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Redefining Global Transactions:

The Rise of DLT-Based CBDCs

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Foreword

It is with great pleasure that I write the foreword for the monograph titled *Redefining Global Transactions: The Rise of Distributed Ledger Technology (DLT)-based Central Bank Digital Currencies (CBDCs)* written by Siddharth Verma. The Ukraine crisis in 2022 was a stark reminder to countries around the world that in the event of a conflict or emergency, global public goods like payment systems can be weaponized against them. Therefore, developing countries like India whose prosperity depends on greater economic engagement with the world must consider alternatives to the SWIFT payment system (which currently dominates international transactions) to safeguard their strategic autonomy.

India's success in building a population-scale digital public infrastructure bodes well for its attempts to play a more proactive role in global payments systems. Accordingly, the RBI has already begun consultations and research on a digital currency, like several other central banks around the world. However, as is often the case with frontier technologies, it is the private sector which is leading the innovation curves. While most digital currencies supported by central banks are centralised in nature, financial heavyweights like Goldman Sachs and J P Morgan are investing in blockchain-based tokenisation technologies.

Therefore, the topic chosen by Siddharth for this monograph is ideal because it is both timely and under-studied. It explores the potential, pitfalls and pathways towards a blockchain-based digital currency that is supported by the central bank. He begins by appreciating the role of technology in shaping the world of finance and creating our globalised world. Next, he explains how a private organization like SWIFT went on to become an intrinsic part of the international economy and its partisan role in geopolitical conflicts, leading to the French Finance Minister Bruno Le Maire calling it a “financial nuclear weapon”. Siddharth also makes a wonderful effort in a separate chapter to explain the rise of distributed ledger technologies after the 2008 Economic Crisis, as a disruptive force to challenge the hegemony of centralised financial institutions. Finally he explains how the dual forces of tokenization and digital currencies are reshaping global finance.

Siddharth makes a strong case for India to adopt a DLT-based digital currency to secure our vital economic and strategic interests.

I hope this paper starts a long overdue conversation in our country about the need to have a well-thought national strategy to navigate the big technological disruptions in global finance and develop a roadmap towards our own DLT-based CBDC. While there is no clear solution and pathway emerging towards a global alternative to SWIFT given that there are so many regulatory challenges and vested interests, India must make serious efforts to solve them and emerge as a global behemoth and thought leader in the fin-tech sector. This will require deep cooperation between the government and our private sector, especially our thriving fin-tech startup ecosystem, in an atmosphere of mutual trust and respect.

If India can leapfrog towards a DLT-based CBDC, it will go a long way towards our efforts to internationalise the rupee, develop resilience in our financial system and become a developed country by 2047. My compliments to Siddharth for undertaking this extraordinary research effort to bring together various strands of this issue into one coherent story about India's engagement with digital currencies and blockchain technology. His knowledge and passion for this topic was self-evident during the multiple conversations we had in the course of his research. I congratulate Siddharth on the publication of this monograph and wish him the very best for a fulfilling career ahead.

Apurv Kumar Mishra
Consultant,
Economic Advisory Council to the Prime Minister

Executive Summary

In today's rapidly changing financial technology landscape, the global payments system is experiencing significant changes. The Society for Worldwide Interbank Financial Telecommunication (SWIFT) has been the central system for cross-border payments. However, geopolitical tensions and the need for more efficient, transparent, and secure systems have highlighted Distributed Ledger Technology (DLT)-based Central Bank Digital Currencies (CBDCs) as promising alternatives. A country's economic independence is closely linked to its international economic interactions, often involving cross-border financial transactions. Policymakers focus on their nation's economic welfare and work to reduce conflicts that can impede progress. This document examines the potential of DLT-based CBDCs, especially from an Indian perspective, to replace traditional systems like SWIFT and the broader effects on the global financial system.

The recent conflict between Russia and Ukraine led to reinstated economic sanctions on Russia. These sanctions have become more common over the past two decades, punishing countries like Iran, North Korea, and Russia for their actions. Economic sanctions are often compared to weapons of mass destruction, causing long-term harm to nations by limiting access to crucial financial assets and transactions, affecting their financial stability and ability to make independent decisions.

SWIFT, a messaging platform central banks and financial institutions use for cross-border transactions, plays a central role. Economic sanctions can disrupt SWIFT, halting a nation's international payments and aid receipts. However, SWIFT's governance favours developed countries, influencing its policies to align with their interests.

SWIFT has facilitated global fund movements securely, but its centralised nature and susceptibility to geopolitical pressure have led to a search for alternatives. Exclusion from SWIFT, as seen with Iran and Russia, causes economic instability, highlighting

the need for decentralised solutions offering resilience and autonomy in financial communications.

Economic sanctions, particularly by the US and its allies, reveal the vulnerability of nations reliant on centralised systems like SWIFT. Russia's sanctions disrupted its financial systems after the conflict with Ukraine, prompting a reconsideration of SWIFT dependence. Similarly, Iran's access to international financial networks has been affected, emphasising the need for resilient and autonomous financial communication systems to counter geopolitical pressures.

SWIFT, the standard for cross-border transaction messaging, faces challenges from new technologies like Distributed Ledger Technology (DLT), which uses blockchain. These technologies address SWIFT's main issues, such as high costs and security flaws, by offering a more secure and cost-effective system. This DLT-based approach encourages countries to explore Central Bank Digital Currencies (CBDCs), digital versions of fiat currency based on blockchain technology, functioning like traditional money. After the war in Europe began, there was a 273% increase in global research projects.

1. Enhanced Economic Policy Control: DLT-based CBDCs provide real-time data transmission from financial institutions to governmental authorities, enabling more precise economic interventions. This capability allows for better monitoring economic trends and spending patterns, fostering sustainable economic growth. For example, governments can quickly deploy fiscal measures during financial crises to stabilise markets and support affected sectors.

2. Efficient Cross-Border Payments: CBDCs can streamline currency swaps, reducing transaction costs and times. This efficiency is particularly beneficial for emerging markets and developing economies, which often grapple with high transaction fees and delays associated with traditional systems like SWIFT. For instance, remittances, a significant source of income for many developing countries, can be processed more quickly and at lower costs with CBDCs.

3. Strengthened Bilateral Trade Relations: Through intelligent contracts, CBDCs can facilitate trade between domestic currencies of cooperating nations, enhancing

bilateral trade relations and promoting the internationalisation of currencies. Smart contracts, which are self-executing contracts with the terms of the agreement directly written into code, can automate and streamline trade processes, reducing the risk of fraud and enhancing trust between trading partners.

4. Transparency and Security: DLT-based systems offer real-time tracking of transactions, enhancing transparency and trust in financial operations. The tamper-resistant nature of blockchain technology also mitigates risks related to Anti-Money Laundering (AML) and Counter-Terrorism Financing (CTF), addressing significant compliance and security concerns.

India began researching Central Bank Digital Currency (CBDC) in 2022, capitalizing on its successful track record with digital payment platforms such as the Unified Payments Interface (UPI). With nearly half of its population, including rural communities, having internet access, India's infrastructure lays a strong foundation for the widespread adoption of Distributed Ledger Technology (DLT)-based CBDCs. This early progress distinguishes India globally, as it swiftly launched pilot projects for wholesale and retail CBDCs, outpacing countries like the UAE, Saudi Arabia, and Hong Kong in speed and strategy.

Introducing an Indian CBDC could hold significant geopolitical implications, particularly in light of the dominant position of the US dollar in global exchanges. By facilitating currency swaps and reducing transaction costs, an Indian CBDC could elevate the international status of the Rupee, thus globalising India's currency. Moreover, a semi-decentralized economic loop could fortify regional economic growth and trade partnerships with neighbouring nations, enhancing India's financial resilience.

Drawing a parallel with China's Digital Yuan, India's wide internet accessibility and robust digital payment adoption are conducive to CBDC development. By emphasising a balance between privacy and security, India's CBDC could emerge as a compelling global choice, contrasting with China's centralised control.

In tandem with CBDC exploration, the private sector, including investment banking giants like Goldman Sachs and J.P. Morgan, is heavily investing in blockchain-based tokenisation technologies. These endeavours aim to streamline cross-border transactions and asset management, complementing the efforts in the public sector.

India's strategic position as the fifth-largest economy and its ambitions to become a $5 trillion economy underscore the importance of leveraging DLT-based CBDCs. With its extensive internet penetration and successful implementation of UPI, India demonstrates its capability to adopt large-scale digital payment solutions, providing a solid foundation for CBDC development.

However, challenges loom in the form of interoperability among national systems, transitioning from traditional financial systems, and ensuring public-private collaboration. Addressing these hurdles requires international cooperation and standardisation efforts to establish global standards for CBDCs. Moreover, careful management during the transition phase is essential to minimise disruption to existing financial systems.

Looking ahead, India's integration of DLT-based CBDCs aligns with its vision for 2047, aiming for leadership across various sectors and sustainable economic growth. Global integration and standardisation efforts are crucial for maximising the potential of CBDCs and fostering a decentralised, transparent, and efficient international financial ecosystem.

India's proactive approach to digital financial innovation, robust infrastructure, and strategic vision position it as a leader in the global shift towards DLT-based CBDCs. By addressing challenges through collaboration and investment in technology, India can secure its economic future and contribute to a more resilient international financial system.

The Evolution of Technology, Finance, and Global Connectivity: A Historical Perspective and Modern Implications

The rapid and transformative evolution of technology from agricultural to industrial societies has reshaped our world profoundly. Despite its relatively short history, modern technologies wield impacts as significant as ancient milestones like the discovery of fire and the invention of the wheel. The onset of the first industrial revolution in 1760[1] marked a turning point catalyzed by the convergence of crucial resources: the steam engine powered by fossil fuels and the concept of economies of scale. These elements facilitated mass production and global business expansion, laying the groundwork for modern economies.

An often overlooked yet pivotal aspect of the Industrial Revolution was the revolution in communication speed, transitioning from letters to telegrams. This accelerated the exchange and availability of information, complemented by the knowledge dissemination enabled by the printing press, contributing to the rise of modern economies and imperialism.

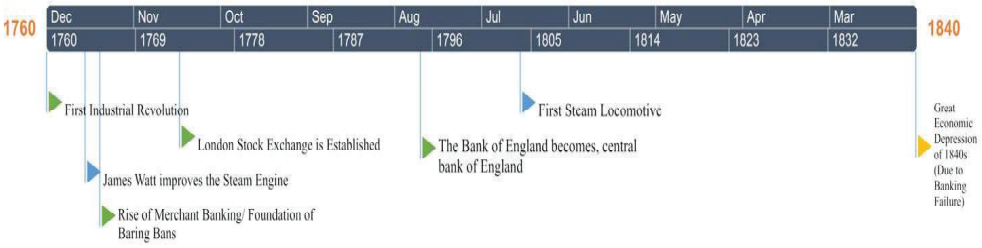
The technology of the Industrial Revolution empowered nations to enhance their financial and economic capabilities, fueling territorial and economic imperialism.

Technology integration has been a driving force behind subsequent industrial revolutions, building upon the foundational model established by the first revolution. Technological advancements such as the steam engine, fossil fuels, and electricity have consistently played central roles in driving these revolutions forward. Similarly, rapid advancements in communication, from telegrams to the internet, have further propelled these revolutions.

Economies of scale have been another critical aspect, transforming small businesses into large-scale production units. The standardization of production processes, facilitated by mechanization and steam-powered engines, has enabled mass production of goods and remains relevant today, evident in the manufacturing models of companies such as Ford and Toyota, which later got adopted worldwide into multiple industries.

The Industrial Revolution ushered in significant developments in finance instruments and institutions. Private banking institutions experienced substantial growth alongside the rise of industrialization, driven by the need to increase economies of scale and generate capital for sustaining businesses. This period laid the groundwork for modern banking practices.

Significant Milestones of the First Industrial Revolution



Trade finance and banking practices transformed to accommodate the expansion of global trade during the Industrial Revolution. Financial services like letters of credit and currency exchange transactions became essential for facilitating international trade. Banks played a crucial role in enabling these operations by providing financial support to importers and exporters and facilitating currency exchange to facilitate trade across borders. Moreover, the era saw efforts to standardize banking practices and regulations to support international trade and finance, including establishing consistent banking laws, accounting standards, and payment systems to facilitate the movement of capital and goods among nations.

The intersection of technology and finance played a pivotal role in driving the success of the Industrial Revolution. In the modern world, this intersection remains crucial, with communication-based technologies like the internet taking center stage. Initially developed as ARPANET[2] by the US government to seamlessly exchange information and data, the internet has become a fundamental cornerstone of the present digital epoch. It serves as a unified communication exchange medium, connecting millions of computers and enabling seamless communication and exchange of information. The internet's fundamental application in communication has led to the emergence of multiple sub-applications, further shaping the landscape of technology and finance integration.

With a global population of 5.3 billion individuals engaging with the internet[3], a consequential outcome emerges in the form of data generation. Statistical evidence reveals a substantial 173 Zettabytes, or 1 trillion gigabytes[4], of data existing on the internet. Within four decades since its inception, data derived from internet usage has evolved into a pivotal element in market analysis and innovative endeavours. This transformation is attributable to the intricate communication network established by millions of interconnected devices facilitated by the internet, thereby reducing the identification of gaps and the formulation of creative solutions.

However, upon analysis of what renders one's presence on the internet a necessity in the 21st century, the answer may be found in two of the most widely utilised applications: e-commerce and digital finance, specifically online banking. The establishment of virtual marketplaces and platforms, demonstrated by entities like Amazon, eBay, and Flipkart, enables casual internet users to partake in global commerce, fostering a widespread appeal. In 2023, online transactions recorded a volume of 103 billion USD[5], underscoring the prevalence of digital finance as a favoured mode of transaction following fiat currencies. In 2022, transactions totalling 125.9 trillion Indian Rupees occurred through UPI[6].

The Unified Payment System (UPI), a cornerstone of India's digital public infrastructure (DPI), has played a crucial role in advancing financial inclusion efforts for policymakers. Its effectiveness stems from several key features that enhance accessibility and efficiency. Firstly, UPI boasts a user-friendly interface, making it

accessible to individuals with minimal technical knowledge. Moreover, it offers flexibility by allowing users to link mobile numbers and UPI IDs, providing access to basic financial services even without a traditional bank account. Additionally, UPI transactions are cost-effective, with minimal to zero transaction fees, making them more affordable compared to traditional banking methods. Furthermore, UPI promotes financial literacy among users by encouraging the adoption of secure digital finance methods through various applications.

It also facilitates micro-entrepreneurship by simplifying online payments and collections, thereby expanding business opportunities for previously excluded populations. Lastly, many government welfare programs and subsidies are now distributed through UPI, ensuring faster and more transparent delivery of benefits to recipients. Overall, UPI's unique features have significantly contributed to advancing financial inclusion objectives in India's digital landscape.

Despite the current state of the global economy, history illustrates the dominance of imperialist powers. While some nations resisted, they were ultimately subdued by the economic strength of Western imperial powers, particularly evident during World War 2. This conflict marked a shift from military conquest to economic competition as the primary focus, a trend that had emerged since the Industrial Revolution.

Today, the world is divided between developed and developing countries, each sharing a mutually beneficial relationship. Some regions boast developed economies with abundant resources, while others struggle with development and resource scarcity. International trade and financial services are pivotal in facilitating economic exchanges between nations. Globalisation has intensified these interactions, emphasising cooperation and competition over conflict and conquest in shaping the current geo-economic landscape.

Two of the 21st century's most significant events, reshaping geoeconomic and geopolitical dynamics, are the COVID-19 pandemic and the conflict between Russia and Ukraine in Europe. The global commerce flow, deeply reliant on global supply chain management, faced unprecedented disruption due to widespread lockdowns – a first in modern history. The pandemic underscored the interdependence of regions worldwide, highlighting the significance of hyper-globalization in geoeconomics.

As a developed nation with abundant energy resources like oil, Russia plays a crucial role in the global energy supply. The conflict in Europe led to fluctuations in international fuel prices, causing an energy crisis in Europe. This demonstrates the critical importance of interconnected economies and the uninterrupted flow of commerce.

In the intricate and highly interlinked global landscape, one critical aspect stands out: global financial communication. At a macro level, nations engage in messaging and record platform transactions. The exchange rate is the primary determinant impacting the international monetary system, influenced by supply and demand, central bank policies, government regulations, and economic variables. Additionally, foreign exchange reserves, often referred to as forex, play a crucial role. Like individuals exchanging currency within a community, countries trade currency, frequently influenced by international agreements or participation in economic blocs.

International transactions between nations involve substantial sums of money, and the efficiency of cross-border payment systems hinges on global economic and political conditions. Notably, from 2018 to 2022, there was a remarkable increase in cross-border payments, surging from $25 trillion to $150 trillion, nearly rivalling the size of the global tech industry[7].

Moving from the era of the Industrial Revolution to the intricacies of modern global finance, it's clear that technology has significantly influenced economic systems. The Industrial Revolution introduced innovations such as the steam engine and the printing press, enabling mass production and faster communication via telegrams. These developments set the stage for subsequent industrial revolutions, which saw the emergence of the internet and digital finance. This blending of technology and finance underscores the vital role of effective communication in linking economies and facilitating international trade.

SWIFT: The Backbone of Global Financial Communication and Its Challenges in the Modern Era

1973, 239 banks from 15 countries formed the Society for Worldwide Interbank Financial Telecommunication (SWIFT) to address cross-border payment communication issues. SWIFT's messaging services, introduced in 1977, replaced Telex technology and quickly gained global trust.

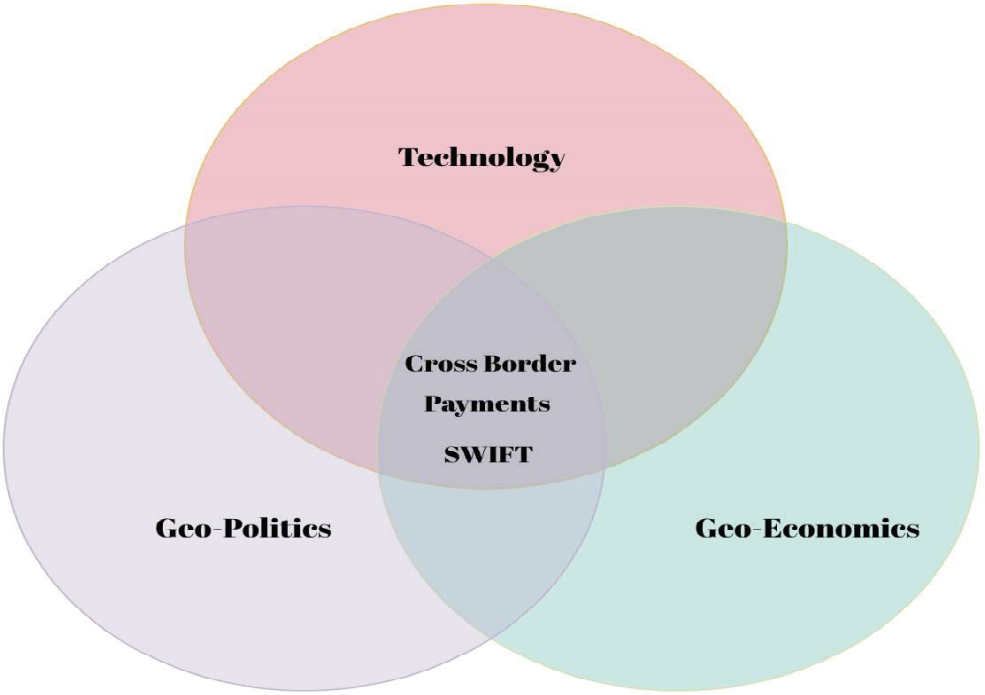
The original services included a messaging platform, a computer system for validation and routing, and standardised message formats.

These standards enabled universal data comprehension across boundaries, facilitating seamless, automated communication exchange between users[8]. SWIFT recorded 44.8 million FIN messages per day in December 2022[9], depicting the volume of international financial transactions between countries and other institutions registered on the SWIFT system. SWIFT primarily utilises ISO 20022 messaging standards[10], an internationally recognised protocol facilitating communication among financial institutions with a standardised language and syntax for financial data exchange.

SWIFT operates as a cooperative society governed by banking institutions from G10 countries, overseen by the National Bank of Belgium. Its Board of 25 Directors, elected by shareholders representing global banking entities, manages the company's affairs. The Executive Committee comprises full-time employees, led by the Chief Executive Officer. With the governance framework primarily derived from G10 countries, SWIFT's board typically exhibits a consistent structure and geopolitical stance. However, this setup raises scholarly questions about how independent sovereign actions may be influenced by reliance on SWIFT, given its centralised operational nature and dependence on specific countries for guidance.

The widespread adoption of SWIFT by both public and private sector entities can be attributed to two main factors. Firstly, SWIFT relies on standardized communication protocols and messaging formats, ensuring consistency and interoperability across

financial transactions. Utilizing standardized MT messages and the ISO 20022 messaging standard, SWIFT provides a common language for interpreting specific information fields, enhancing precision and clarity in financial communications. Each financial institution within the SWIFT network is uniquely identified by a Business Identifier Code (BIC) or FIN code, ensuring language-independent recognition. Additionally, while SWIFT primarily operates on technical standards, aspects such as documentation and customer support may incorporate natural languages like English to improve user experience and facilitate effective communication.



Secondly, SWIFT's adoption is bolstered by its robust security measures and high availability. SWIFT prioritizes the security of financial data through encryption, authentication, and message validation protocols, instilling trust and confidence in the system, particularly for high-value transactions. Moreover, SWIFT ensures high availability with minimal downtime, guaranteeing uninterrupted financial communication. This operational reliability minimizes disruptions and contributes to

the stability of the global financial system, cementing SWIFT's reputation as a secure and dependable platform for international economic transactions.

While some advocate for SWIFT as vital for maintaining the current geo-economic system and promoting global growth and welfare, others question its viability. A closer analysis reveals contrasting observations about its effectiveness in today's world.

1. **Security Concerns:** Despite robust measures, SWIFT faced a significant security breach in the 2016 Bangladesh bank heist. Cybercriminals exploited vulnerabilities, initiating fraudulent SWIFT messages leading to the transfer of nearly $1 billion. This incident underscores persistent security concerns, emphasising the need for continuous cybersecurity improvement[11].

2. **Cost Factor:** Organizations using SWIFT encounter connectivity and traffic charges. Connectivity charges involve fees for network access, infrastructure establishment, and secure communication lines. Traffic charges depend on the quantity of messages transmitted, posing a financial consideration for entities involved in regular transactions[12].

3. **Absent Realtime Monitoring:** The SWIFT system lacks inherent support for real-time transaction validation. Messages are transmitted to recipient institutions for subsequent validation, relying on internal procedures that involve predefined rules and cross-referencing with sender information. For monitoring suspicious activities, SWIFT employs a transaction screening service. While not strictly real-time, this proactive screening mechanism promptly identifies and flags potentially fraudulent transactions by analyzing historical data, message patterns, and established fraud indicators, thus requiring further investigation. This placement ensures a logical flow from describing the SWIFT system's transaction validation process to discussing its approach to monitoring suspicious activities.[13]

4. **Entry Barriers:** Compliance requirements and data privacy pose significant challenges. SWIFT members must adhere to complex compliance frameworks, including incident response plans and reporting protocols. Accessing SWIFT requires robust infrastructure investment for communication, constituting entry barriers beyond financial costs.

The speed of cross-border payments is significantly affected by the time factor, which emerges as the most crucial aspect in this process. A key insight from the BIS study focuses on transaction speed, particularly the time it takes for the beneficiary bank to receive the payment. The study highlights disparities in processing times between lower and middle-income countries compared to higher-income nations. Lower and middle-income countries typically experience longer processing times, indicating the adverse impact of factors such as time complexity and speed on these economies. On average, the processing time is 8 hours and 36 minutes, with a median processing time of 1 hour and 38 minutes. Interestingly, the top 20 routes account for 15% of the total payments volume and 24%[14] of the total payments value, illustrating significant disparities in processing times across different regions[15].

Expanding on the parallels drawn from World War 2, one of the most significant and destructive outcomes of that era was the invention of the atomic bomb, a weapon designed for mass destruction. This triggered an arms race among major nations, each aiming to possess nuclear capabilities, not as a threat but as a means of deterrence.

Within the Permanent five nations of the United Nations Security Council, three are European, one is North American, and the fifth is China. This imbalance towards the developed world is notable. However, there is an additional layer to consider. In 2022, during the conflict between Russia and Ukraine, economic sanctions were imposed on Russia, resulting in its expulsion from SWIFT. A Similar action was also met by Iran in the past. Certainly.

Economic sanctions are diplomatic actions countries take to influence the behaviour of other entities, such as countries, organisations, or individuals, usually for political or economic reasons. These measures can include trade restrictions, freezing assets, imposing travel bans, arms embargoes, financial measures, and technology and export controls. While sanctions aim to prompt changes or address specific concerns, they often result in significant economic and humanitarian consequences for the affected population. The effectiveness of sanctions hinges on factors like international support, the targeted entity's resilience, and the sanctions' goals.

In the broader geopolitical landscape since the establishment of the United Nations after World War II, the global framework has evolved into a neo-realist paradigm

characterised by a pluralist approach. Regional economic dynamics, technological capabilities, and resource distribution shape this framework. The Yom Kippur War serves as a key event, demonstrating geopolitical dynamics and the impact of disruptions like interruptions in oil supplies from the Gulf Bloc on Western nations.

The practice of blocking access to resources has been a long-standing tool throughout history. Understanding the complexities of the current Russian situation poses challenges in predicting the future impact of sanctions on the economy. Remarkably, the Russian Federation currently occupies the foremost position on the list of the most sanctioned countries, boasting 5581 sanctions.[16] Subsequently, Iran, Syria, and North Korea follow suit in this ranking. The immediate repercussions of the sanctions imposed on Russia by Western nations manifest in the steep depreciation of the Russian Ruble. This depreciation results in escalated import costs, rendering the procurement of essential commodities from international trading partners a formidable challenge. Consequently, a direct consequence is the worsening of inflation, rendering goods and services more financially oppressive for the citizens of the sanctioned nations. These delineated outcomes encapsulate some of the spillover effects emanating from the sanctions.

The exchange and circulation of financial information, integral to the contemporary global economy, encountered disruption through the recent decision to curtail SWIFT communication for Russia's central banks. SWIFT prohibitions have been imposed upon Bank Otkritie, Novikombank, and Promsvyazbank resulting in the blocking of 215 billion dollars[17]. Consequently, Iran faced initial SWIFT bans in 2012 and later in 2018 due to concerns over its nuclear program, resulting in blacklisting by the EU and actions from Western nations. These sanctions have effectively isolated Iran economically, compelling it to reconsider its nuclear ambitions. The exclusion of 30 Iranian banks from SWIFT complicates cross-border transactions with neighbouring and allied states. This strategic move, characterised as a "*Financial nuclear weapon*" by French Finance Minister Bruno Le Maire, has evoked concerns within the global banking sector[18].

A deeper analysis, rather than just a surface-level examination, reveals that the parties involved in economic sanctions, both the imposing and the imposed-upon parties,

have their own justifications and shortcomings. Russia and Iran are two countries often portrayed by global media and geopolitics as hostile towards global peace. Historically, these nations have been primary adversaries of the USA and its Western allies. From a domestic perspective, however, they are independent sovereign entities with the right to pursue actions to protect their domestic and economic interests.

While there is no definitive scale for measuring the nature of intent, actions that threaten to destabilise international peace and cooperation are generally viewed as ill-intentioned. Conversely, Western or G10 countries have rarely faced economic sanctions despite their involvement in numerous conflicts that have disrupted peace in various parts of the world.

SWIFT sits at the centre of this dynamic. As the modern-day global financial messaging system, it is highly centralised, serving 200 countries and territories. Countries, especially those in the developing world, perceive economic sanctions as a form of weaponising SWIFT. When actions typically not associated with peacekeeping are necessary, countries with the authority to impose sanctions may do so on India or any other nation. They justify this as a protective measure aimed at preserving global peace.

The uneven decision-making regarding imposing sanctions and excluding countries from SWIFT, holding financial assets as leverage, is a significant concern. Another critical issue is the limited representation within the system, which gives the impression that economic sanctions are decided like rules in a club. Due to the absence of official rulebooks for sanction approval and no available recourse, economic sanctions have become a potent tool without any deterrent.

SWIFT, serving as the global financial messaging platform, faces administrative and technical challenges. A few countries' disproportionate control of the system needs to reflect global agreement on membership restrictions. Without clear rules, decisions can be disputed or reversed only after committee deliberation. The technical challenge, more critical than the administrative one, involves the outdated technology used to run the system. Issues like time, cost, and cybersecurity concerns demand a significant system overhaul on both technical and administrative fronts.

Trade, commerce, finance, and international payments form the foundation of today's global economic system, which involves multiple influential actors. Besides the effects of the COVID-19 pandemic on healthcare and the economy, there's a growing concern about how much nations rely on interconnected trade and commerce[19]. Geopolitical factors, governed by specific countries, further complicate decision-making processes, impacting global outcomes. SWIFT is the centre of international financial transactions, acting as the engine behind cross-border payments. Its regulations, overseen by G10 countries, aim to maintain a balance of power in the global economy. These regulations can be used to steer certain nations deemed hostile. Compliance is often the only choice for others. However, there are drawbacks to SWIFT. Costs, including entry fees and maintenance expenses, are significant. Moreover, transaction processing needs more real-time capability, sometimes taking up to two business days[20].Third-party banks incur costs, and the forex conversion rate fluctuates based on the issuing authority. Now, countries no longer connected to SWIFT still need to handle cross-border payments and keep trade and commerce going, resorting to workarounds. For instance, countries like Russia and Iran, excluded from SWIFT, have turned to alternative methods to manage cross-border transactions. They rely on barter agreements for specific goods and services and currency swaps, as seen in the 20-year deal between Russia and Iran[21]. In this arrangement, Iran provides Russia with privileged access to its oil and gas reserves, receiving goods and services from Russia in return at favourable rates.

Additionally, Iran utilises the Chinese Cross-border messaging system CIPS as part of its broader financial strategies. Furthermore, Iran heavily relies on informal money transfer systems like Hawala for smaller cross-border transactions due to the high volume of transactions. However, the lack of transparency in these systems raises concerns about money laundering and terrorist financing.

The significant impacts of being cut off from a system like SWIFT and relying on loose alternative systems are:

1. **Limited Reach and Global Integration:** Disconnection from the global payment messaging system significantly limits the ability to receive monetary aid. Whether macro or micro, businesses engaged in import and export operations can only

operate within a restricted region, leading to increased costs for international business transactions. This limitation also results in a smaller pool of potential business partners, creating a highly competitive business environment.

2. **Reduced Efficiency and Transparency:** Isolation from the SWIFT banking system greatly impacts transaction speed, as SWIFT offers a global standard transaction format. Alternative methods may involve manual processes, slowing down documentation and authentication procedures. The introduction of new intermediaries also necessitates the establishment of new protocols. Lack of transparency in alternative methods may result from unclear auditing guidelines, leading to opaque and convoluted transaction trails that are difficult to verify. Compliance becomes an issue on the global level for countries using alternative methods for cross-border transactions instead of SWIFT

The Evolution of Global Financial Systems: From SWIFT to Blockchain and Cryptocurrencies

As a vital player in global financial transactions, the SWIFT messaging service plays a crucial role in facilitating trade and commerce worldwide. However, it's important to recognize that SWIFT is not the only platform available in the market; there are several alternatives. For instance, Russia's System for the Transfer of Financial Messages (SPFS), China's Cross-Border Interpayment Bank System, and the Global ACH (International ACH Transfer) are examples of alternative platforms facilitating fund transfers between US and foreign bank accounts. Within Europe, the Single Euro Payment Area (SEPA) dominates international banking, while domestic banking networks like Fedwire, CIPS, BACS, and BECS facilitate international payments. Collaborations such as the linkage of UPI and PayNow between India and Singapore aim to enable instant, low-cost transfers. International card networks like Visa, Mastercard, and Amex are widely accepted for secure cross-border transactions, albeit with potential currency conversion fees. Additionally, in the fintech sector, companies like Airwallex, Nium, and Wise offer innovative solutions using APIs to improve the efficiency of international transactions and address traditional challenges in cross-border payments.[22].

The economic crash 2008 stands out as a significant event in modern history that has compelled world economic policymakers to adopt a more cautious and robust approach. The notion that multinational corporations, private banking, and equity firms were deemed "*too big to fail"* challenged the free market fundamentals. The failure of these businesses posed a risk of creating a spillover effect that could impact the global economy. As a result, policymakers have become more vigilant in addressing systemic risks and reassessing their strategies to prevent similar crises. This event led to another branch, leading to one of the most essential white papers of the 21st century, Satoshi Nakamoto's "Bitcoin: A Peer-to-Peer Electronic Cash System"[23]. This paper introduces the concept of digital currencies and the utilisation of blockchain technology, presenting a novel methodology for the digital financial system. In its

initial sections, the paper asserts that technology, through facilitating trade, commerce, and finance exchanges, emerges as a disruptive force against the prevailing system.

This transformation is characterised by innovative solutions addressing existing gaps, eventually, leading system participants to migrate towards this new paradigm. The emergence of the internet marked a pivotal juncture, providing a platform for developing e-commerce and online banking, thereby empowering both the supply and demand facets of the market. Subsequently, Satoshi Nakamoto's published work introduced two notable elements: Bitcoin, a subject of intense discourse within the crypto enthusiast community, and the Virtual Digital Asset (VDA) trade. However, the primary focus of this paper lies in the comprehensive exploration of blockchain technology.

It is often said that history repeats itself, and this applies to how we record accounting transactions. In an interesting historical anecdote, an individual sought to create a clear and systematic method of recording small business transactions, ensuring their authenticity. This Italian mathematician drew a line on a piece of paper, labelling the right side as 'credit' and the left side as 'debit,' leading to the development of the double-entry bookkeeping journal and ledger we use today. This individual also was Leonardo da Vinci's math teacher in some capacity. Cryptocurrency, like fiat currencies such as INR, USD, EUR, YEN, and others, serves as legal tender issued by countries' central banks for exchanges. However, it differs because it is a tokenised asset stored in a digital wallet, utilizing blockchain technology for transactions and authentication. Blockchain is a Distributed Ledger Technology created in 1991.[24], It is a chain of blocks used for tamper-free security through cryptography, with time stamps ensuring tamper-free records. In accounting terms, think of a blockchain as a ledger where financial transactions are recorded, with each page of the ledger representing a block.

1. **Recording Transaction Blocks:** Every financial transaction is recorded on a new page of the ledger. Similarly, each block contains details of the transaction, such as the amount, date, and parties involved.
2. **Linking Blocks:** First Page (Block #1), filled with transactions, is sealed and linked to the previous page, forming a chain of continuously connected pages.

Similarly, when a block is filled with information, it connects with Page 2, which contains details of different transactions, and the chain extends accordingly.

3. **Decentralized:** Instead of having one central ledger, copies of the entire ledger are distributed across multiple accountants for verification. Similarly, in the blockchain system, each accountant (participant) has their own copy of the ledger.

4. **Consensus Mechanism:** In traditional accounting, accuracy of entries is ensured. In blockchain, consensus mechanisms such as Proof of Work and Proof of Stake are used. Similarly, in the blockchain, accountants (all nodes) collectively agree on the validity of transactions, preventing fraudulent entries.

5. **Immutability:** Once a page is added to the accounting ledger book, it is impossible to remove the page without disturbing the accounting chronology. Similarly, when a block is completed and attached to another one, it is impossible to remove it from the chain.

The seamless incorporation of blockchain technology into the double-entry bookkeeping system has been interpreted above. However, the push behind this monograph lies not only in explicating the operational mechanics of this technology but also in delving into the foundational motivations that led to its conceptualization and how it is charting a course to emerge as a credible alternative to today's centralized system such as SWIFT. One of the principal motivations behind Satoshi Nakamoto's dissemination of the Bitcoin paper and technology was the establishment of a system that operates independently of the centralized financial paradigm. It is imperative to underscore that this dissemination occurred shortly after the 2008 economic crisis, during which numerous investment banking firms and other financial institutions were recipients of bailout packages financed through taxation levied on citizens.

Presently, Satoshi Nakamoto is esteemed not solely for his contributions to blockchain but notably for his seminal creation. Bitcoin. As the inaugural cryptocurrency of its genre, Bitcoin has fundamentally reshaped perspectives concerning the nature of virtual assets and their interaction within the conventional fiat currency framework. The pioneering transaction conducted with Bitcoin involved the purchase of a pizza for 10,000 BTC, a stark juxtaposition to the contemporary valuation of 1 BTC, which now equals 43,000 USD[25].

Governments worldwide showed quick awareness but moved slowly in forming policies about Blockchain due to a lack of understanding of its applications and its classification as a digital asset. It took governments a long time to understand this technology's complexities. One reason for caution is the early adopters of Blockchain. As explained in studies, any technology that combines communication and data exchange, starting from the Internet to E-commerce, and now Blockchain and Bitcoin, has historical precedence. Notably, the Dark Web/Deep Web was among the first to adopt this technology.

Major search engines like Google and Bing can only explore about 5% of the internet due to censorship and policy guidelines. To access the remaining 95%[26], users need to use the Tor browser and other search engines that operate without such restrictions. Some online platforms facilitated illegal activities like drug trade, leaked data, and cybercrime. These platforms were also involved in trading arms and ammunition, often using Bitcoin for transactions. Because Blockchain technology is anonymous and decentralized, Bitcoin became the preferred currency for such transactions, raising concerns for governments.

A new online community emerged, focusing on investment and trading in cryptocurrencies, attracted by the potential for high returns. However, cryptocurrencies are highly volatile, unlike traditional fiat currency. They can offer lucrative opportunities, but they can also lead to substantial losses due to their rapid price fluctuations. Speculative practices and schemes like pump-and-dump[27]further complicate the landscape, leaving many investors vulnerable to financial setbacks.

Blockchain technology has various applications, like a Pandora's box that reveals its potential across different user groups. The evolution of the internet from Web 1 to Web 2 showed how technology rapidly transforms the user experience. Web 1 was about individual forums and webpages, while Web 2 brought e-commerce, social media, and online banking. Now, Web 3, rooted in blockchain technology, emphasizes security and decentralization, merging web applications and commercial activities.

Upon examining cryptocurrency regulations worldwide, two key trends emerge. Firstly, countries generally refrain from outright banning these investment instruments, indicating a degree of acceptance among economic policymakers. However, there's

a growing tendency to impose higher taxes to raise awareness among market participants about the risks associated with Virtual Digital Assets (VDAs).

The regulatory landscape for blockchain and cryptocurrencies varies significantly from country to country. China has adopted strict measures, including banning crypto exchanges and ICOs, while Japan has clear regulations like the Virtual Currency Exchanges Act and KYC/AML requirements for Virtual Asset Service Providers (VASPs). Canada focuses on innovation and consumer protection, while the US adopts a risk-based approach through agencies such as the SEC and FinCEN. Germany prioritizes consumer protection and financial stability, with forthcoming stricter measures for DeFi and ICOs overseen by BaFin. France aligns with EU regulations, indicating efforts towards global harmonization.

This regulatory framework mirrors past trends observed during the early days of the Internet, characterized by speculation and limited regulations until widespread adoption led to the "Dotcom Bubble." Similarly, blockchain technology faces diverse regulations globally, with cautious approaches seen in countries like China, reflecting the increasing significance of blockchain in today's political economy.

The Dual Forces of CBDCs and Tokenization: Reshaping Global Finance

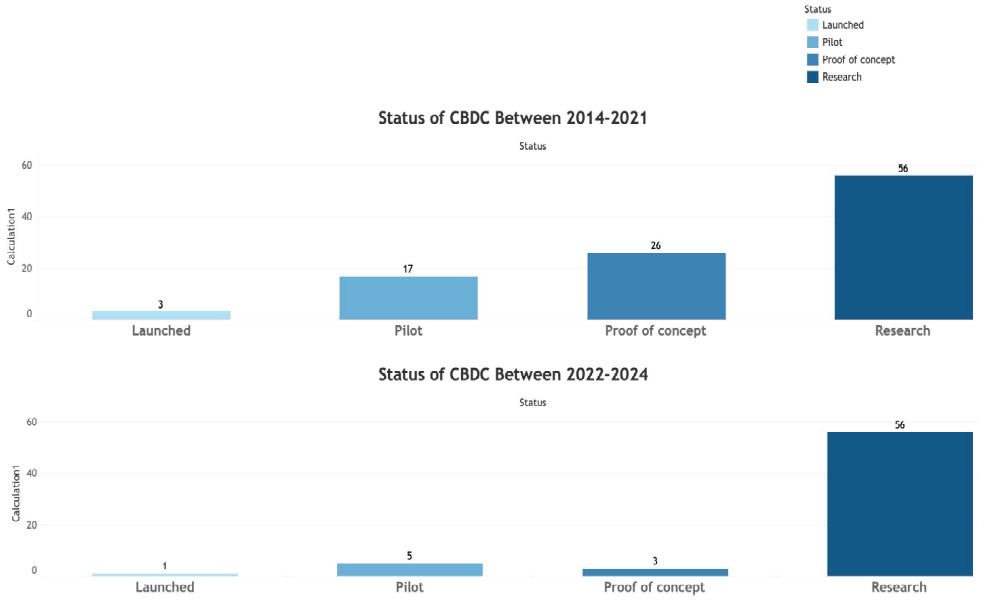
The emergence of Bitcoin and Distributed Ledger Technology (DLT) signifies a significant disruptive force garnering global interest. Central Bank Digital Currencies (CBDCs) are born from a clash between technology and ideology. Originally, Satoshi Nakamoto envisioned decentralization, giving rise to decentralized finance (DeFi) cryptocurrencies for investments. But, as blockchain systems evolved, they introduced tokenized currencies, contradicting DeFi's principles and enforcing regulation. In contrast, CBDCs are regulated, central bank-issued digital tokens, resembling fiat currency, tailored for digital transactions and financial stability.

CBDCs, digital tokens issued by central banks, mimic fiat currency but operate on DLT-based blockchains via digital wallets. Central banks worldwide are exploring this technology within their financial regulations, paving the way for a decentralized financial future, different from the SWIFT system. Currently, about 130 countries are involved in these developments, with some already launching CBDC pilot projects.

CBDCs utilize tamper-proof digital ledgers, powered by DLT -based blockchains, to process transactions. When a transaction begins, its details spread across the DLT network. Nodes, or network computers, then check the sender's account balance to ensure there are enough funds. Valid transactions are recorded in new blocks, forming an unchangeable chain linked to previous blocks. Afterward, all network nodes update their ledger copies, completing the transaction.

The uptake of CBDC projects and a rapid increase in the uptake has taken a significant jump post the covid-19 second wave and intrestibly during the war in the europe. The exploration of digital ledger-based technology by over 100 countries indicates a collective interest in diversifying the exchange medium. Given the centralized nature and global indispensability of the SWIFT messaging system, no nation is inclined to relinquish it, as it poses a significant threat to their banking and financial stability. A

notable trend has emerged, with a 273% increase in research and development of Central Bank Digital Currency (CBDC) projects globally since the Ukraine and Russian conflict, along with the imposition of economic sanctions on the Russian economy and banks.



In the academic sphere it's important to note that only 11 countries engaged in pilot initiatives, research endeavors, and proof-of-concept examinations for their indigenous CBDCs in 2021. However, a significant transition is apparent in 2022, with 41 countries initiating research into CBDCs. This transformation underscores the evolving dynamics and increased scholarly attention toward the development and implementation of CBDCs on a global scale.

1. The widespread interest in Central Bank Digital Currencies (CBDCs) stems from significant changes in the global financial landscape. Economic sanctions, traditionally used to maintain regional security and deter violence, are now receiving increased scrutiny. Nations are becoming more reluctant to endure such sanctions, realizing their potential to cause substantial harm comparable to weapons of mass

destruction. Consequently, measures taken to protect sovereignty are seen as threats to global peace, affecting a nation's ability to manage its own affairs within the broader financial and economic context.

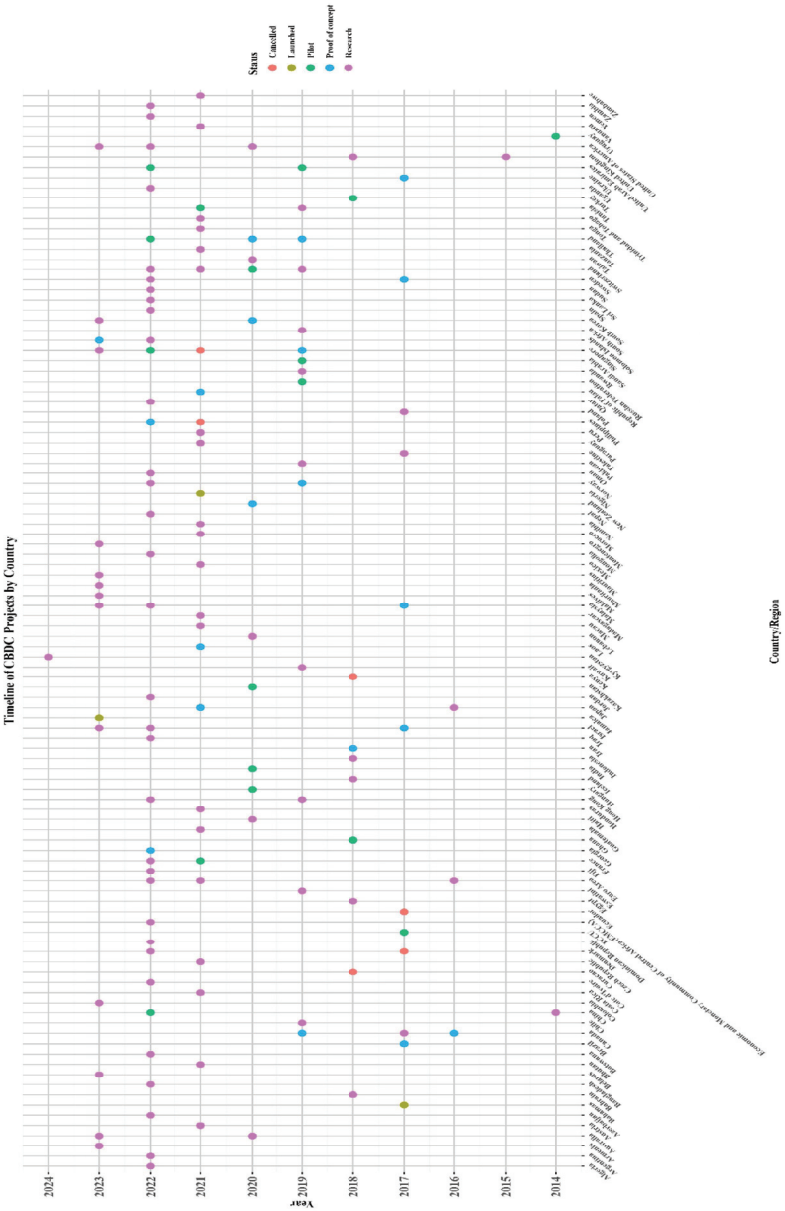
The importance of SWIFT in this regard cannot be overstated, as exclusion from this platform worsens economic instability within a country. Reimagining the global payment system: Incorporating CBDCs, leveraging Distributed Ledger Technology (DLT), signals a passive challenge to the prevailing status quo by multiple stakeholders in the financial ecosystem. The surge in global internet penetration and the burgeoning adoption of digital payment modalities establish a robust groundwork for the integration of DLT-based payment infrastructures at both international and domestic levels.

2. The significant dependence on centralised payment messaging systems, as demonstrated by SWIFT and its selective usage, mainly seen in instances involving Iran and Russia, highlights the necessity for alternative solutions like CBDCs. These alternatives offer the potential for more efficient exchange mechanisms, alleviating both temporal and financial limitations. Additionally, they can facilitate the internationalisation of domestic currencies, even amidst enforced isolation resulting from economic sanctions.

3. Enhanced Economic Policy Control: Introducing CBDCs based on Distributed Ledger Technology (DLT) enables real-time data transmission from financial institutions to governmental authorities. This allows policymakers to understand economic trends and spending patterns better, empowering them to implement more precise interventions tailored to specific economic sectors. As a result, this fosters sustainable economic growth.

4. Fostering Stronger Bilateral Trading Relations: By utilising smart contract technology, CBDCs based on Distributed Ledger Technology (DLT) can act as tools for exchange-based trading between the domestic currencies of cooperating nations. This approach could strengthen bilateral trade relations and facilitate the internationalisation of various currencies in the global market.

While there are mtuiple type of blockchains mechasnims in the existence the major mechanism which are currency being tested to host CBDC are below



The public sector, comprising governments and multilateral organizations, is keen on developing this technology for various public policy and welfare enhancements. Nations are also striving to exert greater control over their cross-border payment systems to mitigate any fallacies arising from geo-economic and geopolitical scenarios. On the very parallel side of this the private sector is not far behind and if not more

than equally interested in tokesiation of the asset which is also the basis of the CBDC where the curreinces which are legal tender are tokenised and shared via blockchain. Something similar is being attempted by the Private sector especially because of the same reasons for which the public sector is exploring the DLT based CBDC which is the cost of transaction and time taken[28].

Tokensiatation of assets could led to a significant drop in the operating expenses and cruch in the time and easier management of the assest. Investment banking firms, private equity firms followed by private banks. According to available reports, investment banking firms and major technology corporations, such as Alphabet (the parent company of Google), collectively invested a significant sum of around $1.5 billion[29] into blockchain research.Notably, Blackrock followed suit with an investment of $1.2 billion, while Morgan Stanley committed $1.11 billion. Concurrently, Samsung contributed $980 million, and Goldman Sachs entered the arena with a noteworthy investment of $690 million specifically earmarked for blockchain development[30].

The primary functions of investment banking firms revolve around managing assets and wealth for their clients. These entities operate on a large scale, handling significant volumes of investments that need settlement across various geographical regions. This complexity stems from the existence of diverse policies and distinct settlement and transfer mechanisms worldwide. The integration of blockchain and private ledger-based transfer platforms is expected to significantly reduce the time required for settlement processes, thus lowering operational costs[31] traditionally associated with these procedures.

The critical feature these firms wants to captialise on is the tokenisation of the assests, as per the professor of georgetown university, "*A traditional stock certificate is nothing more than a token that represents ownership of the keys of a company*"[32]By tokenizing these assets, the settlement mechanism accelerates,

according to Wall Street's estimates that assets worth $5 trillion can be tokenized in the next five years. The integration of the Quorum blockchain by JPMorgan for clearing and settling securities transactions has resulted in significant outcomes, particularly in reducing settlement times and mitigating counterparty risk. This implementation has led to an impressive 99% reduction in the overall duration required for end-to-end transactions. The strategic adoption of blockchain technology within investment banks' operations not only streamlines settlement and clearing processes, thus enhancing accuracy, but also enhances trust and security within financial transactions.[33]

Transforming Global Finance: The Rise of CBDCs and Cross-Border Payment Projects

Presently, the Bank for International Settlements is leading the mBridge project, which aims to create a common platform for wholesale cross-border payments using multi-Central Bank Digital Currencies (CBDCs), with a focus on international trade. This initiative could benefit the public by connecting central banks and commercial banks globally. The mBridge project's platform is built on a custom distributed ledger technology (DLT), backed by legal documents and a governance structure aligned with its objectives.

In the current development phase of the blockchain landscape, a triangular paradigm is emerging. Firstly, decentralized finance (DeFi) cryptocurrencies are already in circulation, serving as investment and trading instruments on exchange platforms. Secondly, Central Bank Digital Currencies (CBDCs) leveraging Distributed Ledger Technology (DLT) are being developed, representing digital versions of traditional fiat currencies issued by sovereign central banks. Multiple countries are conducting experiments in the CBDC space. Lastly, private blockchains are being set up for transaction settlement and asset management by private and legacy banks[34].

At present, the mBridge project involves four central banks and collaborates with 26 observing member countries. Its main goals are to lower costs and speed up cross-border transactions. Additionally, the project aims to improve security measures with the overall objective of developing a potential alternative to SWIFT for cross-border payments.[35].

Inthanon-LionRock2 (ILR2): Beginning in 2021, the project involves collaboration between the Hong Kong Monetary Authority (HKMA) and the Bank of Thailand (BoT). The main goal is to systematically investigate the application of Distributed Ledger Technology (DLT) in expediting real-time cross-border funds transfers. The focus of this exploration is on implementing an atomic payment versus payment (PvP)

mechanism tailored for foreign exchange (FX) transactions between the two jurisdictions. This project actively contributes insights into the use of DLT for facilitating cross-border payments between sovereign nations and addresses strategic considerations for integrating additional participants into the network.

The proposed model for the corridor network includes the corridor operator node, participating bank nodes, and foreign currency liquidity providers. The corridor operator node, a collaborative entity established by the Bank of Thailand (BoT) and the Hong Kong Monetary Authority (HKMA), plays a central role in facilitating the issuance and redemption of wholesale CBDC (wCBDC) while ensuring strict compliance with regulatory frameworks. Participating bank nodes, on the other hand, are responsible for initiating and settling cross-border payments according to defined protocols. Lastly, foreign currency liquidity providers offer essential support during operational gridlock, ensuring the smooth functioning of the cross-border payment system.[36]

Jura: This experiment is a collaboration between the Swiss National Bank, the Bank of France, and Six Digital Exchange, along with a private consortium. Utilizing the consultative blockchain architecture of Accenture R3, the experiment aims to address the need for a robust cross-border payment settlement system in Switzerland, an economy characterized by its compact openness.

Unlike the traditional Payments Vs Payments (PvP) system, Jura utilizes a Delivery Vs Payments (DvP) system. In practical experiments involving the use of Central Bank Digital Currencies (CBDCs) across borders, a setup named Jura Graph 2 comprises four main components.

1. **TARGET2:** This system facilitates the creation and withdrawal of wholesale CBDCs (wCBDC).
2. **SIC System:** The Swiss Interbank Clearing system settles financial transactions and manages wCBDC as well as the issuance and redemption of tokenized commercial paper.
3. **Digital Asset Registry (DAR):** It maintains records of digital assets such as wCBDC and ownership of commercial paper.

4. **SDX Test Platform:** SIX Digital Exchange serves as a testing ground for trading digital tokens (wCBDC and commercial paper). It facilitates peer-to-peer exchanges (PvP) and delivery versus payment (DvP) transactions.

The Jura project has faced challenges primarily at the policy level due to the issuance of wholesale Central Bank Digital Currency (CBDC) on a third-party platform, granting access to non-central bank funds for non-resident financial institutions. Jura's innovative solution involves implementing subnetworks to distribute the network load, establishing a more resilient and efficient system. The dual notary system within Jura enhances transaction authentication by independently validating transactions through two notaries, thereby adding layers of security and reducing the risk of irregularities within the blockchain.[37]

Dunbar- Similar to Jura project and ILR2, project Dunba is also a expitemrnt gping between grouping of 4 countries Malaysia, Australia, Singapore and South Africa. This utlises muitple Wholesale CBDC for international cross border payment settlement between multiple central banks of the grouyping countries.[38]

Design Structure:

1. **CBDC Issuance:** Each participating country's central bank will implement its proprietary digital currency.
2. **Direct Access for Commercial Banks:** Participating commercial banks are afforded the opportunity to directly possess Central Bank Digital Currencies (CBDCs) without intermediary involvement.
3. **mBridge Platform:** The mBridge platform adopts a modular structure, facilitating multiple central banks in the issuance of CBDCs for peer-to-peer transactions.
4. **Financial Lego Set Approach:** The mBridge platform is constructed with a versatile and modular methodology, allowing facile adjustments and integration of new features.
5. **Project Phases:** The project progresses from ILR2 to mBridge, emphasizing technological enhancements, legal considerations, and governance frameworks.

6. **Technology, Legal, and Governance Focus:** In this developmental phase, the collaborators concentrate on refining their technological infrastructure, delving into legal intricacies, and enhancing governance mechanisms.

7. **Access for Commercial Banks:** Conceiving the participants' wallets as analogous to commercial banks, each commercial bank gains direct possession of CBDCs issued by central banks, resembling personalized currency notes. This affords them the ability to access foreign currencies autonomously, eliminating the necessity for accounts with other banking entities.

mBridge: The project mBridge adopts a highly centralized approach, enabling the central banks of the participating countries to collaborate with domestic banks and international private banks alike.[39].

Connected City Model: Each private domestic bank registered with the country's central bank can utilize the CBDC of another country's domestic bank.

Central Validation Mechanism: As domestic private banks are connected with the central banks of their respective countries, central banking institutions handle transaction validation. This places the responsibility of authentication on government monetary and digital policymakers.

Identity, Connectivity, and Discovery: The Common Network serves as the foundational layer for the mBridge platform, employing distributed ledger technology (DLT) to secure and decentralize identity management, ensure connectivity, and facilitate participant discovery. Cryptographic techniques authenticate and authorize participants, establishing a trust layer for transactions.

Wallets Jurisdictional Self-Custody: The Wallets component offers essential control over digital assets. Participants, such as commercial banks, possess secure digital wallets with jurisdictional self-custody, emphasizing control within their regulatory frameworks. Encryption and cryptographic key management ensure wallet security.

Tokens Representation of CBDCs: Tokens on the mBridge platform represent Central Bank Digital Currencies (CBDCs), issued by participating central banks. DLT ensures secure, transparent issuance, transfer, and redemption of tokens, facilitating peer-to-peer transactions on the offshore network. The technology maintains the integrity and traceability of each token, preventing issues like double-spending.

Network Validation Issuing Central Banks' Role: Participating central banks validate transactions within the mBridge architecture. When transactions occur between commercial banks or other participants, the involved central banks authenticate the transaction's legitimacy. This validation process, likely utilizing consensus mechanisms in DLT, enhances trust and security in cross-border transactions.

Feature	ILR2 (Hong Kong, Thailand)	Jura (Switzerland)	Dunbar (Australia, Malaysia, Singapore, Saudi Arabia)	mBridge (Hong Kong, China, Thailand, United Arab Emirates)
Output Type	PoC	Prototype	Prototype	Prototype
Currencies Involved	HKD, THB	EUR, CHF	AUD, MYR, SGD, SAR	HKD, CNY, THB, AED
Use Cases Tested	Various	Various	Various	Various
Technical Design - Interoperability	Common platform	Common plat. w. subnetworks	Common platform	Common platform
Project Scope and Experiment Design	BIS Innovation Hub Centre Hong Kong	Switzerland	Singapore	Hong Kong
DLT Used	Hyperledger Besu	Corda	Corda	mBridge Ledger (M MBL)
Non-resident Banks Can...	Hold and transfer	Hold and transfer	Hold and transfer (approval needed)	Hold and transfer
Platform Operator	Central banks	Private	Central banks	Central banks
Domestic Payments	✓	✓	✓	✓
Cross-border Payments	✓	✓	✓	✓
Offshore Payments	✓	✓	✓	✓
Domestic Payment in Foreign Currency	✗	✓	✓	✗
PvP (Payment vs Payment)	✓	✓	✓	✓
DvP (Delivery vs Payment)	✗	✓	✗	✗

Table 1.0 Central Bank Digital Currency (CBDC) Project Overview: A Comparative Study

Navigating the Future: Challenges and Opportunities in Cross-Border CBDC Adoption

Two major challenges faced by DLT-based (CBDCs) are interoperability and privacy, both of which are critical for the administrative and functional aspects of this project. Interoperability methods enable broader participation from banks, countries, and citizens worldwide. Privacy is another key concern, as cash remains one of the primary mediums of transactions, providing users with a tangible and confidential experience. These two ascpects are cloesley interlined with two possible anticipated outcomes of in th elarger sphere of cross border payments.

Cash and its ability to maintain anonymity regarding the goods and services purchased, as well as user details, foster a high dependence on cash. In contrast, a Central Bank Digital Currency (CBDC) system based on blockchain would record various transactional aspects that users may prefer to keep undisclosed. Therefore, any CBDC project aiming for widespread adoption, especially across borders, must prioritize security and privacy aspects.

A recent study conducted by the Bank for International Settlements (BIS) in South Korea involved 3514 participants assigned to three CBDC privacy modules to assess interest based on the model. Given stringent regulations against money laundering and terrorism financing, any new medium of exchange must be compliance-ready.

The study delineated three CBDC privacy models to participants:

1. **Combined Repository (CR):** This tool aims to thwart illicit financial activities by consolidating transactional data for efficient retrieval, aiding investigations into unlawful activities.

2. **Separate Repository (SR):** It segregates transactional and personal details into distinct databases, enhancing privacy but potentially compromising anti-money laundering (AML) and counter-terrorism financing (CTF) efforts.

3. **Small Amount Anonymity Voucher (SAAV):** It provides anonymity for minor transactions, preserving user identity and transactional data confidentiality, thus facilitating goods and services categorization.

The study, structured as a Randomized Control Trial (RCT), offered distinct models to participants. Offline CBDC adoption rates ranged from 22% to 33%, while online transactions showed higher rates of 36% to 46%. Privacy preservation measures correlated with adoption, with a 10% increase in CBDC adoption and an 8.1% increase in usage for online purchases with the SR treatment.[40]

As CBDC exploration progresses, privacy considerations become imperative, especially for cross-border payments. Intergovernmental deliberations are necessary to establish a cohesive policy framework, determining whether transactional data should be on the blockchain ledger or maintained separately. Discussions must also address the optimal level of user privacy while mitigating AML and CTF risks.

Novel technologies are mainly adopted due to two key factors. First, the push towards innovation driven by the obsolescence of older tech, like the transition from pagers to smartphones, catering to users' evolving needs. Second, compliance with regulatory directives plays a pivotal role, as seen in the shift from magnetic strip cards to PIN and NFC systems in payment technology. This pattern extends to emerging technologies such as DLT-based CBDCs and the rise of DeFi assets, where regulatory alignment heavily influences adoption trends.

The adoption of DLT-based CBDCs brings forth a complex interplay between user privacy and adoption. Similarly, the interportability of multiple CBDCs for cross-border transactions poses another layer of complexity. CBDCs represent a modern alternative to SWIFT for international transactions, but for them to function effectively across borders, they must incorporate interportability mechanisms.

Central banks issue CBDCs in two primary formats: Retail and Wholesale CBDCs. Retail CBDCs cater to bank account holders, while Wholesale CBDCs serve private banks for interbank settlements and overseas transactions.

Common consensus suggests that as multiple central and private banks, along with individual account holders, utilize Central Bank Digital Currencies (CBDCs) for

payments, there is a need for a universal interoperability mechanism. This mechanism would enable seamless cross-border transactions. For instance, if Bank A, a private bank, and User A wish to deposit 100 USCBDC into Bank B in Singapore with User B, both banks must adhere to the same interoperability protocol. Additionally, both CBDCs must share compatible programming to ensure users can utilize the digital token seamlessly for cross-border transactions.

1. **International Standards:** A global interoperability-based rulebook needs to be proposed by multiple nations to create an ISO-level interoperability guideline. This will help new users and other countries to adopt the Distributed Ledger Technology (DLT) based CBDCs.

2. **Reducing Fragmentation:** As the evolutionary trajectory within the Central Bank Digital Currency (CBDC) domain progresses, various interoperability policies are expected to be adopted by governments worldwide. Given the anticipated diversity in communication models, the creation of heterogeneous interoperability models globally is inevitable. To mitigate this, the formulation of predefined policies for interoperability becomes imperative, serving as a mechanism to reduce fragmentation.

3. **Compliance with International Standards:** Adhering to prevailing global compliance standards and interoperability principles is crucial for facilitating the seamless functioning of CBDCs in cross-border settlements. Conforming to international best practices enhances the readiness of CBDCs for integration into the broader financial ecosystem.

4. **Effective and Seamless International Cooperation:** The adoption of a unified interoperability model has the potential to enable central banks worldwide to collaborate seamlessly with regulatory bodies. This collaborative approach fosters an environment conducive to collectively addressing challenges and ensuring the smooth functioning of cross-border CBDC transactions[41]

In a possible scenario the peculiar case which will will have a direct impct on geopolial and geo-economic dynamic is the currency basket situbation. The currency basket siutation is much likey to arise. Central Bank Digital Currencies (CBDCs) are

increasingly viewed as viable instruments for cross-border transactions. Under this paradigm, private banks gain access to Wholesale CBDCs, facilitating trade between the central banks of partnering nations. Consequently, multiple CBDCs may function as foreign exchange reserves, akin to the prevailing use of the USD. This unique arrangement primarily serves to internationalise currencies from various nations.

In regional contexts, such as India's extensive trade relations with ASEAN countries, establishing a common reserve denominated in an ASEAN nation's currency becomes plausible. Subsequent currency swaps with the Indian Rupee could further solidify economic ties. Analogously, the emergence of distinct baskets comprising sets of interoperable DLT-based CBDCs is foreseeable in the Gulf Belt and other regions. Such initiatives directly contribute to diversifying Forex reserves.

Presently, India's Forex reserves primarily comprise major currencies such as USD, EUR, and GBP. However, leveraging a CBDC-based basket network, particularly for facilitating trade, India could construct a region-based basket system for cross-border payments and commerce. Additionally, should the need arise for supplemental reserves, the exchange of one basket for another could be utilized to maintain equilibrium in currency valuations, thereby fostering a dynamic currency exchange rate environment. Ultimately, such measures could pave the way for the internationalisation of multiple new currencies.

If the exploration of a system involving CBDC baskets were to be undertaken, the primary challenge would be establishing standardization and interoperability protocols. Central banks globally would need to collaborate to determine measures that facilitate the trading of CBDC baskets and ensure their widespread acceptance. Discussions at the Bank for International Settlements in 2020 delved into how the transaction architecture could impact the interoperability model concerning both micro and macro financial risks. Currently, there is no universally applicable approach for CBDCs, as even cross-border transaction exchanges remain in an experimental phase.

If there is a preference for prioritizing compatibility and cost-effectiveness within the interoperability model, pursuing such a path may not yield the efficiency levels observed in alternative models adopted by various nations. Presently, three prominent interoperability models are undergoing testing phases, showcasing their applicability

across various Central Bank Digital Currency (CBDC) projects. These models hold the potential to significantly influence the future trajectory of global interoperability in the realm of digital currencies.

Interlinked Model: This model aims to create connections among various central banks using CBDC. It involves implementing technical and contractual agreements to streamline processes related to data exchange, compliance, and provisions for foreign currencies.

Linking Mechanisms: Experiments have provided insights into three main linking mechanisms: single point access, bilateral link, and hub-and-spoke solutions.

1.**Single Point of Access:** Participants can access banking services through a gateway provided by Payment Service Providers (PSPs). The single gateway entity acts as an institutionalized component of the arrangement, serving as a conduit to all participating entities[42]. The lack of global reach in the mentioned models may lead to inefficiencies at the courier level, potentially hindering the effectiveness of cross-border settlement mechanisms.

2. **Bilateral Link:** Involves a direct linkage between two individual CBDC systems, enabling participants in one system to engage in transactions directly with counterparts in the foreign system. Noteworthy examples include projects such as HSBC and Jasper-Ubin. This could potentially lead to the establishment of a convoluted network of connections, necessitating meticulous oversight and management.[43]

3. **Hub and Spoke Solution:** Encompasses a centralized hub connecting two or more distinct CBDC systems associated with participating jurisdictions. The hub, although capable of functioning as a standalone payment system, is not obligatory in this context. The efficacy of the system is contingent upon the intricacies of the design and governance framework of the regional hub[44].

India heavily depends on SWIFT as a comprehensive platform for cross-border messaging and transactions; it is actively working to reduce the Dollar's influence in its trade activities and promote the internationalisation of the Indian Rupee. Reports suggest that a SWIFT member incurs an annual expenditure ranging from $130,000 to $140,000[45] this expenditure is incurred by a SWIFT member.

The recent bans on Russian central banks and freezing of assets have raised concerns about potential geopolitical scenarios where similar actions might target India, potentially resulting in its expulsion from SWIFT. India's reliance on SWIFT exposes it to vulnerabilities from evolving cyber threats, which could compromise transactions and have significant financial consequences if subjected to cyberattacks. India's current share in the global GDP is estimated to be 9.5%.[46] India is the third-largest contributor to the global GDP, and it can be inferred that, due to its interconnected trade and finance policies, India relies significantly on FIN messages from SWIFT. This demonstrates a deep dependency on this centralised system.

India received $125 billion in remittances in 2023, making it the world's largest recipient[47]. The article discusses the global reach of Indian professionals and highlights the significant role of talent export in the Indian economy. Remittances, constituting 3.4%[48] of the total national GDP, play a crucial role in India's geo-economic landscape. Moreover, they serve as a soft power for diplomatic relations with other nations, enhancing India's foreign policy through an expanded network of skilled Indians internationally. In south asia the share of India's remittance has ben 66% shows the fact out global dominance in the work force talent export. The volume of transactions initiated by Indian citizens abroad occurs within a complex network involving multiple central and private banks across the globe. Remittances play a vital role in providing essential financial support to the families of skilled professionals, aiding their economic sustenance worldwide. However, restrictions imposed by SWIFT can complicate these transactions, resulting in significant losses for families and impacting the economies of countries involved. Additionally, the time complexity and transaction charges borne by remittance senders worsen the inefficiency and costliness of the process, reflecting broader economic challenges that CBDCs and DLT-based solutions seek to mitigate.

Many countries are currently developing technology-driven alternatives to SWIFT, where the messaging system is utilized, but the originating country manages hosting. While this approach, exemplified by entities like CIPS in China, is prominent for creating alternatives, it presents inherent challenges when scaled up.

DLT-based solutions offer significant advantages over traditional systems like SWIFT, particularly in terms of time and cost efficiency. By substantially reducing transaction

time and associated costs, DLT-based solutions alleviate one of the primary operational expenses, making them particularly appealing for emerging markets and developing economies seeking to streamline financial processes.

Moreover, the Society for Worldwide Interbank Financial Telecommunication (SWIFT) is exploring integration pathways for DLT-based CBDC methods in cross-border transactions. This strategic initiative reflects the recognition within the primary organization responsible for global trade messaging of the need for technological advancement, surpassing traditional methods.

Another significant advantage of DLT-based CBDC systems is its transparency. Despite security enhancements within the SWIFT system, a notable critique is the lack of real-time tracking capabilities, leading to difficulty in ascertaining message and transaction statuses. In contrast, DLT-based systems offer real-time tracking capabilities, enabling users to monitor transaction progress seamlessly, thereby enhancing trust and confidence in financial transactions.

Additionally, DLT-based solutions mitigate operational risks by providing a blockchain-driven, tamper-resistant ledger recording. This feature attenuates risks associated with AML/CTF-related issues, enhancing traceability and compliance efforts. Moreover, the decentralized nature of DLT mitigates the risk of a singular point of failure inherent in centralized systems like SWIFT, further bolstering its appeal as a viable alternative for financial institutions and governments alike.

While alternatives are being presented and experimented with, it's essential to recognize the fundamental challenge of overhauling a system that the global community heavily relies on, especially when it's centralized and favors specific countries and decision-makers. However, what could potentially occur is a disruption, albeit on a small scale, that initiates a domino effect. With over 100 countries experimenting with Central Bank Digital Currencies (CBDCs), the system will inevitably be pushed for a larger user base, with more inputs and feedback pouring in, which need to be incorporated.

Understanding Distributed Ledger Technology (DLT)-based Central Bank Digital Currency (CBDC) technology requires considering both traditional cash transactions and centralized systems such as SWIFT. Initially, its implementation involves carefully assessing its adoption and interoperability. This approach inherently presents complexity

and challenges due to the semi-decentralized nature of the system. For example, India's proficiency in digital literacy and adoption of digital payment methods provides a strong foundation for integrating such technology widely.

Interoperability mechanisms are currently fragmented, necessitating a global consensus during the experimental phase. Without such consensus, bilateral agreements may be needed, resulting in a complex network of interoperability mechanisms marked by intricate exchanges of information and contracts. DLT-based solutions offer significant advantages over traditional systems like SWIFT, particularly in terms of time and cost efficiency. By substantially reducing transaction time and associated costs, they alleviate one of the primary operational expenses. This makes them appealing, especially for emerging markets and developing economies seeking to streamline their financial processes.

Moreover, SWIFT is exploring integration pathways for DLT-based CBDC methods in cross-border transactions. This strategic initiative reflects the recognition within the primary organization responsible for global trade messaging of the need for technological advancement, surpassing traditional methods. Another significant advantage of DLT-based CBDC systems is transparency. Despite security enhancements within the SWIFT system, a notable critique is the lack of real-time tracking capabilities, leading to difficulty in ascertaining message and transaction statuses. In contrast, DLT-based systems offer real-time tracking capabilities, enabling users to monitor transaction progress seamlessly, thereby enhancing trust and confidence in financial transactions.

Additionally, DLT-based solutions mitigate operational risks by providing a blockchain-driven, tamper-resistant ledger recording. This feature attenuates risks associated with Anti-Money Laundering (AML) and Counter-Terrorism Financing (CTF) issues, enhancing traceability and compliance efforts. Moreover, the decentralized nature of DLT mitigates the risk of a singular point of failure inherent in centralized systems like SWIFT, further bolstering its appeal as a viable alternative for financial institutions and governments alike.

Conclusion

DLT-Based CBDCs: India's Strategic Imperative for Economic Security

The adoption rate of DLT-based CBDC projects globally underscores a unanimous drive to establish alternatives to centralized systems like SWIFT. India's comparative advantage lies in its prior success with digital infrastructure, exemplified by UPI. The widespread adoption of UPI and digital payments, with 46% of transactions occurring in India, attests to the nation's rapid embrace of technological advancements. Moreover, with over half of the Indian population having internet access, including rural areas experiencing steady growth, India's robust infrastructure positions it favorably for the implementation of DLT-based CBDCs as a primary payment mechanism.

While other countries are simultaneously excelling, the specific areas that need to be studied and overcome revolve around the pace of development of CBDC projects. The first pilot began in 2022, introducing wholesale and retail CBDCs to a select group. While the results of these studies aren't publicly available, the swift progress India is making in advancing to new testing stages is notable. In contrast, other countries mentioned in the monograph, such as the UAE, Saudi Arabia, Hong Kong, Thailand, Malaysia, and Switzerland, have already embarked on exploring and experimenting with cross-border payment methodologies. It is evident that the policymakers of the country might be considering the use of this DLT application for domestic or alternative forms of payments first, focusing on the domestic market. This monograph has emphasized the idea that DLT-based CBDCs can serve as a pathway and a solid alternative to SWIFT.

While some countries are making significant progress, there are specific challenges surrounding the pace of CBDC project development that need attention. The initial

pilot phase, which began in 2022, introduced wholesale and retail CBDCs to a limited audience. Although the results of these studies have not been made public, India's rapid advancement to new testing phases is noteworthy. In contrast, other countries like the UAE, Saudi Arabia, Hong Kong, Thailand, Malaysia, and Switzerland have already started exploring cross-border payment methods. It appears that policymakers in India may prioritize the use of DLT applications for domestic or alternative payments, initially focusing on the domestic market. As there are muti-dimesniaol concerns which surround the CBDC project such as cybersecurity, secured technical infrsture, taking banking sector into confidence.

The monograph primarily delves into the potential role of DLT-based CBDCs as an alternative to SWIFT. Given the widespread use of the US dollar in global exchanges facilitated by SWIFT, the USD holds a pivotal position in the global economy. Consequently, the economic policies of nations often revolve around the performance and reactions of the US dollar to various global market events. Introducing a CBDC could potentially globalize the Indian Rupee and streamline currency swaps, resulting in reduced transaction costs and faster transactions, particularly beneficial for cross-border trades. Additionally, when the Indian CBDC is traded among national and private banks of other countries through currency swaps, it could directly enhance the value of the Indian CBDC, creating a situation akin to a currency basket. This would facilitate diverse forms of trading with other countries and regional partners, fostering a semi-decentralized, closed economic loop for enhanced economic growth in the region.

India, following China, stands out as a country with extensive internet accessibility and a high rate of digital payment adoption. Both nations hold competitive and conflicting positions on various issues. China's Digital Yuan has capitalized on being an early mover in the CBDC space. As CBDCs gain traction over time and are adopted by other nations in South Asia, a model similar to China's may be exported.

However, there are geopolitical considerations and challenges related to trade agreements and cross-border payments due to a lack of interoperability consensus and protocols. It is possible that the new policies surrounding DLT based CBDCs in India could be influenced by the Chinese model of the Digital Yuan, and the required digital infrastructure could also heavily rely on the Chinese model. The notable

involvement of China in various cross-border DLT based CBDC experiments, particularly with countries like the UAE and Saudi Arabia, which are significant sources of remittances to India, should serve as a compelling factor for Indian policymakers to expedite the development of the Indian CBDC project for cross-border applications as well.

The consideration by SWIFT, a globally centralized system, to integrate DLT-based CBDCs for FIN messaging and cross-border payment[49]. Indicates the potential benefits of investing in the research and development of such CBDCs, as it merges technology and finance. Furthermore, it's important to highlight that while economic powerhouses like the USA are currently slow in developing CBDC systems[50] due to various reasons, countries in the BRICS and other global south groups are advancing quickly which could be turned into a competitive advantage . This creates an opportunity for global south countries could potentially bring a certain degree of potential disruption the centralized global economic system, which plays a significant role in shaping global geopolitics.

India, as the world's fifth-largest economy[51], aspires to reach a $5 trillion economy in the near future. However, achieving this goal poses challenges within the realm of secure geo-economic mechanisms. To attain such a target, India must navigate the complexities of global geopolitics, where sovereign interests often prioritize survival. India is geographically surrounded by neighbors with conflicting policies, adding to the complexity.

In its 2047 vision, economic security stands as a cornerstone for India. Distributed Ledger Technology (DLT)-based Central Bank Digital Currency (CBDC) emerges as a strategic tool within the domain of geo-economic strategy. This technology has the potential to bolster India's standing in the global economic paradigm and fortify its position in the international political arena.

Contrasting with the Chinese version of CBDC, which reflects the Chinese Communist Party's (CCP) stringent control, India has the opportunity to develop a CBDC that ensures both domestic and cross-border transactions free from such surveillance. By championing a new economic model, India could potentially become a leading exporter, challenging the existing global economic status quo.

India's goal for 2047 is to be a leader in all professional sectors, aiming not just to be among the top three largest economies, but also to prioritize sustainability and have enough resources to run welfare programs effectively. Achieving these ambitious yet realistic goals emphasizes the crucial role of geo-economics, financial communication, and economic interactions. Currently, India's involvement in the SWIFT system reveals a bias in policymaking that favors developed countries and protects their interests. These nations have effectively used the SWIFT system as a powerful tool, causing significant and lasting impacts on India's economy, both in the short and long term. With being a member of the SWIFT system and extending our dependency on suc system, we might be possibly losing on opportunity to explore more viable options. The centralized nature of the SWIFT system presents dual facets of utility and limitation, offering standardized protocols for international financial transactions. Nonetheless, recent actions by nations such as Iran and Russia highlight potential challenges to national sovereignty and draw attention to the scrutiny of their actions by entities prioritizing global peace advocacy. This has led to SWIFT being perceived as an economic weapon of mass disruption.This divergence from SWIFT and the exploration of alternative frameworks serve as mechanisms for developing nations to uphold communication channels amid potential disruptions from the prevailing system.

With increasing geopolitical tensions in regions such as Iran and Israel, as well as ongoing conflicts such as the war in Russia, it becomes apparent that the global economic system and market are highly volatile. Countries are actively seeking the best options to safeguard their own interests. This is where alternatives like DLT-based CBDCs come into play. This research monograph extensively discusses the origin and potential application of CBDCs as an alternative to the existing SWIFT system. As India's goals now include competing with developed nations in various sectors, achieving greater control over monetary policies is a potential benefit of CBDCs. While transitioning away from a centralized system is challenging, both CBDCs and traditional systems are likely to coexist initially, with a gradual migration process potentially taking place.

DLT-based CBDCs are not only being researched by the public sector due to geopolitical considerations, but also by the private sector. Large private equity and

investment banking firms are entering the space of asset tokenization to enhance their business models and increase their research efforts. This clearly indicates the potential of DLT-based technology, as there is widespread interest in capitalizing on its features and diversifying the global payments messaging system paradigm.

India's competitive advantage lies in its seamless adoption of digital payments and widespread internet availability. This has significantly increased financial inclusion, especially in rural and tier 3 cities of the country. The adoption of DLT-based CBDCs could potentially open up multiple applications directly impacting financial inclusion in the country. From a geopolitical standpoint, whoever establishes the integration of DLT-based CBDCs as an option in the economic system could also become a key model for other partnering countries.

In contrast to the Chinese version of CBDC, which reflects the Chinese Communist Party's stringent control, India has the opportunity to develop a CBDC that ensures both domestic and cross-border transactions free from such surveillance. By championing this new economic model, India could potentially become a leading exporter, challenging the existing global economic status quo.

As the saying goes, "Slow is smooth, smooth is fast." India currently possesses all the right ingredients to develop a successful alternative model to the centralized system of SWIFT. While other nations in the same competition are advancing rapidly and presenting cross-border payment applications of DLT-based SWIFT, India needs to enhance its efforts in this project. While this is not a race, but rather an opportunity to have greater control over domestic economic policies and solidify decision-making as a sovereign nation. India can intensify its efforts by partnering with like-minded nations to secure cross-border payment mechanisms and advance research in this area. Over the past two decades, India's significance in the global economic and political sphere has markedly increased, shaping perceptions of its security and economic policies. Consequently, countries are increasingly seeking partnerships with India, recognizing its evolving role on the world stage. India itself is striving to achieve goals that even developed nations aspire to attain. The vision for India in 2047 embodies a convergence of various factors, with DLT-based CBDCs could emerging as a pivotal component ensuring privacy and security in the integration of Indian economic systems.

Serial Num.	Abbreviation	Full Form
1	ACH	Automated Clearing House
2	Amex	American Express
3	APIs	Application Programming Interfaces
4	ASEAN	Association of Southeast Asian Nations
5	BACS	Bankers' Automated Clearing System
6	BaFin	Federal Financial Supervisory Authority (Germany)
7	BECS	Bulk Electronic Clearing System
8	BIC	Business Identifier Code
9	BIS	Bank for International Settlements
10	BTC	Bitcoin
11	BRICS	Brazil, Russia, India, China, South Africa
12	CBDCs	Central Bank Digital Currencies
13	CCP	Chinese Communist Party
14	CIPS	Cross-Border Interbank Payment System
15	DLT	Distributed Ledger Technology
16	DPI	Digital Public Infrastructure
17	Dunbar	Dunbar
18	EU	European Union
19	EUR	Euro
20	Fedwire	Federal Reserve Wire Network
21	FIN	Financial Information Network
22	FinCEN	Financial Crimes Enforcement Network
23	Forex	Foreign Exchange Reserves
24	G10	Group of Ten
25	GBP	British Pound

26	GDP	Gross Domestic Product
27	HKMA	Hong Kong Monetary Authority
28	ILR2	Inthanon-LionRock2
29	INR	Indian Rupee
30	ISO	International Organization for Standardization
31	Jura	Jura
32	KYC/AML	Know Your Customer/Anti-Money Laundering
33	MT	Message Type
34	mBridge	mBridge
35	PvP	Payments Vs Payments
36	SEPA	Single Euro Payments Area
37	SPFS	System for Transfer of Financial Messages
38	SDX	SIX Digital Exchange
39	SWIFT	Society for Worldwide Interbank Financial Telecommunication
40	Tor	The Onion Router
41	UPI	Unified Payment Interface
42	USD	United States Dollar
43	VDA	Virtual Digital Asset
44	wCBDC	Wholesale Central Bank Digital Currency
45	YEN	Japanese Yen

Reference:-

1 *Onion, Amanda. "Industrial Revolution: Definition, Inventions & Dates." HISTORY, March 27, 2023. https://www.history.com/topics/industrial-revolution/industrial-revolution.*

2 *Featherly, Kevin. "ARPANET: Definition, Map, Cold War, First Message, & History." Encyclopedia Britannica, May 11, 2016. https://www.britannica.com/topic/ARPANET*

3 *Statista. "Topic: Internet Usage Worldwide." February 13, 2024. https://www.statista.com/topics/1145/internet-usage-worldwide/#topicOverview.*

4 *Statista. "Data Growth Worldwide 2010-2025." November 16, 2023. https://www.statista.com/statistics/871513/worldwide-data-created/.*

5 *Statista. "Number of Internet Users Worldwide 2022." September 21, 2023. https://www.statista.com/statistics/273018/number-of-internet-users-worldwide/.*

6 *Press Information Bureau. "UPI Transactions Grew from 1 Lakh Crore in FY 2017-18 to 139 Lakh Crore in FY 2022-23 in Value, at a CAGR of 168%." Accessed [date of access]. https://pib.gov.in/PressReleasePage.aspx?PRID=1987764#:~:text=Posted%20On:%2018%20DEC%202023,transactions%20in%20FY%202022%2D23.*

7 *Kennedy, A. "Cross-Border Payments: A $150 Trillion Catalyst for Economic Growth." Visual Capitalist, December 14, 2023. https://visualcapitalist.com/sp/growth-cross-border-payments/#:~:text=Cross-Border%20Payments:%20A%20US,this%20critical%20industry's%20continued%20growth.*

8 *"Swift History." Swift. Accessed https://www.swift.com/about-us/history#:~:text=1973%2C%20Founding%20Swift,connected%20to%20Swift's%20messaging%20services.*

9 *"Swift FIN Traffic & Figures." Swift. Accessed https://www.swift.com/about-us/discover-swift/fin-traffic-figures.*

10 *"About ISO 20022." Swift. Accessed. https://www.swift.com/standards/iso-20022.*

11 *Banka, Neha. "Explained: The Story of How North Korea Hackers Stole $81 Million from Bangladesh Bank." The Indian Express, June 30, 2021. https://indianexpress.com/article/explained/bangladesh-bank-robbery-north-korea-lazarus-heist-7375441/.*

12 *Jupiter Team. "SWIFT Money Transfer: What Is It and How It Works?" Personal Finance, FinTech Updates from Jupiter, June 8, 2023. https://jupiter.money/international-money-transfer/swift-money-transfer-what-is-it-how-it-works/.*

13 *Reuters. "Reuters.com." Reuters, September 29, 2016. https://www.reuters.com/article/idUSKCN11Z2FM/.*

14 *Nilsson, T., Bouther, R., Van Acoleyen, M., and Cohen, L. "SWIFT GPI Data Indicate Drivers of Fast Cross-Border Payments." Bank for International Settlements (BIS), February 8, 2022. https://www.bis.org/cpmi/publ/swift_gpi.htm.*

15 *Bank for International Settlements (BIS). "SWIFT GPI Data Indicate Drivers of Fast Cross-Border Payments." Bank for International Settlements (BIS), Accessed April 17, 2024. https://www.bis.org/cpmi/publ/swift_gpi.pdf.*

16 *Girardone, C. 2022. "Russian Sanctions and the Banking Sector." British Journal of Management 33, no. 4: 1683–1688. https://doi.org/10.1111/1467-8551.12656.*

17 *Bloomberg. 2023. "Are You a Robot?" Bloomberg, May 25. https://www.bloomberg.com/news/articles/2023-05-25/eu-has-blocked-200-billion-in-russian-central-bank-assets.*

18 *Euronews. 2024. "German Minister Calls for British and French Nuclear Weapons to Protect Europe." Euronews, February 21. https://www.euronews.com/2024/02/15/german-minister-calls-for-british-and-french-nuclear-weapons-to-protect-europe.*

19 *Shrestha, N., Shad, M. Y., Ulvi, O., Khan, M. H., Karamehiæ-Muratoviæ, A., Nguyen, U., Baghbanzadeh, M., Wardrup, R., Aghamohammadi, N., Cervantes, D., Nahiduzzaman, K. M., Zaki, R. A., & Haque, U. 2020. "The Impact of COVID-19 on Globalization." One Health 11: 100180. https://doi.org/10.1016/j.onehlt.2020.100180.*

20 *Patel, D. 2024. "11 SWIFT Messaging Types (MTs), What They Do, and How They Are Used in Trade Finance (MT700, MT707, MT710, MT700...)." Trade Finance Global, January 10. https://www.tradefinanceglobal.com/posts/how-do-banks-talk-to-each-other-and-what-are-the-different-types-of-messages-used-by-swift#:~:text=Lack%20of%20real%2Dtime%20processing,processed%20by%20the%20 recipient%20ban*

21 *Watkins, S. 2024. "Russia and Iran Finalize 20-Year Deal That Will Change the Middle East Forever." OilPrice.com, January 22. https://oilprice.com/Energy/Energy-General/Russia-And-Iran-Finalize-20-Year-Deal-That-Will-Change-The-Middle-East-Forever.html#:~:text=Iran's%20Supreme%20Leader%20Ayatollah%20Khamenei,also%20in%20scope%20and%20scale*

22 *BVNK Blog. n.d. "Best 4 Swift Alternatives for Cross-Border Payments in 2023." BVNK Blog. Accessed https://www.bvnk.com/blog/swift-alternatives*

23 *Wright, C. 2008. "Bitcoin: A Peer-to-Peer Electronic Cash System." Social Science Research Network. https://doi.org/10.2139/ssrn.3440802*

24 *Naveen. 2024. "History of Blockchain Technology." Intellipaat, April 10. https://intellipaat.com/blog/tutorial/blockchain-tutorial/history-of-blockchain/#:~:text=As%20we've%20already%20mentioned,couldn't%20be%20tampered%20with.*

25 *Business Today Desk. 2022. "Two Pizzas for Rs 2,260 Crores! 12 Years of the Bitcoin Pizza Day." Business Today, June 17. https://www.businesstoday.in/crypto/story/two-pizzas-for-rs-2260-crores-12-years-of-the-bitcoin-pizza-day-334204-2022-05-19.*

26 *Writers, S. 2018. "The Ultimate Guide to the Invisible Web." OEDB.org, August 2. https://www.oedb.org/ilibrarian/invisible-web/#:~:text=It's%20a%20common%20misconception%2C%20however,0.03%25%20%E2%80%94%20of%20the%20internet.*

27 *Hamrick, J., Rouhi, F., Mukherjee, A., Feder, A., Gandal, N., Moore, T., and Vasek, M. 2021. "An Examination of the Cryptocurrency Pump-and-Dump Ecosystem." Informa-*

tion Processing & Management (Print) 58, no. 4: 102506. https://doi.org/10.1016/j.ipm.2021.102506.

28 *Hamrick, J., Rouhi, F., Mukherjee, A., Feder, A., Gandal, N., Moore, T., and Vasek, M. 2021. "An Examination of the Cryptocurrency Pump-and-Dump Ecosystem." Information Processing & Management (Print) 58, no. 4: 102506. https://doi.org/10.1016/j.ipm.2021.102506.*

29 *Hamrick, J., Rouhi, F., Mukherjee, A., Feder, A., Gandal, N., Moore, T., and Vasek, M. 2021. "An Examination of the Cryptocurrency Pump-and-Dump Ecosystem." Information Processing & Management (Print) 58, no. 4: 102506. https://doi.org/10.1016/j.ipm.2021.102506.*

30 *Chen, R. 2022. "The Top Banks Investing in Crypto and Blockchain Companies." CB Insights Research. https://www.cbinsights.com/research/top-banks-crypto-blockchain-investments/.*

31 *Corporate News from J.P. Morgan. n.d. J.P. Morgan. https://www.jpmorgan.com/about-us/corporate-news.*

32 *Smith, J. 2023. "Why Big Banks Like JPMorgan and Citi Want to Put Wall Street on a Blockchain." CNBC, July 26. https://www.cnbc.com/2023/07/26/why-big-banks-like-jpmorgan-want-put-wall-street-on-a-blockchain.html.*

33 *Blockchain, S. 2023. "Investment Banking in the Digital Age: The Blockchain Advantage." Medium. https://susqublockchain.medium.com/investment-banking-in-the-digital-age-the-blockchain-advantage-157b1fd517db.*

34 *Bank for International Settlements. 2023. "Project mBridge: Experimenting with a Multi-CBDC Platform for Cross-Border Payments." Bank for International Settlements. https://www.bis.org/about/bisih/topics/cbdc/mcbdc_bridge.html.*

35 *Loukoianova, E., Zhou, Y., Jahan, S., Che, N., Li, M., Rawat, U., Papageorgiou, E., and Goel, A. 2022. "Towards Central Bank Digital Currencies in Asia and the Pacific." Fintech Notes 2022(009): 1. https://doi.org/10.5089/9798400221521.063.*

36 *Bank for International Settlements. 2022. "Using CBDCs Across Borders: Lessons from Practical Experiments." June 21. https://www.bis.org/publ/othp51.html.*

37 *IndusInd Bank. 2022. "How Does a SWIFT Money Transfer Work?" December 20. https://www.indusind.com/iblogs/categories/manage-your-finance/how-does-a-swift-money-transfer-work/.*

38 Bank for International Settlements. 2022. "Project Dunbar: International Settlements Using Multi-CBDCs." March 22. https://www.bis.org/about/bisih/topics/cbdc/dunbar.html.

39 *Bank for International Settlements. 2023b. "Project mBridge: Experimenting with a Multi-CBDC Platform for Cross-Border Payments." October 31. https://www.bis.org/about/bisih/topics/cbdc/mcbdc_bridge.html.*

40 *Choi, S., Kim, B., Kim, Y., and Kwon, O. 2023. "Central Bank Digital Currency and Privacy: A Randomized Survey Experiment." November 17. https://www.bis.org/publ/work1147.html.*

41 *Denecker, O., D'Estienne, A., Gompertz, P., and Sasia, E. 2022. "Central Bank Digital Currencies: An Active Role for Commercial Banks." McKinsey & Company, October 13. https://www.mckinsey.com/industries/financial-services/our-insights/central-bank-digital-currencies-an-active-role-for-commercial-banks.*

42 *International Monetary Fund (IMF). 2023. "Exploring Multilateral Platforms for Cross-Border Payments." January 18. https://www.imf.org/en/Publications/analytical-notes/Issues/2023/01/18/Exploring-Multilateral-Platforms-for-Cross-Border-Payments-528297.*

43 *Vixio. n.d. "BIS Tells Central Banks to Plan Ahead for CBDC Interoperability." Accessed August 18, 2024. https://www.vixio.com/insights/pc-bis-tells-central-banks-plan-ahead-cbdc-interoperability.*

44 *International Monetary Fund (IMF). 2023. "IMF Approach to Central Bank Digital Currency Capacity Development." IMF Policy Paper 2023(016): 1. https://doi.org/10.5089/9798400240256.007.*

45 *Sanyal, Sanjeev. (n.d.). "Why India's Financial Messaging System Is an Export-Ready Solution for the World." Swarajyamag. Accessed [date of access]. https://swarajyamag.com/business/sanjeev-sanyal-explains-why-indias-financial-messaging-system-is-an-export-ready-solution-for-the-world.*

46 *World Economics. (n.d.). "India | Share of Global GDP | 2024 | Economic Data." World Economics. Accessed . https://www.worldeconomics.com/Share-of-Global-*

47 *Pti. 2023. "India Tops Remittance Flows at USD 125 bn in 2023: World Bank." The Economic Times, December 19. https://economictimes.indiatimes.com/nri/invest/india-tops-remittance-flows-at-usd-125-bn-in-2023-world-bank/articleshow/106132808.cms?from=mdr.*

48 *Aggarwal, R. 2023. "India's Inward Remittances in 2023 Rise 12.3% to $125 Billion: World Bank." Business Standard, December 19. https://www.business-standard.com/economy/news/india-s-inward-remittances-in-2023-rise-12-3-to-125-billion-world-bank-123121900176_1.html.*

49 *Jones, M. 2024. "SWIFT Planning Launch of New Central Bank Digital Currency Platform in 12-24 Months." Reuters, March 26. https://www.reuters.com/business/finance/swift-planning-launch-new-central-bank-digital-currency-platform-12-24-months-2024-03-25/.*

50 *Jones, M. 2024. "Countries Closing in on Digital Currencies but US Lagging, Study Shows." Reuters, March 14. https://www.reuters.com/markets/currencies/countries-closing-digital-currencies-us-lagging-study-shows-2024-03-14/.*

51 *India, F. 2024. "The Top 10 Largest Economies in the World in 2024." Forbes India, April 10. https://www.forbesindia.com/article/explainers/top-10-largest-economies-in-the-world/86159/1.*

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