model of CBDC Diffusion** (***Figure 27***) and **Model of CBDC Innovation** (***Figure 28***). The literature analysis uncovered an opportunity to explore the intersection of the DOI Theory and CBDCs as the innovation being diffused, in which the DOI theory was extended to identify the three most influential independent variables of Relative Advantage (Usefulness), Complexity (Ease of Use), and Compatibility with respect to CBDC diffusion. The **Model of CBDC Diffusion** is the output of said analysis and discovery, producing an instrument which can be used to measure the influence of each antecedent on the diffusion of a CBDC in the context of cross-border payments. The literature analysis also exposed an opportunity to explore an inverse perspective to the DOI Theory by expressing the innovation which is being diffused, the theoretical opposite to the diffusion of an innovation. In response to this theoretical opportunity unearthed, the **Model**

of CBDC Innovation is introduced, thereby building upon the DOI Theory, in the context of CBDCs, and harnessing the three technical design choices identified. Independently, these two models frame the diffusion of CBDCs; however, their full potential is realized when connected as expressed in the **Combined Model of CBDC Diffusion and Innovation** (***Figure 29***). These diffusion models (individually and collectively) provide practitioners and researchers with instruments that can be utilized with quantitative data to measure how the **Model of CBDC Innovation** influences the **Model of CBDC Diffusion** at a macro level and explore the relationships amongst the antecedents in both models at a micro level.

This intellectual toolset is introduced for the benefit of industry and theory in pursuit of remedying the practical and theoretical gaps identified during the literature analysis, with the acknowledgement that their feasibility and viability is dependent upon those in practice and research testing them in a quantitative or mixed-method exercise, termed stage five within section ***II. Research Methodology***. Recognizing that this research effort is primarily concerned with the introduction of these intellectual tools, the testing of these tools remains a crucial factor in establishing rigor and relevance to legitimize them as contributions to practice and theory. Noting that quantitative data is not yet available to test these tools, testing has instead taken place using qualitative data obtained through interviews with subject matter experts, specifically those who are the target audience for the toolset. The testing of the intellectual toolset for design and diffusion of CBDCs is explained in the following subsection.

VI.C. Interview Qualitative Data

Following the introduction of the models, framework, and typology above in response to address the identified gaps in literature, a series of semi-structured interviews was conducted to obtain feedback, interpretations, validity, and accuracy from relevant subject matter experts

(SMEs) with in-depth knowledge of, and experience with, CBDCs. The interviews yielded rich and colorful insights from these industry practitioners, aided by the semi-structured format which allowed for additional commentary and conversation to occur, thereby enhancing this study with unique perspectives not captured within a questionnaire. The interview questions, noted in ***Appendix C: Interview Questions***, were segmented into six sections as follows: (1) General Questions, (2) CBDC Basic Questions, (3) CBDC Publication Questions, (4) Study Proposed Model Questions, (5) Study Proposed Framework Questions, and (6) Closing Questions. The interviews were conducted via virtual meetings, recorded, and subsequently transcribed, the output of which is expressed in the following paragraphs and accompanied by direct quotes from those interviewed. Not all questions were asked of each SME given time limitations and to allow for uninterrupted responses and a steady flow of information from each individual interviewed.

VI.C.1. General Questions

The interviews began with general questions to better understand the qualifications of each SME interviewed, including their familiarity with CBDCs, how their current or past roles interact with CBDCs, their depth of knowledge pertaining to CBDCs, and their self-proclaimed level of subject matter expertise. The individuals interviewed represented multiple financial system participants including central banks and commercial banks; with roles spanning company executive, legal counsel, product manager; and located within the treasury department, public policy group, government affairs team, innovation department, and other areas within close proximity to CBDCs, specifically within the U.S. The length of SME engagement with CBDCs dates back to 2017, while experience in new payment systems and technologies includes multiple decades, with self-proclaimed scores on a 0-10 scale ranging from 7.5-10 and an average of 8.5 (0 – no knowledge of CBDCs, 10 – most knowledgeable with CBDCs), and active engagement

with CBDCs amongst all SMEs at the time of interview. Lastly, the type of subject matter pertaining to CBDCs the interviews represented included market research, meeting and sharing of information, coordination of legal coverage, strategy advocation and execution, participation in consortiums, and impact analysis measurement. Selected quotes from this first set of questions immediately follow within ***Table 7***.

Table 7. Selected Interview Quotes: Section 1 – General Questions

- *"…most of my career has been on the leading edge of where payments and technology come together going back to the 90s."*
- *"…my experience with digital cash, CBDCs, stable coins goes back to 2017."*
- *"So, the common denominator in my role is digital assets as applies to regulatory policy or advocacy roles."*
- *"I'll give myself and eight because I've thoroughly looked at the market structure impact and the monetary policy impacts to CBDCs, at least within the context of our business and generally within the institutional banking business at large."*
- *"I call myself a 10, maybe a nine…I consider myself the top of the heap."*
- *"…throughout that whole process, I've had a role in helping the bank analyze the important developments with CBDCs and helping to figure out with the various teams what it means or does not mean for the bank and their own development of products."*
- *"I struggle to think anyone is a pure SME on this topic today because the landscape continues to evolve. So, in the context of what exists today, I'm probably closer to an SME than not."*

VI.C.2. CBDC Basic Questions

Following the establishment of a baseline with each SME, the second section of the interview consisted of basic questions regarding CBDCs, specifically the familiarity with the concepts of adoption and diffusion by the SME, and their perception of non-technical and technical elements of CBDCs. Regarding the concepts of adoption and diffusion, the SMEs commonly gravitated towards the use cases of CBDCs, both within the U.S. and internationally, including China. Additionally, the insights provided by the SMEs span both perspectives – that of the Central Bank and the end-user – with the terms adoption and diffusion used interchangeably in some instances. Noting that this research effort in writing categorizes the plethora of CBDC elements into non-technical (e.g., policy, regulation, financial inclusion, etc.) and technical (e.g., Architecture, Interoperability, Technology, etc.), questions were asked of the SMEs as to which elements for both categories were considered. Privacy, anonymity, and compliance were common responses, notable as they were not explicitly referenced within the questions asked, raising a potential trail for future researchers to investigate further. The responses to the non-technical and technical considerations were bi-directional, in that they encompassed the perspectives of both the Central Bank and end-users, including consumers and businesses. ***Table 8*** provides a range of quotes in response to these basic questions spanning adoption, diffusion, non-technical, and technical considerations.

Table 8. Selected Interview Quotes: Section 2 – CBDC Basic Questions

- *"The question I always got was why would any individual want to use it, you know, so that's such an adoption question. But the other part of the equation is payments are two sided. So, we try to think, think about where does the bank think about a CBDC, what is a business."*
- *"…what are some of the non-traditional ways of thinking about why would a person want it?"*
- *"…if you pick on policy, for example, a lot of central banks appear to be struggling with what is the problem that a CBDC is actually solving and why would my people need this above and beyond payment solutions that they have already?"*
- *"We try to think about both sides of the equation and then not as much design considerations. We just didn't go that far. We weren't thinking about…all the features that would…create a demand for users."*
- *"I think those policy related questions are really the most important and difficult questions in the current environment. I see also financial inclusion and interest rate applications, accounting considerations, all being part of that nontechnical, I would say."*
- *"I think a lot of the fear mongering around retail CBDCs is one of the non-technical implications that you have to think about, especially from a diffusion perspective."*
- *"…it's the notion of privacy, the notion of anonymity and it's also how you get it into someone's wallet. We have a significant amount of underbanked in the U.S. If you don't have a mobile phone, how do you get access to a CBDC?"*

- *"I would say first and foremost the questions about is it a DLT or more specifically a blockchain based solution. Maybe another thing that comes to mind is the ability of a central bank to develop that technology and whether they need to leverage technological solutions from third parties to bring in house to able to actually roll out. And then finally, I think this might be technological, but the intermediate, like who are the players in the network, obviously issued by a central bank. Who are the participants of that network and if so, how do they get access to and the ability to become a participant in the network?"*
- *"Because most people would want either full anonymity or at least some privacy, but you still have to catch the bad guys, we think what does that mean relative to the data we kept in the transaction to what was exposed to intermediaries along the way?"*
- *"From a technical perspective, ERC [Ethereum Request for Comments] standards are key, interoperability is key."*

VI.C.3. CBDC Publication Questions

The third section of the interview consisted of questions pertaining to CBDC publications, with the intent to collect data from the SMEs interviewed as to the sources of information they consult and if there were any areas of literature currently lacking. Noting that this study in writing utilized literature from both traditionally rigorous literature databases containing journal articles (i.e., white literature) and less-rigorous literature including industry publications (i.e., grey literature), the perspectives of the SMEs were sought. Responses for these questions varied, spanning the spectrum from *"there's a lot of literature out there"* to reliance on *"experiments in the traditional financial markets."* Recognizing that CBDCs remain a nascent

field of study, multiple SMEs referenced the importance of keeping abreast with new developments, experiments, and use cases globally: *"we were following what was happening all over the world."* In keeping with the previous interview sections, selected responses are included in ***Table 9*** and provide greater insight into the perception of current literature availability and the use of existing projects globally as sources of relevant information on CBDCs.

Throughout this section of questions, two key themes emerged, further justifying this research effort. The first theme pertains to white literature, noting that no SME interviewed referenced academic or peer-reviewed journals or articles; rather, only grey literature (e.g., BIS reports) was accessed and used during the course of fulfilling their professional roles. One of the primary foci of this study in writing is to aid in bridging the divide between academia and industry through the marrying of theoretical and practical elements within a set of tools to be used by researchers and practitioners alike, hence the aforementioned models, framework, and typology. Bridging this divide, if not chasm, between rigor and relevance, is a topic of debate and problem worth addressing (Gulati, 2007), through which research efforts such as the one in writing are positioned to remedy. The second theme pertains to literature on CBDC technical elements as noted during the interviews – "*I think there's literature out there, but maybe not as relevant as the technical piece on what's needed more of*" – further increasing the importance of studies such as this to explicate technical design choices of CBDCs, beginning with the three in scope (i.e., Architecture, Interoperability, and Technology) and expanding outward to include other elements including encryption, processing and throughput rate, virtual machine compatibility, quantum computing implications, and the like. These two themes derived from the interviews warrant recognition and serve as foundations for future research efforts to build upon.

Table 9. Selected Interview Quotes: Section 3 – CBDC Publication Questions

- *"I think there's a lot of literature out there and maybe a little bit on the older side, starting with the technological, we use this type of system to conduct this type of transaction and we connected with another central bank in their own technological solution."*
- *"I think you've got to look into the open, permissionless world as well as experiments in the traditional financial markets…I look at all of the work being done by the open permissionless networks, particularly on Ethereum and the developers supporting that community."*
- *"I think there's a lot of different BIS specific reports about underlying technologies, et cetera. I think that's strong."*
- *"The technical consideration where I look for information, I looked for case studies where others have tried early and potentially come up short. It's great learnings for the industry."*
- *"I do think there's also literature out there on the policy points and use cases. However, I find that less convincing or maybe less necessary because when I think of CBDCs, it's really jurisdiction by jurisdiction analysis as to the need."*
- *"I think there's literature out there, but maybe not as relevant as the technical piece on what's needed more of, I think more work on the policy."*

VI.C.4. Study Proposed Model Questions

The fourth section of the interviews was concerned with obtaining feedback from these relevant SMEs on the three models proposed within this study: the **Model of CBDC Diffusion**,

the **Model of CBDC Innovation**, and the **Combined Model of CBDC Diffusion and Innovation**. The questions were open-ended (e.g., "What are your thoughts?") as to provide each SME with an unconstrained space to provide feedback on each model, and to challenge the appropriateness of the **Model of CBDC Innovation** by requesting the SMEs to identify which, if any, design choices (e.g., Architecture, Interoperability, and Technology) should be replaced. In continuing with the objective of spanning boundaries between theory and practice, SMEs were asked to provide insight as to how each model could be used by practitioners (e.g., decision-makers at a Central Bank). ***Table 10*** provides the rich data from SMEs in response to the proposed models in this study, confirming that the visual depiction, explanation, and purpose of each model was appropriate, with no other design choices identified as more appropriate.

Similar to the previous section, there were two sets of responses during this portion of the interview which warrant attention. The first was a question posed by the SME during their response of, *"I always ask, what did you throw away? If you started with not those top three of architecture and then on the bottom technology, I guess I would debate what was the fourth one you threw away and might I think that technology is not as important. I mean it fits; it fits there. I just want to debate what was also in the running and how did you think about that those three versus maybe number four?"* This response from the SME confirmed the appropriateness (i.e., fit) of the three technical design choices, while also expressing a desire to learn about what would have been the fourth. The SME was informed that the fourth technical design choice under consideration was the type of access, specifically token- or account-based access (Auer & Böhme, 2020), to which the SME responded, *"And I think you're right to eliminate it because I think also it's a red herring… I think it's better to not have included that for technology."*

The second response warranting attention was in regard to the **Combined Model of CBDC Diffusion and Innovation**, specifically the visual placement of the two individual models whereby the **Model of CBDC Innovation** precedes the **Model of CBDC Diffusion**. The SME noted, *"I actually think your diffusion point is where you start. The innovation is what creates that adoption, or, think of it this way, you essentially need to write out the problem statement first, then do a bunch of work that solves for the problem statement and then to the end consumer you bring back in that model of CBDC diffusion to actually drive execution of it. I think you need a little bit of a what are we solving for at the outset because that's what drives the innovation."* This alternative perspective posited by the SME is notable as the order of the two models was revisited on multiple occasions during their construction. Immediately following, the SME added, *"And so when you think about diffusion, yes, the choices you make…are going to be what ultimately drives that diffusion"*, thus also confirming the validity of the model. Additionally, the SME suggested additional independent variables acting as antecedents to the proposed models with the comment, *"But you also have to think about the cultural and practical aspects of the payment first before you make your architecture, interoperability, and technology choices. And after you've made those, you'll drive adoption or diffusion through hitting on those three key areas."* This comment aligns with the breadth of this research effort of which "cultural and practical" aspects are implicitly noted above as being out of scope (i.e., "excludes socioeconomic, political, country development stage, or other external factors"), while also confirming their interest by practitioners and adding credibility for future research efforts to investigate further.

Table 10. Selected Interview Quotes: Section 4 – Study Proposed Model Questions

- *"I think for the three that you've highlighted are the three that I would have picked. So, I'm in agreement with on each of the two slides you just showed."*
- *"I think interoperability is really important and technology goes back to the conversation we had before about…the underlying mechanics and design choices that you make to actually push it out."*
- [In response to the Combined Model] *"…it's definitely intuitive and it seems much, much more useful… this goes way beyond how we thought about it at first…it makes sense when you take what we did and try to think through it on a picture like this."*
- [In response to the Combined Model] *"I like this slide and whatever immediately pops in my mind is the choices that are gonna be made on the left-hand side, I agree are gonna influence, specifically things such as usefulness and ease of use."*
- *"I spent 30 years in payments and have talked to a lot of payments economists and trying to bridge the conversation between payments economists or regular economists and payments practitioners…many times, if not most of the times, the conversations broke down because the practitioner couldn't understand what the theorist was trying to say, the economist was trying to say, and the economist was talking in a different language."*
- *"I think the model you put forth around innovation versus diffusion is really helpful. I think this as a model for CBDCs could be super helpful and it also helps them think about how you balance that blockchain purism and innovation purism versus how you actually push that solution into the market and drive adoption for the benefit of the underlying citizens."*

VI.C.5. Study Proposed Framework Questions

Continuing from the models within the previous interview section, the fifth group of questions pertained to the **CBDC Design Framework**, initial CBDC design typology, and three CBDC types of **Basic**, **Intermediate**, and **Advanced** which are populated within the framework. While the models are tasked with providing researchers and practitioners with intuitive and logical tools to conceptualize how technical design choices of CBDCs influence its ultimate diffusion, the **CBDC Design Framework** is tasked with visually depicting the culmination of said design choices in a single, multi-variate figure. This framework then serves a dual purpose of acting as a potential foundation for practitioners at Central Banks around the world to view these technical design choices in a standard format, while also providing researchers with a tool that can be measured through quantifiable data as to the level of diffusion resulting from each distinct CBDC type (out of the possible 27 types). Accordingly, the questions in this section sought to obtain open-ended feedback as to the applicability and validity of the **CBDC Design Framework** and the initial typology with three types. Selected responses from the SMEs interviewed on this second set of tools are captured in ***Table 11***.

Within this interview section, the majority of time was spent discussing the typology and initial proposed types of **Basic**, **Intermediate**, and **Advanced**, during which the SMEs raised a number of questions in their responses regarding the levels of resolution to each of the four undesirable characteristics (e.g., speed, cost, transparency, and inclusion). Examples for this first feedback theme include the responses of, *"I think it's understandable that my questions immediately go to like 'how do you get to low, medium, high?' You know, what are the calculus there, and if every country built the CBDC but is done independently and is indirect and not*

great necessarily you know fragment your first model here" and *"I'm just trying to understand how you go from low to medium and high."* In response to this feedback, future iterations of the typology are recommended to include more data and detail as to the methodology for measuring the levels of undesirable characteristic resolution. The second theme emanating from this set of questions was regarding the feasibility of these types in practice, noting that the framework and typology reflect the synthesis of a complex set of considerations and conditions, not all of which are captured. This perspective was shared amongst the SMEs, noting, *"I think from a practitioner's point of view, there are concerns with the ability of many central banks to achieve a direct model and whether that could be from a technological point of view"* and *"Also, there's legal considerations that sometimes you hear about."* These comments give rise to the need for further investigation into which types are unachievable or illogical, as not all 27 types may be possible in practice.

Table 11. Selected Interview Quotes: Section 5 – Study Proposed Framework Questions

- *"I think from a practitioner's point of view, there are concerns with the ability of many central banks to achieve a direct model and whether that could be from a technological point of view…I think what you have here on paper is right from the benefits and kind of a little bit maybe more abstract, but I think there's practitioner concerns about the ability to actually execute on that from a direct model."*
- *"I don't disagree with the way you've ranked them. I think the ranking is accurate."*
- *"I know obviously at this stage it's theoretical and know you have no data to measure."*

- *"As you talk about it that way, it all makes perfect sense because I can see how CBDCs, even if they're not designed for the common structured framework and everything can still go faster…So I mean it's definitely making sense and now I'm understanding it's more of posit it and then debate it and try to figure out the margins, is it within the right bucket."*
- [In response to being asked if there are any gaps, information missing, flaws, or inaccuracies] *"Nope, not that I can think of."*
- *"I mean nothing jumps out as intuitively wrong… it seems to track with a lot of the major conversations in the major papers I've read and how I've thought about it as far as what are the more critical things to think about as you're doing."*
- *"The only thing I would change here is that I don't know that advanced is optimal and the reason why is pure decentralization takes time."*

VI.C.6. Closing Questions

This sixth and final section of the interview was devoted to reconfirming the accuracy and validity of the proposed tools (i.e., models, framework, and typology), additional questions to consider for future interviews, and inquiring into other relevant SMEs to contact for interview purposes. Regarding the SMEs, names and details were provided, which will not be included in this document for information security purposes, noting that the additional SMEs identified encompassed both the U.S. and international market, representing both practitioners and researchers within universities and industry consortiums. Regarding the accuracy and validity, noting that these questions were repetitive from earlier in sections four and five, the SMEs raised no new concerns, with only one response as captured in the first quote of ***Table 12***. Noting that

this was the final section of the interview and occurred just prior to the meeting concluding, the SMEs took the opportunity to provide additional insight as to the applicability of the tools for practitioners within industry, also captured in ***Table 12*** as quotes four and five. No new questions to consider for future interviews were identified by the SMEs.

Table 12. Selected Interview Quotes: Section 6 – Closing Questions

- *"Technically, all of this is absolutely correct, though I don't have anything to add."*
- [In response to being asked about the tools in general] *"I think they are very thought provoking, good."*
- *"I would just caution that a lot of the views on CBDCs as you look at this are based on cultural and role specific factors that you may want to footnote somewhere in here."*
- *"I think central banks, especially central banks like the Fed [U.S. Federal Reserve], ECB, of that magnitude have a very difficult task given the nature of their stakeholders and the volume of the stakeholders that would be interested in the CBDC product. I think something like this is a way for them to help take comments back from consultations, public forums, et cetera, and actually organize them in a useful decision-making way going forward. And it gives them the power to see the plethora of choices and have their own discussions about what they view as the key considerations and drivers for their own mandate, their purposes, et cetera. I think the way it's set up in the decision trees is a good way to filter and think through kind of these trigger points across all of them. And to the extent that you can get this in front of them, I think it'd be helpful, especially for the US, which seems to be struggling the most with the question."*

- *"I think it's a great place for central banks, especially those who are maybe not the most advanced central banks on earth to start as they think about this, some of the more advanced central banks are overly focused on, you know, some of the variables that you've held constant here like we talked about at the beginning of the conversation."*

VI.D. Limitations and Future Research Directions

A recurring theme of this research effort is the attention to note that the three choices within the **CBDC Design Framework** are limited and purposely exclude other known technical choices (e.g., account- or token-based systems) and all non-technical considerations (e.g., regulation, interest rates, policy implications, socioeconomic status, political climate and governance, country development stage, financial inclusion, etc.). The scope of this research effort also excludes inter-country and intra-country challenges which have the potential to influence CBDC designs and subsequent diffusion within one specific country and amongst multiple countries, thereby impacting many or all global financial system participants. Additionally, the initial CBDC design typology permutations (i.e., types) are intentionally limited to three of the possible 27 options in pursuit of publishing relevant materials to practitioners so they may begin utilizing this framework within industry, allowing future researchers to refine and mature all options as more quantifiable data becomes readily available.

Regarding future research, scholars and practitioners are encouraged to work together in utilizing the two models, framework, and typology proposed in this writing, as well as obtaining data – potentially through direct measurement of a live CBDC or using secondary data from one or many live CBDCs internationally – so that the tools proposed can be measured, validated, and

refined as appropriate. Optimal CBDC design choices can and likely will evolve as more Central Banks launch CBDCs and as both digitization and globalization further accelerate and permeate our society, introducing new forums and instances to continue exploration of which design choices will yield improved diffusion. The fate and success of CBDCs is still unknown, thus providing scholars and practitioners with unique opportunities to explore and explain this fundamental shift in how our world accesses, stores, and utilizes digital currencies. Accordingly, the aforementioned tools have been constructed and shared to aid in establishing a rigorous and relevant basis upon which global financial system participants can understand and use when coalescing to meet changing market demands as addressed by CBDCs.

VII. CONCLUSION

CBDCs offer a compelling alternative to existing, analog forms of currency, with the potential to solve for the challenges (i.e., undesirable characteristics) identified with cross-border payments of being slow, expensive, lacking transparency, and being exclusive to certain members of society. The extensive review of industry publications and peer-reviewed literature provides validation that the focus on this research effort from an industry perspective – CBDCs as a means to support cross-border transactions – has merit. Similarly, the comprehensive multivocal systematic literature review from a theoretical perspective focused on the Diffusion of Innovation theory and its direct and revised model iterations instills confidence that it has neither yet been adapted to represent the diffusion of CBDCs nor deconstructed and subsequently reconstructed to represent the design of the innovation itself being diffused. Therefore, the convergence of CBDC importance for cross-border payments and the opportunities afforded by extant literature to both build upon theory and create anew has culminated in four contributions to research and practice while also establishing a foundation for future researchers to build upon.

Following the MSLR and literature analysis, this research effort provides four contributions in the areas of Central Bank Digital Currencies and Diffusion of Innovation by means of a set of intellectual tools, specifically: (1) the **CBDC Design Framework** and typology for cross-border payments, a new classification structure, (2) the **Model of CBDC Diffusion**, an extension of existing DOI-related theories adapted for CBDCs, (3) the **Model of CBDC Innovation**, a novel model introduced to satisfy the extant literature gap of design choices that yield the innovation being diffused in the context of a CBDC, and (4) the integration of both diffusion and innovation models with the **Combined Model of CBDC Diffusion and Innovation** to unlock their full potential of addressing how design choices impact CBDC

diffusion. These tools have been further validated by industry subject matter experts, providing insights with qualitative data obtained via semi-structured interviews, noting that they are accurate with no notable flaws or omissions, can provide value to the intended practitioner audience (i.e., CBDC decision makers at Central Banks), and help to provide a starting point for global discussions to occur as CBDCs are being researched and developed.

Combined, the **Model of CBDC Diffusion** and the **Model of CBDC Innovation** bridge research and practice as expressed through the **CBDC Design Framework** with proposed typology, contributing to research and practice regarding design choices for CBDC diffusion in the context of cross-border payments, adhering to an explicit methodology in pursuit of ensuring rigor and relevance while spanning boundaries of theory and industry. These intellectual tools represent the synthesis of literature in peer-reviewed and industry publications and resolve gaps at the intersection of technical CBDC design choices, DOI Theory, and cross-border payments, thus providing rigorous and relevant contributions for researchers and practitioners alike. Through this extensive literature review pertaining to CBDCs, cross-border payments, and the Diffusion of Innovation Theory, combined with the creation of the **CBDC Design Framework**, the **Model of CBDC Diffusion**, and the **Model of CBDC Innovation**, this research effort addresses the questions of, *how can Central Banks improve CBDC diffusion?* and *how do the design choices of Architecture, Interoperability, and Technology jointly affect CBDC diffusion?*

Practitioners at Central Banks are encouraged to utilize this intellectual toolset in designing their CBDC both independently and in conjunction with other Central Banks as to implement a common reference which financial system participants can use for the benefit of mutual understanding and coalescence as CBDCs mature and proliferate. Installing these models, framework, and typology as the de facto foundation for how CBDCs are designed provides the

industry with a standard which can evolve and mature as analog currencies succumb to their digital replacements. In practice, Central Banks can identify their CBDC as one of the 27 types, utilizing the typology as a basis to compare the costs and benefits of the three technical design choices during the research and development phase, which can then be used to compare with CBDC types of other Central Banks to compare effectiveness in improving diffusion per market.

Researchers are equally encouraged to utilize this intellectual toolset to quantifiably measure the influence of CBDC design choices on diffusion and in pursuit of identifying how Central Banks can improve diffusion. Harnessing a common set of tools enables like-for-like comparisons amongst differing countries and regions supported by their respective Central Banks and CBDC offerings. These tools can later be expanded to incorporate additional technical and non-technical design choices, providing further extension of the DOI Theory and its application to CBDCs as an innovation. Ultimately, this intellectual toolset marries theory and practice, while combining rigor and relevance, providing researchers and practitioners with a common set of models, framework, and typology that can be leveraged today and further extended tomorrow in support of CBDC diffusion for the benefit of cross-border payments.

APPENDIX

Appendix A: Interview Research Protocol

Title: Central Bank Digital Currency Diffusion: Design Choices for Cross-Border Payments

Principal Investigator: Qian (Cecilia) Gu, PhD

Student Principal Investigator: Andrew Haskell

I. Summary of Study

The world in which we exist is undergoing a period of change whereby analog structures are yielding to their electronic successors, referred to as digitization. This change envelops much of our society, including the currency we use to transact, as it lacks the immunity to resist this evolution underway. In response, Central Banks around the globe are exploring digital versions of currency – known as Central Bank Digital Currencies (CBDCs) – with many in the research and development stage, and some which have launched and are live in production. In parallel, our world is also undergoing change through globalization as commerce and communications span international boundaries to bring people and organizations closer together. To effectively operate in this rapidly changing market, financial system participants are seeking improvements for orchestrating cross-border payments which currently suffer from being slow, expensive, lacking transparency, and are often exclusive.

As these two dynamics of digitization and globalization converge, CBDCs are positioned to provide cross-border transaction solutions that are faster, cheaper, more transparent, and more inclusive, thus remedying existing limitations insofar as Central Banks appropriately make optimal decisions during the design process. These CBDC design choices include Architecture, Interoperability, and Technology, all of which contribute to the success of currency adoption. However, failure through limited adoption is expensive, time-consuming, and reputationally detrimental to a Central Bank, warranting careful consideration of these CBDC design choices. In response, this challenge presents an opportunity to contribute to practitioners by leveraging theory and proposing a design framework.

This study builds upon and extends the Diffusion of Innovation Theory (Rogers, 1962) by adapting the model to CBDC diffusion while introducing a complementary model expressing how CBDCs as an innovation being diffused are designed. These theoretical additions follow a multivocal systematic literature review (investigating both white [i.e., peer-reviewed journal articles] and grey [i.e., industry consortium reports] literature) to provide scholars with a new foundation for future research. The result is a set of tools – the Model of CBDC Diffusion, the Model of CBDC Innovation, the CBDC Design Framework, and associated typologies – to aid Central Banks as they consider their design choices in the pursuit of improving CBDC diffusion for Cross-border payments. In order to validate the applicability and appropriateness of the

proposed models, framework, and typologies, qualitative data will be obtained via semi-structured interviews with subject matter experts on CBDCs.

II. Involvement of Human Subjects

The primary source of data for this research is a multivocal systematic literature review pertaining to the two key pillars of Theoretical Considerations and Technical Considerations. Theoretical Considerations include an exploration into peer-reviewed journal articles (i.e., white literature) on theories pertaining to adoption (e.g., Technology Acceptance Model [TAM], Theory of Reasoned Action [TRA], and Theory of Planned Behavior [TPB]) and diffusion (e.g., Diffusion of Innovations Theory [DOI] and its many extensions). Technical Considerations include an exploration into peer-reviewed journal articles (i.e., white literature) and industry reports (i.e., grey literature) on CBDCs and the technical elements which serve as design choices for decision makers at Central Banks.

To augment the aforementioned literature review (both of white and grey literature), opinions and commentary from subject matter experts will be obtained through interviews to understand their feedback on the study's proposed models, framework, and typologies. Interviews are not expected to subject participants to duress and will be conducted via Microsoft Teams. Interviews will be recorded and transcribed as conveyed in the Informed Consent form provided to the participant prior to the interview. Interviews will be recorded to be transcribed and analyzed using NVivo software.

III. Description

1. **Rationale:** We seek to investigate how the design choices pertaining to technical elements of CBDCs ultimately influence the diffusion of a CBDC within a specific country. Noting that CBDCs are in their infancy and publicly accessible quantitative data is lacking, this study proposes a combination of models and framework (with associated typologies) that future research efforts can leverage.
2. **Objectives:** The goal of our study is to propose two models: the first being an extension of Rogers' Diffusion of Innovation theory variance model specifically tailored for *CBDC Diffusion*, and the second which incorporates the three technical design choices available to Central Banks as to yield a model of *CBDC Innovation*. Encapsulating these two models is a framework which Central Banks can consider when designing their own CBDC, with typologies to guide them in making decisions. The collection of these two models, framework, and typologies will contribute to research and industry alike.
3. **Methodology (Literature Review):** The multivocal systematic literature review follows the principles of a systematic literature review (Kitchenham, 2004; Kitchenham & Charters, 2007; Webster & Watson, 2002) and conducted utilizing the Web of Science database available through the Georgia State University Library. The literature review is

then extended to include grey literature, thus becoming a multivocal literature review (Butijn, Tamburri, & Heuvel, 2020; Fedorova & Skobleva, 2020) and includes practitioner published literature such as industry consortium reports (R. J. Adams et al., 2017; Giustini, 2019). Augmenting the literature review is a series of interviews with subject matter experts in the field of CBDCs.

4. **Methodology (Interviews):** Interview participants are subject matter experts with knowledge in CBDCs or working directly or indirectly on a CBDC project. The subject matter experts will be interviewed according to a semi-structured interview protocol. The interviews will be conducted virtually through online video using Microsoft Teams. Responses to the interview questions will be recorded and will remain confidential. As a backup, a separate recording device will also be used in case of audio recording. Opportunities exist within the interview protocol to allow more natural conversation and to explore areas that are more salient to subjects for richer data.

5. **Analysis:** Recorded audio will be transcribed using Microsoft Office transcription services. The transcription will then be cleaned up and verified manually by the researchers. The cleaned transcription will then be imported into the NVivo software application for analysis.

6. **Data Management:** All data will be stored on Georgia State University's instance of Microsoft Teams. Access to Teams is available to only the researchers of this study. Participants will be assigned a unique identifier (i.e., pseudonym) for anonymity. A participant-identifier mapping document will be maintained and stored separately from the data and will be password protected. The researchers' individual machines are password-protected. The data will be kept for two years and destroyed afterward.

IV. Ethical Considerations

Participants are free to decline the interview. Participants are also informed that they may stop the interview at any time for any reason. While we will record the interviews for transcription and analysis, we will take steps to ensure anonymity in the final research paper. No conflict of interest has been identified or reported as related to this study.

V. References

Adams, R. J., Smart, P., & Huff, A. S. (2017). Shades of grey: guidelines for working with the grey literature in systematic reviews for management and organizational studies. International Journal of Management Reviews, 19(4), 432-454.

Butijn, B.-J., Tamburri, D. A., & Heuvel, W.-J. v. d. (2020). Blockchains: a systematic multivocal literature review. ACM Computing Surveys (CSUR), 53(3), 1-37.

Fedorova, E. P., & Skobleva, E. I. (2020). Application of blockchain technology in higher education. European Journal of Contemporary Education, 9(3), 552-571.

Giustini, D. (2019). Retrieving grey literature, information, and data in the digital age. In The handbook of research synthesis and meta-analysis (pp. 101-126).

Kitchenham, B. (2004). Procedures for performing systematic reviews. Keele, UK, Keele University, 33(2004), 1-26.

Kitchenham, B., & Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering. Retrieved from

Rogers, E. M. (1962). Diffusion of Innovations (1 ed.). 60 Fifth Avenue, New York 11, N. Y.: The Free Press of Glencoe Division of The Macmillan Co.

Webster, J., & Watson, R. T. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. MIS quarterly, 26(2), xiii-xxiii. Retrieved from http://www.jstor.org/stable/4132319

Appendix B: Interview Informed Consent Form

Georgia State University

Informed Consent

Title: Central Bank Digital Currency Diffusion: Design Choices for Cross-Border Payments

Principal Investigator: Qian (Cecilia) Gu, PhD

Student Principal Investigator: Andrew Haskell

Procedures

You are being asked to take part in a research study. If you decide to take part, you will be interviewed and asked a few questions regarding your professional experience regarding Central Bank Digital Currencies (CBDCs). We will also request your feedback regarding the study's proposed contributions (e.g., models and framework). The Student Principal Investigator will conduct the interview, with the Principal Investigator observing and asking questions as needed. We will conduct the interview once through virtual video conferencing software. The interview will be recorded and transcribed. Please feel free to elaborate on any of the questions. We will finish in approximately one hour.

Voluntary Participation and Withdrawal

You do not have to be in this study. You may skip questions or stop participating at any time.

Contact Information

Contact Andrew Haskell (Student Principal Investigator) at [REDACTED] or ahaskell1@student.gsu.edu; or, contact Dr. Cecilia Gu (Principal Investigator) at [REDACTED] or qgu@gsu.edu.

Consent

You can print or save a copy of this form for your records.

If you agree to participate in this research, please continue with the interview.

Appendix C: Interview Questions

Georgia State University

Interview Questions

Title: Central Bank Digital Currency Diffusion: Design Choices for Cross-Border Payments

Principal Investigator: Qian (Cecilia) Gu, PhD

Student Principal Investigator: Andrew Haskell

Remind the participant that they are being interviewed in accordance with the previously provided Informed Consent form and confirm they have received a copy of the form.

General Questions

1. What is your current role?
2. How long have you held this position?
3. More broadly, what do you consider your profession to be?
4. Are you familiar with Central Bank Digital Currencies (CBDCs), and if so, to what extent?
5. On a scale of 0-10, with 10 being the most knowledgeable on CBDCs and 0 being the least knowledgeable, what number would you give yourself?
6. Do you believe you are a Subject Matter Expert on CBDCs and if so, why?
7. How does your current role interact with CBDCs?
8. How have your prior roles interacted with CBDCs?

CBDC Basic Questions

9. How would you describe the difference between adoption and diffusion?
10. What are the primary non-technical elements of CBDCs (e.g., policy, regulation, etc.) you consider when thinking about diffusion?

11. What are the primary technical elements of CBDCs (e.g., architecture, technology, etc.) you consider when thinking about diffusion?

CBDC Publication Questions

12. What resources are available to you with respect to the non-technical elements of CBDCs?
13. Which resources do you rely upon with respect to technical elements of CBDCs and why?
14. How would you describe the state of published relevant and rigorous information pertaining to the technical elements of CBDCs?
15. Which area of CBDC published information is most lacking, and why?

Study Proposed Model Questions

16. Have you had an opportunity to review the **Model of CBDC Diffusion** (Contribution One) and if so, what are your thoughts?
17. Specifically, how can this model be utilized by a practitioner (e.g., Decision-Maker at a Central Bank)?
18. Have you had an opportunity to review the **Model of CBDC Innovation** (Contribution Two) and if so, what are your thoughts?
19. Specifically, how can this model be utilized by a practitioner (e.g., Decision-Maker at a Central Bank)?
20. What technical design choices would be more appropriate for this Model of CBDC Innovation?
21. Have you had an opportunity to review the **Combined Model of CBDC Diffusion and Innovation** (Contribution Three) and if so, what are your thoughts?
22. Specifically, how can this model be utilized by a practitioner (e.g., Decision-Maker at a Central Bank)?

Study Proposed Framework Questions

23. Have you had an opportunity to review **the CBDC Design Framework and Typologies for Cross-Border Payments** (Contribution Four) and if so, what are your thoughts?
24. Specifically, how can this framework be utilized by a practitioner (e.g., Decision-Maker at a Central Bank)?
25. Similarly, how can the typologies be utilized by a practitioner (e.g., Decision-Maker at a Central Bank)?

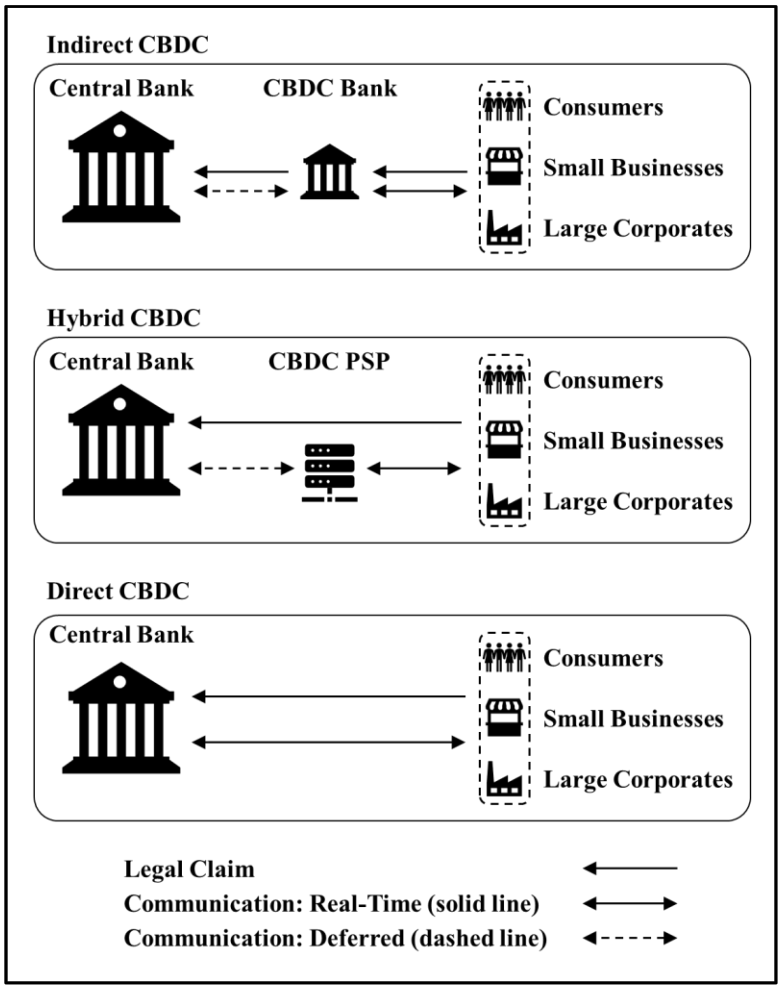
Closing Questions

26. What gaps exist or information is missing from the proposed models, framework, and typology?
27. What flaws or inaccuracies exist in the proposed models, framework, and typology?
28. What questions do you believe should have been asked during this interview and were not?
29. Are there other subject matter experts such as yourself within the U.S. that you would recommend be interviewed, and if so, who and can you please provide their contact information?

Thank the participant for their time, stop the recording, and close the meeting.

Appendix D: CBDC Architecture Options

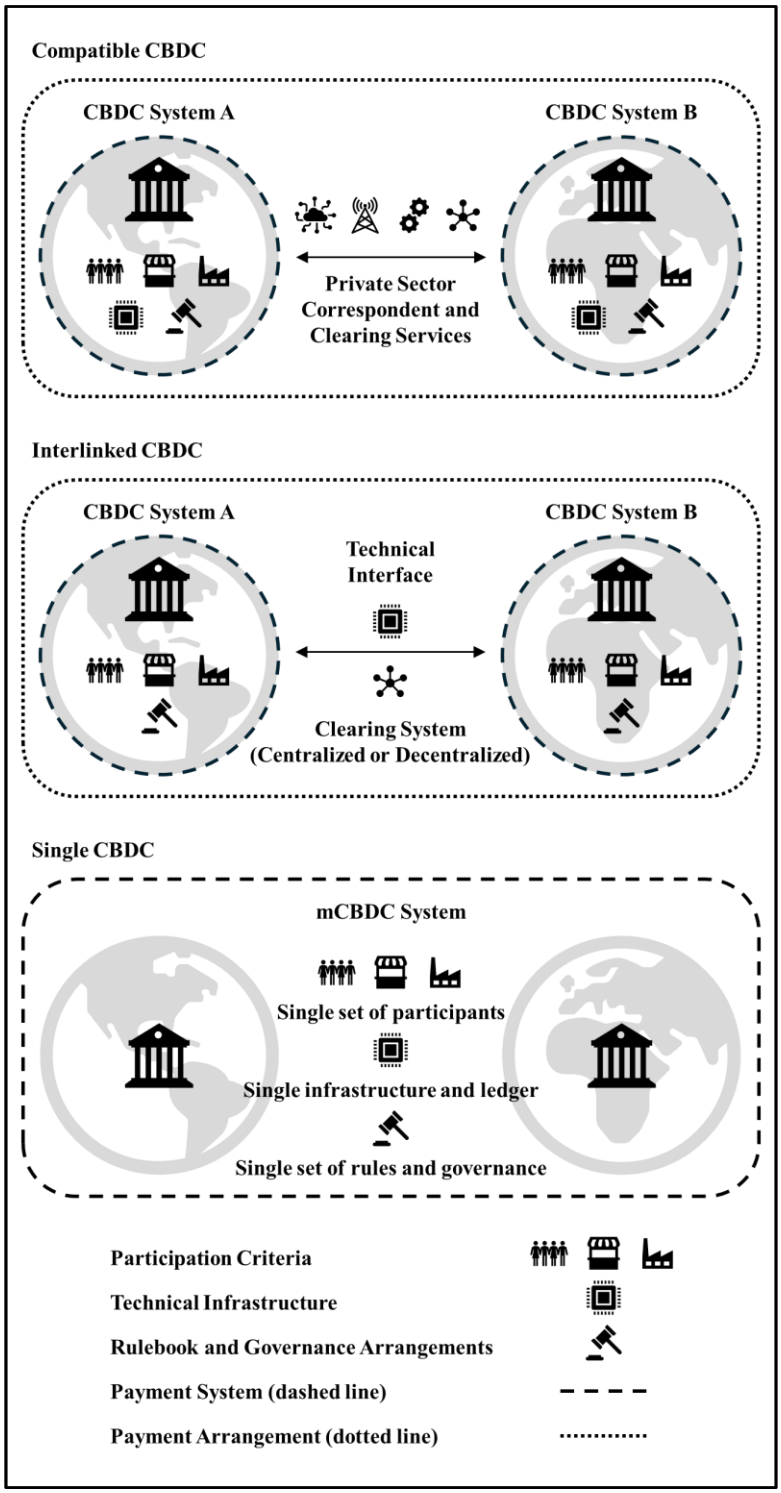
Figure 31. CBDC Architecture Options – All



Source: Adapted from Auer and Böhme (2020)

Appendix E: CBDC Interoperability Options

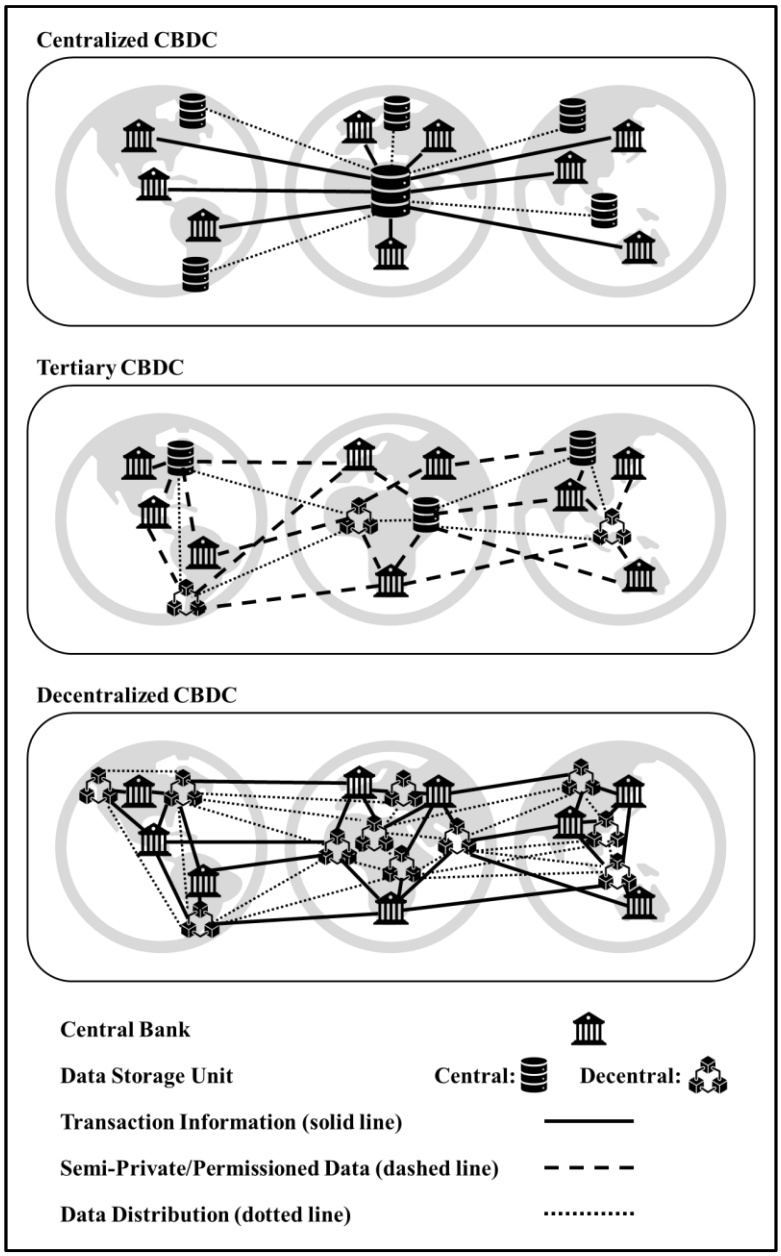
Figure 32. CBDC Interoperability Options – All



Source: Adapted from Auer et al. (2021)

Appendix F: CBDC Technology Options

Figure 33. CBDC Technology Options – All



Source: Author

REFERENCES

Aboelmaged, M., & Gebba, T. R. (2013). Mobile banking adoption: an examination of technology acceptance model and theory of planned behavior. *International journal of business research and development, 2*(1).

Adams, R. H. (2009). The Determinants of International Remittances in Developing Countries. *World Development, 37*(1), 93-103. doi:https://doi.org/10.1016/j.worlddev.2007.11.007

Adams, R. H. (2011). Evaluating the Economic Impact of International Remittances On Developing Countries Using Household Surveys: A Literature Review. *The Journal of Development Studies, 47*(6), 809-828. doi:10.1080/00220388.2011.563299

Adams, R. J., Smart, P., & Huff, A. S. (2017). Shades of Grey: Guidelines for Working with the Grey Literature in Systematic Reviews for Management and Organizational Studies. *International Journal of Management Reviews, 19*(4), 432-454. doi:https://doi.org/10.1111/ijmr.12102

Agarwal, R., & Prasad, J. (1998). A Conceptual and Operational Definition of Personal Innovativeness in the Domain of Information Technology. *Information Systems Research, 9*(2), 204-215. doi:10.1287/isre.9.2.204

Agur, I., Ari, A., & Dell'Ariccia, G. (2021). Designing central bank digital currencies. *Journal of Monetary Economics*. doi:https://doi.org/10.1016/j.jmoneco.2021.05.002

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In *Action control: From cognition to behavior* (pp. 11-39): Springer.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211. doi:https://doi.org/10.1016/0749-5978(91)90020-T

Ajzen, I., & Fishbein, M. (1973). Attitudinal and normative variables as predictors of specific behavior. *Journal of personality and social psychology, 27*(1), 41-57. doi:10.1037/h0034440

Al-Rodhan, N. R., & Stoudmann, G. (2006). Definitions of globalization: A comprehensive overview and a proposed definition. *Program on the geopolitical implications of globalization and transnational security, 6*(1-21).

Ali, M., Syed Ali, R., Chin Hong, P., & Amin, H. (2019). Consumer acceptance toward takaful in Pakistan: An application of diffusion of innovation theory. [Consumer acceptance toward takaful]. *International Journal of Emerging Markets, 14*(4), 620-638. doi:https://doi.org/10.1108/IJOEM-08-2017-0275

Ali, R., Barrdear, J., Clews, R., & Southgate, J. (2014). The Economics of Digital Currencies. *Bank of England Quarterly Bulletin, 54*(3), 276-286. Retrieved from https://EconPapers.repec.org/RePEc:boe:qbullt:0148

Allen, F., Gu, X., & Jagtiani, J. (2022). Fintech, Cryptocurrencies, and CBDC: Financial Structural Transformation in China. *Journal of International Money and Finance, 124*, 102625. doi:https://doi.org/10.1016/j.jimonfin.2022.102625

Allen, S., Čapkun, S., Eyal, I., Fanti, G., Ford, B. A., Grimmelmann, J., . . . Zhang, F. (2020). Design Choices for Central Bank Digital Currency: Policy and Technical Considerations. *National Bureau of Economic Research Working Paper Series, No. 27634*. doi:10.3386/w27634

Ante, L., Fiedler, I., & Strehle, E. (2021). The influence of stablecoin issuances on cryptocurrency markets. *Finance Research Letters, 41*, 101867. doi:https://doi.org/10.1016/j.frl.2020.101867

Araujo, F. (2022). *Initial steps towards a central bank digital currency by the Central Bank of Brazil*. Retrieved from https://www.bis.org/publ/bppdf/bispap123_c.pdf

Auer, R., & Böhme, R. (2020). *The technology of retail central bank digital currency*. Retrieved from https://www.bis.org/publ/qtrpdf/r_qt2003j.htm

Auer, R., Cornelli, G., & Frost, J. (2020). *Rise of the central bank digital currencies: drivers, approaches and technologies*. Retrieved from https://www.bis.org/publ/work880.htm

Auer, R., Frost, J., Gambacorta, L., Monnet, C., Rice, T., & Shin, H. S. (2022). Central Bank Digital Currencies: Motives, Economic Implications, and the Research Frontier. *Annual Review of Economics, 14*(1), 697-721. doi:10.1146/annurev-economics-051420-020324

Auer, R., Haene, P., & Holden, H. (2021). *Multi-CBDC arrangements and the future of cross-border payments*. Retrieved from https://www.bis.org/publ/bppdf/bispap115.htm

Balvers, R. J., & McDonald, B. (2021). Designing a global digital currency. *Journal of International Money and Finance, 111*, 102317. doi:https://doi.org/10.1016/j.jimonfin.2020.102317

Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*: Prentice-Hall.

Bank of England. (2022). *Annual Report and Accounts 1 March 2021 to 28 February 2022*. Retrieved from https://www.bankofengland.co.uk/-/media/boe/files/annual-report/2022/boe-2022.pdf

Bech, M. L., Faruqui, U., & Shirakami, T. (2020). Payments without borders. *BIS Quarterly Review, March*.

Belke, A., & Beretta, E. (2020). From cash to central bank digital currencies and cryptocurrencies: a balancing act between modernity and monetary stability. [Digital

currencies and cryptocurrencies]. *Journal of Economic Studies, 47*(4), 911-938. doi:https://doi.org/10.1108/JES-07-2019-0311

Ben Dhaou, S. I., & Rohman, I. K. (2018). *Everything and its opposite: Socio-economic implications of Blockchain technology: Case of monetary policy.* Paper presented at the Proceedings of the 11th International Conference on Theory and Practice of Electronic Governance.

Bhaskar, R., Hunjra, A. I., Bansal, S., & Pandey, D. K. (2022). Central Bank Digital Currencies: Agendas for future research. *Research in International Business and Finance, 62*, 101737. doi:https://doi.org/10.1016/j.ribaf.2022.101737

Bindseil, U. (2019). Central Bank Digital Currency: Financial System Implications and Control. *International Journal of Political Economy, 48*(4), 303-335. doi:10.1080/08911916.2019.1693160

BIS. (2018). *Markets Committee: Central bank digital currencies* (174). Retrieved from CPMI Publications: https://www.bis.org/cpmi/publ/d174.htm

BIS. (2020). *Central bank digital currencies: foundational principles and core features*. Retrieved from https://www.bis.org/publ/othp33.htm

BIS. (2022a). *Options for Access to and Interoperability of CBDCs for Cross-Border Payments*. Retrieved from https://www.bis.org/publ/othp52.pdf

BIS. (2022b). *Project Dunbar - International settlements using multi-CBDCs*. Retrieved from https://www.bis.org/publ/othp47.htm

BIS. (2023). Central bank digital currencies – Executive Summary [Press release]. Retrieved from https://www.bis.org/fsi/fsisummaries/cbdcs.pdf

Boar, C., Claessens, S., Kosse, A., Leckow, R., & Rice, T. (2021). *Interoperability between payment systems across borders*. Retrieved from https://www.bis.org/publ/bisbull49.pdf

Board of Governors. (2012). *99th Annual Report of the Board of Governors of the Federal Reserve System*. Retrieved from Washington, DC 20551: https://www.federalreserve.gov/publications/annual-report/files/2012-annual-report.pdf

Board of Governors. (2022). *109th Annual Report of the Board of Governors of the Federal Reserve System*. Retrieved from Washington, DC 20551: https://www.federalreserve.gov/publications/files/2022-annual-report.pdf

Butijn, B.-J., Tamburri, D. A., & Heuvel, W.-J. v. d. (2020). Blockchains: a systematic multivocal literature review. *ACM Computing Surveys (CSUR), 53*(3), 1-37.

Carstens, A. (2021). Central bank digital currencies: putting a big idea into practice [Press release]. Retrieved from https://www.bis.org/speeches/sp210331.htm

Casu, B., & Wandhöfer, R. (2018). *The future of correspondent banking cross border payments*. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3261168

Cheah, E.-T., & Fry, J. (2015). Speculative bubbles in Bitcoin markets? An empirical investigation into the fundamental value of Bitcoin. *Economics Letters, 130*, 32-36. doi:https://doi.org/10.1016/j.econlet.2015.02.029

Compeau, D. R., & Higgins, C. A. (1995). Computer Self-Efficacy: Development of a Measure and Initial Test. *MIS quarterly, 19*(2), 189-211. doi:10.2307/249688

Cooper, R. B., & Zmud, R. W. (1990). Information Technology Implementation Research: A Technological Diffusion Approach. *Management Science, 36*(2), 123.

CPMI. (2020). *Stage 2 Report to the G20: Enhancing Cross-border Payments - Technical Background Report, Building Blocks of a Global Roadmap*. Retrieved from https://www.bis.org/cpmi/publ/d194.pdf

Cunha, P. R., Melo, P., & Sebastião, H. (2021). From Bitcoin to Central Bank Digital Currencies: Making Sense of the Digital Money Revolution. *Future Internet, 13*(7), 165. Retrieved from https://www.mdpi.com/1999-5903/13/7/165

Cunliffe, S. J. (2020, April 6). Cross-border payment systems have been neglected for too long. *Financial Times*. Retrieved from https://www.ft.com/content/a241d7e0-e1de-4812-b214-b350cbb7d046

Davis, F. D. (1986). *A technology acceptance model for empirically testing new end-user information systems: Theory and results.* Massachusetts Institute of Technology,

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science, 35*(8), 982-1003. doi:10.1287/mnsc.35.8.982

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1992). Extrinsic and intrinsic motivation to use computers in the workplace. *Journal of Applied Social Psychology, 22*(14), 1111-1132.

Davoodalhosseini, S. M. (2022). Central bank digital currency and monetary policy. *Journal of Economic Dynamics and Control, 142*, 104150. doi:https://doi.org/10.1016/j.jedc.2021.104150

Deloitte. (2020). *Are central banks digital currencies (CBDCs) the money of tomorrow?* Retrieved from https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/financial-services/Banking/lu-are-central-bank-digital-currencies.pdf

Dulany, D. E. (1968). Awareness, rules, and propositional control: A confrontation with SR behavior theory. In T. Dixon & D. Horton (Eds.), *Verbal Behavior and General Behavior Theory* (pp. 340--387): Prentice-Hall.

Eder, L. B., & Igbaria, M. (2001). Determinants of intranet diffusion and infusion. *Omega, 29*(3), 233-242. doi:https://doi.org/10.1016/S0305-0483(00)00044-X

Elsayed, A. H., & Nasir, M. A. (2022). Central bank digital currencies: An agenda for future research. *Research in International Business and Finance, 62*, 101736. doi:https://doi.org/10.1016/j.ribaf.2022.101736

European Central Bank. (2022). *Towards the holy grail of cross-border payments*. Retrieved from 60640 Frankfurt am Main, Germany: https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2693~8d4e580438.en.pdf

Fantacci, L., & Gobbi, L. (2021). Stablecoins, Central Bank Digital Currencies and US Dollar Hegemony. *The Geopolitical Stake of Innovations in Money and Payments*(20200053). doi:doi:10.1515/ael-2020-0053

Fedorova, E. P., & Skobleva, E. I. (2020). Application of blockchain technology in higher education. *European Journal of Contemporary Education, 9*(3), 552-571.

Fernández-Villaverde, J., Sanches, D., Schilling, L., & Uhlig, H. (2021). Central bank digital currency: Central banking for all? *Review of Economic Dynamics, 41*, 225-242. doi:https://doi.org/10.1016/j.red.2020.12.004

Fishbein, M. (1967). Attitude and the prediction of behavior. *Readings in attitude theory and measurement, New York: John Wiley*, 477–492.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behaviour: An introduction to theory and research* (Vol. 27): Boston: Addison-Wesley.

Fletcher, E., Larkin, C., & Corbet, S. (2021). Countering money laundering and terrorist financing: A case for bitcoin regulation. *Research in International Business and Finance, 56*, 101387. doi:https://doi.org/10.1016/j.ribaf.2021.101387

FSB. (2020a). *Stage 1 Report to the G20: Enhancing Cross-border Payments*. Retrieved from https://www.fsb.org/wp-content/uploads/P090420-1.pdf

FSB. (2020b). *Stage 3 Roadmap to the G20: Enhancing Cross-border Payments*. Retrieved from https://www.fsb.org/wp-content/uploads/P131020-1.pdf

Garner, J. (1930). International Convention for the Repression of Counterfeiting. *American Journal of International Law, 24*(1), 135-139.

Geismar, H. N., Sriskandarajah, C., & Zhu, Y. (2017). A Review of Operational Issues in Managing Physical Currency Supply Chains. *Production and Operations Management, 26*(6), 976-996. doi:https://doi.org/10.1111/poms.12593

Genc, H. O., & Takagi, S. (2024). A literature review on the design and implementation of central bank digital currencies. *International Journal of Economic Policy Studies, 18*(1), 197-225. doi:10.1007/s42495-023-00125-9

Giustini, D. (2019). Retrieving grey literature, information, and data in the digital age. In *The handbook of research synthesis and meta-analysis* (pp. 101-126).

Gomis-Porqueras, P., Kam, T., & Waller, C. (2017). Nominal Exchange Rate Determinacy under the Threat of Currency Counterfeiting. *American Economic Journal: Macroeconomics, 9*(2), 256-273. doi:10.1257/mac.20150172

Goodell, G., Al-Nakib, H. D., & Tasca, P. (2021). A Digital Currency Architecture for Privacy and Owner-Custodianship. *Future Internet, 13*(5), 130. doi:https://doi.org/10.3390/fi13050130

Gulati, R. (2007). Tent Poles, Tribalism, and Boundary Spanning: The Rigor-Relevance Debate in Management Research. *The Academy of Management Journal, 50*(4), 775-782. Retrieved from http://www.jstor.org/stable/20159889

Guo, S., Kreitem, J., & Moser, T. (2024). DLT Options for CBDC. *Journal of Central Banking Theory and Practice, 13*(1), 57-88. doi:doi:10.2478/jcbtp-2024-0004

He, D. (2021). Digitalization of cross-border payments. *China Economic Journal, 14*(1), 26-38. doi:10.1080/17538963.2020.1870272

Icon Solutions. (2019). *Central banks and distributed ledger technology: can distributed ledger technologies (DLT) be the basis for a revolution in cross-border payments?* Retrieved from https://iconsolutions.com/wp-content/uploads/2019/07/WPGB50-Central-Bank-Digital-Currency-Report-1.pdf

International Monetary Fund. (2023). *How Should Central Banks Explore Central Bank Digital Currency? A Dynamic Decision-Making Framework*. Retrieved from Washington, DC: https://www.imf.org/-/media/Files/Publications/FTN063/2023/English/FTNEA2023008.ashx

Jin, S. Y., & Xia, Y. (2022). CEV Framework: A Central Bank Digital Currency Evaluation and Verification Framework With a Focus on Consensus Algorithms and Operating Architectures. *IEEE Access, 10*, 63698-63714. doi:10.1109/access.2022.3183092

Jung, H. (2021). Blockchain Implementation Method for Interoperability between CBDCs. *Future Internet, 13*(5), 133. doi:https://doi.org/10.3390/fi13050133

Keister, T., & Monnet, C. (2022). Central bank digital currency: Stability and information. *Journal of Economic Dynamics and Control, 142*, 104501. doi:https://doi.org/10.1016/j.jedc.2022.104501

Keister, T., & Sanches, D. (2022). Should Central Banks Issue Digital Currency? *The Review of Economic Studies, 90*(1), 404-431. doi:10.1093/restud/rdac017

Kim, D. J., Ferrin, D. L., & Rao, H. R. (2009). Trust and Satisfaction, Two Stepping Stones for Successful E-Commerce Relationships: A Longitudinal Exploration. *Information Systems Research, 20*(2), 237-257. Retrieved from http://www.jstor.org/stable/23015482

Kim, J. J., Kim, S., Hailu, T. B., Ryu, H. B., & Han, H. (2023). Does Central Bank Digital Currency (CBDC) Payment Create The Opportunity For the Tourism Industry? *Journal of Hospitality & Tourism Research, 0*(0), 10963480231158773. doi:10.1177/10963480231158773

Kim, J. J., Radic, A., Chua, B.-L., Koo, B., & Han, H. (2022). Digital currency and payment innovation in the hospitality and tourism industry. *International Journal of Hospitality Management, 107*, 103314. doi:https://doi.org/10.1016/j.ijhm.2022.103314

Kitchenham, B. (2004). Procedures for performing systematic reviews. *Keele, UK, Keele University, 33*(2004), 1-26.

Kitchenham, B., & Charters, S. (2007). *Guidelines for performing systematic literature reviews in software engineering*. Retrieved from

Kochergin, D. (2021). Modern models of systems of central bank digital currency. *St Petersburg University Journal of Economic Studies, 37*(2), 205-240. doi:10.21638/spbu05.2021.202

Kóczián, B., Kollarik, A., Kiss, L., & Simon, P. (2022). Central Bank Digital Currency: A New Instrument of Monetary Policy. *Public Finance Quarterly (0031-496X), 67*(4), 522-538. doi:10.35551/PFQ_2022_4_3

Kosse, A., & Mattei, I. (2022). The Potential of Central Bank Digital Currencies for Cross-border Payments. *SUERF Policy Brief*(439). Retrieved from https://www.suerf.org/publications/suerf-policy-notes-and-briefs/the-potential-of-central-bank-digital-currencies-for-cross-border-payments/

Kozhan, R., & Viswanath-Natraj, G. (2021). Decentralized stablecoins and collateral risk. *WBS Finance Group Research Paper*. Retrieved from http://dx.doi.org/10.2139/ssrn.3866975

Kuehnlenz, S., Orsi, B., & Kaltenbrunner, A. (2023). Central bank digital currencies and the international payment system: The demise of the US dollar? *Research in International Business and Finance, 64*, 101834. doi:https://doi.org/10.1016/j.ribaf.2022.101834

Kumhof, M., & Noone, C. (2018). *Central bank digital currencies — Design principles for financial stability*. Retrieved from https://www.bankofengland.co.uk/-/media/boe/files/working-paper/2018/central-bank-digital-currencies-design-principles-and-balance-sheet-implications

Laband, J. (2022). Existential Threat or Digital Yawn: Evaluating China's Central Bank Digital Currency. *Harvard International Law Journal, 63*(2), 515-559. Retrieved from

https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,shib&db=bth&AN=162570158&site=bsi-live&scope=site&custid=gsu1

Laudon, K. C. (1985). Environmental and institutional models of system development: a national criminal history system. *Commun. ACM, 28*(7), 728–740. doi:10.1145/3894.3899

Lee, D. K. C., Yan, L., & Wang, Y. (2021). A global perspective on central bank digital currency. *China Economic Journal, 14*(1), 52-66. doi:10.1080/17538963.2020.1870279

Lee, S., Lee, J., & Lee, Y. (2023). Dissecting the Terra-LUNA crash: Evidence from the spillover effect and information flow. *Finance Research Letters, 53*, 103590. doi:https://doi.org/10.1016/j.frl.2022.103590

Li, Y., & Rocheteau, G. (2011). On the Threat of Counterfeiting. *Macroeconomic Dynamics, 15*(S1), 10-41. doi:10.1017/S1365100510000544

Liu, X., Wang, Q., Wu, G., & Zhang, C. (2022). Determinants of individuals' intentions to use central bank digital currency: evidence from China. *Technology Analysis & Strategic Management*, 1-15. doi:10.1080/09537325.2022.2131517

Lloyd, M. (2022). The Future of Money: Central Bank Digital Currencies. *Atlantic Economic Journal, 50*(3/4), 85-98. doi:10.1007/s11293-022-09748-3

Luo, Y. (2022). New connectivity in the fragmented world. *Journal of International Business Studies, 53*(5), 962-980. doi:10.1057/s41267-022-00530-w

Lyons, R. K., & Viswanath-Natraj, G. (2023). What keeps stablecoins stable? *Journal of International Money and Finance, 131*, 102777. doi:https://doi.org/10.1016/j.jimonfin.2022.102777

Ma, C., Jin, Z., Mei, Z., Zhou, F., She, X., Huang, J., & Liu, D. (2022). Internet of Things background: An empirical study on the payment intention of central bank digital currency design. *Mobile Information Systems, 2022*.

Ma, C., Wu, J., Sun, H., Zhou, X., & Sun, X. (2023). Enhancing user experience in digital payments: A hybrid approach using SEM and neural networks. *Finance Research Letters, 58*, 104376. doi:https://doi.org/10.1016/j.frl.2023.104376

Mancini-Griffoli, T., Peria, M. S. M., Agur, I., Ari, A., Kiff, J., Popescu, A., & Rochon, C. (2018). Casting light on central bank digital currency. *IMF Staff Discussion Notes, 18*(08).

Mandapuram, M. (2016). Applications of Blockchain and Distributed Ledger Technology (DLT) in Commercial Settings. *Asian Accounting and Auditing Advancement, 7*(1), 50-57.

Mohammed, M. A., De-Pablos-Heredero, C., & Montes Botella, J. L. (2023). Exploring the Factors Affecting Countries’ Adoption of Blockchain-Enabled Central Bank Digital Currencies. *Future Internet, 15*(10), 321. Retrieved from https://www.mdpi.com/1999-5903/15/10/321

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group*, t. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine, 151*(4), 264-269.

Moore, G. C., & Benbasat, I. (1991). Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation. *Information Systems Research, 2*(3), 192-222. doi:10.1287/isre.2.3.192

Morales-Resendiz, R., Ponce, J., Picardo, P., Velasco, A., Chen, B., Sanz, L., . . . Hodge, A. (2021). Implementing a retail CBDC: Lessons learned and key insights. *Latin American*

Journal of Central Banking, 2(1), 100022. doi:https://doi.org/10.1016/j.latcb.2021.100022

Morris, R. G., Copes, H., & Perry-Mullis, K. (2009). Correlates of currency counterfeiting. *Journal of Criminal Justice, 37*(5), 472-477. doi:https://doi.org/10.1016/j.jcrimjus.2009.07.007

Muchran, M., Muchran, M., Arsal, M., Badollahi, I., Muchran, M., & Insirat, M. N. (2024). A Test of the Planned Behavior Theory: The Impact on Behavior in the Implementation of Central Bank Digital Currency in Indonesia. *Review of Integrative Business and Economics Research, 13*(3), 451-463.

Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. *Decentralized business review*. Retrieved from https://bitcoin.org/bitcoin.pdf

Natarajan, H., Krause, S., & Gradstein, H. (2017). *Distributed Ledger Technology (DLT) and Blockchain*. Retrieved from https://documents.worldbank.org/en/publication/documents-reports/documentdetail/177911513714062215/distributed-ledger-technology-dlt-and-blockchain

Naughton, T., & Leslie Soon-Lim, C. (1998). Strategic dimensions of correspondent banking. *The International Journal of Bank Marketing, 16*(4), 153-160. doi:https://doi.org/10.1108/02652329810220701

Oliver Wyman. (2021). *Unlocking $120 Billion Value in Cross-Border Payments*. Retrieved from https://www.oliverwyman.com/content/dam/oliver-wyman/v2/publications/2021/nov/unlocking-120-billion-value-in-cross-border-payments.pdf

Oyewo, B. (2021). Do innovation attributes really drive the diffusion of management accounting innovations? Examination of factors determining usage intensity of strategic management accounting. [Diffusion of management accounting innovations]. *Journal of Applied Accounting Research, 22*(3), 507-538. doi:https://doi.org/10.1108/JAAR-07-2020-0142

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., . . . Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ, 372*, n71. doi:10.1136/bmj.n71

Parthasarathy, R., Rangarajan, A., & Garfield, M. J. (2021). Implementation of Secure Health Information Technology Innovations: An Extended Diffusion of Innovations Perspective. *E - Service Journal, 12*(3), 43-76,78. doi:https://doi.org/10.2979/eservicej.12.3.02

Peneder, M. (2022). Digitization and the evolution of money as a social technology of account. *Journal of Evolutionary Economics, 32*(1), 175-203. doi:https://doi.org/10.1007/s00191-021-00729-4

Peter, J. P., & Tarpey, L. X. (1975). A Comparative Analysis of Three Consumer Decision Strategies. *Journal of Consumer Research, 2*(1), 29-37. Retrieved from http://www.jstor.org/stable/2489044

Pieters, G., & Vivanco, S. (2017). Financial regulations and price inconsistencies across Bitcoin markets. *Information Economics and Policy, 39*, 1-14. doi:https://doi.org/10.1016/j.infoecopol.2017.02.002

Pikkarainen, T., Pikkarainen, K., Karjaluoto, H., & Pahnila, S. (2004). Consumer acceptance of online banking: an extension of the technology acceptance model. *Internet research, 14*(3), 224-235.

Popescu, A. (2022). Cross-Border Central Bank Digital Currencies, Bank Runs and Capital Flows Volatility. *IMF Working Papers, 2022*(083), A001. doi:10.5089/9798400209185.001.A001

Prasad, E. (2023). How will digital technologies influence the international monetary system? *Oxford Review of Economic Policy, 39*, 389-397. doi:10.1093/oxrep/grad011

Premkumar, G., Ramamurthy, K., & Nilakanta, S. (1994). Implementation of electronic data interchange: an innovation diffusion perspective. *Journal of Management Information Systems, 11*(2), 157-186.

Qian, Y. (2019). Central Bank Digital Currency: optimization of the currency system and its issuance design. *China Economic Journal, 12*(1), 1-15. doi:10.1080/17538963.2018.1560526

Quarles, R. K. (2020). *FSB Chair's letter to G20 Finance Ministers and Central Bank Governors: February 2020*. Paper presented at the The 2020 G20 Riyadh Summit Riyadh, Kingdom of Saudi Arabia. https://www.fsb.org/wp-content/uploads/P190220.pdf

Quercioli, E., & Smith, L. (2015). The Economics of Counterfeiting. *Econometrica, 83*(3), 1211-1236. doi:https://doi.org/10.3982/ECTA10975

Radic, A., Quan, W., Koo, B., Chua, B.-L., Kim, J. J., & Han, H. (2022). Central bank digital currency as a payment method for tourists: application of the theory of planned behavior to digital Yuan/Won/Dollar choice. *Journal of Travel & Tourism Marketing, 39*(2), 152-172. doi:10.1080/10548408.2022.2061677

Recskó, M., & Aranyossy, M. (2024). User acceptance of social network-backed cryptocurrency: a unified theory of acceptance and use of technology (UTAUT)-based analysis. *Financial Innovation, 10*(1), 57. doi:https://doi.org/10.1186/s40854-023-00511-4

Robertson, R., & White, K. E. (2007). What is globalization. *The Blackwell companion to globalization*, 54-66.

Rogers, E. M. (1962). *Diffusion of Innovations* (1 ed.). New York, New York: Free Press of Glencoe.

Rogers, E. M. (1983). *Diffusion of Innovations* (3 ed.). 866 Third Avenue, New York, N. Y. 10022: The Free Press, A Division of Macmillian Publishing Co., Inc.

Rogers, E. M. (1995). *Diffusion of Innovations* (4 ed.). 1230 Avenue of the Americas, New York, NY 10020: The Free Press, A Division of Simon & Schuster Inc.

Romano, D., & Schmid, G. (2021). Beyond Bitcoin: Recent Trends and Perspectives in Distributed Ledger Technology. *Cryptography, 5*(4), 36. Retrieved from https://www.mdpi.com/2410-387X/5/4/36

Roussou, I., Stiakakis, E., & Sifaleras, A. (2019). An empirical study on the commercial adoption of digital currencies. *Information Systems and eBusiness Management, 17*(2-4), 223-259. doi:https://doi.org/10.1007/s10257-019-00426-7

Schwenk, C. R. (1985). The Use of Participant Recollection in the Modeling of Organizational Decision Process. *Academy of Management Review, 10*(3), 496-503. doi:10.5465/AMR.1985.4278971

Sethaput, V., & Innet, S. (2023). Blockchain application for central bank digital currencies (CBDC). *Cluster Computing, 26*(4), 2183-2197. doi:10.1007/s10586-022-03962-z

SIFMA. (2023). *Quarterly Report: US Equity & Related, 3Q23*. Retrieved from https://www.sifma.org/resources/research/research-quarterly-equities/

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research, 104*, 333-339. doi:https://doi.org/10.1016/j.jbusres.2019.07.039

Söilen, K. S., & Lamiae, B. (2022). Household acceptance of central bank digital currency: the role of institutional trust. *The International Journal of Bank Marketing, 40*(1), 172-196. doi:https://doi.org/10.1108/IJBM-04-2021-0156

Sun, M., & Li, Z. (2024). User Perception and Acceptance of Central Bank Digital Currency in Developed and Developing Countries: An Empirical Study using Technology Acceptance Mode. *UCJC Business and Society Review*(80), 456-511. doi:https://doi.org/10.3232/UBR.2024.V21.N1.11

Taylor, S., & Todd, P. (1995). Assessing IT Usage: The Role of Prior Experience. *MIS quarterly, 19*(4), 561-570. doi:10.2307/249633

The Clearing House. (2020). The Clearing House Customer Documentation: Introduction to the RTP® System, Version 1.0. In T. C. H. P. C. L.L.C. (Ed.).

The World Bank. (2014). *Guidelines for the successful regional integration of financial infrastructures*. Retrieved from http://hdl.handle.net/10986/22110

The World Bank. (2021). Central Bank Digital Currencies for Cross-border Payments: A Review of Current Experiments and Ideas.

Themistocleous, M., Rupino da Cunha, P., Tabakis, E., & Papadaki, M. (2023). Towards cross-border CBDC interoperability: insights from a multivocal literature review. *Journal of Enterprise Information Management, 36*(5), 1296-1318. doi:10.1108/JEIM-11-2022-0411

Thompson, R. L., Higgins, C. A., & Howell, J. M. (1991). Personal Computing: Toward a Conceptual Model of Utilization. *MIS quarterly, 15*(1), 125-143. doi:10.2307/249443

Triandis, H. C. (1977). *Interpersonal Behavior*: Brooks/Cole Publishing Company.

Tushman, M. L. (1977). Special Boundary Roles in the Innovation Process. *Administrative Science Quarterly, 22*(4), 587-605. doi:10.2307/2392402

Tuunanen, T., Rossi, M., Saarinen, T., & Mathiassen, L. (2007). A contigency model for requirements development. *Journal of the Association for Information Systems, 8*(11), 33.

Valente, T. W. (1996). Social network thresholds in the diffusion of innovations. *Social networks, 18*(1), 69-89.

van der Linden, R. W. H., & Łasak, P. (2023). The Digitalization of Cross-Border Payment Systems and the Introduction of the CBDC. In R. W.H. van der Linden & P. Łasak (Eds.), *Financial Interdependence, Digitalization and Technological Rivalries: Perspectives on Future Cooperation and Integration in Sino-American Financial Systems* (pp. 75-92). Cham: Springer Nature Switzerland.

Venkatesh, V., & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science, 46*(2), 186-204. Retrieved from http://www.jstor.org/stable/2634758

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS quarterly, 27*(3), 425-478. doi:10.2307/30036540

Viles, N., Rush, A., & Rohling, T. (2015). *The Social Costs of Currency Counterfeiting*: Reserve Bank of Australia.

Vranken, H. (2017). Sustainability of bitcoin and blockchains. *Current Opinion in Environmental Sustainability, 28*, 1-9. doi:https://doi.org/10.1016/j.cosust.2017.04.011

Waller, C. (2022). *The US Dollar and Central Bank Digital Currencies*. Paper presented at the "Digital Currencies and National Security Tradeoffs" Presented by the Harvard National Security Journal, Cambridge, Massachusetts.

Wang, G.-J., Ma, X.-y., & Wu, H.-y. (2020). Are stablecoins truly diversifiers, hedges, or safe havens against traditional cryptocurrencies as their name suggests? *Research in International Business and Finance, 54*, 101225. doi:https://doi.org/10.1016/j.ribaf.2020.101225

Wang, H. (2023). How to understand China's approach to central bank digital currency? *Computer Law & Security Review, 50*, 105788. doi:https://doi.org/10.1016/j.clsr.2022.105788

Wątorek, M., Drożdż, S., Kwapień, J., Minati, L., Oświęcimka, P., & Stanuszek, M. (2021). Multiscale characteristics of the emerging global cryptocurrency market. *Physics Reports, 901*, 1-82. doi:https://doi.org/10.1016/j.physrep.2020.10.005

Wattenhofer, R. (2016). *The Science of the Blockchain*: Inverted Forest Publishing.

Webster, J., & Watson, R. T. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS quarterly, 26*(2), xiii-xxiii. Retrieved from http://www.jstor.org/stable/4132319

Williams, M. L., Dhoest, A., & Saunderson, I. (2019). Social media, diffusion of innovations, morale and digital inequality: A case study at the University of Limpopo Libraries, South Africa. [Social media, DOI, morale and digital inequality]. *Library Hi Tech, 37*(3), 480-495. doi:https://doi.org/10.1108/LHT-12-2018-0192

Windawi, A. J. (2022). The Diffusion of Blockchain as a General Purpose Technology Driving Digital Transformation. *Technology Innovation Management Review, 12*(1/2), 1-9.

Wohlin, C. (2014). *Guidelines for snowballing in systematic literature studies and a replication in software engineering.* Paper presented at the Proceedings of the 18th international conference on evaluation and assessment in software engineering.

Wohlin, C., & Prikladniki, R. (2013). Editorial: Systematic literature reviews in software engineering. *Inf. Softw. Technol., 55*(6), 919–920. doi:10.1016/j.infsof.2013.02.002

Wong, S. C., Tenk, M. T. T., & Heong, A. Y. K. (2022). Determinants of Cryptocurrency Adoption Behavior in Malaysia. *Jurnal Pengurusan, 65*, 1-15. doi:https://doi.org/10.17576/pengurusan-2022-65-01

World Economic Forum. (2023). *Central Bank Digital Currency Global Interoperability Principles*. Retrieved from https://www3.weforum.org/docs/WEF_Central_Bank_Digital_Currency_Global_Interoperability_Principles_2023.pdf

Xia, H., Gao, Y., & Zhang, J. Z. (2023). Understanding the adoption context of China's digital currency electronic payment. *Financial Innovation, 9*(1), 63. doi:10.1186/s40854-023-00467-5

Xu, J. (2022). Developments and Implications of Central Bank Digital Currency: The Case of China e-CNY. *Asian Economic Policy Review, 17*(2), 235-250. doi:10.1111/aepr.12396

Yanagawa, N., & Yamaoka, H. (2019). *Digital Innovation, Data Revolution and Central Bank Digital Currency*. Retrieved from https://www.boj.or.jp/en/research/wps_rev/wps_2019/wp19e02.htm

Yousafzai, S. Y., Foxall, G. R., & Pallister, J. G. (2010). Explaining Internet Banking Behavior: Theory of Reasoned Action, Theory of Planned Behavior, or Technology Acceptance

Model? *Journal of Applied Social Psychology, 40*(5), 1172-1202. doi:https://doi.org/10.1111/j.1559-1816.2010.00615.x

Yu, C.-S. (2012). Factors affecting individuals to adopt mobile banking: Empirical evidence from the UTAUT model. *Journal of Electronic Commerce Research, 13*(2), 104.

Zhang, J. N., Tian, R., Cao, Y. H., Yuan, X. G., Yu, Z. F., Yan, X., & Zhang, X. (2021). A Hybrid Model for Central Bank Digital Currency Based on Blockchain. *IEEE Access, 9*, 53589-53601. doi:10.1109/access.2021.3071033

Zhang, T., & Huang, Z. (2022). Blockchain and central bank digital currency. *ICT Express, 8*(2), 264-270. doi:https://doi.org/10.1016/j.icte.2021.09.014

Zmud, R. W., & Apple, L. E. (1992). Measuring technology incorporation/infusion. *Journal of Product Innovation Management, 9*(2), 148-155. doi:https://doi.org/10.1016/0737-6782(92)90006-X

VITA

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Summary

Andrew C. Haskell is a banker and scholar, focused on transforming the movement of money across borders and around the world by researching how theory can integrate with technological and operational advancements including Central Bank Digital Currencies (CBDCs), Real-Time Payments, messaging standardization (e.g., ISO 20022, CBPR+), and international collaboration. As a banker, his experience spans Technology and Product Management disciplines at FinTechs and Financial Institutions; as a scholar, his educational pursuits center around Finance, International Business, and Business Management.

Forever in pursuit of the "Holy Grail of Cross-Border Payments", Andrew's endeavors with CBDCs, instant payments, foreign exchange, payment networks, and system automation have led to his doctoral research on how the Diffusion of Innovation Theory can be utilized in conjunction with specific technical design choices for the benefit of decision-makers at Central Banks. Andrew is passionate about optimizing global payments to improve speed, safety, efficiency, transparency, inclusion, and sustainability for all global financial system participants, evidenced through his research, industry engagement, public speaking, and publishing.

Andrew resides and works in New York City, New York, USA, and is an avid fitness enthusiast, finding passion in CrossFit, running, cycling, swimming, hiking, and nutrition.

Education

- **Doctor of Business Administration** (International Business and Finance), J. Mack Robinson College of Business, Georgia State University, Atlanta, GA, USA (2024)
- **Master of Science in Finance** (Investments Specialization), J. Mack Robinson College of Business, Georgia State University, Atlanta, GA, USA (2013)
- **Master of Business Administration** (Finance Concentration), J. Mack Robinson College of Business, Georgia State University, Atlanta, GA, USA (2013)
- **Bachelor of Business Administration** (Managerial Sciences), J. Mack Robinson College of Business, Georgia State University, Atlanta, GA, USA (2008)

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Certifications and Training

- Certified Treasury Professional® (CTP®), Association for Financial Professionals (2017)
- The Payments Institute: Master's Program, Nacha (2016)
- Managing Product Management, Sequent Learning Networks (2015)
- Product Management Essentials, Sequent Learning Networks (2014)
- The Payments Institute: General Payments System Program, Nacha (2014)

Notable Speaking Engagements

- Sibos 2023 Annual Conference, Toronto, Canada, September 18, 2023, *"Is the Future of Money Digital and Instant?"*
- BAFT MENA Bank to Bank Forum, Dubai, UAE, March 13, 2023, *"The Future of Cross-Border Payments: Leadership Insights on Optimizing Innovation and Digitization"*
- BAFT MENA Bank to Bank Forum, Dubai, UAE, May 24, 2022, *"Disruptive vs. Collaborative FinTech – Middle East at the Crossroad"*
- Nacha Smarter Faster Payments 2023, Las Vegas, NV, USA, April 19, 2023, *"The Digital Payments Bullseye: Easy Options for Sending Fast, Secure Payments to Everyone"*
- Nacha Smarter Faster Payments 2023, Las Vegas, NV, USA, April 18, 2023, *"The Evolution of Real-Time Payments is Here: Accelerating Domestic Adoption While Expanding International Reach"*
- Nacha Remote Connect 2023, Virtual, May 9, 2023, *"The Coming Age of Interoperability"*
- U.S. Faster Payments Council: Fall 2022 Member Meeting, Minnesota, MN, USA, September 14, 2022, *"Central Bank Digital Currencies and Their Potential Impacts on Cross Border Payments"*
- Nacha Smarter Faster Payments 2022, Nashville, TN, USA, May 3, 2022, *"Request to Pay: Unleashing the Power of ISO 20022 Data"*
- AFP 2021 Annual Conference, Washington, D.C., USA, November 9, 2021, *"Faster Payments Fraud: Exaggerated or Underrated?"*
- American Banker Podcast with Penny Crosman, American Banker, Arizent, January 27, 2020, *"BNY Mellon's early adoption of real-time payments paying dividends"*

Academic Conferences

- 12th Annual Conference on Engaged Management Scholarship (EMS 2022), Guadalajara, México, September 9, 2022, Poster: *"Race for the Future of Money: How does alignment of consumer preferences with Central Bank Digital Currency (CBDC) design affect diffusion?"*, co-presented with Michael Hakimian, DBA

Awards

- Georgia State University 40 Under 40 Award Honoree, Class of 2024, March 22, 2024

Professional Experience

At the time of writing, Andrew Haskell is the Product Executive for Global FX Solutions at a G-SIFI based in New York City, representing Treasury Services and FX/Markets lines of business, responsible for FX Payments, FX Receipts, and FX Deposit solutions for Financial Institutions, Non-Bank Financial Institutions (NBFIs), Broker Dealers, and Large Corporates (e.g., Fortune 100 companies). Andrew manages a global team of Product Managers, Product Sales Specialists, Program Managers, and Project Managers, focused on the collective goal of optimizing clients' use of FX solutions for payments, receipts, sales, and trading activities.

Previously, Andrew was Head of Immediate Payments Product Management, responsible for the institution's strategy, development, and growth of instant payable and receivable solutions including US and International Real-Time Payments (in partnership with The Clearing House's RTP® Network, the U.S. Federal Reserve's FedNow℠ Service, and the European Banking

Association), Tokenized Payments® with Zelle®, and Disbursement solutions to drive paper to digital transformation and meet the growing demand for 24/7/365 instantaneous funds transfers.

Prior to the G-SIFI, Andrew managed a wide range of payables, receivables, and merchant services products at a super-regional domestic U.S. financial holding company within their Commercial Banking division, ultimately serving as Head of Global Payments. It was during this time that Andrew became intimately familiar with the global banking landscape and cross-border payments through the orchestration of correspondent banking partners, partnerships with FinTech and institutional vendors, third-party payment processors, and payment networks.

Before his employment at financial institutions, Andrew began his banking career at a FinTech company providing white-label solutions for financial institutions, notably desktop and online cash management platforms and back-end payment processing systems. Andrew's tenure at the FinTech afforded him the opportunity to learn the intricate mechanics of cash management, starting as a Quality Assurance Analyst in a time before automated testing, subsequently transitioning into Product Management as a Business Analyst and Product Specialist, discovering the Product Management Lifecycle firsthand.

Andrew participates in various global committees examining opportunities to improve cross-border payments while advocating for the needs of clients and business partners (e.g., BAFT, IIF, ABA/EBA, SWIFT, etc.). His passion for Payments, Product Management, and Treasury Management is expressed through his doctoral research and as a subject matter expert and practitioner within the global financial system, progressing forward the concept of boundary spanning by merging theory and practice to solve challenges with cross-border payments.