

Research on the Impact of Digital Transformation in Commercial Banks on the Financing Environment for Science and Technology Innovation Enterprises

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Abstract: The High-level Financial Work Conference explicitly called for accelerating the building of China into a financial powerhouse, identifying sci-tech finance as one of the five key priorities essential to achieving this goal. Against the backdrop of an accelerating transition from scientific and technological innovation to industrialization, the role of fintech in driving technological innovation has become increasingly prominent. This study focuses on the impact of digital transformation in commercial banks on the financing environment for sci-tech innovation enterprises, examining the current situation and proposing targeted recommendations. Research shows that digital transformation in commercial banks has enhanced financial services for sci-tech innovation enterprises by expanding service coverage, diversifying financing channels, lowering financing costs, and improving financing efficiency. However, it has also introduced adverse effects, such as imbalanced resource allocation among banks, "misjudgments" by risk control models in assessing sci-tech innovation enterprises, and financing disparities arising from differentiated qualification certifications. To address these issues, this study proposes specific measures, including strengthening collaboration and resource sharing among commercial banks, reconstructing model logic and establishing human-machine collaboration mechanisms, and optimizing the guidance of public strategies and the allocation of funds. These recommendations aim to better serve sci-tech innovation enterprises, foster deeper integration of technology and finance, and support China's technological advancement and the sustainable development of high-tech industries.

Keywords: Commercial Banks; Digital Transformation; Sci-Tech Enterprise Financing

1. Introduction

Against the backdrop of a sluggish global economic recovery, China's financial sector faces unprecedented opportunities and challenges. Over the past decades, China's financial system has remained predominantly reliant on indirect financing through banks, which account for over 90% of financial assets. For commercial banks, the accelerated development of technologies and continuous innovation in the business models of technology-based enterprises have introduced practical difficulties and operational challenges in supporting the technology industry and advancing their own digital transformation. Despite China's remarkable progress in the technological field, the deep integration of technology and finance under the traditional banking model still confronts an "impossible trinity" dilemma—the contradiction among the urgent demands of economic transformation, the long cycle and uncertainty of technological innovation, and the risk management requirements of bank funds [1]. Therefore, resolving the imbalance between the supply and demand of technology and finance, ensuring the continuous and efficient flow of financial resources to support technological innovation, and transforming technology into industrial competitiveness to drive the development of the real economy have become critical tasks in national strategic construction. This paper integrates the financing of Sci-Tech Innovation Enterprises and the digital transformation of commercial banks into a unified analytical framework, examines their current development, explores the dual impact of commercial banks' digital transformation on the financing environment of Sci-Tech Innovation Enterprises

during the investment and financing process, and proposes targeted countermeasures. The aim is to address the financing challenges faced by Sci-Tech Innovation Enterprises and promote their sustainable, healthy, and rapid development.

2. Literature Review

As a key pillar of the modern financial system, commercial banks play a pivotal role in financing technology-based innovative enterprises. In recent years, the digital restructuring of their service models has structurally influenced capital allocation, garnering significant scholarly attention. Early literature focused on the transformation of traditional financing models. Mason and Harrison [2] empirically demonstrated in the U.S. market that capital acquisition for small and medium-sized technology innovation enterprises exhibits a dual structure characterized by venture capital and commercial bank credit. Notably, as many innovators inherently resist venture capital involvement, commercial banks have been driven to transcend their traditional intermediary functions, gradually evolving into crucial vehicles for venture capital operations. Hellmann [3] further revealed that capital deployment by commercial banks possesses a dual nature: providing basic debt financing services while also engaging in equity asset allocation through private equity investments, forming a composite return structure of "fixed income + excess returns."

Mid-period literature emphasized institutional collaboration mechanisms. Rupeika-Apoga and Danovi [4] innovatively proposed a "credit-investment" dual-drive model, highlighting the need for commercial banks to form capital complementarities with institutions such as venture capital (VC) and private equity (PE) to address financing challenges for small and medium-sized enterprises by constructing a multi-tiered financing support system. Barras [5] analyzed the impact of long-term bank-firm relationships on the innovation of technology innovation enterprises through natural experiments (e.g., bank mergers), concluding that sustained cooperation enables banks to more accurately assess technological R&D risks—an effect particularly pronounced in technology-intensive industries and high-uncertainty R&D projects.

Digital transformation has catalyzed innovations in risk management systems. Gomber et al. [6]

developed a dynamic monitoring framework advocating the use of technologies such as blockchain traceability and big data profiling to achieve end-to-end penetrative management of credit funds. Domestically, Sun and Zhang [7] designed a credit assessment matrix incorporating dimensions like technology maturity and patent value to address the asset-light characteristics of technology enterprises, successfully transcending the traditional financial indicator-dominated evaluation paradigm. Notably, CLARK et al. [8] cross-national comparative study indicated that a one-standard-deviation increase in the digital infrastructure index raises the probability of financing availability for technology innovation enterprises by 23.6%, providing robust empirical support for building a digital financial ecosystem. The inclusive value of digital finance has been empirically validated in China. Yuan and Zeng [9] constructed a spatial econometric model, revealing that digital technology applications reduce financing costs for private enterprises by 18.7%, with significant regional convergence effects. Li et al. [10] confirmed through panel data regression that the substitution elasticity of digital channels for traditional bank credit reaches 0.43, effectively mitigating financial exclusion.

At the practical level, commercial banks are accelerating the construction of a "value co-creation" service ecosystem. In terms of basic funding support, they have innovatively developed specialized products such as intellectual property securitization and R&D expense compensation loans. In the value-added service domain, they integrate tools like big data risk control and industrial chain finance to provide comprehensive solutions covering the entire enterprise lifecycle. This transition from mere capital intermediaries to strategic partners not only reshapes the efficiency of financial resource allocation but also injects sustained momentum into the implementation of the national innovation-driven development strategy.

3. Analysis of the Current State of Digital Transformation in Commercial Banks and the Financing Environment for Sci-Tech Innovation Enterprises

3.1 Current Status of Digital Transformation in Commercial Banks

The Digital Transformation Index of

Commercial Banks (DLL), developed by the Institute of Digital Finance at Peking University, is designed to assess the digital transformation status of commercial banks. This index quantifies the extent of digitalization within these financial institutions over a specific period. According to the data, China's DLL stood at 54.33% in 2015, and it maintained an average annual growth rate of approximately 5% in the subsequent years. This trend indicates significant strides in the digital transformation across China's banking industry and reflects a phase of concentrated digital infrastructure development within commercial banks during this period. However, with the introduction of certain regulatory measures and policy constraints on some internet-based financial innovations, the pace of digitalization in commercial banks slowed, and the growth rate of the transformation index was consequently affected. In 2022, the DLL reached 94.92%, which represented an increase of only 3.91% compared to the 2021 figure of 91.03%. Although the growth rate decelerated, the overall index continued its upward trajectory, suggesting that most banks had completed the foundational stages and entered a phase of steady development. In summary, driven by China's economic development and sustained promotion of fintech and digital finance, the Digital Transformation Index of Commercial Banks demonstrated a consistent and steady rise, climbing from 54.33% in 2015 to 94.92% in 2022.

Amid the wave of digital transformation in commercial banks, disparities in resource reserves, technical capabilities, and organizational structures may lead to a "Matthew Effect" in the economic outcomes enabled by digitalization—where stronger institutions grow stronger while weaker ones fall further behind. In the current environment of rapid fintech development, large commercial banks, leveraging their scale advantages, are at the forefront of digital transformation, characterized by ample liquidity and lower default rates. In contrast, small and medium-sized banks, constrained by limited technical capacity and financial resources, find themselves at a competitive disadvantage. The expansion of large banks into market segments traditionally served by smaller institutions, coupled with intense intra-industry competition, has compounded operational challenges for small

and medium-sized banks, thereby slowing their pace of digital transformation.

3.2 Current State of the Financing Environment for Sci-Tech Innovation Enterprises

Sci-Tech Innovation Enterprises primarily finance their operations through equity, bonds, credit, and intellectual property pledge loans. Small and medium-sized micro Sci-Tech Innovation Enterprises typically rely more on credit financing or intellectual property pledge loans, whereas their larger counterparts find it easier to access equity or bond financing. In 2024, the total financing for Sci-Tech Innovation Enterprises nationwide amounted to approximately RMB 1.8 trillion. On the equity front, despite the IPO cold spell, with A-share markets raising only RMB 67.4 billion (an 81.11% year-on-year decrease), early-stage venture capital investments in angel and Series A rounds defied the trend, recording 1,700 new cases—a 30% year-on-year increase. The bond market served as a "stabilizer," with the issuance of Sci-Tech Innovation Bonds reaching RMB 1.23 trillion for the year, a 56% increase, accounting for nearly 8% of the total credit bond market. Concurrently, the banking sector intensified its support. The loan balance for small and medium-sized technology-based enterprises grew by 18% year-on-year, with the proportion of medium- and long-term loans rising to 45%. Intellectual property pledge loans surged to RMB 255.6 billion, a 33% increase, benefiting 26,500 enterprises—a 23% rise in the number of beneficiary firms. This has become a critical key to accessing bank financing for asset-light companies.

Driven by policy support, the loan acquisition rate for small and medium-sized technology-based enterprises increased from 15.5% in 2017 to 46.9% in 2024. However, the loan rejection rate for enterprises without specific qualifications remains as high as 60%, while for those designated as "Specialized, Sophisticated, Distinctive, and Novel" enterprises, the rejection rate falls below 30%. This underscores the significant impact of qualification labels on corporate financing. From a regional perspective, eastern regions such as Shenzhen, with initiatives like the "Sci-Tech Bill Chain Connect" model, exhibit higher penetration rates of digital financial products. In contrast, inland and western regions still predominantly rely on

traditional models, indirectly reflecting regional imbalances in the financing environment.

Overall, Sci-Tech Innovation Enterprises remain heavily dependent on credit financing. Equity and bond markets maintain high entry thresholds, banks exercise conservative risk pricing, and low-cost long-term funding remains scarce. Consequently, over half of these enterprises still find themselves excluded from formal financing channels.

4. Analysis of the Impact of Digital Transformation in Commercial Banks on the Financing Environment for Sci-Tech Innovation Enterprises

4.1 Positive Impacts of Digital Transformation in Commercial Banks on the Financing Environment for Sci-Tech Innovation Enterprises

First, the digital transformation of commercial banks has expanded the service coverage for Sci-Tech Innovation Enterprises. Leveraging mobile internet technologies, digital finance transcends geographical and temporal constraints, providing round-the-clock financing information services for enterprises in remote areas. Online platforms streamline transaction processes, effectively mitigating information asymmetry between banks and enterprises.

Second, it has diversified financing channels for Sci-Tech Innovation Enterprises. In recent years, addressing the characteristic "asset-light, high-risk, long-cycle" nature of these enterprises, the banking industry has innovated multiple financial instruments including intellectual property pledge loans and technology points-based loans. Furthermore, it has advanced listing cultivation and equity financing mechanisms, establishing a multi-tiered capital market system. Third, it has reduced financing costs for Sci-Tech Innovation Enterprises. The digital transformation achieves cost reduction and efficiency improvement through dual pathways: For banks, data models replace traditional financial statements, enabling accurate pricing of projects with short operating histories or limited data. This optimizes the entire credit process from approval to disbursement and post-loan management, minimizing frictional costs while building sustainable digital competitiveness. For enterprises, streamlined digital applications allow financing based on technological capability and creditworthiness rather than

physical collateral. One-time data authorization enables full-process traceability, eliminating redundant documentation and significantly shortening approval timelines, thereby reducing both human and time costs.

Fourth, it has enhanced financing efficiency for Sci-Tech Innovation Enterprises. By adopting digital risk assessment models that shift from collateral-based to data-driven credit evaluation, banks have implemented AI-calculated "Sci-Tech credit scores" that have enabled instant online approval and disbursement for 30,000 enterprises. Data indicates that by the end of 2024, the proportion of credit loans had risen to 45%, with average approval times reduced from 7 days to 3.2 days. The number of national-level "Specialized, Sophisticated, Distinctive, and Novel" enterprises exceeded 140,000, including 14,600 "little giant" enterprises, achieving loan growth rates of 13% and 21.9% respectively - significantly surpassing the 7.6% average growth rate of all loans. Projections indicate that by the end of 2025, digital financing for Sci-Tech Innovation Enterprises will account for over 60% of bank lending, with average financing costs further decreasing by 0.8 percentage points, ultimately achieving real-time alignment between financial resources and technological innovation while injecting robust momentum into the cultivation of strategic emerging industries.

4.2 Negative Impacts of Digital Transformation in Commercial Banks on the Financing Environment for Sci-Tech Innovation Enterprises

First, there exists an imbalance in resource allocation among banks. Large banks, leveraging their substantial capital and technological capabilities, have rapidly completed their digital transformation. In contrast, small and medium-sized banks, constrained by insufficient technological investment, talent drain, and uneven regional coverage, have witnessed accelerated concentration of clients, technology, and talent resources toward industry leaders, resulting in a "Matthew effect" where the strong grow stronger.

Second, risk control models exhibit systematic "misjudgment" toward Sci-Tech Innovation Enterprises. Traditional risk management approaches reliant on historical data such as financial statements and collateral systematically misjudge enterprises characterized by high R&D

investment and extended cycles (5-10 years). Compounding this issue, difficulties in intellectual property valuation and slow circulation further undermine their financing capacity.

Finally, financing inequality emerges from differentiated qualification certification. Policy tilting has raised the loan acquisition rate for "Specialized, Sophisticated, Distinctive, and Novel" enterprises to 46.5% - triple the 2017 level - while the rejection rate for non-qualified enterprises remains as high as 60%. Excessive concentration of credit resources among qualified enterprises fosters and potentially triggers over-financing risks. For instance, some banks offer loan interest rates 20%-30% below appropriate risk-based pricing levels, substantially deviating from fundamental risk pricing principles. This not only distorts the original policy intention of guiding enterprises toward specialized development but also creates hidden risks of over-financing that may induce imprudent diversification. Ultimately, these developments challenge the sustainability of technology finance services in commercial banks and amplify systemic risks.

5. Conclusion

5.1 Research Conclusions

This study systematically analyzes the current state of digital transformation in commercial banks and the financing environment for Sci-Tech Innovation Enterprises, along with their interactions, leading to the following conclusions: On one hand, the digital transformation of commercial banks has expanded service coverage, diversified financing channels, reduced financing costs, and enhanced financing efficiency for Sci-Tech Innovation Enterprises. On the other hand, it has also exposed three major structural contradictions: imbalanced resource allocation among banks, systematic misjudgment by risk control models toward Sci-Tech Innovation Enterprises, and financing inequality stemming from differentiated qualification certification. These contradictions reflect a deep-seated conflict between industrial-era financial logic and the digital innovation ecosystem, necessitating resolution through technological reconstruction, cognitive upgrading, and ecological collaboration.

5.2 Policy Recommendations

First, to address the imbalance in resource allocation among banks, it is essential to strengthen collaboration and sharing within the commercial banking sector. Small and medium-sized banks can jointly develop digital infrastructure, sharing technology and talent with fintech companies and industry alliances, while focusing on specialized customer segments to deepen professional financial services. Governments should provide support through subsidies and tax incentives, taking the lead in establishing sci-tech innovation alliances that offer diversified support such as equity, loans, bonds, guarantees, and insurance for startups, thereby improving the sci-tech finance ecosystem.

Second, regarding the "misjudgment" issue of risk control models toward Sci-Tech Innovation Enterprises, commercial banks need to reconstruct model logic. This involves incorporating dynamic weighting mechanisms for factors such as technological milestones and patent value appreciation, while establishing human-machine collaboration mechanisms. For instance, when R&D investment exceeds 30% of total expenditure, cases should be automatically referred to industry experts and data scientists for joint assessment, with misjudged cases being reintroduced into the training dataset in real-time to continuously enhance model accuracy.

Finally, optimized policy guidance and fund allocation can help alleviate financing inequality resulting from differentiated qualification certification. Governments should establish dynamic evaluation mechanisms, drawing inspiration from the EU's "Horizon Europe" program by employing a 13-dimensional data model incorporating intellectual property and R&D intensity to periodically reassess corporate qualifications. Additional incentives should be provided for enterprises undertaking major national science and technology projects, thereby precisely channeling innovation resources toward core technology breakthroughs. Simultaneously, a lifecycle risk-sharing mechanism should be implemented, with government guarantees covering 90% of R&D credit financing for seed-stage Sci-Tech Innovation Enterprises, gradually reducing to 70% for growing "Specialized, Sophisticated, Distinctive, and Novel" enterprises, thereby optimizing policy effectiveness through market-based risk pricing mechanisms.

Acknowledgments

This work was supported by the Fund project, 2023 Ministry of Education Industry-Academia Collaboration Project: Research on Training Models and Practices for FinTech Faculty Based on Information Technology (230805181094333).

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