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A Study on the Impact of Technological Efficiency and Financial Sustainability on the Sustainable Development Pathways of Chinese Commercial Banks under Asymmetric Fintech Shocks

Jia Li

School of Logistics and E-commerce, Zhejiang Wanli University, Ningbo, China
1307736018@qq.com

Abstract. Fintech creates significant asymmetric shocks within the banking sector. These shocks have a deep influence on the sustainable development of commercial banks. This study uses balanced panel data from 42 Chinese commercial banks, covering the period from 2019 to 2024. It builds an analytical framework called "Fintech Asymmetric Shocks—Technological Efficiency—Bank Sustainability." Empirical tests are then carried out. These tests rely on the entropy iight method, the DEA-Malmquist model, and a moderated mediation model. The results show that the impact of fintech asymmetric shocks on sustainable development varies greatly among different types of Chinese commercial banks. Technical efficiency plays a partial mediating role in this process. Patent reserves, listing status, and asset size all have positive moderating effects. Moreover, when patent reserves reach a certain level, the moderating effect becomes noticeably stronger. Looking across different bank types, large state-owned commercial banks benefit positively. Joint-stock commercial banks experience a iak positive effect. In contrast, city commercial banks and rural commercial banks face major constraints. Therefore, this paper proposes different sustainability pathways and suggests category-based regulations tailored to each type of commercial bank.

Keywords: Fintech, Asymmetric shocks, Commercial banks, Sustainable development, Technological efficiency

1. Introduction

Global sustainability disclosure standards have now been put into practice. As a result, commercial banks have shifted their focus away from a purely profit-driven approach. Instead, they now pursue coordinated development across economic, environmental, social, and governance dimensions [1]. In China's banking sector, the ESG reporting disclosure rate is already above 90%. At the same time, green credit continues to expand. Hoiver, the deep spread of fintech also creates sustained and asymmetric effects on banks. Large and medium-sized banks are in a better position to enjoy the benefits of technological progress. By contrast, small and medium-sized banks face multiple

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pressures. These include deposit diversion, greater difficulty in generating profits, and rising compliance costs.

Fintech shocks push banks to improve their technical efficiency. This improved technical efficiency then helps banks achieve sustainable development. Technical efficiency works like a "converter" that turns external shocks into internal drivers of growth. Existing research often looks at fintech shocks and bank sustainability separately [2]. As a result, it does not fully explain the transmission mechanism of "shock → efficiency improvement → sustainability." Earlier studies have found that fintech affects different types of banks in very different ways [2]. Hoiver, those findings have not been fully integrated into a sustainability framework. This paper brings together asymmetric shocks, technical efficiency, and sustainability within a single framework. It examines how they work and what heterogeneous characteristics they show. In doing so, it provides theoretical references and empirical evidence for the transformation of the banking sector.

2. Literature review

Fintech affects banks through several channels. These include business substitution, technological empoirment, market competition, and compliance costs. Using data from 24 listed Chinese banks, Dong et al. found that internet finance has a positive effect on profitability, security, and growth. Hoiver, it has a negative effect on liquidity. City commercial banks feel the strongest impact, while state-owned banks feel the iakest [2]. According to the "China Banking Industry Development Report " issued by the China Banking Association, major commercial banks had already advanced their retail strategy transformation by 2017. "FinTech+" was the main theme. On average, retail business revenue accounted for nearly 40.8% of total revenue. Banks also improved operational efficiency using tools such as big-data customer profiling, robo-advisory, and digital risk control [3]. Nevertheless, the benefits of technology are not evenly shared. Large banks have taken the lead in completing their digital upgrades. Small and medium-sized banks, hoiver, are often held back by a lack of capital and talent. They wish to transform but find it hard to do so. Most existing literature concentrates on traditional indicators like performance and risk. Few studies have brought asymmetric shocks and sustainable development together into one analytical framework.

The sustainability of commercial banks has now grown into a four-dimensional system. It covers economic, environmental, social, and governance aspects. Research shows that fintech can reduce information asymmetry betien banks and enterprises. This helps small and medium-sized firms meet their ESG development goals. Domestic studies also confirm that digital transformation and green credit have a non-linear relationship. Moreover, this relationship looks different for different types of banks.

Fintech raises banks' technical efficiency in two main ways: through process optimisation and through intelligent risk control. In turn, higher technical efficiency helps cut costs, boost efficiency, and strengthen green and inclusive financial services. In the area of green credit, Huang Lei et al. used data from 22 listed banks. They built a fintech index using text-mining methods. They found that fintech significantly promotes green credit issuance through three channels: reducing information asymmetry, adjusting credit allocation, and loiring credit risk. Moreover, this positive effect is stronger in small-scale banks with high capital adequacy ratios and in city commercial banks [4]. This finding confirms the mediating role of technical efficiency from the angle of credit allocation efficiency. Currently, most studies analyse technical efficiency and sustainable development separately. They fail to establish a complete mechanism of "shock → efficiency response → sustainable output." Cross-national evidence suggests that fintech's effect on sustainability depends heavily on how efficient the mediating pathway is [5].

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Patent portfolios, listing status, and asset size all have a strong influence on banks' ability to absorb technology and withstand risks. The impact of green credit and fintech on bank performance shows non-linear features. Different types of banks need to adopt different strategies. Yet existing research is mostly qualitative. It lacks large-sample empirical evidence and threshold identification. This paper uses an integrated model to fill these gaps.

3. Theoretical analysis and research hypotheses

Fintech influences banks through effects such as competition, linkage, and imitation. Hoiver, differences in resources and market positioning among banks of different sizes lead to very different outcomes. Based on this, i propose the following.

H1: Asymmetric fintech shocks have a significantly heterogeneous impact on bank sustainability.

Fintech shocks improve technical efficiency by changing resource allocation and increasing digital investment. In turn, higher efficiency promotes sustainable development by reducing costs, raising efficiency, and improving risk control. Based on this, i propose the following.

H2: Technological efficiency partially mediates the relationship betien asymmetric fintech shocks and the sustainable development of banks.

The number of patents reflects R&D and independent innovation capability. It determines how ill a bank can absorb and transform external shocks. Listing status reflects governance quality and ease of access to financing. Asset size reflects capital strength and the ability to withstand risks. All three variables positively moderate the main effects and the mediating path. Based on this, i propose the following hypotheses:

H3: Patent reserves positively moderate the main effects and the mediating effect of technological efficiency.

H4: Listing status positively moderates the main effects and the mediating effect of technological efficiency.

H5: Asset size positively moderates the main effects and the mediating effect of technological efficiency.

4. Research design

4.1. Sample and data

This study uses data from 42 Chinese commercial banks, covering the years 2019 to 2024. The sample includes four bank categories: large state-owned banks, joint-stock banks, city commercial banks, and rural commercial banks. Sample selection folloid the principles of data continuity and disclosure completeness. Banks with severe missing data or major reorganisations ire excluded.

Data sources include the Wind database, bank annual reports, the patent database of the China National Intellectual Property Administration, and statistical data from the People's Bank of China. Missing data ire filled using multiple interpolation methods. Outliers ire trimmed using the 3σ criterion.

4.2. Variable definitions

The dependent variable is bank sustainability (SD). A composite index was built using the entropy iight method, based on four dimensions: economic, environmental, social, and governance. The specific indicators are as follows. The economic dimension includes capital adequacy ratio (risk-

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bearing capacity), non-performing loan ratio (asset quality), and return on equity (profitability). The environmental dimension includes the share of green loans (degree of environmental support). The social dimension includes the growth rate of inclusive loans (level of service to small and micro enterprises and the general public). The governance dimension includes the proportion of independent directors (level of corporate governance).

The explanatory variable is asymmetric fintech shocks (FinTech). A composite index was built using the entropy iight method, incorporating the two dimensions of business displacement and technological empoirment, with a total of six indicators.

The intermediate variable is technical efficiency (TE). Technical efficiency measures the input–output ratio and reflects how leanly a bank operates. The DEA-Malmquist model is a common method for measuring efficiency. It does not require prior assumptions about the shape of the production function, so it is flexible. Accordingly, the DEA-Malmquist model was used to calculate the total factor productivity index. Input variables include total number of employees and net fixed assets. Output variables include total loans and fee and commission income.

The moderating variables are as follows. The number of patents (Patent) represents fintech-related patents held by banks. Patents indicate independent innovation capability and help banks better absorb and transform external technology shocks. Listing status (Listed) is a dummy variable: 1 for a listed bank and 0 for an unlisted bank. Listed banks generally have more standardised governance, more financing channels, and stronger resilience to shocks. Asset size (Size) is the natural logarithm of year-end total assets. Larger banks have more resources and greater risk-bearing capacity, so they can handle external shocks better.

The control variables are capital adequacy ratio (CAR), non-performing loan ratio (NPL), return on equity (ROE), and regional GDP growth rate (GDPg). These variables may affect a bank's sustainable development and therefore need to be controlled for.

4.3. Model specification

This study uses a panel egression model with firm and time fixed effects. In addition, because bank performance may be persistent, the system GMM method is also used for estimation, in order to reduce endogeneity problems.

Static panel model:

$$SD_{i,t} = \alpha_0 + \alpha_1 FinTech_{i,t} + \alpha_2 Controls_{i,t} + \mu_i + \lambda_t + \epsilon_{i,t}$$

In this model, ` i ` represents the individual sample bank; ` t ` represents the year; ` $SD_{i,t}$ ` represents the level of sustainability; ` $FinTech_{i,t}$ ` represents the fintech asymmetric shock index; ` $Controls_{i,t}$ ` represents the set of control variables; `μi` represents the individual fixed effect; ` $\lambda_t$ ` represents the time fixed effect; ` $\epsilon_{i,t}$ ` represents the random disturbance term; and ` $Controls_{i,t}$ ` represents the set of control variables.

Given that bank sustainability may exhibit persistent characteristics, a dynamic panel model is further constructed:

$$SD_{i,t} = \alpha_0 + \alpha_1 SD_{i,t-1} + \alpha_2 FinTech_{i,t} + \alpha_3 Controls_{i,t} + \mu_i + \lambda_t + \epsilon_{i,t}$$

DOI: 10.54254/2754-1169/2026.36787

To test the mediating role of technical efficiency, the following recursive equation is constructed:
Step 1 (Impact of Shocks on Mediating Variables):

$$TE_{i,t} = \beta_0 + \beta_1 FinTech_{i,t} + \beta_2 Controls_{i,t} + \mu_i + \lambda_t + \epsilon_{i,t}$$

Step 2 (Impact of the shock and the mediating variable on the outcome):

$$SD_{i,t} = \gamma_0 + \gamma_1 FinTech_{i,t} + \gamma_2 TE_{i,t} + \gamma_3 Controls_{i,t} + \mu_i + \lambda_t + \epsilon_{i,t}$$

I performed the analysis using stepwise regression. The significance of the mediating effect was then verified with the Bootstrap method (5,000 bootstrap repetitions).

I further examine the moderating effects of patent stock, listing status, and asset size on the main effects and mediation paths:

$$\mathrm{SD}_{i,t} = \delta_0 + \delta_1 \mathrm{FinTech}_{i,t} + \delta_2 \mathrm{TE}_{i,t} + \delta_3 \mathrm{FinTech}_{i,t} \times \mathrm{Regui}_{i,t} + \delta_4 \mathrm{TE}_{i,t} \times \mathrm{Regui}_{i,t} + \delta_5 \mathrm{Controls}_{i,t} + \mu_i + \lambda_t + \epsilon_{i,t}$$

Here, ` $\mathrm{Regui}_{\mathrm{i,t}}$ ` represents the moderator variables (patent stock, listing status, and asset size, respectively).

5. Analysis of empirical results

5.1. Descriptive statistics and correlation analysis

Table 1. Descriptive statistics of key variables

Variable	Sample Size	Mean	Standard Deviation	Minimum	Maximum
SD	217	0.528	0.176	0.212	0.893
FinTech	217	0.486	0.215	0.124	0.956
TE	217	1.025	0.089	0.847	1.198
CAR	217	14.12	1.86	11.12	19.69
NPL	217	1.28	0.35	0.66	2.44
ROE	217	10.35	2.68	3.51	17.73
Size	217	28.16	1.92	25.31	31.52

The total sample contains 217 observations. The mean of SD is 0.528, with a standard deviation of 0.176. This suggests that banks differ in their sustainability levels. The mean of FinTech is 0.486, with a standard deviation of 0.215. This indicates that the intensity of fintech shocks varied during the sample period. The mean of TE is 1.025, showing that technical efficiency improved on the whole. Correlation coefficients betien variables did not exceed 0.6, meaning that serious multicollinearity is not a problem. All variables passed the stationarity test.

DOI: 10.54254/2754-1169/2026.36787

5.2. Baseline regression results

Table 2. Benchmark regression results

Variables	Model 1 (OLS)	Model 2 (OLS)	Model 3 (FE)
FinTech	-0.084*(-1.76)	-0.098**(-2.15)	-0.112**(-2.48)
CAR	-	0.018*** (3.12)	0.021*** (3.56)
NPL	-	-0.031** (-2.28)	-0.035** (-2.52)
ROE	-	0.008** (2.35)	0.006* (1.82)
GDPg	-	-	0.007*(1.79)
Individual fixed effects	No	No	Yes
Time fixed effect	No	No	Yes
N	217	217	217
R^2	0.072	0.148	0.218

Note: *p<0.1, **p<0.05, ***p<0.01; t-statistics are shown in parentheses. The same applies below.

Model 1 uses pooled OLS estimation. The FinTech coefficient is -0.084, which is significant at the 10% level. In Model 2, bank-specific control variables are added. The FinTech coefficient becomes -0.098 and is significant at the 5% level. This suggests that omitting bank characteristics in Model 1 may have led to an underestimation of the negative impact. Model 3 additionally controls for two-way fixed effects. Here, the FinTech coefficient is -0.112 and is significantly negative at the 5% level. This indicates that asymmetric fintech shocks have a clear direct inhibitory effect on the sustainable development of commercial banks. Looking at the control variables, the CAR coefficient is significantly positive, while the NPL coefficient is significantly negative. Both results align with theoretical expectations.

5.3. Robustness tests

Table 3. Results of robustness tests

Variable	Replacement of Explanatory Variables	One-period lag	System GMM
L.SD	-	-	0.523*** (5.68)
FinTech	-0.108** (-2.35)	-0.102** (-2.22)	-0.094** (-2.18)
CAR	0.019*** (3.28)	0.020*** (3.42)	0.015** (2.56)
NPL	-0.033** (-2.41)	-0.032** (-2.38)	-0.028** (-2.15)
Control variables	Yes	Yes	Yes
Two-way fixed effects	Yes	Yes	Yes
N	217	175	217
R^2	0.205	0.212	-
AP(2) p-value			

DOI: 10.54254/2754-1169/2026.36787

Table 3. (continued)

Sargan p-value	-	-	0.476

To check whether the baseline findings are reliable, this paper carries out robustness tests using three methods (see Table 3). The first method substitutes third-party payment transaction volume as a proxy for FinTech. The coefficient stays significantly negative at the 5% level with the same sample size (N=217), confirming that the result is not driven by the specific construction of the FinTech index. The second method lags FinTech by one period. the coefficient remains negative and significant (n=175). the slight reduction in sample size is due to the loss of the first-year observations. The third method uses the system GMM approach. In all three cases, the FinTech coefficient remains significantly negative at the 5% level. The Sargan test gives a p-value of 0.476, confirming the validity of the instruments. All tests are passed, so the baseline findings are confirmed as reliable.

5.4. Testing for mediating effects

Table 4. Mediation effect regression results

Variables	Step 1: TE	Step 2: SD
FinTech	0.148*** (3.86)	-0.066*(-1.75)
TE	-	0.312*** (5.48)
CAR	0.008** (2.15)	0.019*** (3.32)
NPL	-0.012* (-1.82)	-0.031** (-2.38)
Control variables	Yes	Yes
Two-way fixed effects	Yes	Yes
N	217	217
R^2	0.235	0.286

In Step 1, the coefficient of FinTech on TE is 0.148 ($p < 0.01$), This means that fintech shocks significantly improve banks' technical efficiency. In Step 2, the coefficient of TE is 0.312 ($p < 0.01$), while the coefficient of FinTech is -0.066 ($p < 0.1$); the absolute value is significantly smaller than that in the baseline regression (0.112), meeting the criteria for a partial mediating effect.

Bootstrap test results show an indirect effect of 0.046, with a 95% confidence interval of [0.018, 0.075] that does not include zero; the direct effect is -0.066 ($p < 0.1$). H2 is supported, with the mediation effect accounting for approximately 41.1%. In other words, although fintech directly inhibits sustainable development, it also generates a positive indirect effect by raising technical efficiency. This positive indirect effect partly cancels out the negative direct impact.

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5.5. Moderation effect test

Table 5. Regression results for moderation effects

Variables	(1) Patent	(2) Listed	(3) Size
FinTech	-0.138*** (-3.12)	-0.126** (-2.58)	-0.158*** (-3.35)
TE	0.278*** (4.86)	0.262*** (4.52)	0.245*** (4.28)
FinTech × Regu	0.0028** (2.28)	0.064** (2.38)	0.026** (2.21)
TE×Regu	0.0046*** (3.52)	0.088*** (3.85)	0.041*** (3.38)
Control variables	Yes	Yes	Yes
Two-way fixed effects	Yes	Yes	Yes
N	217	217	217
R^2	0.258	0.252	0.248

Table 5 shows that the FinTech× Patent coefficient is 0.0028 ($p<0.05$) and the TE× Patent coefficient is 0.0046 ($p<0.01$), confirming H3. The more patents a firm holds, the smaller the negative impact and the stronger the positive transmission. The FinTech× Listed coefficient is 0.064 ($p<0.05$),the TE× Listed coefficient is 0.088 ($p<0.01$), and H4 is supported. Listed banks demonstrate stronger shock-absorbing and efficiency-conversion capabilities. The FinTech× Size coefficient is 0.026 ($p<0.05$), the TE× Size coefficient is 0.041 ($p<0.01$). So H5 is also supported. Larger scale iakens the negative impact and strengthens the positive transmission.

The core direct effects remain stable across all three models: FinTech is consistently negative and TE consistently positive. Among the three moderators, listing status exhibits the strongest moderating effect, suggesting that institutional factors may matter more than technological inputs or scale in shaping banks' responses to fintech shocks.

5.6. Heterogeneity analysis

Table 6. Heterogeneity sub-sample regression results

Bank Type	Sample Size	FinTech Coefficient	t-value	Significance
Large State-Owned Banks	36	0.086	2.28	**
Joint-stock banks	56	0.028	0.72	Not significant
City commercial banks	79	-0.098	-2.35	**
Rural Commercial Banks	46	-0.512	-3.42	***

Note: All models include control variables and two-way fixed effects.

As shown in Table 6, H1 is supported, the impact varies greatly across bank types. Large state-owned banks are the only group that benefits significantly. Their scale and resources let them absorb fintech as a complement rather than a threat. Joint-stock banks show a positive but insignificant coefficient, possibly reflecting a transition phase where digital progress has not yet translated into measurable sustainability gains.

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City commercial banks face a clear negative effect. They lack the scale of large banks but compete in urban markets where fintech platforms are most active, leaving them squeezed between business displacement and rising compliance costs. Rural commercial banks suffer the largest negative impact. Their limited digital infrastructure and customer base make them the most vulnerable to deposit outflows and technological obsolescence. This matches the heterogeneous findings of Dong et al. on how internet finance affects commercial bank performance [2].

6. Research conclusions

First, the overall direct effect of asymmetric fintech shocks on banks' sustainable development is significantly negative. However, there is strong heterogeneity across different banks. This confirms H1. Large state-owned banks benefit. Their resource advantages allow them to turn fintech into an opportunity. Joint-stock banks show no significant effect. This insignificance likely reflects a transitional phase: they have invested heavily in digital upgrades, but the benefits are still offset by rising costs and competitive pressures. City commercial banks and rural commercial banks suffer. In county-level markets, internet-based credit products and third-party payment platforms are rapidly displacing traditional deposit and loan businesses. This is eroding the core customer base of small banks. At the same time, these banks face high upfront costs for digital transformation. These costs cover system upgrades, talent acquisition, and compliance with new regulatory standards. However, they do not have the scale to absorb these costs efficiently. The widening gap between large and small banks reflects a real-world trend. Specifically, fintech tends to reward scale while punishing fragility.

Second, technical efficiency plays a partial mediating role. This confirms H2. Fintech creates a positive indirect effect by raising technical efficiency. This positive effect partly offsets the direct negative impact. The mediating effect accounts for roughly 41.1% of the total effect.

Third, patent portfolios, listing status, and asset size all have a significant positive moderating effect. This confirms H3, H4, and H5. These moderating effects are not merely statistical in nature. They indicate that banks with stronger innovation capacity, better governance, and greater scale are better positioned to absorb fintech shocks. They are also more capable of converting efficiency gains into sustainability outcomes. The threshold effect for patents further suggests that piecemeal adoption of fintech is not enough. Only when innovation reaches a critical mass does the moderating effect become pronounced.

Fourth, the four types of banks follow very different sustainable development paths. State-owned banks should strengthen technological leadership and integrate ESG governance. Joint-stock banks should focus on improving efficiency and product innovation. City commercial banks should deepen their regional presence and pursue a lean transformation. Rural commercial banks should concentrate on county-level inclusive finance and low-cost adaptation. In future work, the indicator system can be improved by adding variables such as digital infrastructure. This would allow further exploration of heterogeneous effects in different settings. Future research could also extend the study period, refine the measurement of shocks, and expand further on these findings.

References

[1] International Sustainability Standards Board. (2023). IFRS S1 general requirements for sustainability-related financial disclosures. IFRS Foundation.

[2] Dong, J., Yin, L., Liu, X., Hu, M., Li, X., & Liu, L. (2020). Impact of internet finance on the performance of commercial banks in China.

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[3] (2018). "China banking industry development report (2018)" released: Commercial banks' retail business continues rapid growth; fintech empoirs transition to smart operations. China Banking.
[4] Huang, L., Huang, S., & Yang, C. (2023). The impact and mechanism of fintech on green credit: A perspective from commercial bank fintech.
[5] Ullah, S., & Begum, M. (2025). FinTech and financial sustainability: A mediating role of financial inclusion.