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AN IMPACT OF FINANCIAL TECHNOLOGY ON DIGITAL CURRENCY IN BANKING SECTOR

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Abstract

This study investigates how a country's financial access and financial stability influence the adoption of retail central bank digital currencies (CBDCs) across 71 nations. Using an ordinal legit model, we analyze the effects of individual financial access, credit card ownership, and firms' access to financing, offshore loan exposure, financial sanctions, and the ownership structure of financial institutions on the probability of CBDC adoption. The findings show that countries experiencing financial sanctions and those with high levels of offshore bank loans are significantly more likely to adopt CBDCs, reflecting a strategic move to enhance monetary independence and reduce reliance on traditional global financial networks. Additionally, the results indicate that nations with limited financial inclusion where large segments of the population face restricted access to financial services display a stronger inclination toward CBDC implementation as a means to expand financial accessibility. Conversely, no statistically significant relationship was identified between CBDC adoption and the share of foreign-owned banks within a country. Overall, the results demonstrate that countries with lower financial stability and weaker financial access tend to adopt CBDCs more rapidly. This study contributes to a deeper understanding of how financial pressures and structural conditions shape national motivations for embracing CBDCs and offers relevant insights for policymakers formulating digital currency strategies.

Central bank–issued digital currencies (CBDCs) have generated substantial global interest due to their potential to enhance payment efficiency, reduce transaction costs, expand financial accessibility, and enable more responsive monetary policy. Despite these advantages, CBDCs remain in an early stage of development, and adoption levels vary widely across countries. This study employs partial least squares structural equation modeling (PLS-SEM) to examine the nonlinear relationships between key national development indicators and CBDC deployment across 67 countries. The analysis investigates how technological, environmental, legal, and economic factors shape national readiness for CBDC adoption. The results reveal a statistically significant and positive relationship between CBDC adoption and both the level of democracy and public confidence in governance. In contrast, regulatory quality and income inequality show a negative association with CBDC adoption, while network readiness, foreign exchange reserves, and sustainable development goal rankings display no significant influence. These findings suggest that countries with stronger democratic institutions and higher governance trust are more inclined to advance CBDC initiatives. The study concludes by outlining important policy considerations for broader CBDC implementation and identifying areas for future research on macro-level digital currency adoption.

Keywords

Central bank digital currency (CBDC); finch; block chain technology; digital payments; macro level adoption; governance quality; democracy; regulatory environment; income inequality; PLS SEM; technological readiness; economic development; digital financial innovation

Introduction

The global financial landscape is experiencing a profound transformation driven by rapid advancements in digital technologies. As financial systems become increasingly interconnected and reliant on digital infrastructures, new opportunities and challenges arise for the global monetary order. This shift raises critical questions about the future of monetary hegemony, traditionally anchored in the dominance of major reserve currencies such as the U.S. Dollar and the Euro [1, 2]. The advent of central bank digital currencies (CBDCs) has amplified these debates by offering a new paradigm for financial transactions, cross-border payments, and economic governance. According to the U.S. Congressional Research Service [3], geopolitical changes—including China's economic rise, increasing U.S. sanctions, and the growth of digital currencies—may collectively challenge the long-standing centrality of the dollar in global finance.

In recent decades, the United States has increasingly used financial sanctions as a strategic instrument to influence the behavior of foreign governments. Restrictions on access to the U.S. financial system and the U.S. Dollar have expanded considerably, with sanction designations by the Office of Foreign Assets Control (OFAC) rising by over 933% in the past two decades [5]. These measures can significantly reduce a sanctioned country's financial access and stability, prompting affected nations to explore alternative mechanisms to participate in the global economy [6]. The sanctions imposed on Russia covering the top ten Russian-owned banks and more than 80% of the nation's financial industry assets illustrate how such measures restrict cross-border transactions and disrupt economic activity for both citizens and enterprises [7, 8].

Against this backdrop, CBDCs have garnered substantial attention for their potential to reshape the financial landscape. Prior studies highlight their ability to enhance financial inclusion [9], support green financing and sustainable development initiatives [10], and improve payment efficiency through instantaneous and low cost transfers. Beyond these economic advantages, CBDCs may introduce a new dimension of monetary independence, enabling countries to strengthen economic sovereignty and reduce reliance on dominant global currencies. The U.S. Department of Treasury [5] notes that digital currencies also present opportunities for actors seeking to bypass traditional dollar-based systems, raising important geopolitical considerations.

While numerous countries are exploring CBDCs, the determinants of their adoption vary significantly across different economic, technological, and institutional contexts. Existing research has examined factors such as financial inclusion, remittances, and net foreign assets [11]; however, financial determinants remain comparatively understudied. This gap highlights the need for a more comprehensive understanding of how financial access, financial stability, and monetary independence shape CBDC adoption.

Building on prior literature, this study investigates the complex relationship between financial system characteristics and the adoption of retail CBDCs across nations. Specifically, it examines the influence of financial sanctions, the ownership structure of financial institutions, offshore loan exposure, accessibility of financial services, the availability of financing infrastructure, and credit to businesses. To guide this analysis, we adopt the financial development framework proposed by Cihak et al. [12]. By doing so, the study contributes to a deeper understanding of the transformative forces reshaping the global financial system and offers insights relevant for policymakers seeking to design effective CBDC strategies.

The remainder of this paper is organized as follows. Section 2 provides a review of the literature and theoretical background. Section 3 outlines the materials and methods employed. Sections 4 and 5 present the results, discussion, and implications for future research.

The world is rapidly investing in and adapting digital technologies to reshape business practices, organizational cultures, and customer experiences in response to evolving economic conditions and shifting consumer expectations [1, 2]. These technological advancements have significantly influenced global economic development by enhancing productivity, supporting innovation, and strengthening the financial stability of nations. However, the pace and extent of technology adoption vary considerably across countries, influenced by factors such as economic development, institutional readiness, and infrastructure availability [3].

In the financial sector, the rise of crypto currencies has accelerated interest in block chain-based applications, prompting banks and financial institutions to explore new technological solutions to improve transparency, security, and customer convenience [4, 5]. As a result, block chain technology has emerged as a promising tool for modernizing financial systems and redefining how value is exchanged in the digital era.

Despite these advancements, several long-standing challenges persist—particularly in cross-border payments. Traditional international payment systems often suffer from slow settlement times, high transaction fees, and limited accessibility for underserved populations [6]. These inefficiencies create barriers to global financial integration and highlight the need for more inclusive and effective digital payment infrastructures.

In this context, emerging digital technologies including distributed ledger systems, central bank digital currencies (CBDCs), and next-generation payment networks offer a transformative opportunity to address existing limitations and support broader economic modernization. Understanding the factors that drive technology adoption at the national level is therefore essential for guiding policy decisions, promoting financial innovation, and improving global economic connectivity. Literature Bottom of Form

Literature Review

Central bank digital currencies (CBDCs) have emerged as a significant innovation in global finance. Defined as digital forms of sovereign money issued and regulated by a nation's central bank, CBDCs are typically pegged to the country's fiat currency and may be implemented through either centralized or decentralized technological architectures [20, 21]. With rapid digital transformation reshaping financial systems, many countries are actively exploring CBDCs to evaluate their potential benefits, risks, and implications for monetary stability.

CBDCs and Cross-Border Payment Challenges

One of the central motivations for CBDC research is the potential to improve cross-border payments. Traditional international transactions frequently suffer from delays, high fees, regulatory inconsistencies, and challenges related to time zones and coordination among intermediaries [7, 22]. CBDCs have been proposed as a promising solution to streamline cross-border settlements by reducing reliance on correspondent banking networks and enhancing transaction traceability and interoperability.

User Adoption Factors: Trust, Privacy, and Perception

A substantial body of literature investigates the behavioral and perceptual factors influencing CBDC adoption at the individual and institutional levels. Studies have examined:

- **Privacy concerns** and how consumer perceptions of data protection influence acceptance [20].
- **Trust in institutions**, including confidence in central banks and government bodies, as a determinant of adoption [14, 23].
- **Public perception** regarding the safety, usefulness, and social desirability of CBDCs [16].
- **Performance expectancy**, including perceived efficiency and reliability, which has been shown to positively influence adoption intent [23].

These findings highlight the importance of psychological and social determinants alongside technological ones in shaping public attitudes toward CBDCs.

CBDCs and Their Relationship with Crypto currencies

A second stream of literature focuses on the interplay between CBDCs and crypto currencies. Researchers have explored:

- The **impact of CBDC-related news** on financial markets, including cryptocurrency and stock indices [10, 11, 12].
- The **predictive relationships** between CBDCs and major crypto currencies such as Bitcoin and Ethereal.
- The potential for CBDCs to stabilize markets affected by the volatility of decentralized crypto currencies.

Overall, this line of research underscores CBDCs as both a response to and a force shaping the digital asset ecosystem.

Technological Risks, Design Features, and Policy Considerations

CBDCs introduce both significant opportunities and substantial risks. Technological advantages identified in the literature include:

- Support for **negative interest rate policies** and mitigation of macroeconomic fluctuations [24].
- Enhanced capabilities for **tax compliance** and reduction in financial fraud [25].
- Improved transparency and transaction traceability through block chain technology.

Design attributes such as anonymity features, budgeting tools, bundling of financial services, and potential returns have also been recognized as key determinants of user demand [17].

Conversely, several studies emphasize important concerns that must be addressed before CBDCs are adopted widely:

- **Data protection and privacy** risks, particularly in transparent block chain systems [25].

- The **digital divide**, which may exclude vulnerable populations from accessing CBDC platforms.
- **Cybersecurity vulnerabilities**, including risks of hacking and systemic failures [15].

These risks indicate the need for careful and robust regulatory frameworks.

Gaps in the Literature and Need for Macro-Level Analysis

Although the literature provides insights into technological, behavioral, and market-related aspects of CBDCs, a unified analytical framework explaining differences in CBDC adoption across countries remains lacking. Only limited studies have examined:

- Cross-country variations in technological readiness,
- Differences in legal and political structures,
- Economic development disparities, and
- Sustainability priorities.

As information technologies diffuse unevenly across nations, understanding these macro-level determinants is essential. Moreover, the potential of CBDCs to address issues of trust, verification, and cross-border transaction costs further underscores the importance of evaluating technological, environmental, legal, and economic influences on CBDC adoption status.

Figure 1

Digital Currency: A Technology-Driven Monetary Form

1. **Definition Highlighted**
   - The image defines *digital currency* as money that is **accessible only through electronic devices** such as computers or mobile phones.
2. **Digital–Only Accessibility**
   - Unlike physical cash, digital currency exists **solely in electronic form** and requires internet-enabled devices to access, store, or transact.
3. **Symbolic Dollar Representation**
   - The central **dollar symbol ($)** in the image emphasizes the connection to financial systems and currency value, even though the form is digital.
4. **Technology Integration**
   - The background containing geometric and circuit-like patterns symbolizes the **technological infrastructure**, such as cryptography and digital ledger systems, that support digital currencies.
5. **Source Credibility**

- The image cites *Investopedia*, indicating that the content is based on a reputable financial information source.

6. **Educational Purpose**
   - The phonetic spelling of "digital currency" suggests that the image is intended for **informational or explanatory use**, making the concept easy to understand for learners or general audiences.
7. **Relevance to Fitch and CBDC Contexts**
   - The emphasis on digital-only access relates directly to evolving financial technologies, including **CBDCs, crypto currencies, online banking, and mobile payment ecosystems**.

Research Methodology

This study adopts a comprehensive econometric framework to empirically investigate the bidirectional and spatially interactive relationship between **digital financial technology** and **urban ecological efficiency** across Chinese cities. The methodology consists of four main components: data selection, model construction, spatial weight matrix formulation, and estimation strategy.

1. Data Collection and Variable Description

Panel data from multiple cities over several years were used to construct a balanced dataset. Two core variables were examined:

- **Urban Ecological Efficiency (beef)**
- **Digital Financial Technology Level (d_fintech)**

To control for potential confounding influences, several socio-economic indicators were included:

- Economic development level (pad)
- Urbanization level (rub)
- Industrial structure upgrading (in)
- Openness (open)
- Marketization degree (mar)
- Population density (den)
- Transportation development level (tar)
- Postal development level (pops)

These variables form the control variable sets **Exit** and **Zit** in the model.

2. Baseline Model Construction: Simultaneous Equation Fixed-Effect Panel Regression

To test the fundamental two-way interaction between digital finance and ecological efficiency, a **simultaneous equation model (SEM)** with city-level fixed effects was developed:

Equation (1)

e_eff_it=α0+α1d_fintechit+αExit+πif+ϵitem_off_ {it} = \alpha_0 + \alpha_1 d_ {finch_ {it}} + \alpha X_ {it} + \pili + \epsilon_{it}e_eff_it=α0+α1d_fintechit+αExit+πif+ϵit

Equation (2)

d_fintechit=β0+β1e_effit+βZit+μi+σitd_ {finch_ {it}} = \beta_0 + \beta_1 e_off_ {it} + \beta Z_ {it} + \music + \sigma_{it}d_fintechit=β0+β1benefit+βZit+is+it

These equations capture:

- The effect of digital financial technology on ecological efficiency
- The reciprocal impact of ecological efficiency on digital financial technology

Baseline panel regressions help identify direct relationships but **ignore spatial spillovers** across cities.

3. Spatial Model Construction: Spatial Simultaneous Equation Model (SSEM)

Because both ecological efficiency and digital financial technology may spread or spill across regional boundaries, the study extends the baseline SEM into a **spatial simultaneous equation system**:

Equation (3): Spatial Ecological Efficiency Equation

e_effit=α0+α1∑j≠iWe_effjt+α2∑j≠iWd_fintechjt+α3d_fintechit+αXit+ϵite_eff_ {it} = \alpha_0 + \alpha_1 \sum_{j \ne if} W e_off_ {jt} + \alpha_2 \sum_{j \ne if} W d_ {finch_ {jt}} + \alpha_3 d_ {finch_ {it}} + \alpha X_ {it} + \epsilon_{it}e_effit=α0+α1j□=i∑We_effjt+α2j□=i∑Wd_fintechjt+α3d_fintechit+αXit+ϵit

Equation (4): Spatial Digital Financial Technology Equation

d_fintechit=β0+β1∑j≠iWd_fintechjt+β2∑j≠iWe_effjt+β3e_effit+βZit+σitd_ {finch_ {it}} = \beta_0 + \beta_1 \sum_{j \ne if} W d_ {finch_ {jt}} + \beta_2 \sum_{j \ne if} W e_off_ {jt} + \beta_3 e_off_ {it} + \beta Z_ {it} + \sigma_{it}d_fintechit=β0+β1j□=i∑Wd_fintechjt+β2j□=i∑We_effjt+β3e_effit+βZit+σit

Here:

- **α1, β1** → spatial spillover intensities of digital finance and ecological efficiency
- **α2, β2** → cross-variable spatial interaction (endogeneity across regions)

This model captures:

- Local effects
- Spillover effects from surrounding cities
- Reciprocal interactions between the two variables

4. Construction of Spatial Weight Matrices

To accurately model inter-city spillovers, two weight matrices were developed:

4.1 Geographic Distance Matrix (W_1)

- Based on straight-line distance calculated using city centroid latitude/longitude
- Normalized, reciprocal of distance
- Distance > 30 → weight = 0 (non-adjacent cities)

4.2 Economic–Geographic Distance Matrix (W_2)

To incorporate both economic and spatial proximity:

ECO_GEO_Distanceij=GEO_Distanceij×ECO_DistanceijECO_GEO_Distance_ {is} = GEO_Distance_ {is} \times ECO_Distance_ {is} ECO_GEO_Distanceij=GEO_Distanceij ×ECO_Distanceij

Where:

- **GEO_Distance** = geographic distance
- **ECO_Distance** = absolute gap in per capita GDP

Normalized reciprocal values form the matrix.

W_2 accounts for cities that are both physically close and economically similar/different.

5. Estimation Strategy: GS3SLS Method

Given the **endogeneity** and **spatial dependence** in equations (3) and (4), ordinary least squares (OLS) would yield inconsistent estimates. Therefore, the study applies the:

Generalized Spatial Three-Stage Least Squares (GS3SLS)

This method is selected because it:

- Handles endogenous variables within spatial models
- Accounts for correlation of error terms between equations
- Improves estimation efficiency under spatial autocorrelation
- Ensures correct identification despite simultaneous equations and spatial lags

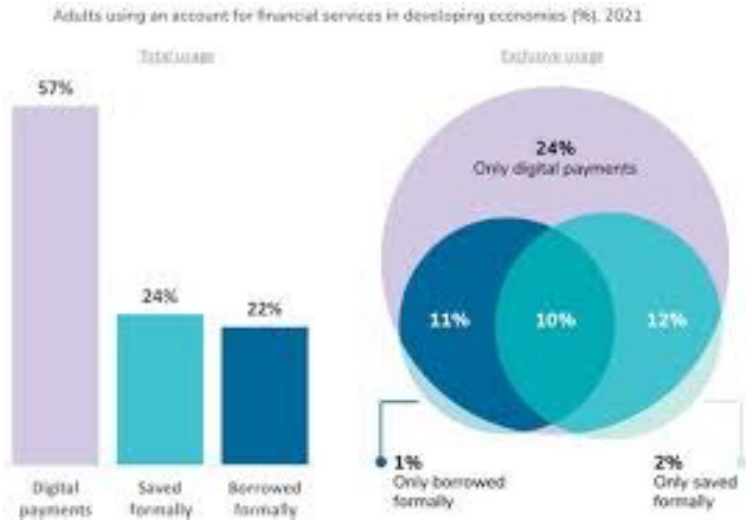
The GS3SLS estimator allows the system of spatial equations to be solved holistically, producing robust estimates for both local and spillover effects.

Final Structure Summary

Methodological Component	**Description**
Data	City-level panel data with ecological, financial, and socio-economic indicators
Baseline Model	Simultaneous panel regression capturing two-way linkage
Advanced Model	Spatial simultaneous equations (SSEM) to capture spillover + reciprocity
Spatial Matrices	Geographic distance (W_1) and economic–geographic distance (W_2)
Estimator	GS3SLS to address endogeneity + spatial autocorrelation

Figure 2

Digital vs. Formal Financial Inclusion Trends in Developing Economies



1. Financial Service Usage in Developing Economies

- The image illustrates how adults in developing economies use financial accounts for different purposes in **2021**.

2. Usage Breakdown (Bar Graph – Left Side)

The bar graph shows three major forms of formal financial usage:

- **57% – Digital Payments** this is the highest share, indicating a strong shift toward digital financial transactions.

- **24% – Saved Formally**
  Nearly a quarter of adults use their accounts for savings through formal financial institutions.
- **22% – Borrowed Formally**
  A smaller but significant portion uses accounts for borrowing from regulated institutions.

3. Digital and Formal Financial Overlap (Venn diagram – Right Side)

The Venn diagram shows the relationship between **digital payments** and **formal financial services** (saving or borrowing).

Digital-Only Users

- **24% only used digital payments**
  these individuals use digital platforms but do not save or borrow formally.

Overlap: Digital + Formal Services

- **10% use both digital payments and saved formally**
- **11% use both digital payments and borrowed formally**

Formal-Only Users

- **12% only saved formally**
- **1% only borrowed formally**

4. Key Insights

- **Digital payments dominate**, showing high acceptance and accessibility of digital financial technology in developing countries.
- A **significant number of people use digital finance without engaging in traditional saving or borrowing**, indicating convenience-driven behavior.
- The overlap shows a positive link between **digital finance and traditional financial inclusion**, suggesting that digital tools encourage broader financial integration.
- Very few people rely **solely on formal borrowing**, indicating barriers or limited borrowing needs.

- Savings behavior is stronger than borrowing behavior among account holders.

Data Analysis Result

This study is based on a balanced panel dataset comprising **284 prefectural-level and above cities in China**, covering the period **2008–2018**, with a total of **3124 observations**. The core purpose of the analysis is to explore the interaction between **digital financial technology (d-finch)** and **urban ecological efficiency (e-off)**, supported by multiple socioeconomic and environmental control variables.

1. Main Variables and Data Sources

1.1 Digital Financial Technology Level (d-finch)

The digital financial technology index is constructed using **Python-based web crawling technology**. Search frequency data for **48 finch-related keywords** were obtained from Badu (accessed on 16 March 2021). These keywords were derived from:

- *The 13th Five-Year National Science and Technology Innovation Plan*
- *Big Data Industry Development Plan (2016–2020)*
- *China Fitch Operation Report (2018)*
- Major ICT-related conferences and policy documents

Keywords include: block chain, digital currency, machine learning, NFC payment, cloud computing, biometric technology, natural language processing, Iota, etc. The Badu search index for each keyword was collected and aggregated to represent the city-level finch development intensity.

1.2 Urban Ecological Efficiency (e-off)

Urban ecological efficiency data were measured using the **Super Efficiency SBM-GML (Slack-Based Measure–Global Malmquist–Durenberger)** Data Envelopment Analysis model.

This method accounts for:

- Desirable outputs (e.g., GDP)
- Undesirable outputs (e.g., industrial pollutants)
- Changes in efficiency over time

The resulting e-off index reflects each city's ability to generate economic output while minimizing ecological and environmental costs.

2. Control Variables

A comprehensive set of socioeconomic variables was included to minimize omitted variable bias:

Variable	Description
pad	Economic development level (log of per capita GDP)
rub	Urbanization level (population in city districts / total population)
in	Industrial structure upgrading (secondary + tertiary industry share of GDP)
open	Openness level (foreign direct investment / GDP)
mar	Degree of marketization (share of private employment)
den	Population density (log of residents per km²)
tar	Transport development (log of passenger volume per capita)
pops	Postal development (postal income per capita, logged)

Data were mainly sourced from **China City Statistical Yearbooks**, and missing values were filled using **trend interpolation**.

3. Software and Data Preprocessing

- **Geode** was used for calculating spatial weight matrices and conducting spatial correlation diagnostics.
- **Stata 16** was applied for panel data processing, descriptive statistics, and simultaneous equation modeling.
- All variables were standardized where necessary; logarithmic transformation was applied to skewed variables to reduce heteroscedasticity.

4. Descriptive Statistics (Regional and Temporal Heterogeneity)

Descriptive statistics were computed for:

- **Three major regions**: eastern, central, and western China
- **Two time periods**: 2008–2012 and 2013–2018

Findings indicate:

4.1 Regional Differences

- **Eastern cities** exhibit significantly higher digital finch adoption and urban ecological efficiency.
- **Central and western cities** lag behind, with western cities showing the lowest average values for both variables.
- Marketization, openness, and economic development also exhibit strong east–west gradients.

4.2 Temporal Differences

- From **2013–2018**, both d-finch and e-off improved substantially compared with 2008–2012.
- This shift aligns with the national ICT expansion, mobile payment adoption, and strengthened ecological regulations during the 13th Five-Year Plan.

These heterogeneous characteristics justify the later in-depth spatial and interaction analysis.

5. Measurement of Digital Financial Technology

Given the absence of publicly available city-level finch data, the study adopts a **web-crawling, keyword-based approach**. Steps include:

1. **Keyword Selection** (48 keywords)
    - Covering emerging technologies: block chain, AI, cloud computing, big data, distributed computing, etc.
2. **Badu Index Extraction**
    - Python crawler retrieves city-specific search frequencies for each keyword.
3. **Data Aggregation and Processing**
    - Standardization
    - Weight adjustment
    - Composite index construction

This method allows for real-time, high-granularity measurement of finch development across cities.

Summary of Data Analysis Insight

- The dataset is robust, comprising 284 cities over 11 years.
- Digital finch data were innovatively constructed using web-scraping and keyword frequency analysis.
- Ecological efficiency was rigorously estimated using advanced DEA techniques.
- Significant regional and temporal heterogeneity was observed, supporting the need for spatial econometric modeling.
- Comprehensive control variables ensure reliability and validity of the regression results.

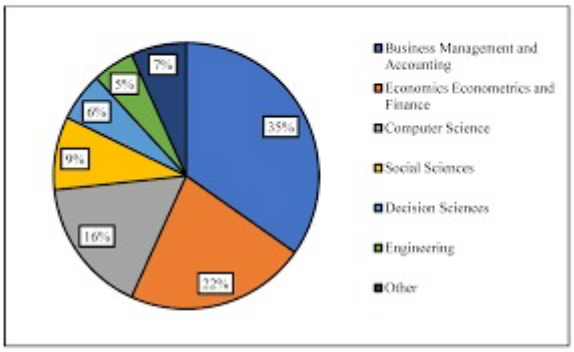
Table 1. Variable Data Sources

Variable	Symbol	Description / Measurement Method	Data Source
Digital Financial Technology Level	d-finch	Composite index constructed using Badu keyword search frequency (48 keywords related to AI, block chain, cloud computing, big data, finch) collected via Python crawler	Badu Index (accessed 16 March 2021)

Variable	Symbol	Description / Measurement Method	Data Source
Urban Ecological Efficiency	e-off	Measured using Super-Efficiency SBM-GML (considering desirable & undesirable outputs)	Calculated by authors using DEA model
Economic Development Level	pad	Log of per capita GDP of each city	China City Statistical Yearbook
Urbanization Level	rub	Population in municipal districts / total population of the city	China City Statistical Yearbook
Industrial Structure Upgrading	in	Share of secondary + tertiary industries in city GDP	China City Statistical Yearbook
Openness Level	open	Foreign direct investment as % of city GDP	China City Statistical Yearbook
Marketization Degree	mar	Share of private and individual employees in total population	China City Statistical Yearbook
Population Density	den	Log of population per km²	China City Statistical Yearbook
Transportation Development Level	tar	Log of (total passenger volume / total population)	China City Statistical Yearbook
Postal Development Level	pops	Log of postal income per capita	China City Statistical Yearbook
Spatial Weight Matrices	W1, W2	W1: Geographic distance matrix; W2: Economic–geographic distance matrix	Calculated using Geode

Figure 3

Distribution of Research Publications across Academic Disciplines



1. Business **Management and Accounting** represents the largest share, accounting for **35%** of the total research publications.
2. Economics**, Econometrics, and Finance** form the second-largest category, contributing **22%** of the publications.
3. Engineering accounts for **16%**, showing a strong presence in the research landscape.
4. Decision **Sciences** contribute **9%**, highlighting their moderate involvement in research output.
5. Social **Sciences** represent **6%**, showing a smaller yet notable participation.
6. Computer **Science** comprises **8%**, reflecting its growing but still moderate share.
7. The **Other** category accounts for **7%**, including interdisciplinary or less frequently represented fields.

Findings and Discussion

The findings of this study highlight a **nonlinear and dynamic relationship** between finch development and the financial risks of China's systemically important commercial banks. Using the Z score and non-performing loan ratio as the primary indicators of bank risk, and aggregated finch search indexes as proxies for finch development, the empirical results reveal an **inverted U-shaped effect** of finch on financial stability.

In the **early stages of finch development**, finch-assisted services—such as third-party payment platforms, P2P lending, and smart financial technologies—expanded rapidly, outpacing the adaptive capacity of traditional commercial banks. This stage is characterized by intensified competition in deposits, loans, and payment services, which challenged traditional revenue models. Consequently, commercial banks often adopted riskier operational strategies to maintain profitability, leading to a temporary **increase in financial risk**. These results align with existing literature noting that finch innovations can disrupt financial markets, weaken banks' intermediary roles, intensify competition, and reduce profitability.

However, as finch progressed into its **middle and mature stages**, its effect on commercial banks became increasingly positive. Faced with sustained competitive pressure, banks accelerated the integration of finch into their operations. Systemically important banks began to utilize digital transformation, risk-control algorithms, data analytics, and intelligent service systems to optimize resource allocation, expand business boundaries, and improve risk management efficiency. During this phase, finch helped reduce information asymmetry, enhanced operational transparency, and strengthened internal control systems, resulting in a **gradual reduction in banks' financial risk**.

Thus, the identified inverted U-shaped relationship confirms that while finch initially introduces disruption and competitive threats, its advanced applications ultimately promote stability, innovation, and risk mitigation within the banking sector. The findings extend the existing literature by demonstrating that finch's evolution has a **two-stage impact** first destabilizing, then stabilizing—and that the timing and degree of finch adoption significantly shape risk outcomes.

From a practical perspective, the results imply that commercial banks must **actively embrace finch innovation**, particularly in its advanced stages, to strengthen competitiveness and reduce exposure to systemic risks. Investment in technological infrastructure, data security enhancement, and digital service improvement is crucial for maintaining sustainable growth.

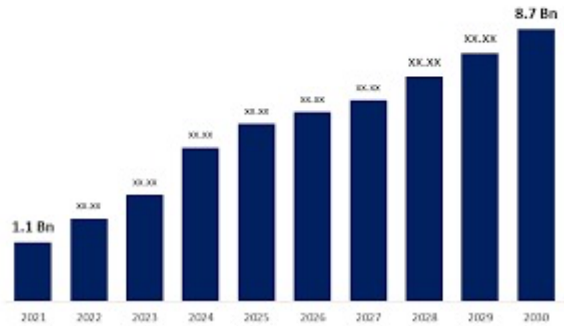
Collaboration between banks and finch companies can reduce innovation costs, enhance product diversity, and further improve risk-control capabilities.

For policymakers, the findings underscore the importance of establishing **balanced, adaptive regulatory frameworks**. Effective governance should define legal boundaries for finch operations, create industry standards, and develop timely policies that support innovation while mitigating systemic risks. Targeted oversight of emerging finch products—including crypto currencies, P2P platforms, and algorithmic financing—can prevent excessive risk accumulation and ensure that finch contributes positively to financial-sector stability.

Overall, the study contributes to a deeper understanding of the complex interplay between technological innovation and financial risk, offering essential insights for academia, industry, and regulatory authorities.

Figure 4

Rapid Market Scaling Toward 2030



1. Steady Growth Trend

- The chart shows a **consistent upward trend** from 2021 to 2030.
- Each bar is higher than the previous, indicating **continuous annual growth**.

2. Initial Value

- In **2021**, the value starts at **1.1 billion**.

3. Final Value

- By **2030**, the value reaches **8.7 billion**, showing a **significant increase over the decade**.

4. Approximate Yearly Growth

- The bars indicate **year-on-year incremental increases**, though exact values from 2023–2029 are not shown (represented as "XX.X").
- The growth pattern visually suggests **strong market expansion**.

5. Interpretation

- The dataset likely represents growing adoption or market size of a digital or financial technology (e.g., finch, CBDCs, digital payments, block chain services).
- The steep increase toward 2030 indicates **accelerated adoption in future years**.

6. Visual Style Notes

- Dark blue bars provide a **clean, professional look**.
- Values are labeled on top of each bar to show progression.
- Simple layout highlights the **long-term growth story** clearly and effectively.

Conclusion

This study provides a comprehensive and timely exploration of the growing role of artificial intelligence (AI) in transforming the banking sector. By integrating bibliometric analysis with conceptual discussion, the research contributes significantly to both academic understanding and practical applications of AI in banking. The findings highlight how AI is reshaping key banking operations—ranging from customer service innovation to advanced risk management—thereby enriching current digital transformation literature with more focused and sector-specific insights.

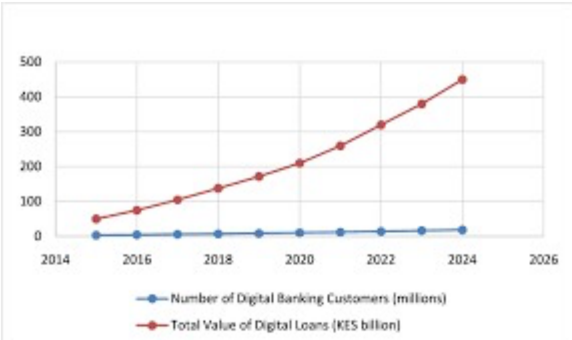
The study also offers meaningful implications for policymakers and banking professionals. For policymakers, the results underline the need for balanced regulatory frameworks that encourage AI innovation while safeguarding data privacy, ethical standards, and financial stability. For banking institutions, the analysis identifies concrete opportunities where AI can enhance efficiency, reduce operational risks, and support long-term competitiveness. Addressing workforce skill gaps emerges as a critical priority, emphasizing the value of specialized training programs to strengthen AI capabilities within the banking profession.

Despite its contributions, the study acknowledges limitations inherent in bibliometric methods, such as restricted data sources and the rapidly evolving nature of AI technologies. Therefore, continuous updates and complementary qualitative approaches—such as interviews and case studies—are essential for capturing deeper insights into real-world AI adoption. Future research should also examine the intersection of AI with other emerging technologies, including block chain, quantum computing, and advanced analytics, to better understand their combined impact on digital transformation in banking.

In summary, this study not only advances theoretical perspectives on AI in banking but also provides practical guidance for industry practitioners and regulators. As AI continues to evolve, ongoing research will be crucial to ensure that the banking sector remains responsive, innovative, and resilient in an increasingly digital financial landscape.

Figure 5

Rise of Digital Banking Services: A Decade of Customer and Loan Value Growth



1. **Two variables are compared:**
   - Number of Digital Banking Customers (in millions)
   - Total Value of Digital Loans (in KES billions)
2. **Time span:**
   The graph covers a 10-year period from **2014 to 2024**.

3. **Consistent upward trend:**
   Both metrics show continuous growth over the years, indicating increasing digital adoption in banking.
4. **Sharp rise in digital loan value:**
   The red line (digital loan value) increases steeply, reaching **over 450 KES billion in 2024**, showing strong demand for digital credit.
5. **Steady but slower customer growth:**
   The blue line (digital banking customers) grows gradually, reflecting moderate increase in user adoption.
6. **Wider gap over time:**
   The difference between loan value and customer numbers becomes larger each year, suggesting **higher loan value per customer** over time.
7. **Key inflection years:**
   Rapid growth is visible after **2018**, showing accelerated digital transformation.
8. **Visual markers:**
   - Blue circles represent customer numbers
   - Red circles represent loan values
   - Both connected by smooth trend lines
9. **Forecast-like endpoint:**
   Data extends to **2024**, hinting at future growth expectations beyond 2025.
10. **Overall message:**
    The graph illustrates how digital banking services—especially lending—are scaling rapidly, highlighting the sector's technological shift.

Reference

1. **Jovanovich et al. (2022)**
   - Explores digital platform evolution and governance.
   - Relevant for understanding AI-driven platform transformation in banking.
2. **Bemba et al. (2022)**
   - Discusses the role of AI in organizational processes.
   - Supports insights on AI integration in banking institutions.
3. **European Commission (2018)**
   - Provides the EU's strategic framework for AI development.
   - Useful for regulatory and policy perspectives in AI adoption.
4. **Popowicz et al. (2024)**
   - Reports trends and risks of AI in finch.
   - Highlights opportunities and threats of AI for banks.
5. **Bhattacharyya et al. (2023)**
   - Examines global banking transitions and emerging technologies.
   - Adds context on how AI is reshaping banking operations.
6. **van Zeeland & Pierson (2024)**
   - Studies digitalization impacts on bank staff post-COVID-19.
   - Useful for understanding digital capability changes caused by AI.
7. **Financial Stability Board (2022)**
   - Analyzes finch disruptions during COVID-19.

- Supports the discussion on financial stability risks related to AI.

8. **Ross (2023)**
   - Provides data on the financial sector's share of the global economy.
   - Helps justify the economic importance of AI-enhanced banking.
9. **Omega et al. (2022)**
   - Explores disruptive technologies and AI in emerging markets.
   - Supports global and regional analysis of AI in banking.
10. **Chung et al. (2020)**
    - Examines Chabot service quality and customer satisfaction.
    - Relevant for AI-driven customer experience in banking.
11. **Godey et al. (2016)**
    - Highlights brand engagement through digital technologies.
    - Supports discussions on digital marketing in financial services.
12. **Kroger (2023)**
    - Discusses the future trajectory of AI in banking.
    - Useful for forecasting AI adoption trends.
13. **Cap Gemini (2024)**
    - Provides insights on global retail banking challenges and AI solutions.
    - Supports industry-level analysis of AI transformation.
14. **European Central Bank (2024)**
    - Highlights supervisory use of AI.
    - Important for regulatory and compliance perspective.
15. **Accenture (2024)**
    - Presents global change index with a focus on technology acceleration.
    - Supports evidence on rapid AI adoption.
16. **Zolkepli & Kamarulzaman (2015)**
    - Explains factors influencing digital media adoption.
    - Adds foundational theory for technology acceptance models.
17. **Silva (2021)**
    - Discusses behavior biometrics and fraud detection.
    - Relevant for AI in security and fraud prevention.
18. **Rosaline et al. (2022)**
    - Presents ML models for fraud detection.
    - Supports technical discussion of AI-enabled fraud solutions.
19. **Maj & Latina (2022)**
    - Explores big data analytics in future banking roadmaps.
    - Useful for big-data–driven AI strategy.
20. **Gag et al. (2021)**
    - Investigates block chain benefits in banking.
    - Provides complementary insights on disruptive digital technologies.
21. **Donahue et al. (2021)**
    - Offers guidelines for bibliometric analysis.
    - Supports methodology for research mapping.
22. **Aria & Cuccurullo (2017)**

- Introduces the Bibliometrix R package.
- Relevant for bibliometric analysis tools.

23. **Donahue et al. (2019)**
    - Presents a bibliometric review of business research trends.
    - Provides methodological support for bibliometric studies.