PRELIMINARY FINANCIAL RISK MANAGEMENT STRATEGIES FOR COMMERCIAL BANKS IN THE ERA OF THE DIGITAL RUPIAH

STRATEGI MANAJEMEN RISIKO KEUANGAN AWAL UNTUK BANK KOMERSIAL DI ERA RUPIAH DIGITAL

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Abstract: This study examines preliminary financial risk management strategies for Indonesian commercial banks in response to the proposed Digital Rupiah. Using a qualitative-exploratory approach, it applies comparative analysis of CBDC implementations in China, India, Nigeria, the Bahamas, and Brazil, supported by crisp-set Qualitative Content Analysis (sQCA). The study integrates ISO 31000, Basel II, Enterprise Risk Management (ERM), Strategic Risk Management (SRM), and Dynamic Capabilities Theory (DCT). Findings show that the Digital Rupiah's hybrid, two-tier, retail-oriented design creates multidimensional risks, including liquidity and disintermediation risk, operational and cybersecurity risk, compliance risk, and strategic business model risk. These risks stem from shifts in deposit behavior, technological dependence, and financial intermediation. The study proposes integrated mitigation strategies, including strengthening liquidity management, enhancing digital capabilities, improving compliance systems, and transforming business models. It concludes that banks must adopt a holistic and forward-looking risk management approach to remain resilient in a digital financial ecosystem.

Keywords: Central Bank Digital Currency, Digital Rupiah, Financial Risk Management, Commercial Bank, Risk Management.

Abstrak: Studi ini meneliti strategi manajemen risiko keuangan awal untuk bank komersial Indonesia dalam menanggapi usulan Rupiah Digital. Menggunakan pendekatan kualitatif-eksploratif, studi ini menerapkan analisis komparatif implementasi CBDC di Tiongkok, India, Nigeria, Bahama, dan Brasil, yang didukung oleh Analisis Konten Kualitatif set-krip (sQCA). Studi ini mengintegrasikan ISO 31000, Basel II, Manajemen Risiko Perusahaan (ERM), Manajemen Risiko Strategis (SRM), dan Teori Kapabilitas Dinamis (DCT). Temuan menunjukkan bahwa desain hibrida dua tingkat Rupiah Digital yang berorientasi ritel menciptakan risiko multidimensional, termasuk risiko likuiditas dan disintermediasi, risiko operasional dan keamanan siber, risiko kepatuhan, dan risiko model bisnis strategis. Risiko-risiko ini berasal dari pergeseran perilaku simpanan, ketergantungan teknologi, dan intermediasi keuangan. Studi ini mengusulkan strategi mitigasi terintegrasi, termasuk penguatan manajemen likuiditas, peningkatan kemampuan digital, peningkatan sistem kepatuhan, dan transformasi model bisnis. Kesimpulannya, bank harus mengadopsi pendekatan manajemen risiko yang holistik dan berwawasan ke depan untuk tetap tangguh dalam ekosistem keuangan digital.

***Kata Kunci**: Mata Uang Digital Bank Sentral, Rupiah Digital, Manajemen Risiko Keuangan, Bank Komersial, Manajemen Risiko.*

INTRODUCTION

Research Background

The global financial system is entering a transformative era marked by the rapid advancement of Central Bank Digital Currencies (CBDCs). These sovereign digital instruments, issued and regulated by national central

banks, represent a systemic response to the accelerating digitization of financial transactions, the growing influence of private digital assets, and the evolving structure of modern monetary systems (BIS, 2021; Raju, 2021). As of 2025, more than 100 jurisdictions are exploring CBDC initiatives, with countries such as China, Sweden, and the Bahamas already piloting or launching their respective models (Atlantic Council, 2025).

Indonesia has joined the global CBDC momentum through Bank Indonesia's Digital Rupiah initiative, which forms part of the Blueprint Sistem Pembayaran Indonesia 2030 (BSPI 2030). The initiative aims to issue a sovereign digital currency designed to function as a legal tender and settlement instrument for both wholesale and retail transactions (Bank Indonesia, 2022). The Digital Rupiah is projected to operate in phases, beginning with the wholesale layer to facilitate interbank settlements and expanding toward the retail domain to integrate with the broader payment ecosystem.

Despite policy-level enthusiasm, the readiness of Indonesia's banking sector to manage CBDC-related risks remains uncertain. Existing policy documents, such as Project Garuda, provide macro-level design blueprints but do not yet articulate a concrete operational framework detailing how the Digital Rupiah will function within Indonesia's banking system. Ambiguities persist regarding legal infrastructure, interoperability with private digital payment systems, public trust dynamics, and institutional agility.

This gap between policy ambition and institutional preparedness constitutes both a practical and scientific problem. Unlike countries such as China or the Bahamas, where pilot data enable empirical evaluation, Indonesia's Digital Rupiah remains in its conceptual design phase. Direct empirical risk identification is therefore constrained by the absence of an operational system. Existing studies tend to examine CBDC impacts retrospectively, focusing on post-implementation outcomes or extrapolating lessons from economies with distinct financial structures.

This limitation highlights the absence of a comprehensive, anticipatory framework linking global CBDC lessons with Indonesia's financial ecosystem. Bridging this gap demands not only risk identification but also conceptual modeling that reflects Indonesia's contextual characteristics, regulatory direction, and digital maturity.
To address these challenges, this study introduces a two-phase analytical design aimed at constructing a grounded yet anticipatory framework for Indonesian commercial banks. Phase 1 develops a functional projection model through comparative exploration of global CBDC experiences. This phase uses qualitative content analysis of international policy documents, academic studies, and central bank reports to model how CBDC features and outcomes might translate into Indonesia's financial environment. Phase 2 builds upon the projection by identifying and interpreting preliminary financial risks and management strategies relevant to Indonesian commercial banks. This involves applying risk management frameworks, particularly ISO 31000 (2018), ERM, SRM, and Dynamic Capabilities Theory to contextualize risk anticipation and response.

In this study, the functional projection model refers to a structured, theory- informed framework that anticipates how the Digital Rupiah could function within Indonesia's multi-layered financial ecosystem. It maps potential operational pathways, systemic interactions, and risk zones based on comparative CBDC insights while maintaining consistency with Indonesia's regulatory and institutional context. Unlike predictive models that depend on quantitative data, functional projection emphasizes scenario-based reasoning, offering a forward-looking analytical structure in data-scarce conditions.

This study is theoretically anchored in the integration of ISO 31000 (2018) for risk governance, Basel II for financial soundness principles, Enterprise Risk Management (ERM) for systemic risk mapping, Strategic Risk Management (SRM) for strategic adaptability, and Dynamic Capabilities Theory (DCT) for institutional agility in rapidly changing environments. This combination provides a multi-level analytical perspective, linking global systemic risk recognition with firm-level strategic response mechanisms. Within this integrated theoretical framework, CBDC-related risks are analyzed to provide a more comprehensive understanding of how Indonesian commercial banks can design dynamic, adaptive, and forward-looking risk management strategies in response to the structural transformation brought about by digital currency developments.

Research Objectives

This study is designed to:

1. Develop a functional projection model for Digital Rupiah by adapting lessons from global CBDC practices.
2. Identify and analyze the types of financial risks that are likely to affect Indonesian commercial banks in the context of the Digital Rupiah, drawing on insights from global CBDC experiences.
3. Examine how commercial banks in other countries have responded to risks associated with the development and implementation of CBDCs.
4. Propose preliminary financial risk management strategies for Indonesian commercial banks to anticipate the introduction of the Digital Rupiah.

LITERATURE REVIEW

Financial Risk Management

Financial risk management refers to the systematic process by which banks identify, measure, and mitigate risks that may affect their stability and performance. Rooted in Basel II, it focuses on credit, market, and operational risks arising from financial intermediation. In the digital era, these risks evolved due to technological dependence and changing liquidity dynamics. Effective risk management ensures capital adequacy, profitability, and resilience, making it essential for banks to adapt to disruptions such as Digital Rupiah (Saunders & Cornett, 2014).

Central Bank Digital Currency (CBDC)

CBDC is a digital form of central bank-issued money that functions as legal tender and complements physical cash. It can be retail or wholesale and is designed to improve payment efficiency, financial inclusion, and monetary control. However, CBDCs may disrupt traditional banking by causing deposit disintermediation, liquidity shifts, and operational challenges. Their impact depends on design features such as access, distribution models, and technological architecture, which shape interactions with existing financial systems (Mancini-Griffoli et al., 2019).

ISO 31000

ISO 31000 provides a globally recognized framework for risk management, defining risk as the effect of uncertainty on objectives. It emphasizes a structured process of risk identification, analysis, evaluation, and treatment, supported by principles such as integration, customization, and continuous improvement. The framework promotes a dynamic and forward-looking approach, ensuring organizations can anticipate and respond to emerging risks (ISO, 2018). In this study, it guides systematic risk assessment and mitigation strategies for banks facing CBDC-related uncertainties.

Basel II

Basel II is an international regulatory framework that strengthens banking supervision and risk management through its three-pillar structure: minimum capital requirements, supervisory review, and market discipline. It classifies key risks into credit, market, and operational categories, providing a foundation for assessing financial stability. Basel II enhances risk sensitivity and transparency, encouraging banks to align capital with risk exposure (BCBS, 2004). In the context of CBDC, it helps evaluate how digital currency adoption may affect banks' risk profiles and capital adequacy.

Enterprise Risk Management (ERM)

Enterprise Risk Management (ERM) is a holistic approach that integrates risk management across all organizational levels, linking it to strategy and performance. Based on the COSO framework, ERM addresses interconnected risks rather than isolated ones, making it suitable for complex environments like digital banking. It enables banks to assess liquidity, operational, compliance, and reputational risks collectively (COSO, 2017). In this study, ERM supports scenario-based analysis and coordinated responses to risks emerging from the Digital Rupiah ecosystem.

Strategic Risk Management (SRM)

Strategic Risk Management (SRM) focuses on identifying and managing risks that impact an organization's long-term objectives and competitive position. It emphasizes forward-looking tools such as risk appetite and scenario planning to navigate uncertainty. SRM treats risk as a strategic variable, guiding decision-making under conditions of technological and regulatory change. In the CBDC context, it helps banks anticipate disruptions like disintermediation and adapt their business models while maintaining alignment with long-term goals (Kaplan & Mikes, 2011).

Dynamic Capabilities Theory (DCT)

Dynamic Capabilities Theory explains how organizations adapt to rapidly changing environments by sensing opportunities, seizing them, and transforming operations. It highlights the importance of agility, innovation, and continuous reconfiguration of resources. In the context of CBDCs, DCT helps explain how banks can respond to technological and regulatory disruptions by developing new capabilities. This theory supports the study's focus on proactive adaptation, enabling banks to remain competitive and resilient in the evolving digital financial ecosystem (Teece, 2014).

Empirical Studies

Linnan (2023) conducts a qualitative legal and policy analysis of Indonesia's CBDC initiative in the research titled "Central Bank Digital Currencies in the Indonesian Setting: Questions and Choices", focusing on institutional readiness and regulatory challenges. The study finds that while the Digital Rupiah offers opportunities for payment system innovation, significant issues remain unresolved, including regulatory fragmentation, legal authority, and coordination between Bank Indonesia and other institutions. It highlights risks such as financial disintermediation, liquidity pressure, and strategic uncertainty for commercial banks. The research emphasizes that unclear governance and institutional overlap may hinder effective implementation, making it crucial for banks to adopt proactive and adaptive risk management strategies in anticipation of structural changes.

Zhang (2025) explored the regulatory framework, technological challenges, and financial sector implications of e-CNY, focusing on its effects on traditional banking business models, deposit structures, and loan issuance mechanisms. The study also examines consumer behavior, market adoption patterns, and the competitive landscape, highlighting the role of fintech firms and digital payment platforms. The discussion extends to financial inclusion, particularly in rural and underbanked regions, assessing the potential of e-CNY in bridging economic disparities. The research further investigates response strategies for commercial banks, including hybrid financial models, fintech collaborations, and AI-driven banking solutions. It also provides policy recommendations to ensure stability in the banking sector amidst digital transformation, including monetary policy adjustments, cross-border e-CNY integration, and cybersecurity measures. Findings suggest that while e-CNY presents short-term disruptions to commercial banks, it also offers long-term opportunities for financial innovation and international trade expansion.

Gunawan, Yatimi, & Sartika (2024) aimed to analyze the potential impact of implementing Central Bank Digital Currency (CBDC) on banking stability in Indonesia and identify factors that influence economic actors in using CBDC. This research used descriptive qualitative methods with literature studies. The data sources for research are bibliographic or come from various types of literature, including books, journals, articles, newspapers, modules, personal documents, etc. The research results show that implementing CBDC can reduce the number of deposits in banks, increase competition, and change banking business models. However, CBDCs can also improve financial inclusion and payment system efficiency. Factors that influence the use of CBDC include the level of trust, security, cost, and public literacy and education.

Research Model

The conceptual framework of this study integrates multiple theoretical perspectives to analyze and address financial risks arising from the Digital Rupiah. It combines Financial Risk Management and Basel II to classify core banking risks, while ISO 31000 provides a structured process for risk identification, analysis, and mitigation. Enterprise Risk Management (ERM) ensures a holistic, organization-wide view of interconnected risks, and Strategic Risk Management (SRM) introduces forward-looking tools such as scenario planning and risk appetite. Dynamic Capabilities Theory (DCT) complements these by emphasizing institutional adaptability through sensing, seizing, and transforming. Together, these frameworks support a comprehensive, anticipatory approach to managing CBDC-related risks in commercial banks

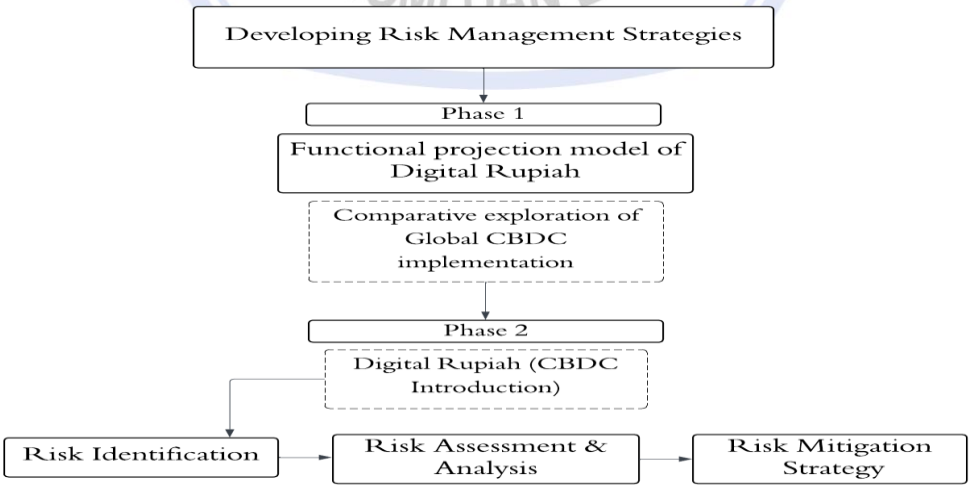

Figure 1. Research Model
Source: Researcher's study

RESEARCH METHOD

Research Design

This study adopts a qualitative-exploratory approach with a two-phase research design. According to Creswell (2014), an exploratory qualitative approach is most appropriate when a phenomenon is relatively new, or little is known about its specific variables and outcomesThe first phase develops a functional projection model of the Digital Rupiah through comparative analysis of global CBDC implementations. The second phase focuses on identifying potential financial risks and formulating preliminary risk management strategies for Indonesian commercial banks using integrated theoretical frameworks.

Data Source

The study utilizes secondary data obtained through document analysis. Sources include policy documents, central bank reports, academic journals, and prior studies related to CBDC implementations in countries such as China, India, Nigeria, the Bahamas, and Brazil. Data collection is conducted through systematic literature review and content extraction to ensure relevant and credible information (Creswell, 2014).

Data Analysis Method

Data is analyzed using qualitative content analysis and crisp-set Qualitative Comparative Analysis (csQCA). This method enables systematic comparison of CBDC characteristics and identification of causal patterns linking design features to financial risks and strategic responses (Schreier, 2012).

RESULTS AND DISUCSSION

Results

Functional Projection Model

Table 1. Functional Projection of Digital Rupiah

Feature	Indonesia (Digital Rupiah)	China (e-CNY)	India (e₹)	Nigeria (eNaira)	Bahamas (Sand Dollar)	Brazil (Drex)
Architecture Model	Hybrid (Centralized + intermediated layers)	Hybrid (Two-tier system)	Hybrid (Two-tier system)	Centralized	Centralized (with intermediaries)	Hybrid (DLT-based, tokenized)
Distribution Model	Two-tier (BI → Banks/Payment System Providers (PSPs) → Users)	Two-tier (PBoC → Commercial Banks)	Two-tier (RBI → Banks)	Direct + intermediated	Intermediated (Central Bank + Financial Institutions)	Two-tier (Central Bank → Financial Institutions)
Access Type	Retail (planned) + potential wholesale	Retail-focused	Retail + Wholesale (pilot phases)	Retail	Retail (financial inclusion focus)	Wholesale-focused (tokenized assets ecosystem)
Technology Infrastructure	Hyperledger Besu (DLT)	Centralized ledger (not fully DLT)	Centralized (with limited DLT exploration)	Centralized ledger	Centralized with secure digital wallets	Distributed Ledger Technology (DLT)
User Access Mechanism	Digital wallets via banks/PSPs	Digital wallets (app-based, offline capable)	Bank-issued wallets/apps	Mobile wallets	Mobile wallets (tiered KYC levels)	Tokenized accounts via financial institutions

Offline Capability	*Under consideration*	Yes (dual offline payment)	Limited/under testing	Limited	Yes (designed for accessibility)	*Not primary focus*
Policy Objective	Payment efficiency, financial stability, monetary sovereignty	Payment efficiency, cash replacement, state control	Payment efficiency, reduce cash dependency	Financial inclusion, reduce cash usage	Financial inclusion, resilience	Financial innovation, tokenization, capital market efficiency

Source: Processed data from sQCA (2025)

The architecture model of a CBDC refers to the underlying structural design that determines how the system is controlled, recorded, and maintained. Centralized architecture places full control of issuance, validation, and transaction recording within the central bank, ensuring high levels of oversight, security, and policy enforcement. However, it may limit scalability and innovation. In contrast, hybrid architecture combines centralized control with delegated operational roles to intermediaries such as commercial banks or payment service providers. This model enhances efficiency and scalability while preserving monetary authority. Meanwhile, DLT-based (Distributed Ledger Technology) architectures introduce decentralized elements where transaction records are shared across multiple nodes, improving transparency and resilience, although often still governed by the central bank in a permissioned environment. The choice of architecture significantly affects system performance, cybersecurity resilience, and institutional coordination.

The distribution model defines how CBDC is issued and circulated within the economy. In a single-tier model, the central bank directly distributes CBDC to end users, assuming full responsibility for account management, compliance, and customer interaction. While this enhances control, it places significant operational burden on the central bank. Conversely, the two-tier model, the most widely adopted approach delegates distribution to financial intermediaries. The central bank issues CBDC to commercial banks or authorized institutions, which then distribute it to users. This model leverages existing financial infrastructure, reduces operational complexity, and minimizes disintermediation risks by maintaining the role of commercial banks within the financial system.

CBDCs can be categorized based on their intended users. Retail CBDC is designed for the public, enabling households and businesses to conduct everyday transactions digitally using central bank money. It emphasizes payment efficiency, financial inclusion, and cash substitution. Meanwhile, wholesale CBDC is restricted to financial institutions and is primarily used for interbank settlements, securities transactions, and large-value payments. Wholesale CBDCs aim to improve efficiency, speed, and security of financial market infrastructures. Some countries explore a dual or hybrid access model, integrating both retail and wholesale functionalities to support a broader financial ecosystem.

The technology infrastructure of a CBDC determines how transactions are processed, recorded, and secured. Systems may rely on centralized databases, which provide high transaction throughput and simplified governance, or on distributed ledger technology (DLT), which enables shared record-keeping across multiple participants. In practice, many CBDCs adopt a permissioned DLT or a hybrid infrastructure to balance efficiency with resilience. Main considerations include scalability, cybersecurity, interoperability with existing payment systems, and the ability to support advanced functionalities such as programmability.

User access mechanisms refer to how individuals and institutions interact with CBDC. Typically, access is facilitated through digital wallets provided by banks or authorized payment service providers. These wallets may be account- based or token-based, depending on system design. The mechanism ensures secure storage, authentication, and transaction execution. Integration with existing banking applications enhances usability and adoption, while tiered access structures may be implemented to accommodate different user segments.

Offline capability refers to the ability to conduct CBDC transactions without real-time internet connectivity. This feature is particularly important in regions with limited digital infrastructure or during network disruptions. Offline functionality enhances system resilience and supports financial inclusion by enabling broader access. However, it introduces technical challenges related to double-spending prevention, synchronization, and security, requiring sophisticated cryptographic solutions and transaction limits.

The policy objective defines the fundamental purpose of CBDC issuance and shapes its overall design. Common objectives include enhancing payment efficiency, promoting financial inclusion, reducing reliance on cash, strengthening monetary sovereignty, and supporting financial innovation. In some cases, CBDCs are also used to improve transparency and control within the financial system. The alignment between policy objectives and system

design is critical, as it determines the effectiveness of CBDC implementation and its impact on the broader financial ecosystem.

The introduction of the Digital Rupiah presents multiple, interrelated layers of financial risk for Indonesian commercial banks. These risks emerge not in isolation but within a complex network of interactions as inherent consequences of specific design choices, reflecting the trade-offs embedded in CBDC implementation. As Digital Rupiah integrates into existing financial channels, it challenges traditional models of intermediation, liquidity management, and operational governance.

The functional projection of the Digital Rupiah reveals that its anticipated design is characterized by a hybrid architecture, two-tier distribution model, retail- oriented access, and potential integration with advanced technologies carries a range of systemic and bank-level risk implications. This study identifies a structured pattern of risks that are highly relevant to Indonesia's financial system by extracting evidence from comparative countries, China, India, Nigeria, Bahamas, and Brazil.

Risk Identification

Table 2. Identified Financial Risks of the Digital Rupiah and International Banking Responses

Feature	Risk Type	Implications		International Banking Responses	
		Level	Implications	Country	Response
Hybrid	Operational Risk	System	Increased complexity in coordination between central bank and intermediaries.	China, India	Banks enhance API integration and operational resilience frameworks
		Bank	Higher dependency on central infrastructure; integration and compliance risks.	China	Strengthening coordination protocols between central bank and intermediaries
Centralized	Cybersecurity Risk	System	Vulnerability to centralized cyberattacks and system outages.	Nigeria, Bahamas	Implementation of multi-layer cybersecurity systems and redundancy protocols
		Bank	Service disruption risks affecting customer trust and transaction continuity.		Central banks enforce strict IT governance and monitoring systems.
Two-tier Distribution	Liquidity Risk	System	Potential shifts of deposits from banks to CBDC wallets.	China, Bahamas	Introduction of holding limits and non-interest-bearing CBDC
		Bank	Reduced deposit base, affecting lending capacity and liquidity positions.	India	Banks adjust liquidity buffers and develop competitive digital products
Retail	Liquidity Risk	System	Rapid conversion from bank deposits to CBDC during stress periods (digital bank run risk)	China, Bahamas, Nigeria	Use of transaction caps, tiered wallet limits, and KYC-based restrictions
		Bank	Increased volatility in deposits and funding structure.	India	Banks strengthen liquidity risk management under Basel frameworks
Wholesale	Operational/ Settlement Risk	System	Changes in interbank settlement mechanisms and infrastructure dependency	Brazil – Drex, India wholesale pilot	Adoption of DLT-based settlement pilots and interoperability frameworks
		Bank	Need for system upgrades and integration with new settlement platforms.		Banks invest in infrastructure modernization
DLT-Based	Operational Risk	System	Increased technological complexity and	Brazil	Development of technical capabilities and blockchain expertise

			potential smart contract vulnerabilities		
		Bank	Skills gap, integration challenges, and higher IT risk exposure.	India, Brazil	Regulatory sandboxes and pilot testing environments
Digital Wallet-Based		System	Increased exposure to fraud, AML/CFT challenges.	Nigeria,	Implementation of tiered KYC frameworks and transaction monitoring systems
	Operational Risk	Bank	Higher compliance burden and customer data protection responsibilities.	Bahamas, China	Banks enhance digital onboarding and fraud detection systems.
		System	Risk of double-spending and delayed transaction verification.	China, Bahamas	Use of transaction limits and secure hardware solutions for offline payments
Offline Capability	Cyber/Fraud Risk	Bank	Reconciliation risks and temporary loss of transaction visibility.		Controlled offline thresholds to minimize exposure.
		System	Expansion to unbanked populations with limited credit history.	Bahamas, Nigeria	Adoption of simplified KYC and tiered account structures
Policy Objective: Financial Inclusion	Credit Risk	Bank	Increased exposure to higher-risk customer segments.		Banks develop alternative credit scoring mechanisms.
		System	Integration with digital assets and tokenized financial markets increases volatility and complexity.		Development of tokenization platforms and regulatory frameworks
Policy Objective: Financial Innovation (Tokenization)	Market Risk	Bank	Exposure to new asset classes and technological uncertainties.	Brazil	Banks engage in pilot programs and innovation sandboxes.

Source: Processed data from sQCA (2025)

At the system level, the adoption of hybrid architecture introduces coordination complexity between the central bank and financial intermediaries. While this model enhances scalability and preserves the role of commercial banks, it also creates operational interdependencies that may amplify systemic vulnerability in the event of infrastructure disruption. This is particularly evident in systems where intermediaries rely heavily on centralized core platforms, necessitating robust governance and synchronization mechanisms. Similarly, a centralized or semi-centralized infrastructure presents cybersecurity risks, as it may become a critical point of failure. Empirical practices from Nigeria and the Bahamas demonstrate that centralized CBDC systems require advanced cybersecurity frameworks and redundancy mechanisms to mitigate such risks.

The two-tier distribution model, widely adopted across observed countries, presents significant implications for liquidity dynamics within the banking sector. While it maintains the intermediary role of banks, it does not eliminate the risk of deposit disintermediation, particularly under a retail CBDC framework. The introduction of retail CBDC access enables the public to hold central bank money directly, which may lead to a reallocation of deposits away from commercial banks, especially during periods of financial stress. This creates potential for digital bank runs, where the speed and scale of fund transfers exceed those observed in traditional banking environments. Evidence from China and the Bahamas indicates that such risks are typically mitigated through the implementation of holding limits, non-interest-bearing CBDC structures, and tiered wallet systems.

From a bank-level perspective, these structural changes directly affect liquidity management and funding stability. Banks may experience increased volatility in their deposit base, requiring adjustments in liquidity buffers and funding strategies in line with Basel II principles. In response, countries such as India have emphasized strengthening liquidity risk frameworks and encouraging banks to innovate digital financial products to remain competitive within an evolving monetary ecosystem.

Technological features further introduce operational and strategic risks. The integration of DLT-based or advanced digital infrastructure, as observed in Brazil's Drex initiative, enhances efficiency and programmability but also increases system complexity. This exposes banks to operational risks, including system integration challenges, technological skill gaps, and potential vulnerabilities in smart contract execution. To address these issues, countries have adopted regulatory sandbox approaches and phased pilot programs, allowing financial institutions to gradually build technical capabilities while managing risk exposure.

In addition, the use of digital wallets as the primary access mechanism raises concerns related to compliance, data privacy, and financial integrity. The expansion of digital access points increases exposure to fraud, money laundering, and cyber threats, particularly in jurisdictions pursuing financial inclusion objectives. Nigeria and the Bahamas, for instance, have implemented tiered Know-Your-Customer (KYC) frameworks to balance accessibility with regulatory compliance. This approach allows broader participation while maintaining control over transaction limits and risk exposure.

The incorporation of offline payment functionality, although beneficial for financial inclusion and system resilience, introduces unique operational risks such as double-spending and delayed transaction validation. These risks necessitate strict transaction limits and secure hardware-based solutions, as demonstrated in China's dual offline payment system. For banks, this creates additional reconciliation challenges and temporary visibility gaps in transaction flows.

The main policy objectives of CBDC implementation significantly shape its risk profile. A focus on financial inclusion, as seen in Nigeria and the Bahamas, may increase exposure to higher-risk customer segments with limited financial history, thereby influencing credit risk dynamics indirectly. Conversely, innovation- driven models such as Brazil's Drex introduce market and operational risks associated with tokenized assets and evolving financial market structures. These developments require banks to adapt strategically by enhancing risk assessment models and participating in innovative ecosystems.

Risk Mapping and Evaluation

Table 3. Risk Mapping and Evaluation Digital Rupiah-Related Financial Risks

No	Risk Type	Likelihood (1–5)	Impact (1–5)	Risk Value	Risk Level	Description
1	Credit Risk	3	4	12	High	Potential deposit disintermediation could reduce loanable funds, indirectly heightening non-performing loan exposure if credit portfolios are not adjusted.
2	Liquidity Risk	4	5	20	Critical	Digital Rupiah holdings may accelerate liquidity outflows and trigger deposit flight, especially during market stress, resembling "digital bank runs."
3	Market Risk	3	3	9	Moderate	Volatility in rates and exchange channels could affect ALM portfolios and capital buffers, though effects remain manageable under prudent hedging.
4	Operational Risk	4	4	16	Critical	The transition to CBDC infrastructure increases exposure to system failures, integration errors, and reputational damage during early implementation.
5	Cybersecurity Risk	5	5	25	Critical	Integration of Digital Rupiah wallets expands the digital attack surface, exposing banks to cyberattacks, fraud, and potential systemic breaches.
6	Strategic & Business Model Risk	4	4	16	Critical	Digital Rupiah adoption may disrupt fee-based revenues and core intermediation functions, forcing banks to redesign their competitive strategies.

Source: Processed data from sQCA (2025)

The mapping results reveal that among the sixth identified risks, cybersecurity, liquidity, operational, and strategic/business model risks emerge as critical, requiring top-priority mitigation. These categories score high both in likelihood and impact due to the systemic and technological nature of the Digital Rupiah. Liquidity risk, for instance, poses a structural threat given Indonesia's deposit-dependent banking system. The potential for rapid digital withdrawals accentuates the need for strong liquidity coverage, central bank coordination, and real-time monitoring tools.

Cybersecurity risk ranks highest overall, reflecting the expanded digital interfaces, integration with wallets, and real-time data exchange that accompany CBDC systems. Past experiences in China, Nigeria, and India validate the vulnerability of new infrastructures to cyber threats during initial deployment stages. This justifies early adoption of multi-layered security architecture, continuous testing, and threat-intelligence integration.

Operational and strategic/business model risks are also critical due to the scale of transformation required. Banks must not only integrate new systems but also adapt business models to sustain revenue and competitiveness. Meanwhile, credit risk falls into the high category, implying that they remain significant but can be mitigated through governance, regulatory coordination, and inclusive design. Market risk registers as moderate, reflecting its indirect nature, it can be managed effectively through asset-liability management (ALM) frameworks and hedging instruments.

Table 4. Risk Mitigation

Risk Type	Risk Source	Risk Implications (Bank-Level)	Mitigation Strategy	Theoretical Basis
Liquidity Risk / Disintermediation Risk	Retail CBDC, Two- tier Distribution	Deposit outflows from banks to CBDC wallets; increased volatility in funding structure	Strengthening liquidity buffers (LCR/NSFR); real-time liquidity monitoring; development of CBDC- linked deposit products; scenario-based stress testing	Basel II, ERM
Operational Risk	Hybrid Architecture, DLT Infrastructure	System integration challenges; dependency on central bank infrastructure; operational disruptions	IT system integration and redundancy frameworks; API standardization; operational risk management enhancement; infrastructure stress testing	ISO 31000, ERM
Cybersecurity Risk	Centralized / Digital Infrastructure, Wallet Systems	Increased exposure to cyberattacks, data breaches, and system vulnerabilities	Multi-layer cybersecurity architecture; real-time threat monitoring; encryption protocols; cyber incident response frameworks	ISO 31000, ERM
Fraud Risk	Digital Wallet Access, Offline Capability	Increased risk of fraud, double- spending, and unauthorized transactions	AI-based fraud detection systems; transaction limits for offline payments; multi-factor authentication; continuous transaction monitoring	ISO 31000
Compliance Risk (AML/CFT)	Financial Inclusion Design, Wallet-Based Access	Increased exposure to unverified users; AML/CFT compliance challenges	Tiered KYC implementation; enhanced AML/CFT monitoring systems; adoption of RegTech solutions; customer risk profiling	Basel II, ISO 31000

Source: Processed data from sQCA (2025)

At the same time, the increasing reliance on digital infrastructure introduces significant operational and cybersecurity risks. The hybrid architecture and integration of advanced technologies, including potential DLT components, require banks to enhance their technological resilience. This includes the implementation of robust IT integration frameworks, system redundancy mechanisms, and standardized API governance. Furthermore, cybersecurity must be elevated as a strategic priority through the adoption of multi-layered security architectures,

real- time threat detection systems, and comprehensive incident response protocols. These measures are essential to safeguard system integrity and maintain public trust in digital financial services.

The expansion of CBDC access through digital wallets also intensifies fraud and compliance risks, particularly in the context of financial inclusion. Increased accessibility may expose banks to higher levels of fraudulent activities, unauthorized transactions, and challenges in enforcing Anti-Money Laundering and Counter-Terrorism Financing (AML/CFT) regulations. To address these risks, banks should implement advanced fraud detection systems, including AI-based transaction monitoring, alongside multi-factor authentication protocols. The adoption of tiered Know-Your-Customer (KYC) frameworks is also critical, allowing banks to balance accessibility with regulatory compliance by applying proportionate controls based on user risk profiles.

Moreover, the introduction of wholesale CBDC and new settlement infrastructures presents operational and settlement risks that require strategic adaptation. Banks must invest in interoperable systems capable of integrating with emerging CBDC platforms, including DLT-based settlement mechanisms where applicable. Participation in pilot programs and regulatory sandbox initiatives is essential to facilitate gradual adaptation, reduce uncertainty of implementation, and build institutional capacity in managing new financial infrastructures.

Beyond operational considerations, the Digital Rupiah also introduces strategic and business model risks. The potential reduction in the intermediary role of banks, particularly under a retail CBDC framework, may disrupt traditional revenue streams and competitive positioning. In response, banks must pursue business model innovation by expanding into digital financial services, leveraging data-driven solutions, and strengthening collaboration with fintech firms and the central bank. This strategic transformation reflects the principles of Strategic Risk Management and Dynamic Capabilities Theory, emphasizing the need for continuous adaptation, learning, and reconfiguration of resources in response to environmental changes.

The adoption of advanced technologies, particularly in systems involving tokenization and DLT, exposes banks to technology and capability risks. These include skill gaps, high implementation costs, and uncertainties related to system scalability and interoperability. To mitigate these challenges, banks should invest in capacity building, develop specialized technical expertise, and adopt a phased implementation approach. Engagement in regulatory sandboxes and innovation ecosystems further supports controlled experimentation and knowledge acquisition.

Reputational risk emerges as a cross-cutting concern, as failures in system reliability, security breaches, or service disruptions may significantly undermine public trust. Banks must therefore ensure high levels of service availability, implement transparent communication strategies, and establish strong customer protection mechanisms to maintain confidence in digital financial systems.

The mitigation strategies outlined in this study highlight that effective risk management in the Digital Rupiah era requires an integrated and forward-looking approach. Risks are inherently interconnected, spanning liquidity, operational, technological, compliance, and strategic dimensions. As such, banks must move beyond fragmented risk responses toward a holistic framework that combines financial resilience with adaptive strategic capabilities. This reinforces the role of banks not merely as financial intermediaries, but as dynamic participants in a digitally transformed monetary system.

Discussion

The projected design of the Digital Rupiah, characterized by a hybrid architecture, two-tier distribution model, and retail-oriented access, generates a complex and multidimensional risk landscape for Indonesian commercial banks. Drawing from comparative CBDC experiences, the study emphasizes that specific design features such as accessibility, distribution structure, and technological infrastructure directly shape the nature and intensity of risks through their interaction with existing banking systems.

Through risk mapping, the study categorizes risks based on their likelihood and potential impact, enabling prioritization. High-priority risks include liquidity and disintermediation risk, which arise from potential deposit migration to central bank digital wallets. This risk is mapped as both high-impact and high-likelihood due to its direct effect on banks' funding stability and lending capacity. Operational and cybersecurity risks are also identified as critical, driven by increased reliance on digital infrastructure, system interoperability, and real-time transaction processing. These risks are mapped in as high impact, particularly due to the systemic consequences of technological failure or cyberattacks. Meanwhile, compliance risks are categorized as moderate-to-high, reflecting uncertainties in regulatory frameworks, data governance requirements, and supervisory expectations. Lastly, strategic business model risks are mapped as long-term but high impact, as CBDC adoption may fundamentally alter banks' roles in financial intermediation and customer relationships.

These risks are not isolated but interconnected, consistent with the Enterprise Risk Management (ERM) perspective. For example, liquidity pressures may intensify strategic risks, while technological vulnerabilities may lead to compliance and reputational consequences. This interdependence reinforces the need for integrated risk assessment rather than fragmented approaches. In response, the study proposes risk mitigation strategies aligned with theoretical frameworks such as ISO 31000, ERM, SRM, and Dynamic Capabilities Theory. To address liquidity and disintermediation risk, banks are encouraged to strengthen liquidity buffers, diversify funding sources, and develop adaptive deposit management strategies. For operational and cybersecurity risks, investment in advanced digital infrastructure, robust cybersecurity systems, and continuous monitoring mechanisms is essential. Compliance risks can be mitigated through enhanced regulatory alignment, implementation of advanced reporting systems, and proactive engagement with regulators.

From a strategic standpoint, banks must pursue business model transformation, including the development of CBDC-integrated financial products, digital service innovation, and partnerships with fintech firms. Strategic Risk Management (SRM) tools such as scenario planning and risk appetite frameworks are crucial in guiding these transformations. Additionally, Dynamic Capabilities Theory emphasizes the importance of organizational agility, requiring banks to continuously sense, seize, and transform in response to evolving digital and regulatory environments.

CONCLUSION AND RECOMMENDATION

Conclusion

This study concludes that the introduction of the Digital Rupiah will significantly reshape the risk landscape for Indonesian commercial banks. Key risks include liquidity and disintermediation, operational and cybersecurity vulnerabilities, compliance challenges, and strategic business disruption. These risks are driven by the interaction between CBDC design features and existing banking structures. The study emphasizes that traditional risk management approaches are insufficient, requiring a holistic, integrated, and forward-looking framework. Ultimately, banks must enhance adaptability, innovation, and resilience to effectively navigate the transition toward a digital financial ecosystem.

Recommendation

This study recommends that commercial banks strengthen liquidity management to mitigate deposit volatility and potential disintermediation. Banks should invest in advanced digital infrastructure and cybersecurity systems to address operational risks. Enhancing compliance frameworks and aligning with evolving regulations is also essential. Strategically, banks are encouraged to transform their business models by integrating digital services and forming partnerships with fintech and regulators. Additionally, adopting integrated risk management frameworks such as ERM, SRM, and dynamic capabilities is crucial to ensure proactive, adaptive, and sustainable responses to the challenges of the Digital Rupiah era.

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