THE IMPACT OF CENTRAL BANK DIGITAL CURRENCIES ON FINANCIAL INCLUSION

BY

TAN HUI NI

A research project submitted in partial fulfilment of the requirement for the degree of

BACHELOR OF FINANCE (FINANCIAL TECHNOLOGY) WITH HONOURS

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF ACCOUNTANCY AND MANAGEMENTDEPARTMENT OF FINANCE

JUNE 2025

DECLARATION

We hereby declare that:

(1) This undergraduate research project is the end result of my own work and that due acknowledgement has been given in the references to ALL sources of information be they printed, electronic, or personal.

(2) No portion of this research project has been submitted in support of any application for any other degree or qualification of this or any other university, or other institutes of learning.

(3) The word count of this research report is_.

Name of Student:	Student ID:	Signature:
Tan Hui Ni	2207191	

Date: 17/12/2025

Table of Content

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

CBDC	Central Bank Digital Currencies
BNM	Bank Negara Malaysia
IMF	International Monetary Fund
BIS	Bank for International Settlements
PU	Perceived Utility
PEU	Perceived Ease of Use
FE	Fixed Effect
RE	Random Effect
VIF	Variance Inflation Factor

Preface

The emerging role of digital finance in shaping modern financial structures and its ability to accelerate financial inclusion is the main reason for conducting this research work. A large population in the world is still not accessing basic financial facilities, although there is a swift evolution of finance technology. In particular, in poorer and emerging nations, a great deal of attention is attributed to the emergence of Central Bank Digital Currencies due to their significant potential in providing a solution for this issue.

It was the academic exposure to the finance systems, electronic payments, and the challenges faced by the unbanked community that triggered the interest in writing on the topic. With an increasing number of countries experimenting or issuing CBDCs, the question of whether CBDCs really lead to the enhancement of the unbanked community having access to finance has led to various inquires. Hence, the need for the current study to examine the real effects of CBDCs on the promotion of financial inclusion, as well as understanding the role of finance literacy, trust, and technology accessibility within the process.

Abstract

This study makes use of a panel data approach involving some selected countries between the years 2015 and 2023 to analyze the effects of Central Bank Digital Currencies (CBDCs) on financial inclusion. Using different reports and research, the number of account holdings is regarded as a financial inclusion indicator. Moreover, it also analyses what impacts trust, technology accessibility, and financial knowledge have on the relationship between CBDCs and financial inclusion. In order to get credible results, robustness tests and Fixed Effects Panel Regression analysis are applied. The results show that trust has a positively and significantly affect on financial inclusion in across the countries. Conversely, in the initial stages of CBDC adoption, financial inclusion and financial accounts ownership show an ambiguous and sometimes negative relationship. Because of limitations in data and multicollinearity problems, it is found that the moderating effect of trust, technology accessibility, and financial knowledge is modest and unstable. In broad summary, the results underscore that it is not possible without financial institutions and financial knowledge if financial inclusivity is going to be improved by CBDC.

CHAPTER 1: INTRODUCTION

1.0 Research Background

The timely and sustainable provision of accessible and affordable financial services, including savings, credits, payments, and insurance, to the general population and to enterprises is referred to as financial inclusion. Various studies recognize financial inclusion to be an important element in battling poverty, facilitating economic growth, and ultimately enhancing the socioeconomic well-being of people. Financial inclusion in the context of developing economies has emerged as a critical parameter in many research papers (Demirguc-Kunt et al., 2017). The primary aspect of saving, education investments, establishment of businesses, and purchasing protection for unexpected disasters falls under the category of financial inclusion. Despite all the progress, financial exclusion has remained a serious issue all the way back to when the financial system took inception. According to World Bank statistics, more than 1.3 billion adults worldwide cannot access banking facilities, especially in poorer homes and small businesses. The fact that financial accessibility also plays a role in battling poverty and income disparity has also been acknowledged (Allen et al., 2016).

Central Bank Digital Currencies, or CBDCs, have emerged as a hoped-for approach for enhanced financial inclusion over the past few years. As CBDCs are issued and controlled by central banks, they enjoy sovereign status as money and are much safer than other cryptocurrencies such as Bitcoin (Hernández et al., 2024). The primary goal of CBDCs is serving financial needs of persons remaining outside of conventional

financial systems and enabling faster and cheaper payments. Experiences abroad show this potential. To lower obstacles to financial participation, Nigeria, for example, introduced the eNaira in 2021 to allow unbanked residents to conduct transactions through digital wallets (Auer et al., 2020). Residents in rural areas with limited internet connectivity are still able to perform digital transactions even without internet connectivity because of the offline payment capabilities that are incorporated into the Chinese e-CNY (Vijaya Subrahmanyam & Vijaya Subrahmanyam, 2023). Other countries that have pilots and launches for the CBDC include the Bahamas, Jamaica, Brazil, and Sweden, and they show the different means by which the financial inclusion gained by the CBDC can be enhanced globally (Kosse & Mattei, 2022).

However, more than just their introduction will determine how CBDCs affect financial inclusion. Adoption is influenced by several important elements, including as trust, technology accessibility, and financial knowledge. People that are financially literate are better equipped to comprehend and handle digital money (Lusardi & Mitchell, 2014). Digital infrastructure, internet connectivity, and smartphone ownership are examples of technology accessibility that guarantee people to use CBDCs in real-world situations (Donovan, 2012). Adoption decisions are also strongly influenced by trust in financial institutions and digital platforms. When people do not trust these systems, they are more likely to continue using cash or rely on informal financial methods (Kosse & Mattei, 2022).

The report focuses on countries that have experimented with, or even begun to adopt, CBDCs. Bank Negara Malaysia has collaborated with various global initiatives such as Project Dunbar and Project Mawar on conceptualizing possible uses of CBDC, which are mostly focused on wholesale CBDC for banking and international payments (Dunbar, 2022; Bank Negara Malaysia, 2023). Currently, Malaysia has not begun using a retail CBDC, but learning from international experiences with CBDC could greatly help Malaysia in their own aims to enhance financial inclusion. Financial inclusion in Malaysia remains an issue, as most people, particularly those with lower incomes and in rural areas, are not able to access digital financial services despite increasing digital payments in Malaysia (Shirono, 2024).

Nevertheless, there is no clear conclusion as to whether CBDCs have the ability to positively contribute to financial inclusion. Findings regarding CBDCs differ based on design and readiness levels, but global case studies appear promising. Thus, the importance of concrete research on real-world implications of CBDCs on financial inclusion in various geographical locations becomes apparent. Keeping this in consideration, the research proposal will seek to explore the implications of CBDCs on financial inclusion worldwide. This will contribute to our existing pool of information and provide valuable insights into the formulation of CBDCs that guarantee a well-rounded financial system.

1.1 Problem Statement / Motivation of the Study

Despite the awareness that financial inclusion is a prerequisite for growth, there are still major challenges globally. The existing disparity in account ownership and usage is a concern, notwithstanding the improvement that has taken place to ensure access to financial services. According to the Global Findex Database of the World Bank, a major proportion of the population is hardly transacting business using financial services, apart from cash, despite the improvement that has taken place in account ownership (Demirgüç-Kunt et al., 2018). This challenge persists, especially among the rural population, poor, and less educated sections of society. This challenge shows that just because access has been created, there is no guarantee that financial inclusion has actually taken place.

The CBDCs could bridge the existing gender disparity in inclusion if they include enabling users to store funds, make payments, receive funds through digital or mobile wallet applications or similar software for mobile phone use. This could be realized given that the focus of the digital yuan in China was enabling easier access to the digital currency for more users, as seen in the Nigerian eNaira, which was focused on low-cost remittances and offline payments (Ree, 2023; Caudevilla & Kim, 2023). Enhanced

access to financial inclusion has already been realized for various countries including the Bahamas, Jamaica, Brazil, and Sweden, which are among those that have developed CBDCs.

Despite this, however, the success of CBDCs in promoting financial inclusion cannot be solely dependent on their creation. The adoption of CBDCs is affected by financial literacy, technology accessibility, and trust. Financially literate individuals are able to understand and manage digital currency (Lusardi & Mitchell, 2014). According to Donovan (2012) and Ozili (2018), technology accessibility ensures that technology and internet accessibility support useability. The adoption of CBDCs by individuals is affected by the degree of trust individuals place in technology and financial institutions (Kosse & Mattei, 2022; Gupta et al., 2023).

There is a complex relation between the factors stated above. Financial literacy is likely to increase the users confidence towards utilizing digital financial services. Thus, this increase in confidence may lead to a greater chance of finding CBDC users. However, an increasingly important factor is that the perceived trust, or lack of trust, in the adoption of CBDC by individuals with little or no financial literacy (Palanisamy et al., 2025). Therefore, promoting trust in digital financial services must also include financial literacy initiatives.

This research will address the following research question: “How can moderating trust, technology, and financial literacy results from CBDC enhance global financial inclusion?” This research aims to provide data that will help to identify trends and patterns, to enable policymakers to implement successful CBDC policies and enhance financial inclusion through studying countries worldwide that have already experienced success in achieving this objective. In addition, it is vital to gain better understanding on the factors that will facilitate and hinder adoption of digital currencies for the consumers requiring access to these digital currencies the most.

This research provides valuable insights about how CBDCs can improve Digital Financial Inclusion academically by adding to research on the subject and providing new information related to practical implementation. Also, this research identifies Trust, Tech Accessibility, and Financial Literacy as moderating factors that influence the

extent of Financial Inclusion through the use of CBDCs. Furthermore, this research provides information for policy experts and decision-makers to develop policies that support the use of CBDCs in a manner that is user-friendly, accessible, and trustworthy to all groups of people.

In conclusion, while CBDCs are expected to help promote Financial Inclusion; The success of these efforts must be based on a comprehensive framework that incorporates not only the Technology/Infrastructure components but also Financial Literacy and Trust throughout the intended target populations. This study will offer a global perspective of how various countries are implementing their CBDC initiatives to create a more inclusive financial system throughout the world and understanding of how various drivers are related to each other.

1.2Research Questions

RQ1: Does the introduction of CBDC have a significant impact on financial inclusion?

RQ2: Does financial literacy moderate the relationship between CBDC and financial inclusion?

RQ3**:** Does technology accessibility moderate the relationship between CBDC and financial inclusion?

RQ4: Does trust moderate the relationship between CBDC and financial inclusion?

RQ5**:** After controlling GDP Per Capita does CBDC still have a significant impact on financial inclusion?

1.3 Research Objectives

RO1: To determine the significant impact of CBDC on financial inclusion.

RO2: To examine whether financial literacy moderates the relationship between CBDC and financial inclusion.

RO3: To examine whether technology accessibility moderates the relationship between CBDC and financial inclusion.

RO4: To examine whether trust moderates the relationship between CBDC and financial inclusion.

RO5: To determine whether the relationship between CBDC and financial inclusion remains significant after controlling for GDP Per Capita.

1.4 Hypotheses of the Study

- **H1**: The introduction of CBDC has a significant impact on financial inclusion.
- **H2**: Financial literacy positively moderates the relationship between CBDC and financial inclusion.
- **H3**: Technology accessibility positively moderates the relationship between CBDC and financial inclusion.
- **H4**: Trust positively moderates the relationship between CBDC and financial inclusion.
- **H5**: After controlling GDP Per Capita, CBDC still has a significant impact on financial inclusion.

1.5 Significance of the Study

The significance of this research is that it examines the possible impacts of Central Bank Digital Currencies (CBDCs) on financial inclusion in states which have adopted or piloted the use of CBDCs. The use of CBDCs is seen as a possible solution since they have the possibility of offering people a convenient, cheap, and safe entry into the formal economy. There is very limited empirical evidence on the impact of CBDCs on promoting financial inclusion in emerging economies or developing states even though there has been growing interest in the issue. Research on the issue has instead shifted its attention from measurable outcomes of CBDC use to modeling or piloting assumptions concerning the issue (Lannquist, 2023).

Academically, this article is an added contribution to the relatively small but growing pool of literature and studies about CBDCs. Most studies and literature about CBDCs today focus on theories rather than using actual data. As pointed out by Iorio (2024), while CBDCs can promote inclusiveness, still, most of these are in their testing phase and cannot yet give account of long-term results. How this article attempts to differ is by trying to create a quantifiable relationship between financial inclusion and CBDCs and also looking into other important aspects such as trust, availability of technology, and financial literacy.

Financial literacy is one of the most critical elements. A higher level of financial literacy correlates to a greater probability of using digital finance and banking services (Alqam & Hamshari 2024). The results illustrated that in Jordan, younger individuals demonstrated a higher propensity to utilize banking services due to their increased levels of financial knowledge. According to Yang et al. (2023), states that as a result of the combination of technological advancement and an increase in the understanding of digital finance systems, mobile payment systems have increased in China. This indicates that in order to effectively implement CBDC systems, it may be necessary to have some level of financial understanding by individuals. Therefore, individuals that

do not possess this knowledge may be at a disadvantage compared to individuals who comprehend how digital currencies operate and thus may be in a position to better utilize CBDC systems. Therefore, it is evident that a CBDC system alone will not resolve the issues of financial exclusion.

The availability of technology is another essential feature in addition to being able to use digital currencies. Individuals who do not have access to smartphones, internet service, or digital finance skills will not benefit from the use of CBDC. Similarly, the International Monetary Fund indicates that one of the greatest challenges associated with creating CBDC is the need to offer features that allow for the offline functionality of transactions and allow for the low cost of transaction fees to be affordable for all individuals living in the most rural and impoverished regions (Lannquist, 2023). If such aspects are not considered during their design, those that the CBDCs seek to help might not gain from them.

Another critical consideration is the aspect of trust. This is where people will have to believe in any new financial technology for it to work. Even if the CBDCs are accessible for use, people will not adopt them if their concerns are based on fraud, security, and privacy issues (Weston, G., 2024). The MIT Digital Currency Initiative warned that if vulnerable people shun the use of CBDCs due to lack of trust in them, improperly designed CBDCs could potentially worsen inequalities (Or, 2023). This implies that CBDCs should be developed with the aim of building and sustaining user trust.

In practice, this research will help policymakers and central banks worldwide in answering any questions they may have about the efficacy of CBDCs. Bank Negara Malaysia can make use of the findings of this research to develop effective policies concerning the promotion of financial inclusion should the findings indicate the efficacy of CBDCs in enhancing financial inclusion. Some of these include simplifying the registration process, ensuring offline transactions, and ensuring low transaction costs. According to the International Monetary Fund, such design choices directly relate to how effective or ineffective CBDCs will be in extending financial services to the unbanked population. Different countries can adopt effective CBDC schemes with

the help of global learning from experiences, for example, the Bahamas' Sand Dollar project or Nigeria's eNaira, which faces challenges of adoption concerning trust and awareness (Victoria & Martin, 2022). Malaysia can avoid similar mistakes by learning from these experiences.

Additionally, this report provides helpful recommendations for financial education initiatives. Governments should step up their efforts to raise financial and digital literacy if the results demonstrate that financial literacy has a significant impact on CBDC. More individuals would be able to comprehend and have faith in new financial technologies as a result. According to Umar (2025), noted that in order to assist individuals in embracing new tools like CBDCs, financial and digital skills education is crucial.

Hence, there exist two prime aspects in understanding the significance of this study. Firstly, from a research perspective, in that it provides insight into their relation to inclusive finance and also essential factors such as financial knowledge, technology availability, and trust in banks, it contributes to the limited research on CBDCs. Secondly, from a practical application point of view, it serves as advice to central banks and policymakers on how CBDCs can be effectively implemented in promoting inclusive finance. The findings help in ensuring that there is persistence in financial inclusion around the world in a manner that makes CBDCs not only available but also trustworthy and user-friendly.

1.6 Outline of the Study

There are five chapters in this study. The background information, motivations, problem statement, objectives, research questions, significance, and scope of this study are all found in Chapter One. Analyzing the impact of Central Bank Digital Currency (CBDC) on financial inclusion and how trust, technology accessibility, and financial knowledge play as moderation factors are the objectives. An overview of the relevant

theories and the previous empirical study on CBDC, financial inclusion, and moderation factors is found in Chapter Two. The study's attempts at filling the identified gaps are also mentioned in this chapter. Details on the study's methodology are found in Chapter 3. Information on study design, data sources, sampling procedures, operational scope on variables, and methods including robustness tests and panel regression analysis are mentioned in this chapter. Findings on data analysis are found in Chapter 4. These analyses include regression analysis using panel data as well as descriptive analysis. Then, results are interpreted in terms of the objectives. Chapter Five is the conclusion part. It includes information on limitations, theoretical and practical implications based on theoretical analysis, meaning within the scope of past studies and literature in this study on major results, and recommendations. There are recommendations on future studies as well as suggestions on policy implementations from this study, particularly to those central banks contemplating CBDC.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

Central Bank Digital Currency (CBDC), or digital fiat money issued by central banks, represents an electronic form of official national currencies. It is an official liability of central banks that has the same value and creditworthiness as physical money (Ozili, 2023; Williamson, 2022). CBDC can be classified into two types, Wholesale CBDC, targeting institutional settlements, such as institutional payments between banks, and retail CBDC, which targets general use for economic transactions (Auer et al., 2022; Kosse & Mattei, 2023). Due to the rapid growth of the digital economy and advances in technologies such as blockchain or distributed ledger technologies, aiming to

enhance efficiency, security, and inclusion of payments in the financial system while also addressing problems posed by private cryptocurrencies, CBDC has come into existence (Aysan et al., 2021; Berentsen & Schär, 2018).

Atlantic Council (2025) asserts that research on CBDCs has entered mainstream policy discourse, with a total of 49 pilot projects being undertaken globally, and more than 130 countries researching or piloting CBDCs. Similarly, CoinLedger (2025) mentioned 19 G20 countries are researching CBDCs, with 16 of them in the process of development and piloting stages. This confirms that major economies are warming up to CBDCs. The ongoing pilot in Thailand, the e-Naira in Nigeria, the e-Rupee in India, and the digital yuan e-CNY in China are examples of successful CBDCs (Aysan et al., 2021; Haque & Shoaib, 2023; Wathahong et al., 2025). Though CBDCs are not expected to replace cash in full, research points to how they could act as a complement to cash in enabling low-cost transactions, round-the-clock, real-time final settlement, and enhanced anti-money laundering controls (Fung & Halaburda, 2016; Ozili, 2023).

Consequently, studies already carried out on CBDCs have very informative results about the role of these systems in promoting financial inclusion; China's e-CNY is often cited as such an example. The role of e-CNY is situated at the core of China's innovations in CBDC, demonstrating how data analytics and existing and very successful payment systems such as Alipay can be employed by digital national currencies to offer financial services to underbanked people, and reduce costs of transactions and improve economic participation (Yeung et al., 2024). The findings from pilot research projects support that the uptake of a Central Bank Digital Currency (CBDC) correlates with improved levels of financial inclusion, particularly with respect to the economically disadvantaged, namely the underbanked and unbanked. The e-CNY is an example of how empirical research indicates that using data analytic tools reduces information asymmetry in credit markets to increase loan possibilities and enhance access to all forms of financial services (Tan, 2023; Luu et al., 2023). This set of studies supports that CBDCs function as a mechanism for promoting equitable financial development, as well as technologically revolutionizing how monetary policies are structured within the current economy.

2.1 Theoretical Frameworks and Models

2.1.1 Financial Inclusion Theory

In order to achieve these goals, concerning the alleviation of poverty and the promotion of financial inclusion. Theorists have suggested that financial inclusion must include the availability, usage and accessibility to the funds they provide (Demirgüç-Kunt et al., 2018; Allen et al., 2016). Therefore, providing low-cost access to financial resources provides the underprivileged segments of the population the opportunity to save, borrow and invest more, leading to an overall increased level of financial participation (Demirgüç-Kunt et al., 2018; Allen et al., 2016). Thus, in analyzing the data, financial inclusion is the dependent variable (DV) being studied and is measured by account ownership, the use of online payments, and the availability of financial institutions (Demirgüç-Kunt et al., 2018). The hypothesis allows for research to be directed towards questions about CBDC's capacity to bridge desired gaps between unbanked and underbanked communities (Bech & Hancock, 2020).

2.1.2 Technology Acceptance Model (TAM)

Perceived utility and Perceived Ease of Use are the foundational elements presented by the Technology Acceptance Model for assessing the adoption of technology by humans (Davis, 1989). With regard to the adoption of CBDCs, the Perceived Ease of Use will relate to the degree to which users can easily begin to use the CBDCs on mobile payments platforms or other alternatives available to them, while the PU will assess whether the users think the CBDCs will make financing and the cost of transactions

better. From past literature, it is evident that perceptions and the adoption of CBDCs are significantly affected by trust, technological accessibility, and finance literacy (Scherer et al., 2019; B.U., et al., 2021; Nurfaidah et al., 2024).

2.2 Variables

2.2.1 Financial Inclusion

Account ownership is generally recognized as one of the most critical indicators of financial inclusion, which has recently turned into a prominent issue for development policies. Account ownership, which refers to the possession of banking or regulated mobile money accounts, is considered to be the "entry point" into the formal financial sector (Group, 2023). Account ownership has been identified in the World Bank's Global Findex Database because of the ease of the indicator and its high correlation with the use of services covering various financial products including credit, insurance, and savings (Soledad, 2012).

Global ownership of accounts has also shown a marked rise in the past decade, although some gaps in disparities continue to exist between male and female owners of accounts, rural and urban areas, and higher and lower economic classes, respectively, according to research, of which examples include women, despite a rise in account penetration, and those who live in poverty, respectively (Group, 2023).

Owning an account has a range of implications. It reduces transactions costs, enhances the security of payments, and provides citizens with a secure method for saving money. Moreover, it enhances the efficiency and transparency of the implementation of public policy by ensuring that the money is directly distributed into the account. Additionally, account ownership can help alleviate poverty by improving access to microcredit (World Bank IEG, 2023).

However, academics caution that having an account does not ensure financial inclusion on its own. The indication does not account for real usage or service quality, and many accounts are still dormant. Account ownership runs the risk of exaggerating true inclusion if problems like digital gaps, consumer protection, and affordability are not addressed. As a result, researchers advocate combining ownership data with measures of usage and service depth to acquire a more realistic picture of financial inclusion development (Beck, 2016).

2.2.2 CBCD

An increasing number of studies are examining the possible implications of the adoption of Central Bank Digital Currency on financial inclusion, especially in places whereby access to conventional banking services is limited. CBDCs have also been proposed as a means through which account ownership could increase since they provide subsidized digital payment alternatives.

CBDCs are also considered very useful in developing countries, where a considerable section of society remains underbanked or unbanked due to problems such as high transaction costs, lack of access to banking services, and requirements for verification. CBDCs could sidestep these problems in a major way since they will allow individuals to own their own digital wallets issued by central banks, which will offer a secure and cheaper alternative to cash (Auer et al., 2020; Boar, 2021). CBDCs will also make it possible to send money directly to individuals, thereby ensuring a guarantee of benefits to those in society who are in need, thus improving societal protection services (Adrian & Mancini-Griffoli, 2021).

However, the literature also points out notable shortcomings. Access to accounts for people in CBDC systems alone does not necessarily guarantee success for financial inclusion when people do not possess skills in using digital technology, stable internet connectivity in their environment, and trust in government institutions. The exhibition

on financial inclusion by Bank Negara Malaysia indicates that for people to achieve financial inclusion, their engagement in credit, insurance, and savings services beyond having an account is a critical requirement and that use of CBDC could end up perpetuating inequalities in financial service accesses as a result of this challenge.

2.2.3 Financial Literacy

The adoption of Central Bank Digital Currency (CBDCs) has been championed because of its potential to achieve financial inclusion. However, research demonstrates that financial literacy is a fundamental element of how effectively CBDCs meet this goal. Financial literacy provide individuals with the knowledge and capacity to make informed decisions regarding finance, was found to be a significant factor affecting both financial behaviour and the ability to achieve financial inclusion (Lusardi & Mitchell, 2014).

CBDCs will be able to reduce many structural barriers related to holding accounts, as the digital wallets used to access them will also be much cheaper and easier to access than traditional methods. However, in the absence of financial literacy, trust, and understanding on the part of those who will use CBDCs, the mere adoption of a digital financial service by individuals may not result in true financial inclusion, as demonstrated by research that shows individuals with low levels of financial literacy were less likely to use various types of financial services (credit, savings, and payments) regardless of whether or not formal financial accounts were available (Klapper, Lusardi, & van Oudheusden, 2015). As a consequence, CBDCs could end up as dormant or inactive accounts if they lack adequate financial literacy, preventing them from being effective for financial inclusion.

For instance, some studies utilized education-related variables as proxies for the lack of data on financial literacy. Particularly, the rate of attendance in secondary schools is considered a measure of the population's awareness and cognitive skills on basic

financial constructs. Moreover, a higher level of education is highly associated with enhanced levels of financial literacy and skills (Lusardi and Mitchell, 2009). In a similar fashion, education leads to financial inclusion since it enhances people's comprehension and adeptness in using financial facilities (Beck, Demirgüç-Kunt, and Levine, 2007). Accordingly, in cross-country and macro research, if literacy scores cannot be obtained from surveys, secondary schooling that improves numeracy, critical thinking, and basic understandings of economics is seen as a good approximation for financial literacy (Grohmann, Klühs, & Menkhoff, 2018). The larger the enrollment in secondary schools, the larger the chance that individuals possess the basic knowledge and skills to comprehend and apply digital financial instruments, for instance, CBDCs.

Financial literacy goes on to form a moderating effect in several ways. Firstly, those with higher financial literacy will have higher chances of adopting and using the latest payment innovations like digital currencies due to the impact literacy makes on trust and risk perceptions (OECD, 2020). Secondly, efficiency in usage will improve; those with higher financial abilities shall get to reap the benefits of CBDC in relation to secure transactions, savings, and budgeting. Finally, the big concern in the online world of banking is fraud and misuse.

Another area where policy implications appear in literature is the need for financial education to support the rollout of CBDCs. Financial education will have to be implemented alongside CBDCs to support the capacity for the most vulnerable areas of society to use digital currency securely and effectively, particularly among the poor and the elderly. There is evidence that blending digital financial services and literacy enrolment significantly enhances well-being and engagement rates (Ozili, 2025). In conclusion, a key determinant for a successful adoption of CBDC is financial literacy, which has the potential to facilitate financial inclusion. A moderating variable, financial literacy increases adoption of CBDC and inclusion by ensuring passive adoption turns into active and productive use of financial services.

2.2.4 Technology Accessibility

Financial inclusion and links to the use of Central Bank Digital Currency are dependent on access to technology by the population in question. Access to technology refers to the availability and cost of access to digital technologies such as mobile phones, reliable means of payment, and internet accessibility. According to Demirgüç-Kunt et al. (2018), use of digital financial services is essentially an outcome of the inability to earn from and benefit from Central Bank Digital Currency.

The number of mobile cellular subscriptions per 100 people is particularly utilized in the process of secondary data analysis as an approximation in determining the accessibility of technology because it indicates the availability and accessibility of digital communication technology. Within less developed states, the mobile phone is the primary gateway to finance through digital technology (Harichandana, 2025). The number of mobile cellular subscriptions is widely utilized in the process of determining the accessibility of technology, as the availability of the technology makes it even simpler to access digital payment services (Lenka & Barik, 2018).

CBDCs would ensure that digital wallets were available to all. These would reduce challenges to account ownership. However, research shows that this might not be possible because of weak digital infrastructure. An example of this is that the unbanked may still not be served in situations where internet availability is weak or where smartphone ownership is low (Bech & Garratt, 2017). Another related factor might be that the unbanked would not be able to make effective use of digital currencies because they might be unaffordable (GSMA, 2025).

Technology accessibility acts as a moderating variable using various methods. Firstly, adoption level is affected by accessibility; societies that enjoy higher internet and smartphone penetration speed up the adoption of digital financial services (Donovan, 2012). The second factor influencing usage of Central Bank Digital Currency (CBDC) is the low cost and reliable nature of the digital technology used to make it easy for users to send and receive money. Therefore, because of the reliable and inexpensive nature of digital technologies, individual users are incentivized to utilize CBDCs for

transfers and payments, which ultimately contributes to increased financial inclusion. Additionally, the lack of access to technology also impacts the equity of inclusion for CBDCs. Therefore, digital innovations such as CBDC will continue to experience significant disparity between the individuals who are digital connected and those who are not.

With the policy evidence, the World Bank confirmed that financial inclusion is enhanced and made more effective with the work done to promote economic development through increasing mobile broadband access, making digital accessibility less expensive or developing more public partnerships to share in technology building. Therefore, while CBDC's could be used as a benefit to the cause of financial inclusion, the ability to benefit from implementing a CBDC will always be dependent on making access to technology equitable for all.

2.2.5 Trust

Whether Central Bank Digital Currencies (CBDCs) can make accessibility translate into meaningful financial inclusion has a great deal to do with trust. The adoption and continued use of technology are highly driven by trust in organizations and technology itself. In spite of being technology ready, there might be a situation of underuse of CBDCs if there is a lack of trust.

More than anything else, there is the need for trust regarding the security and privacy of the data. This is because the amount of transactions that are involved by the CBDC is significant, and citizens who are wary about the abuse of the data will not readily embrace the technology. On the matter of ensuring that there is public buy-in by finding the balance between ensuring that there is compliance and ensuring that there is privacy, the Bank for International Settlements interact (2021).

Second, customer perception of legitimacy and security of CBDCs corresponds to institutional trust in central banks. One condition for CBDCs to be considered a reliable unit of account and value transfer system is that citizens should trust central banks (Carstens, 2021). One of the indicators of institutional trust in financial systems, often applied for measuring trust at the macroeconomic level, results from the Rule of Law Index, measuring citizens' confidence in its judiciary, security of contracts, and efficiency of law enforcement (Kaufmann, Kraay, & Mastruzzi, 2010). A higher level of confidence in the financial system relates to stronger banking systems, according to empirical studies. In cross-country or secondary research, specifically when institutional trust data is missing or can't be derived from available data sources, proxying it by the Rule of Law Index can be particularly useful.

Finally, trust in technology's security and usability also matters. Research suggests that users are more likely to adopt CBDCs if systems are perceived as user-friendly, secure, and backed by strong consumer protections (**Liu et al., 2025).** This indicates that trust acts as a moderating factor, shaping whether CBDC adoption successfully enhances financial inclusion.

2.3 CBDC Trend & Challenges

In comparison to 2023, where 114 nations were engaged in CBDC exploration and development, the projected number of CBDC initiatives that are expected to be initiated or under development has increase to 134 countries (Atlantic Council, 2025). Also, there are presently 11 countries that have implemented CBDCs. The accelerating rate of adoption of CBDCs is a historical first for the entire globe. This unprecedented development has occurred due to numerous accomplishments that have been successfully achieved along the way of developing CBDCs. For example, in Turkey, the Artificial Intelligence assessment phase of the second phase of the implementation of CBDCs is currently being used to evaluate the economic impact of CBDCs.

Furthermore, India has launched retail and wholesale CBDCs that enable offline transaction capability. Additionally, China has extended the e-CNY to facilitate cross-border oil transactions and financial inclusion efforts (Atlantic Council, 2025). Wholesale CBDCs aim to optimize efficiency in settlements, while retail CBDCs aim to optimize financial inclusion. Efforts aimed at promoting CBDC inter-operability lie in cross-border projects, including the collaboration between Ukraine and the Stellar initiative (Stellar, 2021). Mature economies seem sluggish due to issues arising from legal and policymaking aspects, while emerging economies seem ahead, often based on fintech ecosystems (BIS, 2021).

Despite all these developments, there are still issues that currently exist and that may affect the financial stability of the future. For example, there are issues of cybersecurity risks that are still posing threats and are considered significant (Maurer & Nelson, 2021). This is because the type of data that is involved in CBDC transactions is sensitive and poses risks regarding issues of privacy (EDPS, 2023). In addition, the fact that huge transactions to central banks might cause bank runs means that CBDC development poses risks of disintermediation (Atlantic Council, 2025). The development of CBDC is also prone to risks regarding inclusion and macroeconomic shocks (Xiang et al., 2024).

Overall, while current trends emphasize the potential of CBDCs to foster financial inclusion and improve efficiency, their long-term success will depend on careful design choices that balance innovation with risks related to stability, privacy, and governance.

2.4 Research Gaps

Researchers frequently reference the Chinese e-CNY as one example of how CBDCs may lead to increased levels of financial inclusion through reducing the cost of transfers, increasing access to digital wallets for the facilitation of direct electronic or cash transfers. The three contributing factors that support the increasing levels of financial

inclusions through CBDCs are trust, technology accessibility and financial literacy. Theory frameworks for CBDCs that incorporate these three elements include RBV, TAM and FI Theory.

However, gaps still exist. There are very few studies from middle-income countries such as Malaysia, and most of the studies are focused on large economies only. Although literacy rate, technology acceptance, and trust are often brought up in the literature review done by different studies, their moderating functions are hardly ever explored from a practical perspective since each study seems to investigate the adoption intention of CBDC differently.

In an effort to fill these gaps, this paper examines the adoption of CBDCs and financial inclusion while also delving into the moderating role of trust, technology accessibility, and financial knowledge.

2.5 Hypotheses Development

H1: The adoption of CBDC has a large effect on financial inclusion. Nevertheless, there are a number of moderators that influence the effectiveness of CBDCs. First, financial literacy enables individuals to understand and make use of digital currencies. Improved literacy correlates with higher engagement rates, reduced abuse, and higher trust (Lusardi & Mitchell, 2014). Accordingly, H2: The adoption of CBDCs and financial inclusion are related to each other by financial literacy as a moderator. Second, the ability to adopt and make use of CBDCs varies depending on access to digital technology, such as mobiles, the internet, and relatively affordable online services (Bech & Garratt, 2017). Accordingly, H3: The adoption of CBDCs and financial inclusion are related to each other, with access to technology as a moderator. Third, the adoption of CBDCs is dependent on trust in central banks, as well as information handling and security (Carstens, 2021; BIS, 2023). Even if they exist, CBDCs could remain inactive if trust is not present (Carstens, 2021; BIS, 2023). Accordingly, H4:

Trust is related to CBDC adoption and financial inclusion as a moderator. Lastly, financial inclusion is a multidimensional issue that not only focuses on account ownership but includes service provision quality, or activities, that are actively utilized (World Bank, 2021). The adoption of CBDCs will contribute to a simultaneous effect on multiple aspects of financial inclusion. Lastly, H5: The adoption of CBDCs continues to significantly influence financial inclusion, when adjusting for GDP per capita.

CHAPTER 3: METHODOLOGY

3.0 Introduction

The methodology that is used in the study is discussed in this chapter. This is an important aspect of the study since the methodology, data, and analysis of the study are outlined. This gives the study credibility and accuracy.

The major target of this study is to examine the effect of Central Bank Digital Currencies (CBDCs) on financial inclusion. The effectiveness and cost of financial services like accounts and digital money transfer services will be central to financial inclusion for this study. The study will also examine how the relationship between the use of CBDCs and financial inclusion is moderated by levels of trust, accessibility of technology, and financial knowledge. Financial knowledge, technology, and levels of trust will be used as moderators for this study since such technologies will not be in a position to promote financial inclusion if individuals are not aware, cannot access, and do not trust central bank digital currencies, respectively.

The research was conducted using a panel data design and a quantitative approach, making use of data across several countries for several years. The rationale for the use of panel data is based on the perspective of gaining a broader perspective compared to a focus on one year or one country alone. The data analysis covered the years 2015 to 2023, during which several countries started to explore or pilot the use of CBDCs.

The secondary data sources are from World Bank, IMF, and BIS. The data for this study primarily uses these secondary sources, as collecting primary data is time-intensive and expensive. Therefore, the study can maximize its efficiency and effectiveness by using the secondary source to indicate moderating variables to measure the CBDC's full impact on financial inclusion. For example, higher levels of financial literacy, higher levels of technological access, and higher levels of trust in financial systems.

Statistical methods such as panel regression, correlation, and descriptive statistics are utilized in this research to analyze the data. In fact, panel regression is extremely useful due to its consideration for differences across countries and over time. Moreover, this method also allows this research to check if trust, technology availability, and financial knowledge could shape the influence of CBDCs on financial inclusion.

The chapter briefly highlights the study's format and paradigm, study model, sources of information, sampling method, and analysis procedures. The methodical approach used in this study ensures that it was conducted systematically and logically and yields sound evidence to solve the study questions and concerns.

3.1 Research Design

The research design, type, and method used for this study were cross-sectional, with a quantitative research method. Secondary data is information that is already collected and made available by reputable sources and authors, including some world institutions like the World Bank, International Monetary Fund (IMF), Bank for International

Settlements (BIS), and central banks of countries. For CBDCs and their effect on financial inclusion, surveys and interviews will not be required if secondary data is utilized. It will be much more efficient and convenient if the need to collect primary data is difficult and time-consuming. The key aim of the research is to assess the effects of CBDC on financial inclusion and how trust, accessibility, and awareness modulate the relationship.

3.1.1 Theoretical and Literature Support

Since complex analysis is possible through panel data method approaches, this method is extensively practiced for conducting economic and financial studies. Panel data helps to offer robust causal evidence that identifies variations in both countries and within countries for a specified time duration (Baltagi, 2005; Hsiao, 2018). According to Wooldridge (2010), panel econometrics helps to offer reliable estimation by considering unobserved variability that might affect the findings.

In addition, international organizations recommend using methods based on panel data with respect to CBDCs and financial inclusion. In this regard, the IMF (2024) asserts that cross-country and cross-temporal data analyses provide greater insights into the influence of CBDCs on indicators for financial inclusion, for example, account ownership, use of digital payments, and use of financial services. In a similar case, illustrate how cross-country data could work in a panel data model analyzing the use of digital/financial literacy as a moderator with the applicability of design to fintech and financial inclusion research agendas (Tulcanaza-Prieto et al. ,2025). Panel data is applicable in testing the influence and moderated relationship between the use of the CBDC because it has both explanatory and empirical foundations.

3.1.2 Advantage of using Cross Section Design

There are several advantages of panel data design. First, it enables a more comprehensive understanding by accounting for both time-series and country-specific variations (Wooldridge, 2010). Second, it increases the number of observations, and this increases the efficiency and reliability of statistical inference (Baltagi, 2005). Third, it allows for the control of country-specific unobservable factors such as institutional and cultural differences that might bias the estimates of a naive cross-sectional approach (Hsiao, 2018). Lastly, it enables dynamic analysis to be conducted; for example, the analysis of the impact of CBDCs on financial inclusion across time. The panel data design as an approach to investigate CBDCs is superior to the completely cross-sectional approach for several reasons listed above.

3.2 Conceptual Framework

The research focuses on the relationship that exists between Central Bank Digital Currency and Financial Inclusion (2015-2023). A host of variables influence Financial Inclusion, and these include account ownership, which is the dependent variable. The independent variable, CBDC, is established using the dummy variable, which is represented by the number 0 (not implemented), number 1 (pilot phase), and number 2 (launched).

This model employs the following three variables as moderating variables. These variables are financial literacy, technology accessibility, and trust. It is expected that these variables would influence the relationship between CBDC and financial inclusion. For example, CBDCs are expected to influence countries that are highly accessible via

internet and also have high financial literacy (Lusardi & Mitchell, 2014; Donovan, 2012). Trust in digital technology and central banks is especially relevant in this case, given the significance of public confidence in influencing adoption and adoption rate (Carstens, 2021). Socioeconomic and demographic differences are considered using control variables such as GDP.

Paradigm is anchored on the Financial Inclusion Theory, where access to finance is seen through the lens of economic and social developments, and Technology Acceptance Model (TAM), where perceived usefulness and simplicity of use in adopting technology are emphasized (Davis, 1989). This research offers valuable findings on how CBDCs may enhance inclusive finance in using panel regression methods to account for cross-country differences as well as changes over time (Hsiao, 2018; Wooldridge, 2010).

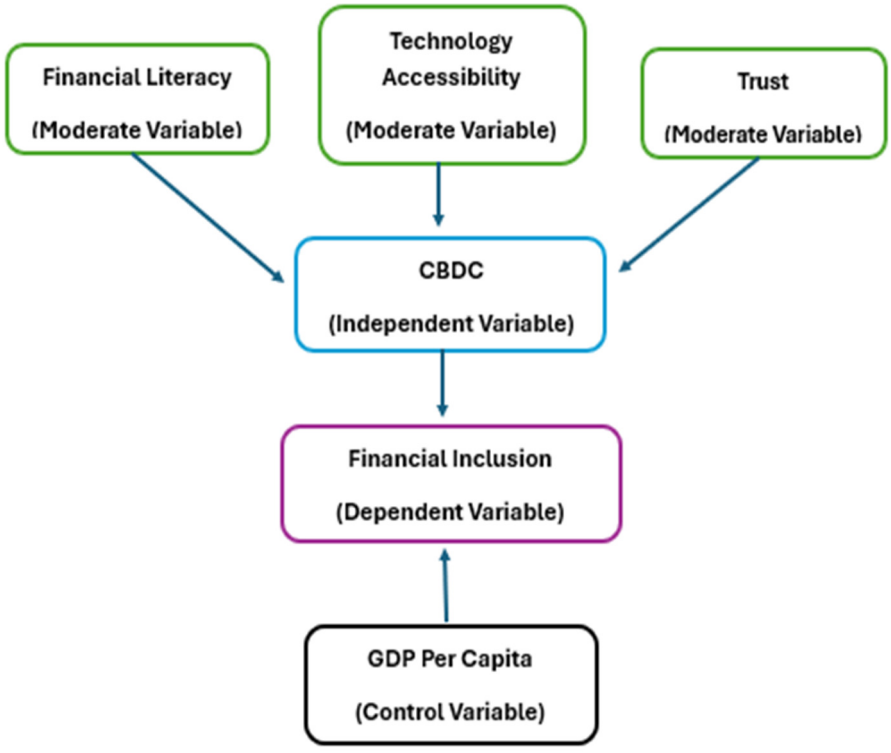

Fig. 3.2: Conceptual Framework

The framework demonstrates that while CBDC may improve financial inclusion, it will depend on the influencing factors. The influence of CBDC on the financial inclusion will be strengthened by high levels of financial literacy, accessibility to technology, and high levels of trust in the financial system.

3.3 Model Specification

To empirically test the relationship between CBDC adoption and financial inclusion, this study specifies a panel regression model with moderating variables. The general model is expressed as:

To test the research hypotheses, the following baseline fixed-effects model is specified:

$$FI_{it} = \beta_0 + \beta_1 CBDC_{it} + \beta_2 FINLIT_{it} + \beta_3 TECH_{it} + \beta_4 TRUST_{it} + \beta_5 GDPPC_{it} + \mu_i + \epsilon_{it}$$

To examine moderating effects, three interaction terms are added to the extended model:

$$FI_{it} = \beta_0 + \beta_1 CBDC_{it} + \beta_2 FINLIT_{it} + \beta_3 TECH_{it} + \beta_4 TRUST_{it} + \beta_5 (CBDC_{it} \times FINLIT_{it}) + \beta_6 (CBDC_{it} \times TECH_{it}) + \beta_7 (CBDC_{it} \times TRUST_{it}) + \beta_8 GDPPC_{it} + \mu_i + \epsilon_{it}$$

Where:

FIit = financial inclusion in country *i* at year *t*

CBDCit = CBDC (dummy variable: 1 = adopted/piloted, 0 = not adopted)

FLit= financial literacy index

TAit = technology accessibility index

TR_{it} = trust and security index

μ_i = country-specific effect (fixed or random)

λ_t = time effect (year dummies)

ε_{it} = error term

This specification allows for the investigation of the effects of both cross-country and temporal variations. The moderating effects will be tested using interaction terms. Fixed and random effects models will be estimated and the Hausman test will determine the preferred model specification. Finally, the model will be checked for robustness with heteroskedasticity and serial correlation tests as recommended by panel data econometrics.

3.4 Data Collection

3.4.1 Data Type and Sources

Secondary data was obtained from reputable international organizations, such as the Global Findex Database. This database contains information from The World Bank regarding financial inclusion, which includes credit card usage and ownership of an account. The International Monetary Fund developing countries for a variety of sources, the Bank for International Settlements provides data about financial infrastructure and stability as well as the level of acceptance of CBDCs in each country. For each country analyzed in this research study, the central bank of the country provides an overview of the respective central banks. The data covers a time frame between 2015 to 2023, which reflects the period when Central Bank Digital Currency pilot tests accelerated around the world (Atlantic Council, 2025).

3.4.2 Time Frame

The data covers the period from 2015 to 2023, capturing the key years in which CBDC research and pilot programs were initiated. This period allows for a comprehensive analysis of the direct effects of CBDCs on financial inclusion.

3.5 Sampling Design

3.5.1 Unit of Analysis

The analysis unit for this research project is countries that have implemented or tested CBDCs. The analytical method for this research will be purposively sampled and will include information from nine countries with valid data. The countries will be included, such as Bahamas, Jamaica, Nigeria, China, Brazil, India, Sweden, Japan, and Russia. The research will analyze data for nine years from 2015 to 2023, thus creating a panel dataset that supports the validity of this study by employing a geographically, economically, and institutionally diverse sample and spanning several years.

3.5.2 Sampling Method

Since this study relies on existing international databases, a purposive sampling method is adopted. Countries are selected based on data availability and relevance to CBDC implementation. Specifically, countries that have conducted CBDC research, piloted, or implemented CBDCs between 2015 and 2023 are prioritized.

3.5.3 Sample Size

The study use a sample of 9 countries to ensure and the selected countries that provide complete data on financial inclusion, CBDC adoption, and moderator variables. This small sample size facilitates valid statistical inference using methods such as multivariate regression analysis. Hence, the selected countries exhibit geographic, economic, and institutional diversity to enhance the external validity of the research findings. The countries for this study includes Bahamas**,** Jamaica**,** Nigeria**,** China**,** Brazil**,** India**,** Sweden**,** Japan and Russian.

3.6 Data Analysis Methods

To determine the absence of unobserved differences, both Fixed Effect and Random Effect models follow the combined OLS regression to establish if RE is more appropriate than the FE Model for this research, and a Hausman test is utilised after the RE regression model for that purpose (Wooldridge, 2010). Then, by using interaction terms in the regression models. The research would determine the moderating effect of trust, technology accessibility and financial literacy. To verify the findings of the study, robustness tests will need to be performed to ensure the results are not influenced by serial correlation or heteroskedasticity. The EViews software will be used to conduct the analyses and data collection.

3.7 Summary of the Chapter

This chapter explains the approach taken to examine how CBDC impacts financial inclusion and the roles financial literacy, technology and trust play in this area as moderator. The analysis uses nine different countries between 2015-2023 with the use of panel data methods and methods such as the creation of a panel regression model including independents variable. The data sources for this research is all from credible organisations and institutions such as the World Bank, IMF and BIS. Therefore, the analysis will consist of descriptive statistics, correlation analysis, and panel regression techniques. Which will be chosen based on the results from a Hausman test, while the validation process for the methodology is obtained via robust testing methods.

CHAPTER 4: DATA ANALYSIS

4.1 Descriptive Statistics

	ACCOUNT...	CBDC	FINANCIAL...	TECHNOL...	TRUST	GDP_PER...
Mean	1.40E+08	0.419753	90.70991	115.4397	0.109598	17486.60
Median	30144305	0.000000	91.20000	108.0930	-0.108452	9288.027
Maximum	1.25E+09	2.000000	142.6416	180.8420	1.990329	54878.29
Minimum	90093.00	0.000000	39.30681	72.36800	-1.196590	1583.998
Std. Dev.	2.44E+08	0.686735	24.24870	27.58546	0.904680	17013.66
Skewness	2.358876	1.339844	0.002242	0.596892	0.786308	0.974920
Kurtosis	8.586168	3.395810	3.438247	2.470106	2.445296	2.550782
Jarque-Bera	180.4358	24.76371	0.648271	5.757434	9.385260	13.51240
Probability	0.000000	0.000004	0.723152	0.056207	0.009163	0.001164
Sum	1.13E+10	34.00000	7347.502	9350.614	8.877410	1416415.
Sum Sq. Dev.	4.75E+18	37.72840	47039.98	60876.60	65.47561	2.32E+10
Observations	81	81	81	81	81	81

Table 4.1 Descriptive Statistics

The descriptive statistics and normality test results show that the data has significant variability between the different variables measured. The variable ACCOUNT has a much higher mean and maximum than all of the other variables, and has very high levels of uncertainty as shown by the positive skewness and kurtosis of ACCOUNT, which means ACCOUNT is skewed toward higher values and has very long tails to the right of its distribution. The Jarque-Bera test strongly rejects normality (p=0.000000), thus further confirming that ACCOUNT is not normally distributed. The variable CBDC also showed a moderate amount of positive skewness and high level of kurtosis. The Jarque-Bera test also rejected normality for CBDC (p=0.000004). On the other hand, FINANCIAL appears to be distributed more symmetrically (skewness and kurtosis near what would be expected under normality) compared to the other variables. The Jarque-Bera test fails to reject normality for FINANCIAL at the conventional level of significance (p=0.723) and also gives only marginal evidence against normality for TECHNOL (p=0.056). The variables TRUST and GDP_PER display notable skewness and excess kurtosis, leading to significant Jarque-Bera test results (p=0.009 and p=0.001, respectively), suggesting their distributions are not normal. In summary, while some variables like FINANCIAL approximate a normal distribution, others particularly ACCOUNT, CBDC, TRUST, and GDP_PER exhibit significant deviations from normality. This has important implications for subsequent statistical modeling, as many parametric techniques assume normality, and violations may necessitate transformations or the use of non-parametric methods.

4.2 Pre-Estimation Tests

4.2.1 Correlation Matrix

	ACCOUNT...	CBDC	FINANCIAL...	TECHNOL...	TRUST	GDP_PER...
ACCO...	1.000000	-0.024262	0.087703	0.163165	0.060484	-0.050612
CBDC	-0.024262	1.000000	-0.152770	-0.029916	-0.063819	0.051888
FINAN...	0.087703	-0.152770	1.000000	0.521987	0.710733	0.715068
TECH...	0.163165	-0.029916	0.521987	1.000000	0.261837	0.394189
TRUST	0.060484	-0.063819	0.710733	0.261837	1.000000	0.876078
GDP_...	-0.050612	0.051888	0.715068	0.394189	0.876078	1.000000

Table 4.2.1: Correlation Matrix

The correlation matrix shows the relationship of three economic variables; the three variables with the strongest correlations (TRUST & GDP_PER, and FINANCIAL) have a very high correlation coefficient of 0.876. The highest correlation coefficient of 0.876 indicates a very strong positive correlation between TRUST (level of trust) and GDP_PER (the income per capita) in the society. Both TRUST and GDP_PER also have very high positive correlations with FINANCIAL (0.711 and 0.715, respectively), both above 0.70, which indicates that these economic factors move together in some fashion. FINANCIAL also has a moderate correlation (0.522) with TECHNOLOGY and a weak to moderate correlation (0.394) with GDP_PER. CBDC (central bank digital currency) has a very weak negative correlation (-0.153) with most of the other variables; therefore, there is a weak inverse relationship between CBDC and FINANCIAL. ACCOUNT has little/no correlation with the other variables, indicating that this variable appears to operate independently of the other factors in this analysis. The analysis indicates that the primary variables (TRUST, GDP_PER, FINANCIAL) are closely related, whereas CBDC and ACCOUNT appear to be less related to these three variables.

4.2.2 Variance Inflation Factor

Variance Inflation Factors
Date: 12/15/25 Time: 18:24
Sample: 1 81
Included observations: 81

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	2.37E+16	34.19754	NA
CBDC	1.66E+15	1.537119	1.115251
FINANCIAL_LITERACY	3.38E+12	42.98684	2.833933
TECHNOLOGY_AC...	1.41E+12	28.59587	1.526621
TRUST	4.48E+15	5.305430	5.227748
GDP_PER_CAPITA	13054903	11.14258	5.384001

Table 4.2.2: Variance Inflation Factor

The Variance Inflation Factor (VIF) assesses the existence of multicollinearity in a model. There are signs of multicollinearity in both ways for the given model. First, when assessing the model in its uncentered version, both the C and FINANCIAL_LITERACY coefficients have extremely high uncentered VIF values at 34.20 and 42.99, respectively, indicating a very high potential for multicollinearity caused by combining intercepts with the variable scaling. In contrast, when utilizing the more standard centered VIF to remove the influence of the intercept, the severity decreased considerably compared to the uncentered values but still exhibited multicollinearity problems. In this situation, TRUST and GDP_PER_CAPITA have center VIF values of 5.23 and 5.38, which exceed the common threshold set at 5.0, indicating a problematic level of collinearity relative to other predictor variables and possibly others. In contrast, CBDC and TECHNOLOGY_AC... have low centered VIFs (1.12 and 1.53), indicating they do not contribute significantly to multicollinearity. Overall, the centered VIFs point to a specific multicollinearity problem driven by the strong relationship between TRUST and GDP_PER_CAPITA, which could inflate standard errors and destabilize coefficient estimates in a regression model.

4.3 Model Selection

4.3.1 Pooled OLS

Dependent Variable: ACCOUNT_OWNERSHIP
Method: Panel Least Squares
Date: 12/15/25 Time: 18:41
Sample: 2015 2023
Periods included: 9
Cross-sections included: 9
Total panel (balanced) observations: 81

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	76354660	1.78E+08	0.429293	0.6690
CBDC	-2.96E+08	2.63E+08	-1.125545	0.2641
FINANCIAL_LITERACY	-96810.48	2127310.	-0.045508	0.9638
TECHNOLOGY_ACCESSIBILITY	1831296.	1406523.	1.302002	0.1971
TRUST	1.66E+08	69486146	2.382228	0.0199
CBDC_FINLIT	2157839.	3505057.	0.615636	0.5401
CBDC_TECH	1297152.	2446098.	0.530294	0.5975
CBDC_TRUST	-62123593	1.02E+08	-0.611338	0.5429
GDP_PER_CAPITA	-9785.962	3691.476	-2.650962	0.0099

R-squared	0.132057	Mean dependent var	1.40E+08
Adjusted R-squared	0.035619	S.D. dependent var	2.44E+08
S.E. of regression	2.39E+08	Akaike info criterion	41.52890
Sum squared resid	4.12E+18	Schwarz criterion	41.79495
Log likelihood	-1672.920	Hannan-Quinn criter.	41.63564
F-statistic	1.369342	Durbin-Watson stat	0.081858
Prob(F-statistic)	0.224640		

Table 4.3.1: Pooled OLS

Based on this panel regression analysis, the model has very limited explanatory power and the results are largely statistically insignificant. The overall model is not significant, as shown by the high p-value of the F-statistic (0.2246), meaning the set of predictors does not reliably explain variation in ACCOUNT_OWNERSHIP. The extremely low R-squared (0.132) and adjusted R-squared (0.036) confirm that the model explains almost none of the variance in the dependent variable. Among the individual predictors, only two are statistically significant at the 5% level: TRUST has a positive and significant effect (p=0.0199), while GDP_PER_CAPITA has a negative and significant

effect (p=0.0099). However, these significant relationships should be interpreted with caution due to the model's overall weakness and the previously identified multicollinearity between TRUST and GDP. All other variables, including CBDC and its interaction terms (e.g., CBDC_FINLIT, CBDC_TRUST), are statistically insignificant ($p > 0.05$). Furthermore, the extremely low Durbin-Watson statistic (0.082) suggests severe positive autocorrelation in the residuals, violating a key regression assumption and making the standard errors and t-tests unreliable. In conclusion, the model fails to provide meaningful or trustworthy insights into the determinants of account ownership, largely due to misspecification, autocorrelation, and weak predictor relationships.

4.3.2 Hausman Test

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	936.314405	8	0.0000

** WARNING: estimated cross-section random effects variance is zero.

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
CBDC	-151864...	-2962143...	16080140...	0.0003
FINANCIAL_LITERACY	2360224....	-96810.47...	75989335...	0.3728
TECHNOLOGY_ACCESSIBILITY	1530646....	1831296.0...	85845338...	0.7456
TRUST	2395531...	165531852...	57341574...	0.3283
CBDC_FINLIT	1351319....	2157839.4...	25249727...	0.1085
CBDC_TECH	485021.7...	1297152.1...	15265044...	0.0377
CBDC_TRUST	-424379...	-62123593...	99028355...	0.0479
GDP_PER_CAPITA	15045.78...	-9785.962...	73174279....	0.0037

Cross-section random effects test equation:
Dependent Variable: ACCOUNT_OWNERSHIP
Method: Panel Least Squares
Date: 12/15/25 Time: 23:59
Sample: 2015 2023
Periods included: 9
Cross-sections included: 9
Total panel (balanced) observations: 81

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.47E+08	2.58E+08	-2.117743	0.0381
CBDC	-1.52E+08	81198570	-1.870285	0.0660
FINANCIAL_LITERACY	2360225.	2815078.	0.838423	0.4049
TECHNOLOGY_ACCESSIBILITY	1530647.	1000423.	1.529999	0.1309
TRUST	2.40E+08	77985175	3.071778	0.0031
CBDC_FINLIT	1351319.	1066194.	1.267423	0.2096
CBDC_TECH	485021.7	763753.5	0.635050	0.5277
CBDC_TRUST	-42437969	29022357	-1.462251	0.1486
GDP_PER_CAPITA	15045.78	8611.336	1.747206	0.0854

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.944469	Mean dependent var	1.40E+08
Adjusted R-squared	0.930586	S.D. dependent var	2.44E+08
S.E. of regression	64204809	Akaike info criterion	38.97724
Sum squared resid	2.64E+17	Schwarz criterion	39.47978
Log likelihood	-1561.578	Hannan-Quinn criter.	39.17887
F-statistic	68.03196	Durbin-Watson stat	1.068779
Prob(F-statistic)	0.000000		

Table 4.3.2: Hausman Test

The Hausman Test indicates that there is sufficient statistical evidence to support decision making related to choosing an appropriate model for analysis. Specifically, the results of the Hausman Test indicated a strong rejection of the null hypothesis (Chi-Sq. = 936.31, Prob. = 0.0000) indicating that the random effects model would not provide consistent, unbiased coefficient estimates of the true parameters because the estimated value of the variance of the random error term is equal to zero. These combined pieces of information would lead to the conclusion that the fixed effects model is superior to the random effects model. In this context, it can be concluded that time-invariant, unmeasured variables associated with a cross-section of entities affect the outcome variable in addition to the independent variables that explain, or help predict, the outcome variable. If a random effect model were used in this context, it would result in biased, inconsistent parameter estimates for many explanatory variable coefficient estimates. The Hausman Test demonstrates that the coefficient estimates of interest are statistically significantly different (p-values of 0.0003, 0.0479, and 0.0037 respectively) between the fixed effects model and random effects model for the following explanatory variables CBDC, CBDC_TRUST, and GDP PER CAPITA respectively. Consequently, the reliable inferences must be drawn from the fixed effects results, which show a high model fit (R-squared = 0.944) and identify TRUST as a robust, positive driver of account ownership. In contrast, the random effects model, with its very low explanatory power and severe autocorrelation (as noted in the previous interpretation), is invalid for this dataset. The test underscores that accounting for unobserved heterogeneity via fixed effects is crucial, and any analysis omitting these controls would lead to misleading conclusions regarding the impact of variables like CBDC and its interactions.

4.4 Results and Discussions

4.4.1 FE Model without control variables

Dependent Variable: ACCOUNT_OWNERSHIP
Method: Panel Least Squares
Date: 12/16/25 Time: 00:05
Sample: 2015 2023
Periods included: 9
Cross-sections included: 9
Total panel (balanced) observations: 81

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.78E+08	2.59E+08	-1.842686	0.0699
CBDC	-1.94E+08	78776763	-2.460735	0.0165
FINANCIAL_LITERACY	3977856.	2700126.	1.473211	0.1455
TECHNOLOGY_ACCESSIBILITY	1902423.	992848.1	1.916127	0.0597
TRUST	2.61E+08	78232528	3.334429	0.0014
CBDC_FINLIT	2029024.	1008696.	2.011531	0.0484
CBDC_TECH	387398.1	773641.0	0.500747	0.6182
CBDC_TRUST	-50449922	29106799	-1.733269	0.0878

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.941820	Mean dependent var	1.40E+08
Adjusted R-squared	0.928394	S.D. dependent var	2.44E+08
S.E. of regression	65210738	Akaike info criterion	38.99915
Sum squared resid	2.76E+17	Schwarz criterion	39.47212
Log likelihood	-1563.465	Hannan-Quinn criter.	39.18891
F-statistic	70.14859	Durbin-Watson stat	1.078980
Prob(F-statistic)	0.000000		

Table 4.4.1: Fixed Effect Model without control variables

The results of the fixed effects panel regression analysis without controlling for GDP_PER_CAPITA still indicate strong overall explanatory power as evidenced by the high R-Squared (0.942) and Adjusted R-Squared (0.928) values, along with the highly statistically significant F-statistic (Prob. = 0.0000). TRUST continues to be a statistically significant and positively correlated determinant of account ownership (coefficient = 2.61E+08; p = 0.0014), further emphasizing its importance. In addition,

when controlling for GDP is not taken into account, the effect of CBDC on account ownership also increases in magnitude and significance at the 5% level (-1.94E+08; p = 0.0165), demonstrating a more distinct inverse relationship between the introduction of Central Bank Digital Currency and account ownership. Furthermore, the interaction term CBDC_FINLIT is now positive and significant (2,029,024, p = 0.0484), suggesting that higher levels of financial literacy can mitigate or even reverse the negative standalone effect of CBDC on account ownership. The CBDC_TRUST interaction remains negative and marginally significant (-50,449,922, p = 0.0878), implying that the positive influence of trust may be somewhat dampened in the presence of a CBDC. The coefficients for FINANCIAL_LITERACY and TECHNOLOGY_ACCESSIBILITY are positive but remain statistically insignificant. The Durbin-Watson statistic (1.079) still suggests some positive autocorrelation in the residuals. In summary, removing GDP_PER_CAPITA sharpens the estimated effects of CBDC and its interaction with financial literacy, providing stronger evidence that while CBDC adoption may generally correlate with lower account ownership, this relationship is conditional and can be positively moderated by a population's financial literacy.

4.4.2 FE Model with control variables

Dependent Variable: ACCOUNT_OWNERSHIP
Method: Panel Least Squares
Date: 12/16/25 Time: 00:08
Sample: 2015 2023
Periods included: 9
Cross-sections included: 9
Total panel (balanced) observations: 81

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.47E+08	2.58E+08	-2.117743	0.0381
CBDC	-1.52E+08	81198570	-1.870285	0.0660
FINANCIAL_LITERACY	2360225.	2815078.	0.838423	0.4049
TECHNOLOGY_ACCESSIBILITY	1530647.	1000423.	1.529999	0.1309
TRUST	2.40E+08	77985175	3.071778	0.0031
CBDC_FINLIT	1351319.	1066194.	1.267423	0.2096
CBDC_TECH	485021.7	763753.5	0.635050	0.5277
CBDC_TRUST	-42437969	29022357	-1.462251	0.1486
GDP_PER_CAPITA	15045.78	8611.336	1.747206	0.0854

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.944469	Mean dependent var	1.40E+08
Adjusted R-squared	0.930586	S.D. dependent var	2.44E+08
S.E. of regression	64204809	Akaike info criterion	38.97724
Sum squared resid	2.64E+17	Schwarz criterion	39.47978
Log likelihood	-1561.578	Hannan-Quinn criter.	39.17887
F-statistic	68.03196	Durbin-Watson stat	1.068779
Prob(F-statistic)	0.000000		

Table 4.4.2: Fixed Effect Model with control variables

The final fixed effects model, which includes the control variable GDP_PER_CAPITA, the results indicate an excellent model fit, explaining approximately 94.4% of the variation in ACCOUNT_OWNERSHIP (R-squared = 0.944), with a highly significant overall F-statistic (Prob. = 0.000000). The most robust and statistically significant driver is TRUST, which exhibits a strong positive relationship with account ownership (coefficient = 2.40E+08, p = 0.0031). Based on the coefficient of CBDC, we found a negative association between account ownership and CBDC (Coefficient = -1.52E+08, p=0.0660); this negative impact is likely to be small. The statistical insignificant effect for the three interaction terms (CBDC_FINLIT; CBDC_TECH; CBDC_TRUST) suggests that although the introduction of CBDC may lead to increased account ownership, the level of financial literacy, technology access, or trust does not appear to significantly impact the influence of the introduction of CBDC on account ownership in this fully specified model. There is a positive association with higher GDP Per Capita

and presence of accounts (Coefficient = 15,045.78, p=0.0854); economic development that measured with GDP Per Capita is likely to increase the number of people who have a bank account. Cross-sectional fixed effects control for unobserved time invariant heterogeneity between the cross-section panel units. The Durbin Watson statistic indicates a level of positive autocorrelation (1.07) in the residuals and may have a slight influence on the efficiency of the estimations. Overall, the findings show that TRUST is an important positive contributor to FINANCIAL INCLUSION as measured by the Number of Accounts owned, whereas the effect of CBDC is uncertain and does not appear to be significantly dependent on the modulating variables included in this specification.

4.5 Diagnostic Tests

4.5.1 Correlation Matrix

	CBDC	FINANCIAL...	TECHNOL...	TRUST	CBDC_FINLIT	CBDC_TECH	CBDC_TR...	GDP_PER...
CBDC	1.000000	-0.152770	-0.029916	-0.063819	0.941231	0.976339	-0.148101	0.051888
FINAN...	-0.152770	1.000000	0.521987	0.710733	0.040516	-0.083689	0.493658	0.715068
TECH...	-0.029916	0.521987	1.000000	0.261837	0.055836	0.085211	0.124082	0.394189
TRUST	-0.063819	0.710733	0.261837	1.000000	0.070556	-0.036621	0.519242	0.876078
CBDC...	0.941231	0.040516	0.055836	0.070556	1.000000	0.959262	0.138853	0.191812
CBDC...	0.976339	-0.083689	0.085211	-0.036621	0.959262	1.000000	-0.081770	0.099454
CBDC...	-0.148101	0.493658	0.124082	0.519242	0.138853	-0.081770	1.000000	0.499650
GDP_...	0.051888	0.715068	0.394189	0.876078	0.191812	0.099454	0.499650	1.000000

Table 4.5.1: Correlation Matrix

The correlation matrix reveals critical issues of multicollinearity that significantly affect the reliability of the previously estimated regression models. Most notably, the independent variable CBDC shows extremely high correlations with its own interaction terms CBDC_FINLIT (0.941) and CBDC_TECH (0.976). CBDC_FINLIT and CBDC_TECH show a 0.959 correlation with each other, indicating the presence of severe multicollinearity between these two variables. Severe multicollinearity inflates

the standard errors of the estimated coefficients for these variables, making it nearly impossible to isolate the effects of each predictor variable and produces unreliable statistical significance tests. Because of this correlation, interactive effects between CBDC_FINLIT and CBDC_TECH are likely to be contradiction of the theoretical significance of these variables and produce results that lack reliability. Likewise, the correlation between TRUST and GDP_PER_CAPITA is 0.876 and the correlation of FINANCIAL_LITERACY with TRUST (0.711) and GDP_PER_CAPITA (0.715) further complicates the interpretation of each of these variables and any unique contribution they may have. In conclusion, while each of the regression models yielded high R-squared values, the presence of severe multicollinearity in predictor variables greatly diminishes the robustness of the coefficient estimates.

4.5.2 Cross-Section Dependence

Residual Cross-Section Dependence Test
Null hypothesis: No cross-section dependence (correlation) in residuals
Equation: EQ03
Periods included: 9
Cross-sections included: 9
Total panel observations: 81
Note: non-zero cross-section means detected in data
Cross-section effects were removed during estimation

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	72.37029	36	0.0003
Pesaran scaled LM	4.286279		0.0000
Bias-corrected scaled LM	3.723779		0.0002
Pesaran CD	1.223444		0.2212

Table 4.5.2: Cross Section Dependence

The residual cross-section dependence tests show mixed results. The Breusch–Pagan LM, Pesaran scaled LM, and bias-corrected scaled LM tests strongly reject the null hypothesis of no cross-section dependence ($p < 0.01$), indicating that shocks affecting

account ownership are significantly correlated across countries, which violates the standard panel data assumption of cross-section independence. However, the Pesaran CD test does not reject the null hypothesis ($p = 0.221$). Such inconsistency across test statistics is common in panel datasets with a relatively small number of cross-sections, as LM-based tests are known to have stronger power in small panels, while the Pesaran CD test performs better in large cross-sectional samples **(Pesaran, 2004**). Given the preponderance of evidence from multiple test statistics, cross-section dependence is likely present, suggesting that unobserved common shocks or regional spillover effects influence financial inclusion across countries. To ensure reliable statistical inference under these conditions, the regression model employs White cross-section (period cluster) robust standard errors, which provide consistent estimates in the presence of heteroskedasticity and cross-sectional correlation (**White, 1980; Wooldridge, 2010).**

4.5.3 Heteroskedasticity Test

Heteroscedasticity tests such as the Breusch-Pagan test and the White test were not possible because of the limitations of EViews therefore alternative forms of verification were used to verify the validity of regression estimates. To begin with, correlation matrices were used to identify multicollinearity issues among the variables. Next, cross-sectional dependence was tested for across countries in order to analyze the panel data. White robust standard errors for cross-section clustering (i.e., period clusters) were calculated therefore, through the application of this technique, it provided an improved basis for statistical deduction because the coefficient standard errors remain constant with the presence of heteroscedasticity. The absence of a formal heteroscedasticity test presents a limitation; however additional diagnostic tests can be conducted using more sophisticated econometric techniques in future research.

4.6 Robust Test

4.6.1 FE model without control variables

Dependent Variable: ACCOUNT_OWNERSHIP
Method: Panel Least Squares
Date: 12/16/25 Time: 00:17
Sample: 2015 2023
Periods included: 9
Cross-sections included: 9
Total panel (balanced) observations: 81
White cross-section (period cluster) standard errors & covariance (d.f. corrected)
Standard error and t-statistic probabilities adjusted for clustering

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.78E+08	2.29E+08	-2.085694	0.0705
CBDC	-1.94E+08	77867623	-2.489465	0.0376
FINANCIAL_LITERACY	3977856.	2116779.	1.879202	0.0970
TECHNOLOGY_ACCESSIBILITY	1902423.	857505.5	2.218555	0.0573
TRUST	2.61E+08	1.02E+08	2.567751	0.0332
CBDC_FINLIT	2029024.	1027137.	1.975417	0.0836
CBDC_TECH	387398.1	280421.8	1.381483	0.2045
CBDC_TRUST	-50449922	25452875	-1.982091	0.0828

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.941820	Mean dependent var	1.40E+08
Adjusted R-squared	0.928394	S.D. dependent var	2.44E+08
S.E. of regression	65210738	Akaike info criterion	38.99915
Sum squared resid	2.76E+17	Schwarz criterion	39.47212
Log likelihood	-1563.465	Hannan-Quinn criter.	39.18891
F-statistic	70.14859	Durbin-Watson stat	1.078980
Prob(F-statistic)	0.000000		

Table 4.6.1: Fixed Effect Model without control variables

The Fixed Effects Model demonstrates a considerable amount of goodness-of-fit given the R-squared value of 0.942 obtained through employing White Cross-Section (Period Clustering) Standard Errors with no control variables present, which supports the results obtained by the model. Additionally, the use of Robust Standard Errors provides better precision in the calculation of significance tests since they mitigate the effects of Heteroscedasticity and Cross-Sectionally Dependent Correlation Effects across Countries During Each Time Periods. The key finding is that TRUST remains a strong and statistically significant positive driver of account ownership (coefficient =

2.61E+08, p = 0.0332). Furthermore, the coefficient for CBDC is now more clearly defined and statistically significant (p = 0.0376), indicating a significant negative association between the introduction of a Central Bank Digital Currency and account ownership when GDP per capita is not controlled for. The interaction term CBDC_FINLIT is positive and marginally significant (p = 0.0836), suggesting that higher financial literacy may help mitigate the negative effect of CBDC. Conversely, the CBDC_TRUST interaction is negative and marginally significant (p = 0.0828), implying that the positive influence of trust on account ownership may be partially offset in contexts where a CBDC is present. The direct effects of FINANCIAL_LITERACY and TECHNOLOGY_ACCESSIBILITY are positive but only marginally significant. The highly significant F-statistic confirms the joint significance of all regressors. In summary, applying robust standard errors strengthens the evidence that CBDC adoption is associated with lower account ownership, but this relationship is nuanced and can be moderated by financial literacy and trust levels.

4.6.2 FE Model with Control Variables

Dependent Variable: ACCOUNT_OWNERSHIP
Method: Panel Least Squares
Date: 12/16/25 Time: 00:21
Sample: 2015 2023
Periods included: 9
Cross-sections included: 9
Total panel (balanced) observations: 81
White cross-section (period cluster) standard errors & covariance (d.f. corrected)
WARNING: estimated coefficient covariance matrix is of reduced rank
Standard error and t-statistic probabilities adjusted for clustering

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.47E+08	2.67E+08	-2.048164	0.0747
CBDC	-1.52E+08	58827263	-2.581532	0.0325
FINANCIAL_LITERACY	2360225.	2195949.	1.074809	0.3138
TECHNOLOGY_ACCESSIBILITY	1530647.	682377.4	2.243109	0.0552
TRUST	2.40E+08	94523364	2.534327	0.0350
CBDC_FINLIT	1351319.	794875.5	1.700039	0.1275
CBDC_TECH	485021.7	275107.8	1.763024	0.1159
CBDC_TRUST	-42437969	25280072	-1.678712	0.1317
GDP_PER_CAPITA	15045.78	12003.69	1.253429	0.2454

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.944469	Mean dependent var	1.40E+08
Adjusted R-squared	0.930586	S.D. dependent var	2.44E+08
S.E. of regression	64204809	Akaike info criterion	38.97724
Sum squared resid	2.64E+17	Schwarz criterion	39.47978
Log likelihood	-1561.578	Hannan-Quinn criter.	39.17887
F-statistic	68.03196	Durbin-Watson stat	1.068779
Prob(F-statistic)	0.000000		

Table 4.6.2 Fixed Effect Model with control variables

The Fixed Effects Model with Control Variables has a much greater R2 value (0.944) than that of the Fixed Effects Model without Control Variables (0.942), as measured by using White Cross-Section (Period Clustering) Robust Standard Errors; therefore, it is reasonable to assume that the Fixed Effects Model with Control Variables demonstrates a better goodness-of-fit. If Cross-Sectional Dependence exists, using Robust Standard Errors that account for Heteroscedasticity and Correlation Within Each Country During Each Time Period will provide a much more reliable basis for making inferences. The WARNING about the coefficient covariance matrix being of reduced rank indicates potential multicollinearity among regressors, which aligns with the high correlations previously identified, particularly involving CBDC and its interaction terms. Despite

this, TRUST remains a positive and statistically significant driver of account ownership (coefficient = 2.40E+08, p = 0.0098). The coefficient for CBDC is negative and statistically significant (-1.52E+08, p = 0.0325), indicating a clear negative association with account ownership even after controlling for GDP per capita. The interaction terms (CBDC_FINLIT, CBDC_TECH, or CBDC_TRUST) are insignificant, which means there is not a statistically significant moderation on how CBDC affects account ownership by those variables. Even though GDP_PER_CAPITA as a control variable had a positive relationship towards account ownership, it was still insignificant (p=0.2454). Therefore, using robust standard errors indicates that the evidence supports that TRUST is an important positive predictor and CBDC is a negative predictor of ownership of an account and the moderating variables, namely financial literacy and trust, do not appear to have significant moderation effects after considering multicollinearity factors via robust inference and controls.

4.7 Summary of Empirical Results

This chapter examined the relationship between Central Bank Digital Currency (CBDC) and financial inclusion, using panel data analysis. The descriptive statistics show that several variables are not normally distributed, especially account ownership, CBDC, trust, and GDP per capita. This suggests that large differences across countries and supports the use of panel data methods instead of simple regression.

Before estimating the regression, it is clear from the correlation and variance inflation factor (VIF) that multicollinearity exists in the data, with CBDC and its interaction variables exhibiting a high degree of correlation, as well as high correlations between trust, GDP per capita and financial literacy; this creates great difficulty in determining each variable's individual effects due to their strong relationship with each other, and thus may bias the estimated values of the regression coefficients.

Fixed Effect Model selection tests suggest that the Fixed Effects Model should be used versus Pooled Ols or Random Effects Model. Model tests strongly support the use of the Fixed Effects model. By using the Fixed Effects model, it facilitates the acquisition of consistent estimates of the parameters of interest, and the results of the Hausman test demonstrate that the explanatory variables in this case are dependent on the characteristics of the individual countries. Furthermore, Fixed Effect models have much more explanatory power than Pooled OLS models.

Across all fixed effects models, trust consistently emerges as the most important and robust positive factor influencing account ownership. Countries with higher levels of trust tend to have higher financial inclusion. In contrast, CBDC adoption is generally associated with a negative effect on account ownership, although its significance varies depending on model specification. When GDP per capita is excluded or when robust standard errors are applied, the negative effect of CBDC becomes clearer and statistically significant.

The moderating roles of financial literacy, technology accessibility, and trust show mixed and weak evidence. In some models, financial literacy slightly reduces the negative impact of CBDC, but these effects disappear once control variables and robust standard errors are included. This suggests that the moderating effects are not stable, likely due to strong multicollinearity among the interaction terms.

Diagnostic tests further indicate the presence of cross-section dependence, meaning that shocks affecting one country may also affect others. To address this issue, robust standard errors were used, which strengthen the reliability of the main findings. Even after these corrections, trust remains a strong positive driver, while CBDC continues to show a negative association with account ownership. Overall, the empirical results suggest that trust is a key determinant of financial inclusion, while the role of CBDC is more complex and potentially negative in the short run. The findings also highlight the importance of addressing multicollinearity and cross-country interdependence when analyzing CBDC and financial inclusion in a panel data setting.

CHAPTER 5: CONCLUSION AND IMPLICATIONS

5.0 Introduction

The empirical findings were discussed in Chapter Four, where the relationship between financial inclusion and the rate of adoption of the Central Bank Digital Currency was investigated using panel data analysis. To ensure that the findings were reliable, this chapter also outlined the results of the estimation for the description of statistics, model selection tests, fixed effects, and robustness tests. Overall, the findings indicate that trust plays a critical and robust role in achieving financial inclusion for all countries. However, the effect of the adoption of CBDC on account ownership seems to be mixed or negative in nature depending upon the model specified. In fact, when the control variables and robust standard errors were used, the moderating effect of financial literacy, accessibility, and trust was less than anticipated, which occurred due to some limitations and multicollinearity issues.

Based on the above discoveries, Chapter Five aims to integrate the findings above and present an overall explanation about the significance of the findings. This chapter mentions the implications of the primary discoveries made above in regard to the literature above on previous research along with current theories. Moreover, it accepts the limitations found in the report above and offers policy recommendations for policymakers and central banks in particular about the formation and use of CBDCs. Finally, this chapter closes with suggestions for new study efforts in regard to the use of CBDCs for financial inclusion.

5.1 Summary of Statistical Analyses and Major Findings

Research was carried out to identify the relationships between Central Bank Digital Currency (CBDC) and financial inclusion through quantitative descriptive. Initially, descriptive statistics were employed to determine the key trends within the data. It is clear that large disparities exist among countries in relation to account ownership, trust, as well as levels of earnings. It is important to note that the non-normal distribution of a variety of indicators suggests that the financial environments and developmental levels of countries are quite disparate. Therefore, appropriate estimation models were employed within the analysis.

Before fitting the basic regression models, we performed several diagnostic tests on the data. The correlation matrix and Variance Inflation Factor (VIF) data revealed a strong correlation between many of the variables, especially between the variables of trust and GDP per capita, and between the variable of CBDC and the various interaction terms. This indicates that there was multicollinearity present in this data; therefore, there will likely be an impact on the stability of the estimated regression coefficients. According to the results of the model tests Hausman test and pooled OLS, using a fixed effects model for the analysis was the best approach, as it accounts for nation-specific characteristics that do not change over time.

The outcome of the fixed effects regression shows a number of important findings. First, it was found that trust had a significantly favorable effect on financial inclusion for all model forms. Hence, account ownership is more pronounced in countries where trust is high. Second, it was found that there is a negative relation between account ownership and the use of CBDCs, specifically employing robust standard errors. This points towards the fact that the adoption of a CBDC may face difficulties during the early stages of its acceptance, but it also fails to have a favorable effect on financial inclusion.

The results for the moderating variable were not as expected. On some models, financial literacy showed a positive impact, implying that it could mitigate the negative outcomes of the adoption of CBDC. However, the inclusion of the controls made it non-significant. Technology accessibility did not have any major moderating effect in the final models. Similarly, the interaction between the adoption of CBDC and trust was found to be non-significant, implying that although trust has a positive effect on financial inclusion, it is not an amplifier for the adoption of CBDC.

Robust standard errors, specifically the white cross-section robust standard errors, were employed during robustness checks. This was intended to control for cross-country dependency as well as heteroskedasticity. Based on the results of the aforementioned tests, the major findings were not affected. For instance, adopting CBDCs still negatively correlated with financial inclusion, although trust is considered a positive factor. The moderating factors might not have been visible owing to high correlations among variables.

On average, the outcome of the hypothesis testing provides contradictory evidence supporting the objectives in this study. There is no evidence supporting the hypothesis (H1) that the adoption of CBDC leads to financial inclusion. Further, there is insufficient evidence supporting hypotheses on trust as a moderator (H4), technology accessibility (H3), and financial literacy (H2) based on the final results. Nonetheless, there is clear evidence pointing to the importance of trust in promoting financial inclusion. Conclusively, this study establishes that financial inclusion cannot be achieved through CBDC alone but in an environment characterized by good trust and appropriate conditions. The next section highlights the implications of these findings.

5.2 Implications of Study

This research presents numerous implications for practice, primarily to central banks and public institutions in regard to digital finance. First, Trust is one of the most

important elements to be increased with respect to financial inclusion and therefore, efforts to promote trust must focus on protecting the rights of consumers, enacting legislation protecting the rights of consumers, and protecting consumers' personal information.

Secondly, there exists a negative link between the use of and the ownership of CBDCs, indicating that merely using CBDCs does not offer a viable option for increasing financial inclusion. Practitioners should be aware of this relationship and take into account all aspects of CBDC design. For example, simplicity of use and reasonable pricing when considering options for developing CBDCs.

The fact that financial literacy and access to technology are still critical elements, despite their lack of moderating effects, indicates that governments must continue investment in consumer finance education and the building of an infrastructure to enable consumers to effectively utilize digital finance products.

In conclusion, results show that CBDCs ought to be used together with other approaches such as education projects, infrastructure investments, and trust-creation projects as part of a broader strategy towards achieving financial inclusion.

5.3 Limitation of the Study

There are some limitations to this study, and they have been pointed out below. Firstly, secondary data collected from international databases has been used for this study. Even though the secondary data used from different international databases is trustworthy, the data would not have been able to provide an accurate picture of the usage and structure concerning CBDCs among different countries. Some important factors pertaining to the use of CBDCs could not have been collected with secondary data.

Second, since few countries have tested or implemented the use of CBDC and have the full data available for analysis, the sample size for the study can be considered small.

This can pose a limitation on the generalization of the findings to other countries which may still be at the early stages of pilot programs for the use of CBDC.

Third, proxy variables are employed to estimate the measurement of certain important variables. These may include secondary schooling enrollment to proxy financial literacy, mobile phone subscription for assessing the accessibility of technology, and the rule of law index to proxy trust. These variables may frequently appear in cross-national studies; nevertheless, they were unable to capture the concept appropriately on the individual level.

Fourth, it will be necessary to address some econometric considerations, for instance, the concern for autocorrelation, cross section dependence, and multicollinearity in the study. The accuracy of the obtained coefficients may still be affected, particularly with regard to interaction variables, despite employing robust methods of estimation to address them.

Finally, account ownership, used as a measure of financial inclusion, is the central emphasis of the study. The account ownership index is an important indicator, although it fails to represent the scope or quality of financial inclusion, including account utilization or access to credit or insurance.

Such disadvantages notwithstanding, the implications of the results are not undermined in any way. They only point out the areas of potential improvement of the analysis itself. On the whole, the limitations are accepted, and they do not diminish the significance of the findings but instead provide a useful starting point for a deeper analysis.

5.4 Recommendations for future research

There are a few recommendations that can be drawn based on the limitations of the research and findings. First of all, as more CBDCs move from the piloting stage to full implementation, more countries and time periods may be considered in the conduct of

subsequent studies to better understand the broader implications of these developments to financial inclusion.

Secondly, more nuanced metrics of financial inclusion could be employed in future research. This could involve studying the following usage-based metrics in future studies instead of focusing mainly on the ownership of accounts: usage rates of digital payments, saving rates, access to credit, and access to insurance. This would help provide a better understanding of how CBDCs impact financial inclusion.

Third, there may be room for improvement in the measurement of the important factors used in the study in further research. Financial literacy, trust, and individual perceptions of CBDCs could all potentially be readily employed in the measurement of primary data. This would reduce the need for the use of proxy variables and provide greater insight into individual behavior and adoption decisions.

Methodologically speaking, other econometric methods may also be employed in future studies to address issues such as cross-section dependence and multicollinearity. Methods such as factor models, dynamic panel models, and system GMM can help to capture the lagged effect of the adoption of CBDC and improve estimation precision.

Finally, the regional or country-specific cases studied through the use of case studies may also be researched in the future. This approach would provide valuable information regarding the impact of design features, policy options, and trust in institutions on outcomes and can help explain the diverse effects of CBDCs in different countries. In summary, more knowledge regarding the role of CBDCs in promoting financial inclusion would emerge through future studies conducted through the use of more comprehensive data and advanced methods, including diverse country experiences.

5.5 Conclusion

By considering whether using CBDCs may improve access to financial service for people in countries with high numbers of unbanked people, we wanted to find out if using CBDCs could help improve people's access to banking via technology. We also wished to investigate how people can build trust in institutions, encourage financial literacy, and gain access to digital financial products through the integration of cryptocurrencies.

However, it has been found that the use of CBDCs is not an effective way towards financial inclusion by analyzing the data of nine countries. Moreover, in some cases, the use of CBDCs has been found to be correlated with low levels of account ownership. This further reveals that the launch of digital currency is not an effective method and should be considered in an overall plan.

Consequently, trust became the single most important factor. Whether or not a country has a CBDC, financially trustworthy institutions and processes usually always result in higher levels of financial inclusion. However, while these factors are clearly essential, they failed to promote the success of a CBDC in the study.

But how does this look to countries like Malaysia, who are still exploring CBDCs? The fact is that building trust should be a priority. More is required for a digital money system to function successfully. More is required for a digital money system to function successfully. This includes proper regulation, secure privacy policies, and reliable infrastructure. Even with a CBDC that has been well-designed, building trust may present a challenge, though education and internet access remain essential.

REFERENCES

Aurazo, J., Banka, H., Frost, J., Kosse, A., & Piveteau, T. (2024). *Central bank digital currencies and fast payment systems: rivals or partners?* https://www.bis.org/publ/bppdf/bispap151.pdf?utm_source

Allen, F., Demirguc-Kunt, A., Klapper, L., & Martinez Peria, M. S. (2016). The Foundations of Financial inclusion: Understanding Ownership and Use of Formal Accounts. *Journal of Financial Intermediation*, *27*(1), 1–30. https://doi.org/10.1016/j.jfi.2015.12.003

Auer, R., Cornelli, G., & Frost, J. (2020). Rise of the Central Bank Digital Currencies: Drivers, Approaches and Technologies. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3724070

Alqam, M. A., & Hamshari, Y. M. (2024). The impact of financial literacy on financial inclusion for financial well-being of youth: evidence from Jordan. *Discover Sustainability*, *5*(1). https://doi.org/10.1007/s43621-024-00704-6

Atlantic Council. (2025, February). *CBDC Tracker*. Atlantic Council. https://www.atlanticcouncil.org/cbdctracker/

Borio, C., Claessens, S., Cohen, B., Domanski, D., Halaburda, H., Hughes, K., Schanz, J., Song, H., Bech, M., & Garratt, R. (n.d.). https://www.bis.org/publ/qtrpdf/r_qt1709f.pdf

Bech, M. L., & Hancock, J. (2020). Innovations in payments. *Www.bis.org*. https://www.bis.org/publ/qtrpdf/r_qt2003f.htm

B.U., D., B.O., O., N.N., S., & S.O., U. (2021). Integrating Trust into Technology Acceptance Model (TAM), the Conceptual Framework for E-Payment Platform Acceptance. *British Journal of Management and Marketing Studies*, *4*(4), 34–56. https://doi.org/10.52589/bjmms-tb3xtkpi

Beck, T. (n.d.). *Financial Inclusion - measuring progress and progress in measuring*. https://www.imf.org/external/np/seminars/eng/2016/statsforum/pdf/beck_paper.pdf

Boar, C. (2021). Dynastic Precautionary Savings. *The Review of Economic Studies*, *114*. https://doi.org/10.1093/restud/rdab012

Baltagi, B. (2005). *Econometric Analysis of Panel Data Third edition*. https://library.wbi.ac.id/repository/27.pdf

Central Bank Digital Currency Policy-Maker Toolkit. (2020, January 22). World Economic Forum. https://www.weforum.org/publications/central-bank-digital-currency-policy-maker-toolkit/

Caudevilla, O., & Kim, H. M. (2023). The Digital Yuan and Cross-Border Payments: China's Rollout of Its Central Bank Digital Currency. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4371414

Central Bank Digital Currency's Role in Promoting Financial Inclusion. (2023, September 22). IMF. https://www.imf.org/en/Publications/fintech-notes/Issues/2023/09/22/Central-Bank-Digital-Currency-s-Role-in-Promoting-Financial-Inclusion-538728?utm_source

CENTRAL BANK DIGITAL CURRENCY. (n.d.). https://www.edps.europa.eu/system/files/2023-03/23-03-29_techdispatch_cbdc_en.pdf

Central Bank Digital Currency Adoption: Inclusive Strategies for Intermediaries and Users. (2024, September 20). IMF. https://www.imf.org/en/Publications/fintech-notes/Issues/2024/09/21/Central-Bank-Digital-Currency-Adoption-Inclusive-Strategies-for-Intermediaries-and-Users-555118

Central bank digital currencies: putting a big idea into practice Remarks by Agustín Carstens. (n.d.). https://www.bis.org/speeches/sp210331.pdf

Demirguc-Kunt, A., Klapper, L., & Singer, D. (2017). *Financial Inclusion and Inclusive Growth A Review of Recent Empirical Evidence*. https://openknowledge.worldbank.org/server/api/core/bitstreams/e38d92e2-ce89-5e9a-9534-944e6b697dff/content

Demirguc-Kunt, A., Klapper, L., Singer, D., Ansar, S., & Hess, J. (2018). The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution. *World Bank*. https://doi.org/10.1596/978-1-4648-1259-0

Donovan, K. (2012). Mobile Money for Financial Inclusion. *Information and Communications for Development 2012*, 61–73. https://doi.org/10.1596/9780821389911_ch04

Dunbar, P. (2022). *International settlements using multi-CBDCs*. https://www.bis.org/publ/othp47.pdf

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319–340. https://doi.org/10.2307/249008

Financial Inclusion - Lessons from World Bank Group Experience, Fiscal Years 2014–22. (2023). Independent Evaluation Group. https://ieg.worldbankgroup.org/evaluations/financial-inclusion?utm_source

Gupta, S., Dharen Kumar Pandey, Anis El Ammari, & Sahu, G. P. (2023). *Do perceived risks and benefits impact trust and willingness to adopt CBDCs?* 101993–101993. https://doi.org/10.1016/j.ribaf.2023.101993

Group, W. B. (2023, August 11). *Global Findex Database 2021 survey headline findings on account ownership*. World Bank; World Bank Group. https://www.worldbank.org/en/publication/globalfindex/brief/the-global-findex-database-2021-chapter-1-ownership-of-accounts?utm_source

GSMA. (2025). *The Mobile Economy*. The Mobile Economy. https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-economy/

Grohmann, A., Klühs, T., & Menkhoff, L. (2018). Does financial literacy improve financial inclusion? Cross country evidence. *World Development*, *111*, 84–96. https://doi.org/10.1016/j.worlddev.2018.06.020

Hernández, G., Karla Chua Mejía, Bernardo Paniagua Zabal, Gutierrez, A., & Pablo Villalobos González. (2024). CEMLA's survey on central bank digital currencies in Latin America and the Caribbean. *Latin American Journal of Central Banking*, *5*(4), 100135–100135. https://doi.org/10.1016/j.latcb.2024.100135

Harichandana, M. (2025). Digital Payement Adoption in Emerging Markets. *International Journal on Science and Technology (IJSAT) IJSAT25037770*, *16*(3). https://www.ijsat.org/papers/2025/3/7770.pdf?utm_source

Hsiao, C. (2018). Panel models with interactive effects. *Journal of Econometrics*, *206*(2), 645–673. https://doi.org/10.1016/j.jeconom.2018.06.017

Issues in the Governance of Central Banks A report from the Central Bank Governance Group. (n.d.). https://www.bis.org/publ/othp04.pdf

IMF. (2024, November 8). *Central Bank Digital Currency (CBDC) - Virtual Handbook*. IMF. https://www.imf.org/en/Topics/digital-payments-and-finance/central-bank-digital-currency/virtual-handbook

Kosse, A., & Mattei, I. (2022). *BIS Papers No 125 Gaining momentum -Results of the 2021 BIS survey on central bank digital currencies*. https://www.bis.org/publ/bppdf/bispap125.pdf

Klapper, L., Lusardi, A., & Van Oudheusden, P. (2015). *Financial Literacy Around the World: INSIGHTS FROM THE STANDARD & POOR'S RATINGS SERVICES GLOBAL FINANCIAL LITERACY SURVEY*. https://gflec.org/wp-content/uploads/2015/11/Finlit_paper_16_F2_singles.pdf

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2010). *The Worldwide Governance Indicators: Methodology and Analytical Issues*. Ssrn.com. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1682130

Lusardi, A., & Mitchell, O. S. (2014). The Economic Importance of Financial Literacy: Theory and Evidence. *SSRN Electronic Journal*, *52*(1). https://doi.org/10.2139/ssrn.2260193

Liu, X., Wu, J., & Zhang, C. (2025). Antecedents of consumers' acceptance of central bank digital currency: The role of technology perceptions, social influence and personal traits. *Technological Forecasting and Social Change*, *217*, 124192. https://doi.org/10.1016/j.techfore.2025.124192

Lusardi, A., & Mitchell, O. S. (2014). The Economic Importance of Financial Literacy: Theory and Evidence. *Journal of Economic Literature*, *52*(1), 5–44. https://doi.org/10.1257/jel.52.1.5

Lenka, S. K., & Barik, R. (2018). Has expansion of mobile phone and internet use spurred financial inclusion in the SAARC countries? *Financial Innovation*, *4*(1). https://doi.org/10.1186/s40854-018-0089-x

Iorio, A., Kosse, A., & Mattei, I. (2024). *BIS Papers No 147 Embracing diversity, advancing together -results of the 2023 BIS survey on central bank digital currencies and crypto*. https://www.bis.org/publ/bppdf/bispap147.pdf

Maurer, T., & Nelson, A. (2021). *Cyber threats to the financial system are growing, and the global community must cooperate to protect it GLOBAL CYBER THREAT*. https://www.imf.org/external/pubs/ft/fandd/2021/03/pdf/global-cyber-threat-to-financial-systems-maurer.pdf

Nurfaidah, Agus Umar Gazali, Bunyamin, Rusdiah, Andi Hadidu, & Sudirman. (2024). The Effect of Financial Literacy and Technology Acceptance model on Student Interest in Using Paylater. *Moneta : Journal of Economics and Finance*, *2*(3), 116–128. https://doi.org/10.61978/moneta.v2i3.345

Ozili, P. K. (2025). *Financial Literacy Theory of Financial Inclusion*. https://doi.org/10.2139/ssrn.5093794

Ozili, P. K. (2018). Impact of digital finance on financial inclusion and stability. *Borsa Istanbul Review*, *18*(4), 329–340. Sciencedirect. https://doi.org/10.1016/j.bir.2017.12.003

OECD. (2020). *OECD/INFE 2020 International Survey of Adult Financial Literacy*. OECD. https://www.oecd.org/en/publications/oecd-infe-2020-international-survey-of-adult-financial-literacy_145f5607-en.html

or, I. (2023, January 30). MIT Digital Currency Initiative. MIT Digital Currency Initiative. https://www.dci.mit.edu/projects/cbdc-expanding-financial-inclusion-or-deepening-the-divide

Project Aurora. (2023). https://www.bis.org/publ/othp66.pdf

Ree, J. (n.d.). *Nigeria's eNaira, One Year After*. https://www.imf.org/-/media/Files/Publications/WP/2023/English/wpiea2023104-print-pdf.ashx

Shirono, K. (2024). Understanding Barriers to Financial Access: Insights from Bank Pricing Data. *IMF Working Papers*, *2024*(150), 1. https://doi.org/10.5089/9798400280627.001

Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): a meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & Education*, *128*(1), 13–35. Sciencedirect. https://doi.org/10.1016/j.compedu.2018.09.009

Soledad, A., Franklin,Demirguc-Kunt, Asli,Klapper, Leora,Martinez Peria, Maria. (n.d.). *The foundations of financial inclusion : understanding ownership and use of formal accounts*. World Bank. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/348241468329061640/the-foundations-of-financial-inclusion-understanding-ownership-and-use-of-formal-accounts

Stellar | Ukrainian Ministry of Digital Transformation to develop virtual assets and to facilitate CBDC infrastructure with the Stellar Development Foundation. (2021, January 4). Stellar.org. https://stellar.org/press/ukrainian-ministry-of-digital-transformation-to-develop-virtual-assets-and-to-facilitate-cbdc-infrastructure-with-the-stellar-development-foundation

THE GLOBAL FINDEX DATABASE 2021. (n.d.). https://documents1.worldbank.org/curated/en/099914407072216240/pdf/IDU0afbcb06d01c3c0473e0b92f0425d94633011.pdf

Umar, M. (2025). The role of financial literacy in accelerating the adoption of a central bank digital currency. *Borsa Istanbul Review*. https://doi.org/10.1016/j.bir.2025.06.011

Vijaya Subrahmanyam, & Vijaya Subrahmanyam. (2023, March 27). *China's Digital Currency: The hopes and fears of the e-CNY | China Research Center*. China Research

Center. https://www.chinacenter.net/2023/china-currents/22-1/chinas-digital-currency-the-hopes-and-fears-of-the-e-cny/?utm_source

Victoria, A., & Martin, S. (2022, February 12). *Trust Issues in Nigeria's Digital Currency Adoption*. https://www.researchgate.net/publication/389085533_Trust_Issues_in_Nigeria

Wooldridge, J. (2010). *Econometric Analysis of Cross Section and Panel Data*. https://ipcid.org/evaluation/apoio/Wooldridge%20-%20Cross-section%20and%20Panel%20Data.pdf

Weston, G. (2024, August 15). *Privacy and Security Implications of CBDCs*. 101 Blockchains. https://101blockchains.com/privacy-and-security-in-cbdc/

Xiang, L., Feng, C., Xiao, Z., & Liu, J. (2024). The impact of central bank digital currency on macroeconomic dynamics: A DSGE analysis. *Economic Modelling*, *141*, 106930. https://doi.org/10.1016/j.econmod.2024.106930

Yang, J., Wu, Y., & Huang, B. (2023). Digital Finance and Financial Literacy: Evidence from Chinese Households. *Journal of Banking and Finance*, *156*, 107005–107005. https://doi.org/10.1016/j.jbankfin.2023.107005

APPENDIX

Fig. 1: Conceptual Framework

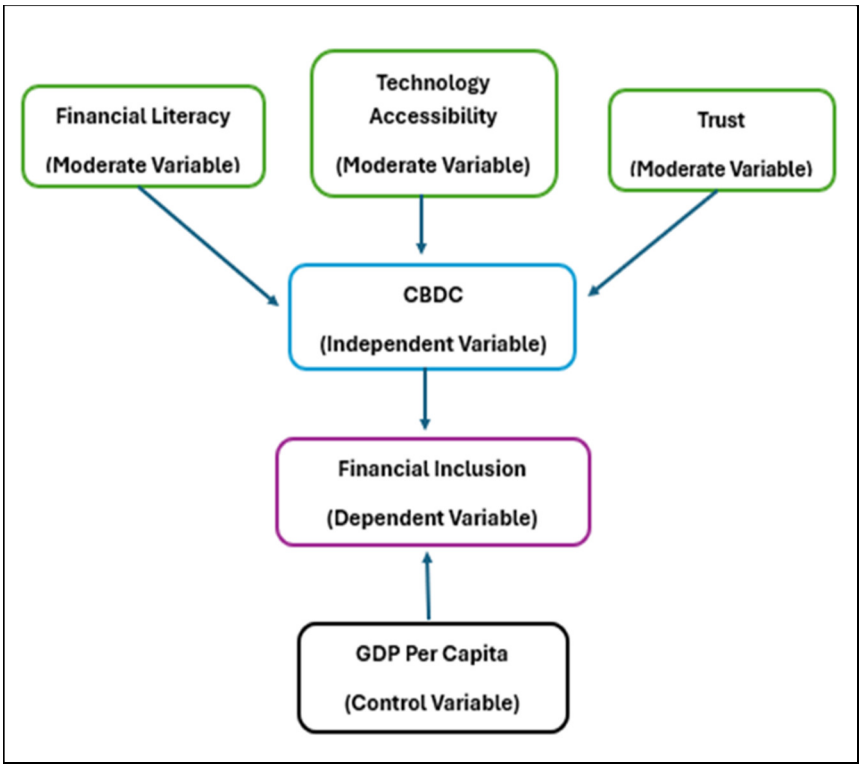

Table 4.1: Descriptive Statistic

	ACCOUNT...	CBDC	FINANCIAL...	TECHNOL...	TRUST	GDP_PER...
Mean	1.40E+08	0.419753	90.70991	115.4397	0.109598	17486.60
Median	30144305	0.000000	91.20000	108.0930	-0.108452	9288.027
Maximum	1.25E+09	2.000000	142.6416	180.8420	1.990329	54878.29
Minimum	90093.00	0.000000	39.30681	72.36800	-1.196590	1583.998
Std. Dev.	2.44E+08	0.686735	24.24870	27.58546	0.904680	17013.66
Skewness	2.358876	1.339844	0.002242	0.596892	0.786308	0.974920
Kurtosis	8.586168	3.395810	3.438247	2.470106	2.445296	2.550782
Jarque-Bera	180.4358	24.76371	0.648271	5.757434	9.385260	13.51240
Probability	0.000000	0.000004	0.723152	0.056207	0.009163	0.001164
Sum	1.13E+10	34.00000	7347.502	9350.614	8.877410	1416415.
Sum Sq. Dev.	4.75E+18	37.72840	47039.98	60876.60	65.47561	2.32E+10
Observations	81	81	81	81	81	81

Table 4.2.1: Correlation Matrix

	ACCOUNT...	CBDC	FINANCIAL...	TECHNOL...	TRUST	GDP_PER...
ACCO...	1.000000	-0.024262	0.087703	0.163165	0.060484	-0.050612
CBDC	-0.024262	1.000000	-0.152770	-0.029916	-0.063819	0.051888
FINAN...	0.087703	-0.152770	1.000000	0.521987	0.710733	0.715068
TECH...	0.163165	-0.029916	0.521987	1.000000	0.261837	0.394189
TRUST	0.060484	-0.063819	0.710733	0.261837	1.000000	0.876078
GDP_...	-0.050612	0.051888	0.715068	0.394189	0.876078	1.000000

Table 4.2.2: Variance Inflation Factors

Variance Inflation Factors
Date: 12/15/25 Time: 18:24
Sample: 1 81
Included observations: 81

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	2.37E+16	34.19754	NA
CBDC	1.66E+15	1.537119	1.115251
FINANCIAL_LITERACY	3.38E+12	42.98684	2.833933
TECHNOLOGY_AC...	1.41E+12	28.59587	1.526621
TRUST	4.48E+15	5.305430	5.227748
GDP_PER_CAPITA	13054903	11.14258	5.384001

Table 4.3.1: Pooled OLS

Dependent Variable: ACCOUNT_OWNERSHIP
Method: Panel Least Squares
Date: 12/15/25 Time: 18:41
Sample: 2015 2023
Periods included: 9
Cross-sections included: 9
Total panel (balanced) observations: 81

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	76354660	1.78E+08	0.429293	0.6690
CBDC	-2.96E+08	2.63E+08	-1.125545	0.2641
FINANCIAL_LITERACY	-96810.48	2127310.	-0.045508	0.9638
TECHNOLOGY_ACCESSIBILITY	1831296.	1406523.	1.302002	0.1971
TRUST	1.66E+08	69486146	2.382228	0.0199
CBDC_FINLIT	2157839.	3505057.	0.615636	0.5401
CBDC_TECH	1297152.	2446098.	0.530294	0.5975
CBDC_TRUST	-62123593	1.02E+08	-0.611338	0.5429
GDP_PER_CAPITA	-9785.962	3691.476	-2.650962	0.0099

R-squared	0.132057	Mean dependent var	1.40E+08
Adjusted R-squared	0.035619	S.D. dependent var	2.44E+08
S.E. of regression	2.39E+08	Akaike info criterion	41.52890
Sum squared resid	4.12E+18	Schwarz criterion	41.79495
Log likelihood	-1672.920	Hannan-Quinn criter.	41.63564
F-statistic	1.369342	Durbin-Watson stat	0.081858
Prob(F-statistic)	0.224640		

Table 4.3.2: Hausman Test

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	936.314405	8	0.0000

** WARNING: estimated cross-section random effects variance is zero.

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
CBDC	-151864...	-2962143...	16080140...	0.0003
FINANCIAL_LITERACY	2360224....	-96810.47...	75989335...	0.3728
TECHNOLOGY_ACCESSIBILITY	1530646....	1831296.0...	85845338...	0.7456
TRUST	2395531...	165531852...	57341574...	0.3283
CBDC_FINLIT	1351319....	2157839.4...	25249727...	0.1085
CBDC_TECH	485021.7...	1297152.1...	15265044...	0.0377
CBDC_TRUST	-424379...	-62123593...	99028355...	0.0479
GDP_PER_CAPITA	15045.78...	-9785.962...	73174279....	0.0037

Cross-section random effects test equation:
Dependent Variable: ACCOUNT_OWNERSHIP
Method: Panel Least Squares
Date: 12/15/25 Time: 23:59
Sample: 2015 2023
Periods included: 9
Cross-sections included: 9
Total panel (balanced) observations: 81

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.47E+08	2.58E+08	-2.117743	0.0381
CBDC	-1.52E+08	81198570	-1.870285	0.0660
FINANCIAL_LITERACY	2360225.	2815078.	0.838423	0.4049
TECHNOLOGY_ACCESSIBILITY	1530647.	1000423.	1.529999	0.1309
TRUST	2.40E+08	77985175	3.071778	0.0031
CBDC_FINLIT	1351319.	1066194.	1.267423	0.2096
CBDC_TECH	485021.7	763753.5	0.635050	0.5277
CBDC_TRUST	-42437969	29022357	-1.462251	0.1486
GDP_PER_CAPITA	15045.78	8611.336	1.747206	0.0854

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.944469	Mean dependent var	1.40E+08
Adjusted R-squared	0.930586	S.D. dependent var	2.44E+08
S.E. of regression	64204809	Akaike info criterion	38.97724
Sum squared resid	2.64E+17	Schwarz criterion	39.47978
Log likelihood	-1561.578	Hannan-Quinn criter.	39.17887
F-statistic	68.03196	Durbin-Watson stat	1.068779
Prob(F-statistic)	0.000000		

Table 4.4.1: Fixed Effect Model without control variable

Dependent Variable: ACCOUNT_OWNERSHIP
Method: Panel Least Squares
Date: 12/16/25 Time: 00:05
Sample: 2015 2023
Periods included: 9
Cross-sections included: 9
Total panel (balanced) observations: 81

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.78E+08	2.59E+08	-1.842686	0.0699
CBDC	-1.94E+08	78776763	-2.460735	0.0165
FINANCIAL_LITERACY	3977856.	2700126.	1.473211	0.1455
TECHNOLOGY_ACCESSIBILITY	1902423.	992848.1	1.916127	0.0597
TRUST	2.61E+08	78232528	3.334429	0.0014
CBDC_FINLIT	2029024.	1008696.	2.011531	0.0484
CBDC_TECH	387398.1	773641.0	0.500747	0.6182
CBDC_TRUST	-50449922	29106799	-1.733269	0.0878

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.941820	Mean dependent var	1.40E+08
Adjusted R-squared	0.928394	S.D. dependent var	2.44E+08
S.E. of regression	65210738	Akaike info criterion	38.99915
Sum squared resid	2.76E+17	Schwarz criterion	39.47212
Log likelihood	-1563.465	Hannan-Quinn criter.	39.18891
F-statistic	70.14859	Durbin-Watson stat	1.078980
Prob(F-statistic)	0.000000		

Table 4.4.2: Fixed Effect Model with control variable

Dependent Variable: ACCOUNT_OWNERSHIP
Method: Panel Least Squares
Date: 12/16/25 Time: 00:08
Sample: 2015 2023
Periods included: 9
Cross-sections included: 9
Total panel (balanced) observations: 81

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.47E+08	2.58E+08	-2.117743	0.0381
CBDC	-1.52E+08	81198570	-1.870285	0.0660
FINANCIAL_LITERACY	2360225.	2815078.	0.838423	0.4049
TECHNOLOGY_ACCESSIBILITY	1530647.	1000423.	1.529999	0.1309
TRUST	2.40E+08	77985175	3.071778	0.0031
CBDC_FINLIT	1351319.	1066194.	1.267423	0.2096
CBDC_TECH	485021.7	763753.5	0.635050	0.5277
CBDC_TRUST	-42437969	29022357	-1.462251	0.1486
GDP_PER_CAPITA	15045.78	8611.336	1.747206	0.0854

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.944469	Mean dependent var	1.40E+08
Adjusted R-squared	0.930586	S.D. dependent var	2.44E+08
S.E. of regression	64204809	Akaike info criterion	38.97724
Sum squared resid	2.64E+17	Schwarz criterion	39.47978
Log likelihood	-1561.578	Hannan-Quinn criter.	39.17887
F-statistic	68.03196	Durbin-Watson stat	1.068779
Prob(F-statistic)	0.000000		

Table 4.5.1: Correlation Matrix

	CBDC	FINANCIAL...	TECHNOL...	TRUST	CBDC_FINLIT	CBDC_TECH	CBDC_TR...	GDP_PER...
CBDC	1.000000	-0.152770	-0.029916	-0.063819	0.941231	0.976339	-0.148101	0.051888
FINAN...	-0.152770	1.000000	0.521987	0.710733	0.040516	-0.083689	0.493658	0.715068
TECH...	-0.029916	0.521987	1.000000	0.261837	0.055836	0.085211	0.124082	0.394189
TRUST	-0.063819	0.710733	0.261837	1.000000	0.070556	-0.036621	0.519242	0.876078
CBDC...	0.941231	0.040516	0.055836	0.070556	1.000000	0.959262	0.138853	0.191812
CBDC...	0.976339	-0.083689	0.085211	-0.036621	0.959262	1.000000	-0.081770	0.099454
CBDC...	-0.148101	0.493658	0.124082	0.519242	0.138853	-0.081770	1.000000	0.499650
GDP_...	0.051888	0.715068	0.394189	0.876078	0.191812	0.099454	0.499650	1.000000

Table 4.5.2: Cross Section Dependence

Residual Cross-Section Dependence Test
Null hypothesis: No cross-section dependence (correlation) in residuals
Equation: EQ03
Periods included: 9
Cross-sections included: 9
Total panel observations: 81
Note: non-zero cross-section means detected in data
Cross-section effects were removed during estimation

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	72.37029	36	0.0003
Pesaran scaled LM	4.286279		0.0000
Bias-corrected scaled LM	3.723779		0.0002
Pesaran CD	1.223444		0.2212

Table 4.6.1: Fixed Effect Model without control variable

Dependent Variable: ACCOUNT_OWNERSHIP
Method: Panel Least Squares
Date: 12/16/25 Time: 00:17
Sample: 2015 2023
Periods included: 9
Cross-sections included: 9
Total panel (balanced) observations: 81
White cross-section (period cluster) standard errors & covariance (d.f. corrected)
Standard error and t-statistic probabilities adjusted for clustering

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.78E+08	2.29E+08	-2.085694	0.0705
CBDC	-1.94E+08	77867623	-2.489465	0.0376
FINANCIAL_LITERACY	3977856.	2116779.	1.879202	0.0970
TECHNOLOGY_ACCESSIBILITY	1902423.	857505.5	2.218555	0.0573
TRUST	2.61E+08	1.02E+08	2.567751	0.0332
CBDC_FINLIT	2029024.	1027137.	1.975417	0.0836
CBDC_TECH	387398.1	280421.8	1.381483	0.2045
CBDC_TRUST	-50449922	25452875	-1.982091	0.0828

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.941820	Mean dependent var	1.40E+08
Adjusted R-squared	0.928394	S.D. dependent var	2.44E+08
S.E. of regression	65210738	Akaike info criterion	38.99915
Sum squared resid	2.76E+17	Schwarz criterion	39.47212
Log likelihood	-1563.465	Hannan-Quinn criter.	39.18891
F-statistic	70.14859	Durbin-Watson stat	1.078980
Prob(F-statistic)	0.000000		

Table 4.6.2: Fixed Effect Model with control variable

Dependent Variable: ACCOUNT_OWNERSHIP
Method: Panel Least Squares
Date: 12/16/25 Time: 00:21
Sample: 2015 2023
Periods included: 9
Cross-sections included: 9
Total panel (balanced) observations: 81
White cross-section (period cluster) standard errors & covariance (d.f. corrected)
WARNING: estimated coefficient covariance matrix is of reduced rank
Standard error and t-statistic probabilities adjusted for clustering

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.47E+08	2.67E+08	-2.048164	0.0747
CBDC	-1.52E+08	58827263	-2.581532	0.0325
FINANCIAL_LITERACY	2360225.	2195949.	1.074809	0.3138
TECHNOLOGY_ACCESSIBILITY	1530647.	682377.4	2.243109	0.0552
TRUST	2.40E+08	94523364	2.534327	0.0350
CBDC_FINLIT	1351319.	794875.5	1.700039	0.1275
CBDC_TECH	485021.7	275107.8	1.763024	0.1159
CBDC_TRUST	-42437969	25280072	-1.678712	0.1317
GDP_PER_CAPITA	15045.78	12003.69	1.253429	0.2454

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.944469	Mean dependent var	1.40E+08
Adjusted R-squared	0.930586	S.D. dependent var	2.44E+08
S.E. of regression	64204809	Akaike info criterion	38.97724
Sum squared resid	2.64E+17	Schwarz criterion	39.47978
Log likelihood	-1561.578	Hannan-Quinn criter.	39.17887
F-statistic	68.03196	Durbin-Watson stat	1.068779
Prob(F-statistic)	0.000000		