

Article

The Role of Financial Sanctions and Financial Development Factors on Central Bank Digital Currency Implementation

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Abstract: This study investigates the influence of a country's financial access and stability and the adoption of retail central bank digital currencies (CBDCs) across 71 countries. Using an ordinal logit model, we examine how individual financial access, the ownership of credit cards, financing accessibility by firms, offshore loans, financial sanctions, and the ownership structure of financial institutions influence the probability of CBDC adoption in nations. These findings reveal that nations facing financial sanctions and those with substantial offshore bank loans are more inclined to adopt CBDCs. Furthermore, a significant relationship is observed in countries where many people have restricted financial access, indicating heightened interest in CBDC adoption. Interestingly, no statistically significant relationship was found between the adoption of CBDCs and the percentage of foreign-owned banks in each country. The results show that countries with low financial stability and financial access adopt CBDCs faster. This study expands our knowledge of how a nation's financial situation influences its adoption of CBDCs. The results provide important and relevant insights into the current discussion of the direction of global finance.

Keywords: central bank digital currencies; financial development; financial access; financial stability; CBDC

JEL Classification: E42; E58



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1. Introduction

The global financial landscape is undergoing a dynamic shift, driven primarily by emerging technologies. This transformation introduces opportunities and challenges to the monetary system. As the world becomes increasingly interconnected and reliant on digital financial systems, the idea of monetary hegemony is facing new challenges [1]. This digital transformation not only reshapes the way we perceive and utilize money but also raises critical questions about the dynamics of power and control. Monetary hegemony traditionally rests on the dominance of a few global reserve currencies, such as the Dollar and the Euro [2]. The emergence of central bank digital currencies (CBDCs) is projected to challenge this established order by offering a new paradigm for financial transactions and cross-border trade. The report prepared by the U.S Congressional Research Service [3] addresses this concern as follows: “some observers have speculated whether changes in the global economy and geopolitical shifts could cause a shift from the dollar to other currencies. Focus in particular is centered on China's economic rise, U.S. sanctions, and digital currencies” (p. 1).

The U.S. government has progressively imposed restrictions on access to U.S. dollars and the U.S. financial system to influence foreign governments' behaviour [4]. A report by the U.S. Department of Treasury [5] reveals that sanction designations by the Office of

Foreign Assets Control (OFAC) have increased over the past 20 years by +933%. At the core of this evolving landscape, the question of financial access also lies, which is the ability of individuals, businesses, and nations to participate in the global economy on equitable terms. These measures affect these countries' financial access and stability, potentially prompting them to explore alternative routes and seek to reduce their dependency [6]. More recently, the United States and its closest allies have subjected Russia to severe sanctions. The top ten Russian-owned banks and over 80% of the financial industry's assets are among the penalties [7]. The imposition of such sanctions harms citizens and enterprises operating in designated nations, thus impeding their capacity to conduct cross-border transactions [8].

Various studies have projected that CBDCs have immense potential to revolutionize the financial landscape. CBDCs have the potential to significantly enhance universal financial inclusion [9], stimulate green financing initiatives, and advance sustainable development [10] by improving payment efficiency and expanding financial access. Simultaneously, they have the potential to introduce a novel dimension of monetary independence because the control and distribution of these digital currencies can significantly impact a nation's economic sovereignty and global influence. The U.S. Department of Treasury [5] explains the projected potential of CBDCs as "These technologies offer malign actors opportunities to hold and transfer funds outside the traditional dollar-based financial system. They also empower our adversaries seeking to build new financial and payment systems intended to diminish the dollar's global role" (p. 2).

Many nations are presently investigating the potential applications of CBDCs and analyzing the associated risks and their effects on economies, monetary systems, and stability. Current research on the determinants of CBDC adoption reveals a complex landscape shaped by economic, financial, and cultural factors (see Table 1). Financial factors remain relatively understudied despite some examination of variables by Dong et al. [11], such as the influence of financial inclusion, net foreign assets, and remittances on CBDC adoption. However, there is scope to address further financial variables.

Building on prior research, this study illuminates the complex relationship between financial access, stability, and adoption of retail CBDCs across nations, with a particular focus on the role of monetary independence in this dynamic equation. This study examines the impact of financial sanctions, financial institution ownership structures, offshore loans, accessibility to financial institutions, availability of financing infrastructure, and credit to businesses on a country's adoption of CBDCs. We adopted the financial development framework built by Cihak et al. [12]. In doing so, we hope to contribute to a deeper understanding of the transformative forces that reshape the global financial landscape and the implications of these changes for nations. Such a study can assist countries in crafting appropriate policies and initiatives to encourage the adoption of central bank digital currency. The remainder of this paper is organized as follows. Section 2 provides a literature review and theoretical background. Section 3 presents the materials and methods used in this study. Sections 4 and 5 present the results and discussion and directions for future research, respectively.

Table 1. Literature findings on the determinants of nations' CBDC adoption.

Themes	Significant Drivers	References
Economic developmental factors	High level of democracy, public confidence in governance, regulatory quality, income inequality, FDI inflow, young populations, urban societies	[13,14]
Financial factors	Higher levels of financial inclusion, net foreign assets, remittances, income	[11]
Cultural factors	High power distance, masculinity, and long-term orientation	[15]
A mix of one or more of the above factors	Government performance, inflation rate, economic inequality, technological literacy, anti-money laundering, and terrorist financing	[16,17]
CBDC Implications	Enhance the effectiveness of current monetary policy instruments, financial inclusion, financial stability, Inclusive welfare	[18–21]

2. Conceptual Background and Hypothesis Development

Contemporary investigations of the determinants of CBDC adoption have revealed a multifaceted landscape shaped by a confluence of economic, financial, and cultural factors (Table 1). In-depth analyses of these determinants provide insights into the dynamics that influence the decision-making processes in countries' CBDC adoption.

Previous studies reveal various facets that can influence a country's inclination to adopt CBDCs. Potential macroeconomic factors considered include nations' population demography, foreign direct investment inflow, and legal factors. Notably, the findings from these studies reveal that democratic governance and high regulatory quality correlate with countries' CBDC adoption [13,14]. Luu et al. [15] also addressed cultural dimensions such as the role of power distance, masculinity, and long-term orientation in shaping nations' CBDC adoption. Moreover, Le et al. [17] and Ngo et al. [16] outlined factors such as government performance and technological literacy to understand how these variables shape the adoption landscape. It is noteworthy that financial factors have not been extensively addressed. Nonetheless, Dong et al. [11] examined the relationship between a country's likelihood of adopting CBDCs and its level of revenue, remittances, and net foreign assets.

These studies have made substantial contributions to our knowledge of the factors influencing CBDC adoption across different countries. Building on earlier studies, our study primarily focuses on the elements of financial stability and accessibility that influence a country's decision to implement CBDCs. The literature extensively highlights the significance of CBDCs in enhancing financial stability [18,19] and broadening access to financial services [20,21]. Given this context, we believe that it is essential to understand the precise roles of financial stability and access in shaping a nation's inclination to adopt CBDCs.

2.1. Financial Stability

2.1.1. Financial Sanction

Numerous studies have found that sanctions can hinder the targeted nation's access to global financial markets. Peksen and Woo's [22] comprehensive study covering emerging market economies observed that countries facing economic sanctions, particularly those imposed by the United States and international institutions, are less likely to secure funds from the International Monetary Fund (IMF). This study also suggests that nations implementing sanctions may utilize their political influence within the IMF to withhold funds from the economies they target. Sanctions not only restrict a nation's ability to access financial resources but also obstruct its engagement in global trade. As highlighted in Caruso's [23] study, this stresses the substantial negative impact of sanctions on bilateral trade. This constrained participation in global trade can adversely affect foreign exchange reserves and the overall economic stability. Some countries may develop and adopt alternative financial systems or technologies to counteract sanctions. As Selden [6] underlines, sanctions tend to stimulate the growth of domestic industries in the targeted country over time, reducing

external dependencies and diminishing the ability of sanctioning entities to influence the target via economic pressure [24]. Thus, we propose the following hypothesis:

Hypothesis 1 (H1). *Countries under sanction are highly likely to adopt CBDCs more rapidly.*

2.1.2. Ownership Structure

The presence of foreign-owned banks in a country shapes the economy's financial landscape in several ways. As highlighted by Beck, Thorsten Demirgüç-Kunt, Asli, and Martinez Peria [25], the ownership structure of banking systems significantly influences the level of barriers encountered by customers. When a nation places a high priority on government control, consumers encounter various challenges, including access to finance. Beck, Thorsten Demirgüç-Kunt, Asli, and Martinez Peria [25] further highlight despite higher fees charged by foreign banks, financial systems dominated by foreign institutions often exhibit lower fees and increased accessibility for services such as opening bank accounts and applying for loans. However, nations with many financial institutions controlled by the government may benefit from quick monetary policy decisions that consider the needs of the public. As Spendzharova [26] emphasizes, in instances where a smaller proportion of banks are foreign-owned, reliance on external financial institutions is lower, which grants domestic regulators a more direct influence on monetary policies. Due to these dynamics, countries with a higher proportion of locally owned banks may show a propensity to embrace innovative financial technologies, such as CBDCs. Luu et al. [27] suggested that CBDC adoption is associated with expanded lending, increased asset quality, and reduced loan loss reserves. Moreover, substantial ownership by local banks and the government might foster the consideration of local interests, extending beyond private concerns. This control over monetary policies allows them to tailor their financial strategies to specific needs without excessive external influence. Thus, we propose the following hypothesis:

Hypothesis 2 (H2). *Countries with a low proportion of foreign-owned banks are more likely to adopt CBDCs quickly.*

2.1.3. Offshore Loan

An offshore loan indicates a country's indebtedness to a foreign bank (usually located in low-tax jurisdictions or tax havens) that provides financial and legal advantages [12]. This ratio is an indicator of a country's ability to meet financial obligations, with default on debt posing risks to both the domestic and international markets. According to Grennes et al. [28], in emerging economies, a debt-to-GDP ratio surpassing 64 percent can lead to a notable loss in annual real growth. Furthermore, countries heavily reliant on offshore bank loans face various risks, such as currency risks (due to exchange rate fluctuations), which potentially affect debt repayments [29]. Moreover, these offshore transactions often entail additional costs, such as fees for currency conversions and cross-border transfers [30]. A report from the Bank of England [31] suggests that CBDCs can promote nations' financial stability by accelerating or modifying policy rate transmission and adjusting the quantity and cost of credit. As wholesale CBDCs are also being established by various regional governments and new emerging partnerships in developing economies, they may offer diverse opportunities for new financial collaboration. Furthermore, because CBDCs are digital and decentralized, they can facilitate cost-effective transactions. The adoption of CBDCs by countries may reduce them from incurring excessive costs and heavy reliance on offshore financial services. Nations with high offshore bank loans may adopt CBDCs for both technical use and as a strategic move to foster economic growth. Therefore, we propose the following hypothesis:

Hypothesis 3 (H3). *Nations with outstanding offshore bank loans are likely to adopt CBDCs.*

2.2. Access to Finance

2.2.1. Accessibility of Financial Institutions

As articulated in a policy research paper by the World Bank, the availability of physical infrastructure is one of the most robust predictors of barriers to deposit, loan, and payment services in developing countries [25]. The study further highlights that in more competitive, open, and transparent economies and those with superior contractual and informational frameworks, banks tend to impose lower barriers [25]. According to the International Monetary Fund [32], 152 developing nations currently have a population of approximately 6.75 billion, representing a significant proportion (approximately 85%) of the global population. Some studies posit that central bank digital currencies could offer an effective solution to financial access challenges in these nations [33]. The attributes of CBDCs, such as tokenization [34], decentralization, digital nature, and smart contract functionality [35], may enable financial institutions to establish a robust presence in underserved areas. This contrasts with traditional banking hours and physical branch limitations that provide more flexible and convenient options for individuals with restricted access to conventional banking services. In nations in which a significant proportion of the population encounters obstacles in traditional banking, the adoption of CBDCs may be actively endorsed as a strategic component to enhance financial inclusion [11]. Hence, we propose the following hypothesis:

Hypothesis 4 (H4). *Countries with a high number of individuals with limited access to financial institutions are more interested in adopting CBDCs.*

2.2.2. Accessibility of Financing

Access to finance refers to a person's or business's capacity to obtain various financial services such as loans, deposits, and risk control. However, this study refers only to two variables. The first is the possibility of enterprises obtaining credit in each country, followed by individual ownership of credit cards. The motivation behind CBDC's introduction in emerging markets, as Singh et al. [36] highlighted, revolves around enhancing financial inclusion and payment efficiency. CBDCs may offer financially feasible possibilities for enterprises in these circumstances owing to their distinctive qualities, which include decentralization and their digital nature. Wronka [37] emphasizes that CBDCs have the potential to provide cost-effective digital payment solutions for businesses that are unbanked, fostering economic growth. Businesses operating in places where traditional banking is limited may face obstacles to accessing finance. Therefore, governments in countries with low bank dependence may consider adopting CBDCs to boost financial inclusion and economic expansion. Consequently, we propose the following hypothesis:

Hypothesis 5 (H5). *Countries with fewer firms that access banks to finance asset purchases exhibit faster adoption rates of CBDCs.*

However, nations with widespread credit card accessibility may exhibit a greater propensity to adopt CBDCs than those that lack access. The literature attributes the prevalence of credit card ownership in nations to a range of factors, including the technological ecosystem [38], culture [39], digital payment familiarity [40], and trust in digital transactions. In regions where credit cards are highly available, the economic prosperity stemming from credit card usage may foster an environment conducive to CBDC adoption. Moreover, the convenience and efficiency associated with digital transactions via credit card usage may contribute to a seamless transition to CBDCs in these areas. Thus, we propose the following hypothesis:

Hypothesis 6 (H6). *Countries with citizens who have high access to credit cards exhibit a faster adoption rate of CBDCs.*

Drawing from the existing literature, we formulated a conceptual model (depicted in Figure 1) that organizes the crucial financial factors influencing a nation's adoption of CBDC, along with the impact of the independent variables.

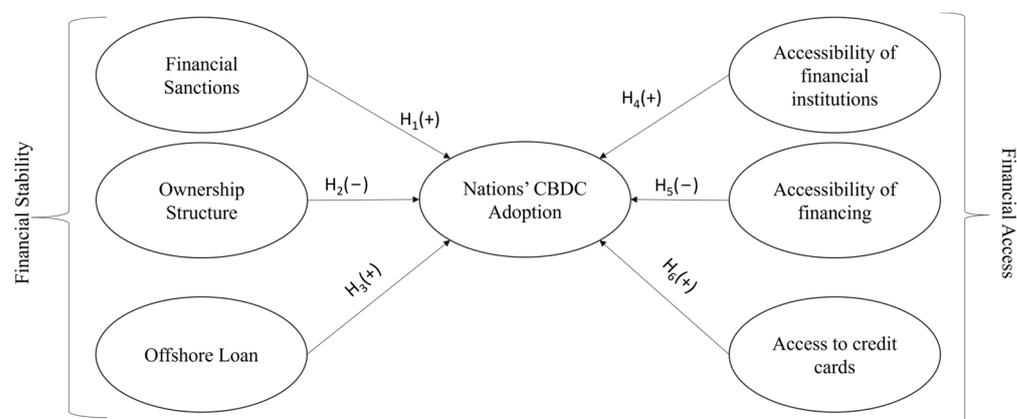


Figure 1. The conceptual model and hypotheses.

3. Data and Methods

To investigate how the level of financial development in different nations affects the adoption of retail central bank digital currencies, we use the financial development framework originally formulated by Cihak et al. [12]. They introduced the “Global Financial Development Database”, an extensive global database that combines and updates several financial datasets. The database generates several metrics for four key attributes of financial institutions and markets: first, the extent to which individuals utilize financial institutions and markets (access); second, the size of financial institutions and markets (financial depth); third, the effectiveness of financial institutions and markets in delivering financial services (efficiency); and fourth, the resilience of financial institutions and markets (stability) [12]. In this study, we concentrated specifically on the components of “Access” and “Stability” within the framework, utilizing a subset of the indicators for assessing their role in nations’ CBDC adoption. This emphasis aligns with prior research predictions, indicating that the adoption of CBDCs has the potential to enhance both access to [11] and stability of financial services [19]. We used the most recent data available for each variable in our study. Specifically, the data for FINA, TRUS, FIRMCR, and DEBT are based on data from the year 2021. However, it is important to note that for the OWN variable, the latest available data pertain to the year 2013. This approach was adopted to ensure the incorporation of the latest data for the variables.

Additionally, we incorporated a binary variable to account for countries subject to financial sanctions, specifically those imposed by the United States Office of Foreign Assets Control (OFAC), the United Kingdom, the European Union, and those mandated by the United Nations Security Council. The selection of these sanctions is further substantiated by the existing literature, which suggests that nations subject to economic sanctions, particularly those imposed by the United States and international institutions, face various challenges, including securing funds from the International Monetary Fund (IMF) [22].

Our assessment of access to finance encompasses the following indicators:

- Accessibility of financial institutions: this was measured as the percentage of respondents who neither deposited nor withdrew funds from their accounts in the past year, including those engaging in any form of digital payment.
- Availability of financing for firms: this is gauged by the percentage of firms that use banks to finance the acquisition of fixed assets.
- Access to credit cards: this variable was determined by the percentage of respondents who reported having credit cards.

In evaluating financial stability, we use the following variables:

- Offshore Loan: this is represented by the outstanding amount of debt securities held by offshore investors as a percentage of the GDP.
- Foreign investment: this variable is expressed as the percentage of foreign banks out of the total number of banks.
- Financial sanction: this variable captures the presence of global sanctions impacting financial stability.

In this study, the dependent variable is ordinal, with values of 1, 2, and 3 representing distinct stages in the adoption of retail central bank digital currencies by country. Specifically, a value of one corresponds to countries in the research stage, two to those in the proof-of-concept stage, and three to those that have advanced to the pilot and launch stages of the CBDCs. The data for this study were obtained from the CBDC Tracker (2023), encompassing 71 countries across a spectrum of economic statuses ranging from developed to developing nations. The methodology employed in this study is ordinal logistic regression, chosen for its suitability in modelling the relationship between an ordinal response variable (representing the CBDC adoption stages) and six explanatory variables (see Table 2 and Appendix A for details). Given the nature of the outcome variable “CBDC” being ordinal, the study judiciously utilizes the ordinal logistic regression model to capture the nuances and ordinal nature of the CBDC adoption process in different countries. This methodological choice ensured a rigorous exploration of the factors influencing the progression of countries via various stages of CBDC implementation.

Table 2. List of variables.

Variables Description	Label	Value and Description	Variable Type	References
Country retail CBDC adoption	CBDC	Dependent variable	Ordinal	
Financial sanctions on nations	SANC	Positive	Dummy	[6,22–24]
Accessibility of financial institutions	ACC	Positive	Numeric	[25,32,33]
Availability of credit financing to firms	FIRMCR	Negative	Numeric	[36,37]
Offshore bank loans	DEBT	Positive	Numeric	[28–30]
Foreign-owned banks	OWN	Negative	Numeric	[25–27]
Credit card ownership	FINA	Positive	Numeric	[36]

4. Results

The outcomes from the ordered logistic regression analysis, investigating the association between diverse independent variables and the adoption status of CBDCs across nations, reveal noteworthy patterns. The literature explores the potential influence of financial access and stability on countries’ CBDC adoption of CBDC. In this section, we scrutinize the identified factors and evaluate their impact on adoption status. The model outputs are presented in Table 3.

4.1. Analysis of Model Fit

The results in Table 3 reveal a statistically significant overall model, as evidenced by a $\text{prob} > \chi^2$ value of 0.0001. This value represents the likelihood of observing the likelihood ratio chi-square statistic of 28.03 if there is no collective impact of the independent variables on the dependent variable [41]. Additionally, the pseudo- R^2 of 0.3834 suggests that the model explains a substantial proportion of the variation in the dependent variable, CBDC. The cutoff points indicate the increments in log odds, which illustrates a progression in the likelihood of CBDC adoption across different categorical stages [41]. Progressing from the absence of CBDC adoption to the first category (cut1) entails a log-odds increase of 1.641014, indicating a notable shift in the likelihood of favouring CBDC adoption at the initial level. Subsequently, advancing from the first category to the second category (cut2) leads to an additional log-odds increase of 3.959928. This highlights a substantially further

enhancement in the odds of CBDC adoption when transitioning from the initial to the subsequent level. The following section presents the estimated coefficients of each variable.

Table 3. Ordered logistic regression on nations' financial development and CBDCs adoption status.

						Number of Obs	40
						Log-likelihood	-22.540485
						LR $\chi^2(6)$	28.03
						Pseudo R ²	0.3834
						Prob > χ^2	0.0001
CBDC	Coefficient	Std. err.	z	p > z	[95% Conf. Interval]		
SANC	3.47084	1.791629	1.94	0.053	-0.0406887	6.982369	
ACC	0.3207459	0.1265858	2.53	0.011	0.0726422	0.5688495	
FIRMCR	-0.1253228	0.0428092	-2.93	0.003	-0.2092273	-0.0414184	
DEBT	0.1106195	0.051294	2.16	0.031	0.010085	0.211154	
OWN	-0.0001059	0.0249527	-0.00	0.997	-0.0490122	0.0488005	
FINA	0.0881731	0.0329024	2.68	0.007	0.0236855	0.1526607	
/cut1	1.641014				-1.512674	4.794701	
/cut2	3.959928				0.4491786	7.470678	

4.2. Statistical Significance

Looking at the coefficient estimates, the parameter estimate for the variable SANC is 3.47084, signifying that a one-unit increase in SANC, transitioning from a state of no sanctions to being sanctioned, is linked to a 3.47084 increase in the dependent variable CBDC. This relationship remains consistent when all other independent variables are held constant [41]. Practically, this implies that when countries face sanctions, the logit of favouring CBDC adoption is anticipated to increase by 3.4. Larger logits indicate higher probabilities, suggesting that nations subjected to substantial sanctions are inclined to embrace CBDC adoption [41]. However, the *p*-value of 0.053 was slightly above the conventional significance level of 0.05, indicating a marginally significant relationship. The confidence interval, encompassing zero, introduces some uncertainty regarding statistical significance.

Similarly, a one-unit increase in ACC, DEBT, and FINA corresponded to increases of 0.3207459, 0.1106195, and 0.0881731, respectively, for the dependent variable CBDC. The positive coefficient of ACC implies that higher levels of individuals lacking access to financial institutions are associated with an increased probability of favouring CBDC adoption. A *p*-value of 0.011 signifies statistical significance at the level of 0.05, and a confidence interval entirely above zero reinforces the significance of the relationship. The positive coefficient of DEBT indicates that higher levels of offshore loans are linked to an increased probability of favouring CBDC adoption. A *p*-value of 0.031, which is below 0.05, indicates statistical significance, and a confidence interval entirely above zero supports the significance of this relationship [41]. The positive coefficient of FINA suggests that high credit card ownership is associated with an increased probability of favouring CBDC adoption. A *p*-value of 0.007 was below 0.05, indicating statistical significance, and a confidence interval entirely above zero supported the significance of the relationship.

Conversely, the coefficients for the variables OWN and FIRMCR are negative, with values of -0.0001059 and -0.1253228, respectively. The negative coefficient of FIRMCR implies that firms' greater access to credit is associated with a decrease in the probability of favouring CBDC adoption. A *p*-value of 0.003 indicated a highly significant relationship, and a confidence interval entirely below zero reinforced this significance. The coefficient of OWN is very close to zero, and a high *p*-value of 0.997 indicates insufficient evidence to

conclude a significant relationship between ownership structure and CBDC adoption. The confidence interval, including zero, supported the lack of statistical significance.

In a one-tailed test with a predetermined significance level of 0.05, we determined null hypotheses for various variables. Specifically, as shown in Table 4, we reject the null hypothesis for the variables SANC, ACC, FIRMCR, DEBT, and FINA because each of these variables exhibits a p -value of less than 0.05, indicating statistical significance. This implies that there is evidence of a significant relationship or effect between these variables. Conversely, when assessing OWN, the null hypothesis was not rejected at a significance level of 0.05. The p -value associated with this variable surpassed 0.05, leading us to accept the null hypothesis for OWN. In practical terms, this suggests that there is insufficient statistical evidence to conclude a significant relationship or effect of OWN in the analysis.

Table 4. Testing the hypotheses.

		Coeff. $p > z$	Result
H1	Financial sanction (SANC) → Adoption of retail CBDCs	($\beta = 3.47, p = 0.05$)	Pass
H2	Access to banks (ACC) → Adoption of retail CBDCs	($\beta = 0.32, p = 0.01$)	Pass
H3	Availability of credit financing to firms (FIRMCR) → Adoption of retail CBDCs	($\beta = -0.12, p = 0.003$)	Pass
H4	Offshore bank loans (DEBT) → Adoption of retail CBDCs	($\beta = 0.11, p = 0.03$)	Pass
H5	Foreign-owned banks (OWN) → Adoption of retail CBDCs	($\beta = -0.0001, p = 0.99$)	Reject
H6	Ownership of credit card (FINA) → Adoption of retail CBDCs	($\beta = 0.08, p = 0.007$)	Pass

5. Discussion and Directions for Future Research

5.1. Discussion

The global financial landscape is changing due to the advent of new technologies and increased interest in innovative financial technologies, such as CBDCs. As CBDCs gain prominence worldwide, understanding the factors that influence their adoption is crucial. This study investigates the role of bank ownership structures, offshore loans, financial sanctions, and financial institution accessibility in shaping countries' CBDC adoption. These findings offer valuable insights for scholars, financial institutions, and policymakers, shedding light on the complex processes that shape the evolution of international monetary systems. The first three hypotheses focus on a country's financial stability, whereas the last three address financial access.

5.1.1. Central Bank Digital Currencies and Nations' Financial Stability

To test the first hypothesis, we explore the impact of financial sanctions and countries' inclinations to adopt CBDCs. As the literature suggests, sanctions can harm bilateral trade [23] and a nation's access to global financial markets [22], potentially prompting countries to explore and adopt innovative financial technologies such as CBDCs. In line with this, Selden [6] also underlines that countries under sanctions may navigate these economic pressures by reducing external dependencies and diminishing the influence of sanctioning entities via regional collaborations. The findings of this study indicate a positive association between a nation's CBDC adoption status and the presence of financial sanctions, with a p -value of 0.053, approaching marginal significance. While these results lend some support to our hypothesis, the marginal significance and confidence interval, including zero, indicates the importance of cautious interpretation. The observed association aligns with our expectations, suggesting that financial sanctions may act as a catalyst, compelling nations to explore alternative financial systems such as CBDCs.

International organizations have imposed financial sanctions on numerous countries, targeting individuals, entities, and sectors within their economies. The CBDC developments in China and Russia may serve as compelling evidence, illustrating the role that CBDCs play in shaping countries' responses to financial sanctions and influencing their broader

economic strategies. Current data from the CBDC tracker [42] and Atlantic Council CBDC tracker [43] indicate that both China and Russia are actively engaged in piloting central bank digital currencies. This places both countries among the top 18% of countries exploring CBDC implementation [43]. China, which announced its exploration of CBDCs in 2014 [44], took a significant step in April 2020 by becoming among the world's first major economies to pilot a digital currency known as E-CNY [21]. On the other hand, Russia, despite announcing its exploration of CBDCs in 2019 [42], is also in an advanced stage of CBDC development [34]. Russia has faced financial sanctions by various countries and entities, including the EU and the U.K., due to geopolitical tensions and alleged interference in other countries' affairs [45].

For instance, after Russia's military operation in Ukraine in February 2022, the EU adopted restrictive measures on 28 February 2022, including a ban on transactions with the Central Bank of Russia, restrictions on overflight of EU airspace, and exclusion of key Russian banks from the SWIFT system (1 March 2022) [46]. Similarly, China has encountered financial sanctions, particularly from the United States [47], driven by concerns related to human rights, trade practices, and geopolitical tensions. The possible implications of these sanctions include restricted access to international financial markets and currency depreciation [48]. In response to financial sanctions, Russia may explore CBDCs to reduce reliance on traditional global banking networks. China, with its strategic focus on internationalizing the yuan [49], may see the use of CBDCs to facilitate cross-border transactions and increase its influence in the global financial system [50]. These instances substantiate the affirmative association between the implementation of central bank digital currencies by countries and the imposition of financial sanctions.

The second hypothesis posits that countries with a lower proportion of foreign-owned banks would adopt CBDCs at a faster pace. The literature suggests that countries with few foreign-owned banks often have a lower reliance on external financial institutions that grant domestic regulators a more direct influence on monetary policies [26]. These dynamics may allow nations to embrace innovative financial solutions, such as CBDCs. Despite the expectation that countries with fewer foreign-owned banks will be more receptive to CBDC adoption, the lack of statistical significance in this study suggests that the proportion of foreign-owned banks may not be a determining factor in the rate of CBDC adoption. Contrary to the literature emphasizing the impact of bank ownership structure on the adoption of innovative financial solutions, this hypothesis is not supported by the empirical results. Nevertheless, the data highlight a temporal constraint linked to the OWN variable, given that data are available only up to the year 2013. Researchers should be cognizant of this temporal gap when interpreting and extending the findings concerning the OWN variable within the framework of our study.

These results also confirm the third hypothesis, indicating that countries with substantial offshore bank loans are more likely to embrace CBDCs at an accelerated rate. The variable in this study (DEBT), which symbolizes offshore loans, has a positive and statistically significant coefficient ($p = 0.031$). This observation corresponds to the International Monetary Fund's [29] assertion that nations heavily dependent on offshore bank loans face financial and currency risks that can potentially lead to economic instability. The adoption of CBDCs by these nations may be due to the government's strategic response to address challenges stemming from exchange rate fluctuations, additional costs, and heavy reliance on offshore financial services. These findings are also in agreement with the Bank of England [31], which underscores that CBDCs can promote nations' financial stability by accelerating or modifying policy rate transmission and adjusting the quantity and cost of credit. The adoption of CBDCs by countries with offshore loans may focus on cultivating a positive economic environment, attracting investments, and fostering sustainable growth.

As highlighted in the literature, also per the findings of Grennes et al. [28], it is emphasized that emerging economies witnessing a debt-to-GDP ratio surpassing 64 percent may endure a substantial loss in annual real growth. This insight serves as a critical benchmark for evaluating the financial health and growth prospects of nations. A closer

examination of the financial landscapes of both the Bahamas and Jamaica indicates the significance of debt-to-GDP ratios in shaping their economic trajectories. Notably, from the data of the Global Financial Development Database [12], as of 2021, the Bahamas exhibited a debt-to-GDP ratio of 99.14%, showcasing a relative decrease from the previous year's 105.28%. Despite this reduction, the ratio still signals a considerable dependence on offshore bank loans, emphasizing the potential economic vulnerability of the nation. Similarly, Jamaica, while experiencing a commendable reduction from 78.49% in 2020 to 68.49% in 2021, maintains a relatively high debt-to-GDP ratio. This reduction reflects a concerted effort by Jamaica to enhance its economic stability, signaling a proactive approach to fiscal management. The implementation of central bank digital currencies in both nations, with the Bahamas launching the Sand Dollar in 2020 [12,51] and Jamaica's introduction of JAM-DEX [52], aligns with the findings of the study. These initiatives further pinpoint the commitment of these countries to embrace technological advancements and digital financial solutions as integral components of their evolving financial landscapes.

As indicated above, the first three hypotheses validate two of these. These findings provide insights into why nations with lower financial stability may expedite the implementation of CBDCs. One possible rationale for this phenomenon could be the adverse impact of economic instability on individuals and businesses in these countries. The attraction to CBDCs in these high-instability nations may stem from CBDC's digital characteristics, distinctive technological attributes, and the collective efforts of various countries in establishing regional wholesale CBDCs.

5.1.2. Central Bank Digital Currencies and Nations' Access to Finance

The findings from the following three hypotheses focus on how a country's ability to access finance affects its likelihood of adopting CBDCs. The findings from testing the fourth hypothesis reveal a positive association between the prevalence of individuals lacking access to financial institutions and nations' inclinations to adopt CBDCs. This implies that nations with higher levels of this demographic—that is, individuals lacking access to financial institutions—are linked to an increased likelihood of favouring CBDC adoption.

Furthermore, in this study, the average ACC (inaccessibility of financial institutions) across the sample countries is 3.57%. However, when we delve into the data of individual countries, interesting variations emerge. In 2021, Jamaica demonstrated an ACC of 11.81%, reflecting the proportion of respondents not depositing or withdrawing funds [12]. Comparatively, in 2017, this figure was slightly higher at 13.17%, suggesting a subtle shift over time. Similarly, India's ACC in 2021 was 27.44%, a decline from the 30.62% reported in 2017 [12]. Notably, India entered the pilot phase of implementing the Digital Rupee on 1 December 2022, marking a significant milestone in its digital currency journey [53]. Concurrently, Jamaica has already made strides by launching JAM-DEX, further emphasizing its commitment to digital financial innovations. These distinctive developments in India and Jamaica serve as compelling supportive evidence, potentially substantiating the positive associations between access to financial institutions and the accelerated implementation of central bank digital currencies. This observation also aligns with insights from the literature that emphasize the potential role of CBDCs in minimizing the challenges individuals face in accessing traditional banking services. Studies have proposed that the features of CBDCs, including tokenization, decentralization, digital nature, and smart contract functionality, empower financial institutions to overcome their financial accessibility limitations [34,35]. The attributes of CBDCs facilitate the establishment of a robust presence in underserved areas, providing a flexible and convenient option for individuals with limited access to conventional banking services [34,35]. According to policy studies conducted by the World Bank, in most developing nations, insufficient physical infrastructure is the main factor preventing consumers from accessing financial institutions [25]. Considering that among 152 developing nations, representing approximately 85% of the global population [32], a significant proportion of individuals may face financial access challenges, CBDCs may emerge as a potential solution for these nations. Policymakers may actively endorse the

adoption of CBDCs in regions where a significant proportion of the population encounters barriers to accessing traditional banking.

Hypotheses 5 and 6 are also accepted at a significant level. Hypothesis 5 posits that countries with a lower percentage of firms that rely on banks to finance fixed asset purchases exhibit a faster adoption rate of CBDCs. The highly significant relationship, supported by the low p -value of 0.003, emphasizes the robustness of this finding. As highlighted, the studies by Singh et al. [36] and Wronka [37] support this observation by emphasizing that CBDCs, with their decentralized and digital nature, present viable alternatives that are useful to enterprises, especially in regions where businesses have minimal access to traditional banking. Furthermore, looking into the most recent data from the countries under investigation reveals that, on average, the proportion of firms accessing banks to finance fixed asset purchases in each country is 26.81%. It is particularly interesting to observe that Nigeria deviates from this trend, displaying a relatively lower percentage at 6.9%. This distinctive pattern coincides with a significant event as Nigeria officially launched eNaira on 25 October 2021 [54,55]. This development supports our findings, pointing to a potential relationship between the accessibility of financing for firms and the inclination toward implementing central bank digital currencies on a national scale. The lower percentage in Nigeria, coupled with the recent introduction of eNaira, suggests that advancements in digital currency initiatives may be influenced by the dynamics of financial accessibility for businesses. Hypothesis 6 suggests that countries with high access to credit cards have higher CBDC adoption rates. The positive coefficient for FINA, indicating increased log odds of favouring CBDC adoption with high credit card ownership, supports this hypothesis. The literature suggests that widespread credit card access in a country stems from an advanced technological ecosystem, a culture of digital payment familiarity, and established trust in digital transactions [38–40]. Awareness of extensive credit card usage coupled with government support for financial education and innovation may create an environment conducive to the adoption of CBDCs.

The results of the last three hypotheses indicate that the percentage of individuals and enterprises with access to finance affects a nation's adoption of CBDC. The findings show that the inaccessibility of financing and the absence of banking infrastructure are both important determinants. From this, we can infer that governments in nations with large populations of people and enterprises with limited financial access might actively support CBDCs to improve financial inclusion and therefore spur economic growth. The findings of this study underscore the complex relationships among factors influencing the adoption of CBDCs across nations. While some variables exhibit statistically significant relationships, others show marginal significance or a lack thereof. This nuanced perspective highlights the complexity of the adoption landscape and emphasizes the multifaceted dynamics at play.

5.2. Practical Implications and Direction for Future Research

The findings of this study have significant practical implications for understanding the adoption dynamics of CBDCs across different nations. Our study found that nations with high instability and low access to financial institutions and services tend to adopt CBDCs faster. The positive association between CBDC adoption and the presence of elevated offshore bank loans and financial sanctions indicates that countries in such a situation are more inclined to explore alternative financial systems such as CBDCs.

We propose that policymakers, countries, and institutions imposing sanctions on nations explore alternative negotiation approaches that do not violate certain global agreements. It is crucial to find methods that address these concerns without jeopardizing the welfare of small businesses and individuals in the affected nations. As Selden [6] has highlighted, conventional sanctions may not consistently achieve their intended goals but rather prompt nations to seek alternative avenues. Moreover, there is a pressing need for technological advancements in the development of CBDCs to safeguard against misuse of technology for malicious purposes. Sanchez-Roger and Puyol-Antón [56] pointed out

that the design of a CBDC significantly determines its implementation success rate and impact on the banking sector. In essence, our suggestion advocates a balanced strategy that involves diplomatic alternatives and technological safeguards, navigating the complexities of sanctions while fostering responsible technological evolution.

The identified positive associations, notably the relationship between constrained financial access and hastened adoption of CBDCs, imply that countries might strategically embrace CBDCs to foster financial inclusion and access. To expedite CBDC adoption, we recommend that governments and policymakers implement various strategies. These initiatives include the formulation of supportive regulatory frameworks, fostering collaboration with financial institutions, investing in technological infrastructure, and consistently dedicating R&D resources. These proactive measures may cultivate a conducive environment, instill public trust, and streamline the integration of CBDCs into the existing financial systems.

One limitation of this study is its dependence on fixed-year data without considering changes in variables over time. A potential avenue for improvement in future research would involve addressing this limitation by integrating temporal variations in the variables. Future research within the CBDCs domain may also focus on various crucial aspects. Future research may include longitudinal studies to track CBDC adoption over time (by considering the variables considered previously), which may offer a deeper understanding of the evolving patterns and influential factors. Furthermore, a qualitative comparative analysis across countries with diverse adoption rates may shed light on best practices and provide valuable insights. Subsequent studies may also delve into the effects of CBDCs on a nation's financial autonomy, with a particular focus on identifying the factors that contribute to achieving monetary independence. Another interesting study might investigate the impact of regulatory frameworks, technological advancements, and regional collaborations on wholesale CBDC implementation for a more profound comprehension of these pivotal elements. Further research directions may also encompass assessing the tangible effects of CBDCs on financial inclusion, investigating cybersecurity and privacy concerns, and integrating principles from behavioural sciences.

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Data Availability Statement: Links and information about the data source can be found in Appendix A.

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Appendix A

Table A1. Origin of the database, clarification of indicators, corresponding code, and associated description.

	Indicator Code in Our Study	Indicator Name	Definition	Source	Code at Source
Access	FINA	Owens a credit card (% age 15+)	The percentage of respondents who report having a credit card.	Global Financial Inclusion (Global Findex) Database, World Bank	Global Findex fin7_t_d
Access	TRUS	Has an inactive account (% age 15+)	The percentage of respondents who report neither a deposit into nor a withdrawal from their account in the past year. This also includes making or receiving any digital payment.	Global Financial Inclusion (Global Findex) Database, World Bank	Global Findex fin9N_10N_t_d

Table A1. Cont.

	Indicator Code in Our Study	Indicator Name	Definition	Source	Code at Source
Access	FIRMCR	Firms using banks to finance investments (%)	Percentage of firms using banks to finance purchases of fixed assets.	Enterprise Surveys, World Bank	GFDD.AI.28
Stability	DEBT	Debt securities by offshore investors (amounts outstanding) to GDP (%)	The ratio of outstanding offshore bank loans to GDP. An offshore bank is a bank located outside the country of residence of the depositor, typically in a low-tax jurisdiction (or tax haven) that provides financial and legal advantages.	Debt Securities Statistics (DSS), Bank for International Settlements (BIS). International debt securities—all issuers.	GFDD.OI.09
Stability	OWN	Foreign banks among total banks (%)	Percentage of the number of foreign-owned banks to the number of the total banks in an Economy. A foreign bank is a bank where foreigners own 50 percent or more of its shares.	CLAESSENS, S. and VAN HOREN, N. (2014), "Foreign Banks: Trends and Impact", Journal of Money, Credit and Banking, 46: 295–326. [57] CLAESSENS, S. and VAN HOREN, N. (2015), "The Impact of the Global Financial Crisis on Banking Globalization", DNB WP No. 459 [58]	GFDD.OI.15
Stability	SANC	Global Sanction dummy (1 = sanction exists on the country, 0 = none)	We considered the imposition of sanctions by various countries and on other nations, including: U.S. OFAC Sanctions: These sanctions can be either broad-based or targeted, involving measures such as asset freezes and trade restrictions to achieve foreign policy and national security objectives. Financial sanctions enforced by the United Kingdom . Sanctions imposed by the United Nations Security Council . Sanctions imposed by the European Union (EU) .	https://ofac.treasury.gov/sanctions-programs-and-country-information (accessed on 12 February 2024) https://www.sanctionsmap.eu/#/main?checked=40 (accessed on 12 February 2024) https://www.gov.uk/government/collections/financial-sanctions-regime-specific-consolidated-lists-and-releases (accessed on 12 February 2024)	SELF CREATED
	CBDC		CBDC refers to the status of countries' adoption of CBDC. We assigned a value of 1 for countries in the research stage, 2 for countries that have published proof of concept, and 3 for countries that have advanced to the pilot and launch stages of CBDC.	https://cbdctracker.org/ (accessed on 12 February 2024)	SELF CREATED

Note: The indicator name and definitions for the variables "FINA" and "TRUS" are adapted from Global Findex (World Bank) (<https://www.worldbank.org/en/publication/globalfindex> (accessed on 12 February 2024)). The definitions, and indicator name for the variables FIRMCR, DEBT, and OWN is adapted from the Global Financial Development Database (<https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database> (accessed on 12 February 2024)).

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