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Implications of Fintech Developments for Traditional Banks

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ABSTRACT

As financial technology has developed, the Chinese government has deregulated banks. The first Internet-only bank was established in 2014, but the effects of Internet-only banking on traditional banks remain unclear. However, we discussed two stages (2009-2014; 2015-2018), namely before and after the entry of Internet-only banking into the financial market. Data envelopment analysis and regression methods were used to evaluate efficiency and performance and observe changes between banks in different periods, of 20 banks. The highlights of our findings are as follows: First, overall bank efficiency has improved since Internet-only banking entered the financial market. Second, in the era of low-interest spreads, banks are diversifying operational income while improving performance and efficiency. Furthermore, with the development of FinTech and competitive pressure, banks should downsize to strengthen their competitiveness and improve their internal environments. Finally, operating income generated by employees has increased, but profits have decreased, implying that employees are highly skilled and efficient. Thus, banks may be required to offer higher salaries, which reduce profits.

Keywords: Internet-only Bank, Network DEA, Bank Efficiency, Bank Performance
JEL Classifications: G19, G20, G29

1. INTRODUCTION

In China, because of the lack of financial universality, individuals, small- and medium-sized enterprises (SMEs), and rural areas have difficulties obtaining loans from traditional banks. However, financial technology (FinTech) has developed to provide various financial services on the Internet. This not only changes the business model of traditional banks but also creates an emerging industry of Internet-only banks, which have no physical branches, and all financial services are conducted online or through mobile channels.

China's Internet-only banking has its own ecosystem. Alibaba Group, which owns the Taobao and Tmall shopping platforms, provides financial services on Alipay. The group founded MYBank in 2015. In addition, Tencent Group owns WeChat, which is the most widely used communication software in China, and founded WeBank in 2014. These two groups not only have numerous customers and diverse types of business services but also integrate logistical services, gold flow, and information flow to form a complete operating ecosystem. In addition, by offering innovative financial services that combine artificial intelligence and big data to perform accurate analyses, these Internet-only banks provide customers with more convenient services to achieve inclusive finance.

Under the Chinese government's reforms, the deregulation and opening of new banks can improve performance, enhance efficiency, and provide diverse financial services in competitive financial markets. Moreover, the banking industry has begun to focus on introducing new financial technologies and innovations to increase their market share and enhance profitability as costs increase (Zhao et al., 2010; Fries and Taci, 2005; Lensink and Hermes, 2004). Studies have compared the efficiency of state-owned and private banks and discussed the effects of foreign banks entering a country on the performance of domestic

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banks. However, few have analyzed the effects on traditional and Internet-only banks by using empirical evidence. Thus, this was our research purpose. After Internet-only banks entered the financial industry, we focused on the following topics: (1) Whether overall efficiency can be improved through competition, (2) which financial indicators have changed profits during financial reform, and (3) whether the main profit source for banks will shift from interest on loans to noninterest income as the financial market diversifies.

We not only focused on bank efficiency but also observed performance changes in different periods. This study analyzed efficiency by using data envelopment analysis (DEA) and evaluated performance by using financial indicators in a regression to identify main impact variables. We obtained four conclusions regarding banking after Internet-only banking entered the financial market. First, banks' overall efficiency has improved, particularly in profitability efficiency. Regarding efficiency decomposition, the efficiency of employees has improved and has greatly increased profitability efficiency. Second, noninterest income positively affects banks' efficiency and performance. This indicates that in the era of low-interest spreads, banks are diversifying operational income while improving performance and efficiency. Third, operating income generated by employees has increased, but profits have decreased, indicating that employees are highly skilled and efficient. In other words, banks may be required to offer higher salaries, which reduce profits. Finally, bank size significantly increased return on equity (ROE) in 2009-2014. However, after Internet-only banking entered the financial market, bank size has considerably reduced both return on assets (ROA) and *Z*-scores. Thus, banks should downsize to strengthen their competitiveness, improve performance, and reduce operational risk.

This paper is organized as follows. Section 2 reviews the literature on Internet-only banking, bank efficiency and performance. Section 3 discusses the empirical methodology and data. Section 4 presents the results of the empirical analysis, and Section 5 concludes.

2. LITERATURE REVIEW

China's banking system is dominated by four major state-owned banks, commercial banks, and numerous regional banks. Internet-only banks entered the banking industry in 2014, and they employ technology to provide convenient and rapid financial services to customers. This paper not only uses DEA to evaluate the efficiency but also uses regression to estimate the performance of traditional and Internet-only banks. This analysis can improve management decisions.

2.1. Internet-only Bank

The advancement of network technology has not only changed people's lives and habits but also accelerated the digital transformation of enterprises. Currently, the new industry of Internet-only banking is emerging. The entrance of new banks in the market may increase peer competition, which may reduce profits. However, new banks introduce advanced technology to diversify risks and deepen financial reforms (Detragiache et al., 2008). Furthermore, the banking industry can effectively control operations and reduce costs through digitization strategies (Malhotra and Singh, 2009). Although the deregulation of the banking system and diversification of bank types have caused competition pressure, they may improve efficiency in the financial market (Sturm and Williams, 2004).

Banks not only improve customer service but also strengthen customer relationships through new technologies. Some studies have demonstrated the consumer benefits of Internet-only banking. Ahn and Lee (2019) indicated that because Internet-only banks have no physical branches, all transactions are completed online. Therefore, they provide high interest rates and low lending rates, and consumers enjoy using their financial services. DeYoung (2005) demonstrated that Internet-only banking can enter new geographic markets through the Internet, not only providing consumers with quality services but also increasing their growth potential. As the banking business model gradually changes, digital technology has a growing role in providing professional services and financial products to banks to enhance profitability and customer loyalty.

2.2. DEA Methodology

Conventional DEA uses only inputs and outputs without considering the structure of the transformational process. However, some studies have adopted two-stage network systems to estimate bank efficiency and identify competitive advantages (Sturm and Williams, 2004; Fries and Taci, 2005; Lensink et al., 2008; Cook et al., 2010; Kanghwa, 2010; Holod and Lewis, 2011; Yang and Liu, 2012; Fukuyama and Matousek, 2011; 2017). In this two-stage network, inputs in the first stage produce intermediate products, which become inputs for the second stage that produces the final output. Most studies have measured profitability efficiency by using employees, assets, capital, operation costs, and other factors as inputs. Intermediate products include profits and deposits, and outputs include net interest income, noninterest income, loans, and profits. Thus, variables can change when considering different dimensions of banking performance (Yang and Liu, 2012).

After economic reform, the Chinese government allowed foreign and domestic private banks to enter its market. Sturm and Williams (2004) indicated that after deregulation, bank types and services have gradually diversified through competition to increase profits and efficiency. This result is consistent with our findings. Fries and Taci (2005) and Yang and Liu (2012) have presented evidence of higher efficiency in private banks than in state-owned banks. However, we demonstrated that state-owned banks are the most efficient. These banks are large and abide by national policies. In other words, when the government enacts policies, state-owned banks must rapidly implement and achieve their goals. Therefore, they are more efficient than other bank types.

2.3. Measuring Bank Performance

The financial ratio is a crucial indicator of a company's operating ability and profitability. As in the previous literature (Boubakri et al., 2017; Kabajeh et al., 2012; Sufian and Habibullah, 2009), we adopted the profitability indicators of ROA and ROE to measure bank performance. Japparova and Rupeika-Apoga (2017) argued

that new devices and FinTech are changing business models in the finance industry. In a highly competitive environment, bank risk must be considered. The *Z*-score model can be a main or supporting tool for predicting bankruptcy and financial distress in both academic and practical settings (Altman et al., 2017). Therefore, we adopted *Z*-scores as a proxy for system risk (Li et al., 2017). Higher *Z*-scores indicate that a bank's assets are more secure and that it has a low bankruptcy rate and operating risk. We argued that after Internet-only banks enter the financial market, banks should downsize to reduce operational risks.

During the 2008 financial crisis, the central banks of various countries adopted quantitative easing policies to stabilize their economies by adjusting interest rates. However, these policies reduced bank profits and interest rate spreads. Currently, bankers regard value-added mobile services as a business opportunity for providing flexible customer services and increasing revenues by charging fees and financial transferring (Japparova and Rupeika-Apoga, 2017). Therefore, numerous studies have explored the effects of noninterest income on bank performance. Stiroh and Rumble (2006) demonstrated that noninterest income activities increase earnings volatility and reduce profits after risk adjustment. Hayden et al. (2007) concluded that diversified returns are decreased for low- and moderate-risk banks but are improved for high-risk banks. By contrast, Edirisuriya et al. (2015) determined that banks have improved risk–return profiles as a result of diversification. However, our results indicated that noninterest income improved bank performance between 2015 and 2018.

3. EMPIRICAL MODEL AND DATA

3.1. DEA Model

DEA is a management tool for evaluating inefficiencies and potential improvement factors (Yang and Liu, 2012). In this approach, costs and profits are inputs and outputs, respectively. To clarify whether deposits are defined as an input or output, some studies have introduced a two-stage network system that treats deposits as an intermediate product in a bank's production process, thus overcoming problems in production. (Fukuyama and Matousek, 2017). Moreover, this intermediary approach considers the complete costs of the banking industry (Yildirim, 2002). Thus, the current analysis included three inputs and four outputs. The number of employees, size, and total assets of a bank were productivity-stage, the output of which was deposits. Deposits formed the intermediary item that became the second-stage input in capital conversion. Outputs were loans, net interest income, commission income, and net profit before tax. The result of the outputs was profitability efficiency. Table 1 describes the contents of each variable.

We adopted the measure methodology proposed by Yang and Liu (2012). Decision-making units (*DMUs*) represent individual banks. For any DMU_j (j=1…n), the model uses m inputs x_{ij} (i=1…m) in the first stage and produces intermediate items of z_{pj} (p=1…q). These z_{pj} outputs then become inputs for the second stage, and the second-stage outputs are y_{rj} (r=1…s). Yang and Liu (2012) suggested that the evaluation model must be composed of a series of relationships between the whole system and the two

Table 1: Variable definition for input, intermediate and output

Variable	Description
Input	
Employees	Number of workers
Size	Natural logarithm of total assets
Total asset	Total loans, investments, reserves, and other items
Intermediate item	
Deposits	Total corporate and personal deposits
Output	
Commission income	Total income from credit card, cash management, and other fees
Net interest income	Interest income minus interest expenses
Total loan	Total loans, discounted notes, and other items
Net profit before tax	Operating income minus total expenses

corresponding stages. In other words, overall efficiency must be the product of two-stage efficiencies. On this basis, the overall efficiency model measure is denoted as

$$\theta_k = max\sum_{r=1}^{s} u_r y_{rk} / \sum_{i=1}^{m} v_i x_{ik}$$

$$= max\left[\sum_{p=1}^{q}\gamma_p z_{pk} / \sum_{i=1}^{m} v_i x_{ik} \times \sum_{r=1}^{s} u_r y_{rk} / \sum_{p=1}^{q}\gamma_p z_{pk}\right]$$

$$\text{s.t.} \sum_{r=1}^{s} u_r y_{rj} / \sum_{i=1}^{m} v_i x_{ij} \le 1, j = 1,\ldots,n$$

$$\sum_{p=1}^{q}\gamma_p z_{pj} / \sum_{i=1}^{m} v_i x_{ij} \le 1, j = 1,\ldots,n$$

$$\sum_{r=1}^{s} u_r y_{rj} / \sum_{p=1}^{q}\gamma_p z_{pj} \le 1, j = 1,\ldots,n$$

$$u_r, \gamma_p, v_i \ge \varepsilon > 0 \quad r = 1,\ldots,s; i = 1,\ldots,m; p = 1,\ldots,q \qquad (1)$$

where θ_k is the overall efficiency of DMU_k. Here, m denotes an input that produces an s output for each DMU, and the intermediate product is z_{pj}.

Because z_{pj} is the output of the first stage, it is the input for the second stage. The stage efficiency model is expressed as

$$\theta_k^1 = max\sum_{p=1}^{q}\gamma_p z_{pk} / \sum_{i=1}^{m} v_i x_{ik}$$

$$\text{s.t.} \sum_{r=1}^{s} u_r y_{rj} / \sum_{i=1}^{m} v_i x_{ij} = \theta_k$$

$$\sum_{r=1}^{s} u_r y_{rj} / \sum_{i=1}^{m} v_i x_{ij} \le 1, j = 1,\ldots,n$$

$$\sum_{p=1}^{q}\gamma_p z_{pj} / \sum_{i=1}^{m} v_i x_{ij} \le 1, j = 1,\ldots,n$$

$$\sum_{r=1}^{s} u_r y_{rj} / \sum_{p=1}^{q}\gamma_p z_{pj} \le 1, j = 1,\ldots,n$$

$$u_r, \gamma_p, v_i \ge \varepsilon > 0 \quad r = 1,\ldots,s; i = 1,\ldots,m; p = 1,\ldots,q \quad (2)$$

$$\theta_k^2 = max\sum_{r=1}^{s} u_r y_{rk} / \sum_{p=1}^{q}\gamma_p z_{pk}$$

$$\text{s.t.} \sum_{r=1}^{s} u_r y_{rj} / \sum_{i=1}^{m} v_i x_{ij} = \theta_k$$
$$\sum_{r=1}^{s} u_r y_{rj} / \sum_{i=1}^{m} v_i x_{ij} \le 1, j = 1, \ldots, n$$
$$\sum_{p=1}^{q} \gamma_p z_{pj} / \sum_{i=1}^{m} v_i x_{ij} \le 1, j = 1, \ldots, n$$
$$\sum_{r=1}^{s} u_r y_{rj} / \sum_{p=1}^{q} \gamma_p z_{pj} \le 1, j = 1, \ldots, n$$
$$u_r, \gamma_p, v_i \ge \varepsilon > 0 \quad r = 1, \ldots, s; i = 1, \ldots, m; p = 1, \ldots, q \quad (3)$$

For each DMU, θ_k^1 and θ_k^2 are the first and second stages of measuring efficiency, respectively.

3.2. Regression Model

Since economic deregulation in China, banks have increased their competitiveness while focusing on risk assessment. Therefore, we analyzed the relationship among bank efficiency, performance, risk, and financial indicators. Selected variables that may affect bank efficiency, performance, and risk are displayed in Table 2. The linear regression model is defined as follows:

$$\begin{aligned} \ln(\mu)_{it} &= \alpha + \beta_1 ln(\text{Income diversification})_{it} + \\ &\beta_2 ln(\text{Loan to asset ratio})_{it} + \beta_3 ln(\text{Profit margin ratio})_{it} + \\ &\beta_4 ln(\text{Asset turnover ratio})_{it} + \beta_5 ln(\text{Size})_{it} + \\ &\beta_6 ln(\text{Revenue per employee})_{it} + \varepsilon_{it} \end{aligned} \quad (4)$$

Where μ represents the overall and profitability efficiency, *i* denotes an individual bank, *t* refers to year, and ε is the disturbance term.

$$\begin{aligned} \ln(\varphi)_{it} &= \alpha + \beta_1 ln(\text{Income diversification})_{it} + \\ &\beta_2 ln(\text{Loan to asset ratio})_{it} + \beta_3 ln(\text{Profit margin ratio})_{it} + \\ &\beta_4 ln(\text{Asset turnover ratio})_{it} + \beta_5 ln(\text{Size})_{it} + \\ &\beta_6 ln(\text{Revenue per employee})_{it} + \varepsilon_{it} \end{aligned} \quad (5)$$

Where ϕ represents ROA, ROE and Z-score, *i* denotes an individual bank, *t* refers to year, and ε is the disturbance term.

3.3. Data

China's banking information is incomplete and difficult to collect from public databases. Thus, data were collected mainly from bank financial statements. Regarding traditional banks, the research sample included four large state-owned banks, nine commercial banks, and five regional banks in China. However, the selection of commercial and regional banks depended on the completeness of their financial statements. Banks with incomplete financial statements were not included in the sample. A total of 20 Chinese banks comprised the sample for analysis and included WeBank and MYBank, which represented Internet-only banks (Table 3). Changes were examined in two periods: 2009-2014 and 2015-2018.

4. EMPIRICAL RESULTS

4.1. Descriptive Statistics

ROA and ROE decreased from 2015 to 2018, but *Z*-scores increased, as reported in Table 4. Regarding financial indicators, noninterest income increased, indicating that bank managers changed bank operations. In addition, the operating income generated per employee was higher in 2015-2018 than in 2009-2014.

4.2. Bank Efficiency Analysis

This study was conducted in two parts. First, the efficiency of traditional banks from 2009 to 2014 was analyzed. We then analyzed the effects of Internet-only banks entering the financial market in terms of overall bank efficiency from 2015 to 2018. Efficiency analysis results are presented in Tables 5 and 6. For 2009-2014, we obtained average scores of 0.628, 0.952, and 0.660

Table 2: Variable definition for measuring bank efficiency and performance

Variable	Description
Dependent	
Efficiency	
Overall efficiency	Productivity efficiency×Profitability efficiency
Profitability efficiency	Output variables include: commission income, net interest income, total loans and net profit before tax
Performance	
ROA	Return on total assets
ROE	Return on shareholder equity
Z-score	$Z\text{-}score_{it}=(ROA_{it}+E/A_{it})/\sigma ROA_i$
Independent	
Income diversification	Ratio of noninterest income to operating revenue
Loan-to-asset ratio	Measure of liquidity and default risk
Profit margin ratio	Ratio of before-tax profit to operating revenue
Asset turnover ratio	Ratio of operating revenue to total assets
Size	Natural logarithm of total assets
Revenue per employee	Ratio of operating revenue to number of employees

We used the Z-score method described by Munteanu (2012) for evaluating bank risk, where E/A_{it} is the ratio of equity to total assets. High Z-scores indicate low risk for a bank. By contrast, high-risk banks have low Z-scores

Table 3: Sample of 20 Chinese banks

No.	Bank name	Type of bank
01	Shanghai Pudong Development Bank	Joint-stock commercial bank
02	Industrial and Commercial Bank of China	Large state-owned bank
03	China Minsheng Bank	Joint-stock commercial bank
04	China Everbright Bank	Joint-stock commercial bank
05	Agricultural Bank of China	Large state-owned bank
06	China Construction Bank	Large state-owned bank
07	China Citic Bank	Joint-stock commercial bank
08	Bank of China	Large state-owned bank
09	Bank of Beijing	Regional bank
10	Bank of Ningbo	Regional bank
11	Ping An Bank	Joint-stock commercial bank
12	Bank of Communications	Joint-stock commercial bank
13	Industrial Bank	Joint-stock commercial bank
14	Hua Xia Bank	Joint-stock commercial bank
15	China Merchants Bank	Joint-stock commercial bank
16	Bank of Nanjing	Regional bank
17	Bank of Hangzhou	Regional bank
18	Bank of Jiangsu	Regional bank
19	WeBank	Internet-only bank
20	MyBank	Internet-only bank

for overall, productivity, and profitability efficiency, respectively. However, although production efficiency (0.915) decreased, both overall efficiency (0.761) and profit efficiency (0.832) improved significantly in 2015-2018. Industrial and Commercial Bank of China (ICBC) was the most efficient in both 2009-2014 and 2015-2018, indicating that under the Chinese government's financial reforms, state-owned banks have adopted policy-oriented business practices and effective resource inputs that have improved performance in all aspects of operations. However, regional banks in the overall sample were generally inefficient.

Table 4: Descriptive statistics

Variable	Minimum	Maximum	Median	Std. dev.
Date: 2009-2014				
ROA	0.005	0.065	0.011	0.005
ROE	0.129	1.152	0.195	0.096
Z-Score	4.497	13.514	7.86	1.295
Income diversification	0.09	0.95	0.38	0.191
Loan-to-asset ratio	0.305	0.619	0.504	0.065
Profit margin ratio	21.95	47.32	37.81	4.544
Asset turnover ratio	0.02	0.037	0.028	0.004
Revenue per employee	0.5	3.55	1.715	0.568
Date: 2015-2018				
ROA	(0.092)	0.022	0.009	0.012
ROE	(0.241)	0.207	0.139	0.052
Z-Score	6.55	17.785	8.617	1.816
Income diversification	0.0004	2.78	0.585	0.394
Loan-to-asset ratio	0.241	0.602	0.497	0.084
Profit margin ratio	(258.41)	41.29	33.235	33.760
Asset turnover ratio	0.008	0.083	0.027	0.010
Revenue per employee	0.33	11.34	2.34	1.614

Negative values denoted in parentheses; MYBank entered the financial market in 2015, resulting in negative profits

From 2009 to 2014, four major state-owned banks had higher overall efficiency (valuations between 0.859 and 0.912), whereas regional banks, such as Bank of Nanjing (0.263), Bank of Hangzhou (0.237) and Bank of Jiangsu (0.211), were mostly inefficient. However, the productivity efficiency of Bank of China (0.938, ranked 12th) was lower than that of regional and commercial banks. To understand how efficiency changed, we analyzed the contributions of variables to efficiency by performing a variable decomposition of inputs and outputs. Employees at banks such as Bank of Beijing, Shanghai Pudong Development Bank, and Bank of Nanjing were highly efficient. Therefore, Bank of China had space for improving staff efficiency by 6.2%.

We observed changes during the post-Internet-only bank period of 2015-2018 (Table 6). The overall efficiency of state-owned banks (Agricultural Bank of China and Bank of Communications) declined, whereas commercial banks (China Merchants Bank and Ping An Bank) improved in efficiency, ranking third and fifth, respectively. These changes were due to substantial changes in commission income efficiency. The efficiency of Internet-only banking was a main concern of this study. In the productivity stage, MYBank's staff efficiency (0.893, ranked first) was higher than that of other banks, indicating that in the FinTech era, Internet-only banks tend to hire information technology (IT) professionals to reduce resource waste and enhance customer satisfaction. Moreover, in the profitability stage, WeBank's commission income (0.662) was more efficient than that of Bank of China (0.601), Agricultural Bank of China (0.436), commercial banks (Shanghai Pudong Development Bank, China Citic Bank, Bank of Communications and Hua Xia Bank), and regional banks (Bank of

Table 5: Efficiency scores and decomposition: 2009-2014

Bank	Overall efficiency	Productivity efficiency	Efficiency decomposition			Profitability efficiency	Efficiency decomposition			
			Employees	Size	Total asset		Commission income	Net interest income	Total Loan	Net profit before tax
01	0.758 (9)	0.979 (6)	0.869 (3)	0.844 (16)	0.826 (10)	0.775 (10)	0.247 (14)	0.680 (10)	0.690 (8)	0.672 (8)
02	0.912 (1)	0.996 (1)	0.875 (2)	0.963 (1)	0.992 (1)	0.915 (2)	0.815 (1)	0.855 (3)	0.837 (3)	0.907 (1)
03	0.787 (7)	0.920 (15)	0.588 (14)	0.845 (15)	0.812 (12)	0.855 (7)	0.615 (5)	0.774 (4)	0.689 (9)	0.744 (5)
04	0.591 (12)	0.908 (16)	0.573 (15)	0.851 (12)	0.786 (14)	0.651 (12)	0.402 (9)	0.542 (12)	0.573 (12)	0.571 (12)
05	0.859 (4)	0.991 (4)	0.612 (11)	0.927 (6)	0.986 (2)	0.867 (5)	0.579 (6)	0.859 (2)	0.719 (7)	0.652 (9)
06	0.904 (2)	0.996 (1)	0.867 (4)	0.932 (5)	0.975 (3)	0.908 (3)	0.813 (2)	0.866 (1)	0.830 (4)	0.898 (2)
07	0.777 (8)	0.988 (5)	0.812 (7)	0.847 (13)	0.870 (6)	0.786 (9)	0.313 (11)	0.672 (11)	0.744 (6)	0.627 (11)
08	0.879 (3)	0.938 (12)	0.824 (6)	0.902 (8)	0.861 (8)	0.937 (1)	0.720 (3)	0.746 (7)	0.934 (1)	0.820 (3)
09	0.360 (14)	0.993 (3)	0.974 (1)	0.878 (9)	0.802 (13)	0.363 (14)	0.165 (17)	0.297 (14)	0.218 (17)	0.363 (13)
10	0.284 (15)	0.944 (11)	0.604 (12)	0.943 (4)	0.727 (16)	0.300 (15)	0.300 (12)	0.255 (16)	0.254 (15)	0.257 (16)
11	0.655 (11)	0.898 (17)	0.431 (18)	0.866 (10)	0.594 (18)	0.729 (11)	0.628 (4)	0.703 (9)	0.657 (10)	0.629 (10)
12	0.837 (5)	0.926 (13)	0.684 (9)	0.843 (17)	0.815 (11)	0.903 (4)	0.361 (10)	0.758 (6)	0.897 (2)	0.719 (7)
13	0.724 (10)	0.892 (18)	0.564 (16)	0.839 (18)	0.682 (17)	0.811 (8)	0.458 (8)	0.764 (5)	0.600 (11)	0.803 (4)
14	0.447 (13)	0.921 (14)	0.560 (17)	0.865 (11)	0.828 (9)	0.485 (13)	0.195 (16)	0.465 (13)	0.389 (13)	0.320 (14)
15	0.822 (6)	0.957 (9)	0.656 (10)	0.846 (14)	0.873 (5)	0.859 (6)	0.541 (7)	0.730 (8)	0.781 (5)	0.741 (6)
16	0.263 (16)	0.957 (9)	0.833 (5)	0.947 (3)	0.778 (15)	0.275 (16)	0.275 (13)	0.260 (15)	0.259 (14)	0.261 (15)
17	0.237 (17)	0.961 (8)	0.812 (7)	0.956 (2)	0.866 (7)	0.246 (17)	0.246 (15)	0.244 (17)	0.244 (16)	0.244 (17)
18	0.211 (18)	0.967 (7)	0.594 (13)	0.907 (7)	0.936 (4)	0.218 (18)	0.150 (18)	0.206 (18)	0.137 (18)	0.209 (18)
Avg.	0.628	0.952	0.707	0.889	0.834	0.660	0.435	0.593	0.581	0.580

Values in parentheses are efficiency rankings

Table 6: Efficiency scores and decomposition: 2015-2018

Bank	Overall efficiency	Productivity efficiency	Efficiency decomposition			Profitability efficiency	Efficiency decomposition			
			Employees	Size	Total asset		Commission income	Net interest income	Total Loan	Net profit before tax
01	0.866 (7)	0.891 (14)	0.825 (8)	0.662 (15)	0.683 (17)	0.972 (6)	0.658 (9)	0.744 (7)	0.869 (4)	0.883 (4)
02	0.972 (1)	0.972 (5)	0.853 (6)	0.950 (1)	0.972 (2)	1.000 (1)	0.951 (1)	0.921 (1)	0.953 (3)	0.950 (1)
03	0.834 (9)	0.848 (17)	0.723 (11)	0.662 (15)	0.700 (16)	0.984 (4)	0.897 (3)	0.607 (12)	0.783 (10)	0.792 (6)
04	0.760 (12)	0.878 (16)	0.685 (15)	0.659 (18)	0.747 (12)	0.865 (13)	0.702 (6)	0.575 (14)	0.774 (11)	0.701 (8)
05	0.874 (6)	0.992 (1)	0.635 (17)	0.889 (2)	0.992 (1)	0.882 (10)	0.436 (13)	0.849 (3)	0.820 (7)	0.682 (12)
06	0.962 (2)	0.970 (7)	0.877 (4)	0.889 (2)	0.956 (3)	0.992 (3)	0.796 (4)	0.878 (2)	0.972 (2)	0.869 (5)
07	0.845 (8)	0.971 (6)	0.888 (3)	0.672 (12)	0.788 (8)	0.871 (11)	0.648 (10)	0.619 (11)	0.801 (8)	0.612 (14)
08	0.907 (4)	0.926 (12)	0.839 (7)	0.843 (5)	0.910 (4)	0.980 (5)	0.601 (11)	0.718 (8)	0.973 (1)	0.761 (7)
09	0.786 (11)	0.973 (4)	0.889 (2)	0.659 (18)	0.710 (15)	0.808 (14)	0.317 (16)	0.631 (10)	0.727 (13)	0.701 (8)
10	0.531 (18)	0.804 (18)	0.473 (18)	0.682 (9)	0.729 (13)	0.661 (17)	0.343 (15)	0.542 (15)	0.511 (18)	0.639 (13)
11	0.886 (5)	0.946 (9)	0.693 (13)	0.663 (14)	0.838 (6)	0.937 (7)	0.751 (5)	0.766 (5)	0.730 (12)	0.595 (15)
12	0.820 (10)	0.943 (10)	0.869 (5)	0.694 (7)	0.778 (9)	0.870 (12)	0.396 (14)	0.585 (13)	0.838 (5)	0.684 (11)
13	0.717 (14)	0.775 (20)	0.696 (12)	0.656 (20)	0.611 (18)	0.926 (8)	0.683 (7)	0.761 (6)	0.714 (14)	0.894 (3)
14	0.689 (15)	0.777 (19)	0.389 (20)	0.660 (17)	0.773 (10)	0.887 (9)	0.535 (12)	0.674 (9)	0.831 (6)	0.700 (10)
15	0.951 (3)	0.955 (8)	0.806 (9)	0.681 (10)	0.839 (5)	0.996 (2)	0.950 (2)	0.832 (4)	0.788 (9)	0.897 (2)
16	0.593 (17)	0.985 (2)	0.769 (10)	0.679 (11)	0.816 (7)	0.603 (18)	0.115 (19)	0.536 (16)	0.439 (19)	0.573 (16)
17	0.487 (19)	0.887 (15)	0.685 (15)	0.690 (8)	0.725 (14)	0.548 (19)	0.009 (20)	0.425 (19)	0.513 (17)	0.335 (19)
18	0.631 (16)	0.927 (11)	0.689 (14)	0.666 (13)	0.752 (11)	0.681 (16)	0.175 (18)	0.492 (17)	0.647 (15)	0.507 (17)
19	0.728 (13)	0.914 (13)	0.427 (19)	0.851 (4)	0.604 (19)	0.797 (15)	0.662 (8)	0.456 (18)	0.602 (16)	0.401 (18)
20	0.381 (20)	0.976 (3)	0.893 (1)	0.834 (6)	0.544 (20)	0.390 (20)	0.290 (17)	0.384 (20)	0.349 (20)	0.298 (20)
Avg.	0.761	0.915	0.730	0.732	0.773	0.832	0.546	0.650	0.732	0.674

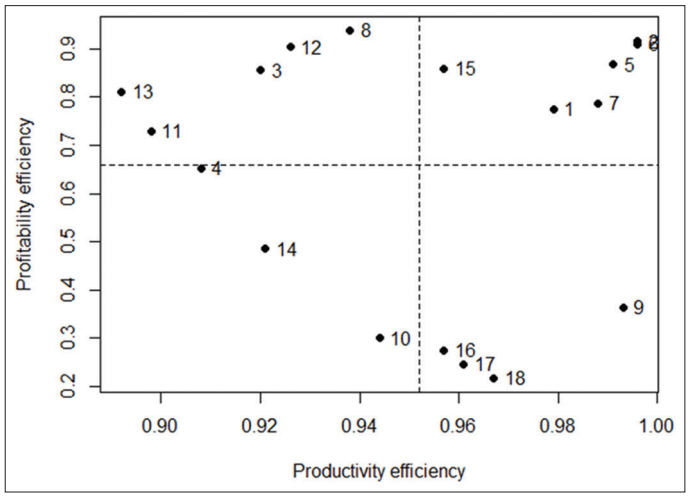
Values in parentheses are efficiency rankings

Beijing, Bank of Ningbo, Bank of Nanjing, Bank of Hangzhou and Bank of Jiangsu). This indicates that after 2015, noninterest income gradually became a crucial profit source. Furthermore, the overall efficiency of WeBank was higher than that of regional banks (Bank of Ningbo, Industrial Bank, Hua Xia Bank, Bank of Nanjing, Bank of Hangzhou and Bank of Jiangsu). In addition, WeBank's size had the largest contribution score of 0.851 (ranked fourth). Because Internet-only banking is a young industry, production efficiency in the first stage should be improved to obtain deposits, and funds should be used flexibly to enhance profitability.

4.3. Matrix Analysis of Management Decisions

To determine the efficiency distribution of banks, we constructed a matrix and identified differences among them. Figure 1 illustrates the efficiency matrix of banks in 2009-2014. The average productivity efficiency values in the first and second stages were 0.952 and 0.660, respectively.

Figure 1: Efficiency matrix, 2009-2014



The six banks in the first quadrant of Figure 1 were benchmarks for other banks. In particular, ICBC performed the highest. The five banks in the second quadrant had lower productivity efficiency averages, indicating that they required not only staff reductions and strengthened training but also adjustments to the scale and direction of internal operations. Although these banks were inefficient, their profitability efficiency averages were higher than the average. The three banks in the third quadrant had lower-than-average efficiency in both productivity and profitability, and they comprised the lowest-performing group in the sample. This indicated that managers were required to adjust internal policies and staff training. In addition, these banks required enhanced loan and noninterest income by performing internal adjustments to enhance profitability. Finally, the four banks in the fourth quadrant had low profitability efficiency but high productivity efficiency, implying that banks' business directions required revision by increasing loans and noninterest income to improve performance.

We mainly analyzed the effect of Internet-only banks entering the financial market on traditional banks. Evaluation results for 2015-2018 are illustrated in Figure 2. In the matrix, average productivity and profitability efficiencies were 0.915 and 0.832, respectively.

The productivity and profitability efficiencies of the eight banks in the first quadrant were higher than the average, and ICBC was the most efficient bank. The commercial banks in the second quadrant improved their profitability efficiency after internal adjustments. The regional banks in the third quadrant were inefficient in both productivity and profitability. Moreover, Internet-only banks

occupied the fourth quadrant, indicating that because they must invest more operating costs in the early stages of entry, thus their profitability is less efficient than the average.

Figure 2: Efficiency matrix, 2015-2018

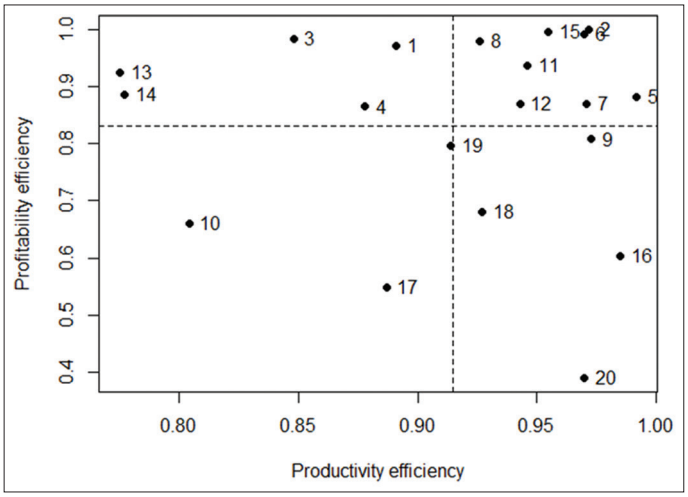


Table 7: Bank performance regression results

Date: 2009-2014			
	(1) Overall efficiency	(2) Profitability efficiency	(1)(2) VIF
Income diversification	0.022 (0.270)	0.017 (0.200)	5.287
Loan/Asset	−0.041 (−0.284)	−0.043 (−0.279)	1.397
Profit margin	0.010 (0.071)	0.039 (0.263)	1.114
Asset turnover	0.425* (1.870)	0.465* (1.921)	3.042
Size	0.226 (0.685)	0.205 (0.584)	3.177
Revenue per employee	0.067 (1.174)	0.066 (1.085)	1.363
Constant	0.841* (0.804)	0.933 (0.837)	
R^2	0.165	0.156	
Adjusted R^2	0.115	0.106	
Durbin-Watson test	1.91	1.899	
No. of observations	108	108	
Date: 2015-2018			
	(3) Overall efficiency	(4) Profitability efficiency	(3)(4) VIF
Income of diversification	0.101** (2.383)	0.100** (2.429)	2.763
Loan/Asset	0.134 (1.339)	0.045 (0.471)	1.921
Profit Margin	−0.042 (−0.442)	−0.074 (−0.813)	4.247
Asset turnover	−0.164 (−1.595)	−0.130 (−1.315)	4.591
Size	0.020 (0.092)	−0.018 (−0.083)	3.279
Revenue per employee	−0.059 (−1.203)	−0.100** (−2.109)	2.581
Constant	−0.298 (−0.555)	0.005 (0.010)	
R^2	0.189	0.168	
Adjusted R^2	0.119	0.096	
Durbin-Watson test	1.956	1.726	
No. of observations	80	80	

Values in parentheses are t statistics; Variance inflation factor (VIF) value < 10, indicating no collinearity in the independent variable; ***, **, and * indicate significance at the 1%, 5%, and 10% levels

4.4. Bank Efficiency Regression Analysis

Table 7 presents several results. First, in 2009-2014, the asset turnover rate significantly increased banks' overall and profitability efficiency, indicating that banks could enhance operational capabilities by attracting customers to make deposits, investments, and loans. Second, in the FinTech era, banks' main source of profit is no longer interest on loans; profit sources have gradually diversified to include commissions and other fees. Therefore, noninterest income and profitability efficiency increased significantly. Finally, the bank revenue generated by each employee reduced profitability efficiency, which indicated that banks have improved labor quality, but they may be required to increase employee salaries, which reduce profits.

4.5. Bank Performance Regression Analysis

The findings summarized in Table 8 are as follows: First, in 2009-2014, noninterest income reduced ROE, indicating that the main income source for traditional banks was interest on loans and was relatively stable. By contrast, noninterest income was unstable, and peer competition in the market reduced profits. However, after Internet-only banks entered the financial market (2015-2018), noninterest income increased ROE, implying that to acquire new revenue sources, banks discovered new business opportunities for mobile banking that can provide customers with more flexible loans and financial-transfer services (Japparova and Rupeika-Apoga, 2017). Moreover, the loan-to-asset ratio significantly reduced ROE; the high ratios not only reduced liquidity but also increased default risk. Furthermore, size and *Z*-score results were negative and significant, implying that to promote steady development in the banking system, banks should downsize to increase their *Z*-scores and reduce bankruptcy risk. Finally, bank revenue generated by each employee significantly reduced ROA, indicating that enhancing competitiveness and digital transformation requires banks to hire high-level professionals, such as those with FinTech or IT backgrounds. As labor costs increase, bank profits decrease.

5. CONCLUSIONS

Fintech is gradually entering people's lives and changing business models. We studied the effects of Internet-only banking on traditional banks by analyzing bank efficiency with DEA and estimating performance by using regression. The analysis periods were 2009-2014 and 2015-2018, respectively. Empirical results are summarized as follows: First, in 2009-2014, the four major state-owned banks were the most efficient mainly because they complied with national policies to achieve their goals. However, during 2015-2018, the efficiency of commercial banks improved, and ICBC was the most efficient (2009-`2018). Second, profitability efficiency improved substantially between 2015 and 2018. Although productivity efficiency decreased, staff efficiency increased. This indicated that that after employees absorb deposits, most banks can effectively use funds and offer loans to improve revenue efficiency. Third, Internet-only banks had low profitability efficiency because they have higher operating costs in the start-up period and offer higher salaries to professionals. However, Internet-only banking has a complete ecosystem with potential

Table 8: Bank performance regression results

Date: 2009-2014				
	(1) ROA	(2) ROE	(3) Z-score	(1)(2)(3) VIF
Income of diversification	−0.053 (−0.681)	−0.169* (−1.744)	0.063 (1.215)	3.499
Loan/Asset	−0.048 (−0.331)	−0.129 (−0.727)	0.051 (0.539)	1.411
Profit margin	1.078*** (7.820)	0.300* (1.754)	0.769*** (8.458)	1.115
Asset turnover	0.806*** (4.566)	0.417* (1.909)	0.482*** (4.140)	1.862
Size	0.248 (0.763)	1.031** (2.560)	−0.229 (−1.068)	3.079
Revenue per employee	0.055 (0.955)	0.045 (0.640)	0.060 (1.595)	1.359
Constant	−6.067*** (−5.826)	−3.649*** (−2.829)	1.460** (2.124)	
R^2	0.517	0.147	0.557	
Adjusted R^2	0.488	0.096	0.530	
Durbin-Watson test	2.066	1.524	1.505	
No. of observations	108	108	108	
Date: 2015-2018				
	(4) ROA	(5) ROE	(6) Z-score	(4)(5)(6) VIF
Income of diversification	−0.003 (−0.108)	0.104** (2.362)	−0.049 (−1.358)	1.336
Loan/Asset	0.030 (0.546)	−0.684*** (−6.657)	0.542*** (6.492)	1.918
Profit margin	1.008*** (19.623)	0.673*** (6.921)	0.367*** (4.648)	4.212
Asset turnover	1.097*** (25.117)	0.766*** (9.262)	0.294*** (4.378)	2.811
Size	−0.644*** (−5.379)	0.533** (2.353)	−0.443** (−2.406)	3.255
Revenue per employee	−0.073*** (−2.742)	0.011 (0.224)	−0.036 (−0.881)	2.538
Constant	−2.382*** (−8.173)	−3.850*** (−6.978)	3.737*** (8.341)	
R^2	0.929	0.714	0.616	
Adjusted R^2	0.923	0.690	0.584	
Durbin-Watson test	1.846	1.446	1.592	
No. of observations	80	80	80	

Values in parentheses are t statistics; Variance inflation factor (VIF) value < 10, indicating no collinearity in the independent variable; ***, **, and * indicate significance at the 1%, 5%, and 10% levels

for future development and profitability. Fourth, market ecology has changed since 2015, and noninterest income improved overall efficiency and ROE. Moreover, loans were difficult for SMEs and individuals to obtain in the past. They became more accessible after Internet-only banks entered the financial market by providing improved services to people in need. However, the analysis results indicated that the loan-to-asset ratio was high, thereby increasing default risk. Furthermore, bank size was significantly negatively related to ROA and *Z*-score, indicating that the size should be appropriately adjusted to reduce operational risks. Finally, although revenue per employee increased, ROA decreased. These results implied that although banks hire high-level employees to enhance competitiveness, this practice reduces their profits.

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