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Sehubungan dengan surat Ketua Jurusan Manajemen Nomor : 025-KJM/577/FE-UNTAR/V/2022, Perihal : Permohonan Penugasan Penelaah Jurnal, dengan ini Pimpinan Fakultas Ekonomi dan Bisnis Universitas Tarumanagara menugaskan Saudara :

DR. SAWIDJI WIDOATMODJO SE., MM., MBA.

Sebagai **Penelaah (*Reviewer)*** pada *International Journal of Economics and Business Research* (IJEBR), untuk paper yang berjudul "***Competition and Bank Performance: The Mediating Role of Innovation for Chinese Banking Industry***".

Demikian Surat Tugas ini dibuat untuk dilaksanakan dengan sebaik-baiknya dan yang bersangkutan melaporkan hasil penugasan tersebut kepada Pimpinan Fakultas Ekonomi dan Bisnis Universitas Tarumanagara sesuai ketentuan yang berlaku.

17 Mei 2022

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Competition and bank performance: the mediating role of innovation for Chinese banking industry

Abstract: This paper tests the relationship between competition and bank performance in Chinese banking industry and the mediating effect of innovation in this relationship. The authors introduce two indicators to measure competition and innovation: Boone index, based on the reallocation of profits from inefficient banks to efficient ones; Technology Gap Ratio (*TGR*), based on the metal-frontier theory. The Structural Equation Model (SEM) is also employed here to test the hypotheses with data collected from Chinese commercial banks. The results of regressions confirm that competition has a positive effect on performance, and innovation plays a full mediator in the relationship between competition and performance.

Key words: Banking industry, Competition, Performance, Innovation, Mediating effect

1. Introduction

There are two competing hypotheses in banking performance literature over 40 years. Although the attitudes of these two hypotheses are different, both of them are supported by researchers. The traditional structure-conduct-performance (SCP) hypothesis insists that the level of competition and market structure deeply affect the profitability of bank, a higher concentration leads to a higher profitability (Gilbert, 1984; Hannan, 1991).

But according to the efficiency hypothesis (EH), the performance of a bank depends on bank's degree of efficiency (Smirlock, 1985). In other words, the relationship between competition and the performance of a bank is dependent upon bank's degree of efficiency. Moreover, bank's degree of efficiency depends on its financial innovation activities. Kero (2013) hold the point that financial innovation promotes bank's efficiency of screening and monitoring of borrowers, which enhances the performance of a bank. In addition, financial innovation leads to new forms of bank products. Technology-based products, such as Internet banking, mobile banking, telephone banking, ATM and POS network, provide relative low risk, high return, and low cost advantages (Akhisar et al., 2015). All of these advantages enhance banks' performance.

The relationship between competition and innovation has long been subject to theoretical debates. Schumpeter (2013) and his supporters insist that increased competition restrains innovation. Normally innovation activities always accompany with risk, however larger firms have advantages in withstanding risk and offering capital supports for innovation than smaller ones. Opponents on the contrary assert that the Schumpeter hypothesis is not comprehensive (Arrow, 1962). Compared with monopolistic market, there are more incentive factors in competitive market. For

example, competition facilitates innovation activities as firms attempt to escape competition to obtain monopoly profits.

This paper contributes to the literature by demonstrating a new method to test the relationship between competition and bank performance. Innovation is used as a mediator in this relationship. There are two reasons of using Chinese banking industry as sample. The first reason is that the Chinese banking industry has been experienced a comprehensive reform since 1979, and the market structure is transformed from monopoly to monopolistic competition (Ye et al., 2001; Zhang and Pan, 2013). The other is that the international financial innovation has deeply influenced Chinese banks in many aspects, such as management, production, and business (Frame and White, 2004).

The remainder of this paper is organized as follows. Section 2 illustrates the progress of the transformation in Chinese banking structure. And section 3 contains a brief discussion of the existing empirical and theoretical literature on competition, innovation and performance. In section 4, the authors present samples, introduce indicators to measure the variables and employ the Structural Equation Model (SEM) to test the relationship among these variables. Section 5 organized empirical results and related analysis; section 6 exposes the conclusions.

2. The transformation in Chinese banking

There are three periods of the transformation in Chinese banking industry since 1979.

Period 1: Before 1979, the People's Bank of China (PBC) not only issued currency, but also was the financial hub of each State Economic Plan. Period one began with the reopen of four state owned banks: the Industrial and Commercial Bank of China (ICBC), the Agricultural Bank of China (ABC), the Bank of China (BOC), and the China Construction Bank (CCB). And these four banks have absolute monopoly in their business such as foreign exchange, construction, enterprise finance (Xiaochuan and Li, 1987).

Period 2: Since 1994, to promote more competition among banks, Chinese government authorized new "small and medium sized" commercial banks to be established, such as the Bank of Communications, the CITIC Industrial Bank, the Shenzhen and Guangdong Development banks, China Merchants Bank, China Everbright Bank and Hua Xia Bank (Fu, Heffernan. 2009). The policy-related business of the four largest state-owned commercial banks (BOC, CCB, ICBC, ABC) are abrogated. And since then, these four largest state-owned banks compete with other commercial banks under market discipline.

Period 3: Starting from 2004, the four largest state-owned commercial banks (ICBC, ABC, BOC, CCB) initiated ownership reforms. Actions were taken such as cleaning up the non-performing loans, liberalizing the financial market, changing the ownership structure, inviting foreign investor, and enhancing financial regulation and supervision (Berger et al. 2009). At the same time, other joint stock banks, city commercial banks, foreign banks are continuously expanding.

Over the past 30 years, the Chinese banking industry opens its door to the world.

The structure is transformed from absolute monopoly to monopolistic competition.

3. Literature review and hypotheses

The Structure–Conduct–Performance (SCP) hypothesis from traditional industrial organization literature hold the point that the performance of a firm is decided by its business strategy which is influenced by industry structure, and suggests that there is a positive relationship between the degree of market concentration and the firm's performance (Bain, 1951). Because of the collusion and monopoly, firms in a concentrated market will earn higher profits than in a less concentrated market (Lloyad-Williams, 1994). For banking industry, banks will earn higher profits in a concentrated market due to scale economy, asymmetric information. Demirgüç-Kunt and Huizinga (1999) use pooled data of banks all over world to test the relationship between market concentration and profitability, the positive relationship is consistent with SCP hypothesis. Bhatti and Hussain (2010) test the SCP hypothesis in the context of Pakistan banking industry, and find support in favor of SCP hypothesis. Tan and Floros (2014) investigate the relationship between market concentration, profitability and risk-taking in Chinese banking industry over the period 2003-2009. Their result shows that Chinese commercial banks in less competitive market have better profitability, which suggests the negative relationship between competition and profitability. In addition, a number of researches about banking industry provide empirical supports for SCP hypothesis (Chirwa, 2003; Maudos and De Guevara, 2004；Kamau and Were, 2013; Uddin and Suzuki, 2014). Thus, this paper hypothesizes that competition is harmful to bank performance.

Hypothesis 1：Competition has a negative relationship with bank performance in Chinese banking industry.

However, the efficiency hypothesis (EH) insists that the performance of a bank depends on bank's degree of efficiency (Smirlock, 1985). Moreover, bank's degree of efficiency depends on its financial innovation activities. Banks' innovation leads to the improvement of technology, which makes banks more efficient in screening and monitoring borrowers, and in turn, reduces credit risk and enhances performance (Chen, 2007). Schaeck and Cihák (2014) find that the improvement of banks' technology reduces the probability of borrower default and enhances the quality of banks' assets. Allen et al. (2011) confirm that more efficient screening and monitoring lead to better quality of loans. Empirical works by Wheelock et al. (1995) and Berger et al. (1997) also support these assumptions. In addition, financial innovation leads to new forms of bank products. Technology-based products, such as Internet banking, mobile banking, telephone banking, ATM and POS network, provide relative low risk, high return, and low cost advantages (Ciciretti et al., 2009; Weigelt and Sarkar, 2012; Akhisar et al., 2015). All of these advantages enhance banks' performance.

The results of existing literature lead to the prediction of Hypothesis 2:

Hypothesis 2: Innovation has a positive relationship with bank performance in Chinese banking industry.

The relationship between industry structure and innovation is always a focal spot in industrial organization theory. Schumpeter (2013) first proposes that increased

competition has a negative effect on innovation activities. Normally innovation activities always accompany with risk. Large firms not only have advantages on scale economy and risk diversification, but also are capable to afford more capitals for innovation activities. Rothaermel et al. (2004) investigate 325 biotechnology firms over a 25-year period, and find that larger firms have better innovation capability in concentrated market than others. This result is consistent with the Schumpeter hypothesis. On the contrary, some researchers assert that the Schumpeter hypothesis is not comprehensive, and there are more incentive factors in competitive market than in monopoly market (Arrow, 1962). Aghion et al. (2001) arise that increased competition encourages innovation activities because firms in competitive market attempt to escape competition to obtain monopoly profits. Sandulli et al. (2012) investigate over 7000 Spanish firms over the period 2003-2008, and find that larger firms in competitive markets are more inclined to innovation activities. Hou et al. (2014) investigate the impacts of market structure on the efficiency of Chinese commercial banks, and results shows increased competition compels banks to develop advanced technical experience and skills. Aghion et al. (2005) propose a theoretical model and confirm two effects of competition work in opposite directions leads to an unclear net effect on innovation. Also, the intensities of these two effects vary with competition. The "escape competition effect" (positive effect of competition on innovation) initially dominates until competition reaches a critical level, and then the "Schumpeterian effect" (negative effect of competition on innovation) takes over and plays a stronger role. These two effects lead to an inverted-U relationship between competition and innovation.

In view of the market share of listed banks, the authors deduce that Chinese banking industry is highly concentrated, and that means the market is not competitive. This observation leads to a prediction that competition facilitates banks' innovation activities.

Hypothesis 3: Competition has a positive relationship with bank innovation in Chinese banking industry.

The combination of Hypothesis 1-3 leads to the prediction of Hypothesis 4:

Hypothesis 4: Innovation plays a mediator in the relationship between competition and bank performance in Chinese banking industry.

4. Data and model description

4.1 Data

The authors test their hypothesizes with the data gathered from China Statistical Yearbook, Almanac of China's Finance and Banking, Bankscope Database and Banks' Annual Reports. Sample focuses on Chinese commercial banks and includes 14 commercial banks, namely Bank of China, Industrial & Commercial Bank of China, China Construction Bank, Agricultural Bank of China, Bank of Communications, China CITIC Bank, China Merchants Bank, China Minsheng Bank, Industrial Bank, China Everbright Bank, Huaxia Bank, China Guangfa Bank, Pingan Bank, Shanghai Pudong Development Bank. The full sample runs from 2004 to 2017 with 196 observations. These 14 listed banks dominate in deposits and loans market of the

entire Chinese banking.

4.2 Variables

4.2.1 Measuring competition

Traditional indicators, such as Herfindahl-Hirschman Index (*HHI*), Competition Ratio (*CR*), Lerner Index (*L*) and so on, measure competition by examining the level of market concentration. However, researchers recently point out that market concentration is a poor proxy for competition, because the link between competition and concentration is very weak, especially in banking industry (Berger et al., 2004; Claessens and Laeven, 2004).

Therefore, this paper uses a competition indicator based on the efficient structure hypothesis (Boone, 2008). Under the efficient structure hypothesis, more efficient banks (i.e., banks with lower marginal costs) achieve better performance than less efficient ones. Along with the increase in market competition, the difference of banks' performance is more obvious. In a sense, market competition has a reallocation effect on banks. Increased competition enhances the performance of more efficient banks, and weakens the performance of less efficient ones. Stiroh (2000), Stiroh and Strahan (2003) confirm that increased competition transfers assets from low profitable banks to high profitable banks. These results are consistent with the efficient structure hypothesis mentioned above.

The theoretical model of Boone index is described as:

$$\pi_{it} = \alpha + \beta \ln(C_{it}) \tag{1}$$

where the *i* subscript refers to a bank, *t* subscript refers to a sample year. π_{it} and C_{it} are the profits and marginal cost, respectively. Since the marginal cost cannot be directly observed, the authors follow the method proposed by Griffith et al. (2005) and use average cost as a proxy.

For banking industry, the profits (π_{it}) equals operating income minus operating expense, and the average cost (C_{it}) equals operating expense divide by profits. The operating income includes net interest income, net fee and commission income, gains or losses from changes in fair values, invest income and other operating incomes, and the operating expense includes business tax and surcharge, general and administrative expense, impairment losses on assets and other operating expense.

The operating income includes net interest income, net fee and commission income, gains or losses from changes in fair values, invest income, and the operating expense includes business tax and surcharge, general and administrative expense, impairment losses on assets.

β refers to the Boone index and is always negative, because the indicator expresses the reduction of profits that arises from cost inefficiencies. The absolute value of Boone index ($|\beta|$) represents the level of competition, and the larger $|\beta|$ is, the more intense competition is.

To allow for time variation and capture β at every single unit of time, we include time dummy variable and estimate the Boone model as follows:

$$\pi_{it} = \alpha_i + \sum_{k=1}^{T} \beta_{k1} d_{kt} \ln(c_{it}) + \sum_{k=1}^{T-1} \beta_{k2} d_{kt} + u_{it} \tag{2}$$

where T is the total number of periods in years, d_{kt} is a time dummy variable where d_{kt} =1 if k=t and zero otherwise, and u_{it} is the error term.

4.2.2 Measuring innovation

Traditional ways to measure innovation, such as patents, R&D expense and so on (Lee, 2005), are not suited for the banking industry. Therefore, this paper introduces an indicator, which is based on the meta-frontier theory, to measure bank innovation. In order to obtain this innovation indicator, the authors construct the cost function of banks and examine banks' ability to minimize costs via innovation.

Given that the technology level and inputs prices are unchanged, the set of estimated parameters reflects the state of technology since the cost function describes the relationship between output and costs. A parallel shift in the cost curve refers to the technological change caused by innovation for a certain level of output.

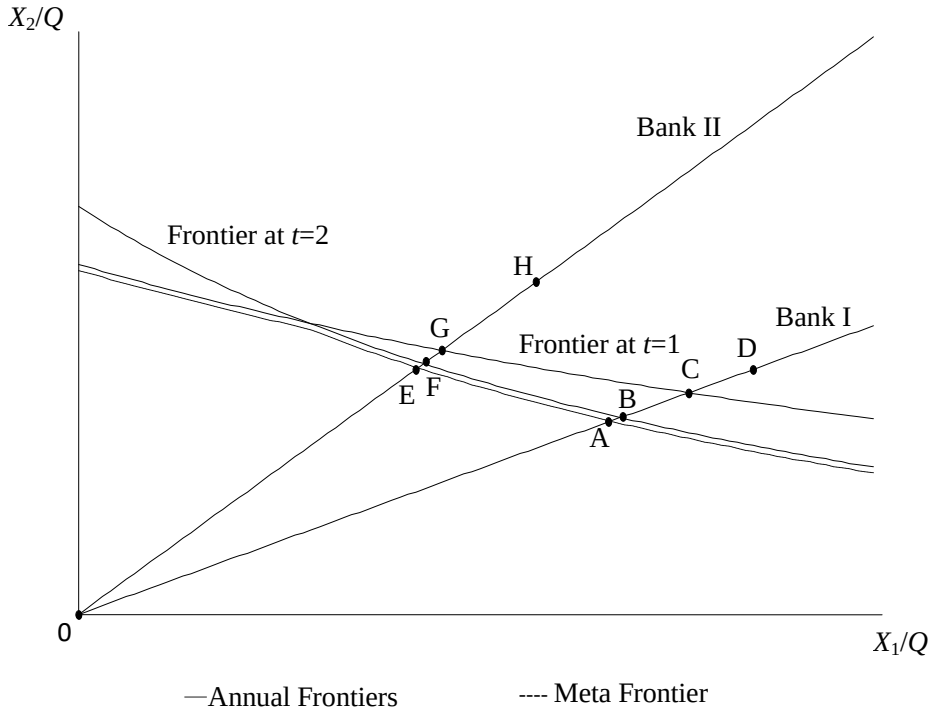

Fig.1. Metal-Frontier theory.

Fig.1 illustrates the meta-frontier theory using a simple paradigm with two inputs (X_1, X_2) and one output (Y) for two firms. Since the available technology of firms changes over time, there are two annual frontiers corresponding to t =1 and t =2. Each frontier represents the minimum cost curve based on available technology for a certain level of output. The dashed line which envelops annual frontiers is the meta-frontier, which is the minimum cost curve over the whole period. The distance between meta-frontier and annual frontier is defined as the technology gap which measures the gap between currently available technology level and optimal technology level over the whole period. Innovation is reflected by the technology gap, because innovation activities lead to the improvement of technology; improvement thereby results in a smaller gap. Battese et al. (2004) introduce the meta-frontier

approach and measure the technology gap ratio (*TGR*) by constructing a cost function.

TGR represents the ratio of minimum cost on meta-frontier to annual frontier for a certain level of output over the whole period. Since meta-frontier is always below annual frontier, the value of *TGR* is bounded between 0 and 1, where the latter is reached when firms operate on the meta-frontier. Fig.1 shows that *Firm I* is located at point D and faces a technology gap of *OA/OC* at time $t = 1$ and *OA/OB* at time $t = 2$. Similarly, *Firm II* is located at point H and faces a technology gap of *OE/OG* at time $t = 1$ and *OE/OF* at time $t = 2$. The change of technology gap represents the improvement of technology resulted from firms' innovation activities.

Based on a sample of Chinese provinces, Wang et al. (2013) adopt the meta-frontier approach to compare the energy efficiency and technology gap among provinces in China. They find that most of the eastern provinces maintain high energy efficiency and advanced production technology, while provinces in the west is on the contrary. According to the economic development, Zhuo and Shunfeng (2008) divide China into four areas and employ the meta-frontier approach to study their county-level agricultural data. Their result shows that agricultural technology of the Southeast area is dominant. (i.e., developed area has possessed better agricultural technology).

Following recent work by Bos and Schmiedel (2007) and Bos et al. (2013), this paper gets access to the technology gaps by initially employing Stochastic Frontier Analysis (SFA) to estimate the annual cost frontiers in each year, and then using linear program to get the meta-frontier.

The authors define TC_{it} as total cost, y_{it} as output and p_{it} as the price of output, x_{it} as input and w_{it} as the price of input. Then a bank's total cost is obtained as follows:

$$TC_{it} = w_{it} x_{it}, \tag{3}$$

Since x_{it} could be expressed as $x_{it}(w_{it}, y_{it}, z_{it})$, the cost function for bank i at time t is characterized as:

$$TC_{it} = f\left(w_{it}, y_{it}, z_{it}\right) e^{v_{it}+u_{it}}, \tag{4}$$

where z_{it} is a vector of control variables, v_{it} is random noise assumed to be i.i.d.$N(0, \sigma_v^2)$, and u_{it} is the inefficiency term assumed to be i.i.d.$N(0, \sigma_v^2)$ and independent from v_{it}.

This paper model banks' production by employing the intermediation approach because of banks' financial intermediary role. The intermediation approach considers banks' fixed assets, labour and funds as inputs (*xit*) to produce outputs (*yit*): loans and investments. The total cost consists of capital cost, operating cost and labour cost (Ariff and Luc, 2008).

Table 1 Definition of variable

Variable	Constitutive content
	Total cost

Capital cost	Interest expense
Operating cost	Business and management cost + loss of impairment of assets
Labor cost	Employee's salary and welfare
	Inputs price
Labor price	Cash payments for salaries and staff expenses / Amount of labors
Fixed assets price	Depreciation / Net fixed assets
Funds price	Interest expense / customer deposits + borrowed fund
	Output
Investment	Financial assets at fair value through profit or loss + Available-for-sale financial assets + Held-to-maturity investment + Receivables-bond investment
Loans	Personal loans + corporate loans + other loans

This table reports the definitions and measurements of variables in equation (4).

The translog cost function accepts more flexible functional forms without assuming the constrained condition (Zhao and Kang, 2015). Therefore, it is applied in this paper.

According to the general form of translog frontier, Eq. (5) is obtained as:

$$\begin{aligned}\ln TC = {} & \beta_0 + \beta_1 \ln y_1 + \beta_2 \ln y_2 + \beta_3 \ln w_1 + \beta_4 \ln w_2 + \beta_5 \ln w_3 \\ & + \frac{1}{2}\beta_6 (\ln y_1)^2 + \frac{1}{2}\beta_7 (\ln y_2)^2 + \frac{1}{2}\beta_8 (\ln w_1)^2 + \frac{1}{2}\beta_9 (\ln w_2)^2 + \frac{1}{2}\beta_{10} (\ln w_3)^2 \\ & + \beta_{11} (\ln y_1 * \ln y_2) + \beta_{12} (\ln y_1 * \ln w_1) + \beta_{13} (\ln y_1 * \ln w_2) \\ & + \beta_{14} (\ln y_1 * \ln w_3) + \beta_{15} (\ln y_2 * \ln w_1) + \beta_{16} (\ln y_2 * \ln w_2) \\ & + \beta_{17} (\ln y_2 * \ln w_3) + \beta_{18} (\ln w_1 * \ln w_2) + \beta_{19} (\ln w_1 * \ln w_3) \\ & + \beta_{20} (\ln w_2 * \ln w_3) + v_{it} + u_{it},\end{aligned} \tag{5}$$

By enveloping the annual cost frontiers to obtain the meta-frontier, the authors utilize the parameter estimates for the annual cost frontiers f_n and obtain estimates of the technology gap by fitting the minimum cost meta-frontier f_{meta} as follows:

$$\begin{aligned}&\text{Min. Distance} = \sum_{i=1}^{N}\sum_{t=1}^{T}[\mathrm{f}_i(w_{it}, y_{it}, z_{it})e^{v_{it}+u_{it}} - \mathrm{f}_{meta}(w_{it}, y_{it}, z_{it})e^{v_{it}+u_{it}}]^2 \\ &\text{s.t. } \mathrm{f}_i(w_{it}, y_{it}, z_{it})e^{v_{it}+u_{it}} \geq \mathrm{f}_{meta}(w_{it}, y_{it}, z_{it})e^{v_{it}+u_{it}}\end{aligned} \tag{6}$$

Constraint condition in Eq. (6) means that the total cost on the meta-frontier is less than or equal to the total cost on the annual frontier. As a result, the *TGR* is defined as:

$$TGR_{it} = \frac{\mathrm{f}_{meta}(w_{it}, y_{it}, z_{it})}{\mathrm{f}_n(w_{it}, y_{it}, z_{it})} \tag{7}$$

Innovation activities result in the improvement of technology level, and then, it reduces the gap between current technology level (i.e., the annual frontier) and the potentially available technology level over the whole period (i.e., the meta-frontier). Ultimately, these innovation activities lead to an increase in *TGR*. And the *TGR* is bounded between 0 and 1, where the latter is reached when banks operate on the meta-frontier.

In conclusion, *TGR* is obtained in following three steps:

Step 1: construct banks' cost function and obtain the parameter estimates of the annual cost frontiers by employing Stochastic Frontier Analysis (SFA);

Step 2: solve Eq. (6) by linear programming with constraint condition to obtain the parameter estimates of the meta-frontier;

Step 3: solve Eq. (7) by substituting parameters in pervious steps.

4.2.3 Measuring performance

The factor analysis is commonly used in multivariate statistical analysis (Abdi et al., 2013). The basic idea of factor analysis is based on correlation to group the original variables, to make variable correlation in the same group higher, and in different groups less.

This paper applies the factor analysis to measure bank performance. Except for the traditional profitability, mobility and safety indicator, the authors also introduce a technology indicator in consideration of the possible mediating effect of innovation. Five indicators are used in factor analysis: Return on total assets *(ROA, X_1)*, accounts for profitability; Loan to deposit ratio *(X_2)*, accounts for mobility; Core capital adequacy ratio (*CCAR, X_3*) and *Z-score (X_4)*, account for safety; and Input to output ratio(*X_5*), accounts for technology.

The *Z-score* is obtained as Eq. (8). By the definition of *Z-score*, one word in short is the higher of *Z-score*, the lower of bank risk.

$$Z = \frac{ROA + CAR}{\sigma(ROA)}, \tag{8}$$

The calculation of Input to Output ratio is based on the intermediation approach mentioned in Section 4.2.2.

The Bartlett's test of Sphericity is 0.000，which means there are significant correlations among these five financial indicators. And the KMO statistic is 0.670，which suggests that these five financial indicators are suited for factor analysis.

Table 2 Total variance explained

Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of variance	Cumulative %	Total	%of variance	cumulative%
X_1	2.554	51.083	51.083	2.552	51.508	51.033
X_2	1.373	27.458	78.542	1.375	27.508	78.542
X_3	0.566	11.313	89.855			
X_4	0.316	6.321	96.176			
X_5	0.191	3.824	100.000			

This table reports the total variance explained in factor analysis.

Table 3 shows that the first two components contribution on the sample variance is 78.542%.

Table 3 Component Score Coefficient Matrix

	Component	
	F_1	F_2
X_1	0.329	-0.105
X_2	-0.116	-0.596
X_3	0.359	-0.059
X_4	0.349	0.153
X_5	-0.142	0.579

This table reports the component score.

Accord to the component score coefficient in Table 3, the authors combine these two principal components into a vector：

$$\begin{aligned} F_1 &= 0.329 * X_1 - 0.116 * X_2 + 0.359 * X_3 + 0.349 * X_4 - 0.142 * X_5, \\ F_2 &= -0.105 * X_1 - 0.596 * X_2 - 0.059 * X_3 + 0.153 * X_4 + 0.579 * X_5, \end{aligned} \tag{9}$$

And the bank performance indicator (*BP*) is calculated based on the contribution rate of variance in Table 1:

$$BP = \left(\frac{51.083}{78.542}\right) F_1 + \left(\frac{27.458}{78.542}\right) F_2, \tag{10}$$

4.2.4 Control variables

Equity ratio is a reverse measure of bank's debt pressure and equals the ratio of total shareholders' equity to total assets. A high equity ratio means that bank is over-debt, which is harmful to the stability of bank. In contrast, a low equity ratio indicates that bank has not yet taken full advantage of financial leverage. This paper introduces equity ratio as one control variable to account for different risk profiles of banks.

In addition, because the non-performing loans and the preference of bank managers to risky policies change with the economic development, this paper introduces China's annual real GDP growth rate as the other control variable.

4.3 Model description

According to the existing literature, this paper assumes that the relationships among competition, innovation and performance are illustrated in Fig.2.

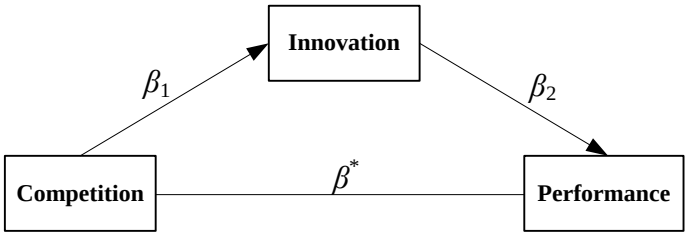

Fig.2. Relationships among competition, innovation and performance

In Fig.2, β_1 represents the direct effect of competition on performance, β_2 represents the effect of competition on innovation, β^* represents the effect of

innovation on performance.

This paper follows the method proposed by Wen et al. (2004) and employs the Structural Equation Model (SEM) to test the mediating effect of innovation in the process of competition affects performance.

There are three steps of SEM:

$$\begin{aligned} BP_{it} &= aCompetition_{it} + \beta_1 ER_{it} + \beta_2 GDP_t + e_1 \\ TGR_{it} &= bCompetition_{it} + e_2 \\ BP_{it} &= a^* Competition_{it} + cTGR_{it} + \beta_1^* ER_{it} + \beta_2^* GDP_t + e_3 \end{aligned} \tag{11}$$

where BP_{it} represents the performance of bank i at time t, TGR_{it} represents the technology gap ratio of bank i at time t, and $Competition_{it}$ represents the competition pressure of bank i at time t, which is equal to the Boone index multiply by the loan market share of bank i at time t. ER_{it} represents the equity ratio of bank i at time t, GDP_t represents the GDP growth rate at time t.

Fig.3 illustrates the specific test procedure of mediating effect:

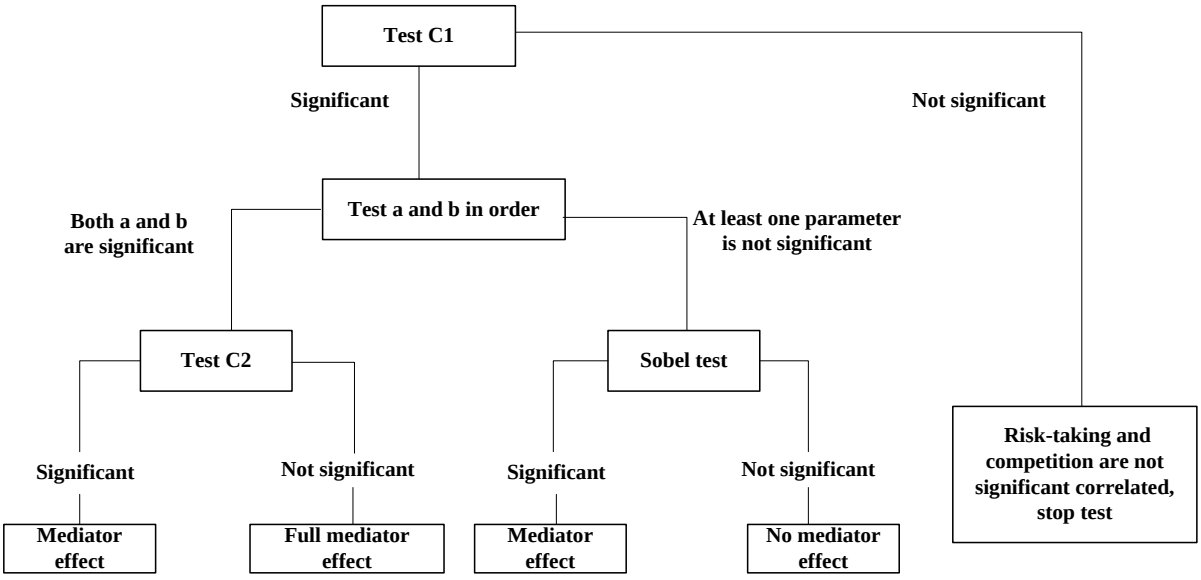

Fig.3. Test procedure of mediating effect.

5. Empirical results

5.1 Descriptive statistics

Table 4 presents the descriptive statistics for bank performance (*BP*), technology gap ratio (*TGR*), *Boone index*, competition pressure (*Competition*), *equity ratio* and *GDP growth rate*.

Table 4 Descriptive statistics

Variable	Mean	Std.dev.	Median	Minimum	Maximum
BP	10.816	5.453	10.344	-9.840	24.410
TGR	0.425	0.054	0.425	0.292	0.530
Boone Index	1.685	0.745	1.738	0.772	2.874
Competition	0.120	0.142	0.056	0.011	0.651
Equity Ratio	0.048	0.022	0.054	-0.121	0.083
GDP growth	10.00	2.038	9.60	7.4	14.2

This table reports the descriptive statistics based on the sample of 14 Chinese commercial banks over the period 2004–2017.

From Table 4, it is observable that the average of *BP* is 10.816, and the difference between the maximum and minimum value indicates that *BP* obviously varies within sample period.

According to the definition of *TGR* mentioned above, the average value of *TGR* illustrated in Table 4 indicates that the current technology level of sample banks is far below the potentially available technology level over the whole period.

Table 4 also shows that the difference between the maximum and minimum value of *Competition* is obvious, it also means banks' competition pressure varies obviously.

In addition, it is also observable that the Boone index ranges between 0 and 3 from Table 4. While Fig.4 shows the distribution of Boone index, which illustrates how competition evolves in Chinese banking industry.

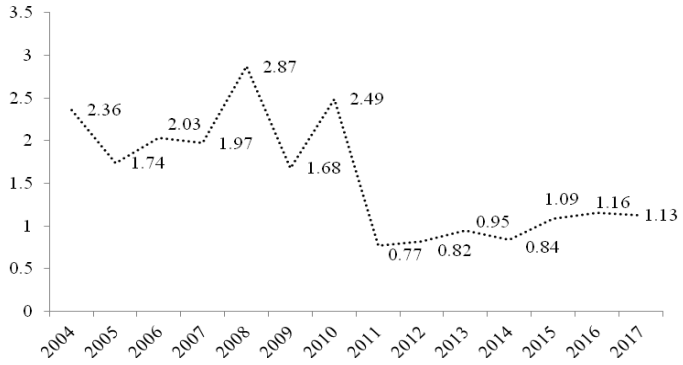

Fig.4. Absolute value of Boone index in Chinese banking industry.

Based on the definition of Boone index mentioned before, this paper deduces that competition in Chinese banking industry is not fierce, even after a comprehensive reform the Chinese government has already practiced. Besides this, the variation of Boone index is non-monotonic and irregular.

5.2 Results

Table 5 presents the estimated results of empirical regressions.

Table 5 Regression results

Step	1	2	3
Dependent	*BP*	*TGR*	*BP*
Competition	0.1297**	0.0433***	0.0718
	(0.0523)	(0.0098)	(0.0487)
TGR			1.9167***
			(0.2857)
Equity ratio	0.0663*		0.0638**
	(0.0368)		(0.0318)
GDP growth	-0.0791***		-0.0199
	(0.0160)		(0.0162)
Adjust R^2	0.7104	0.8848	0.6723

This table reports the coefficients' estimates of equations (10), (11) and (12). BP refers to the performance of bank i at time t; TGR refers to the technology gap ratio of bank i at time t; Competition refers to the competition pressure of bank i at time t, which is equal to the Boone index multiply by the loan market share of bank i at time t.

*Statistically significant at 10%, **statistically significant at 5%, ***statistically significant at 1%.

In step 1, c_1 represents the total effect of competition on bank performance. The value of c_1 is positive and significant (c_1=0.1297, p<0.05), which shows a positive relationship between *Competition* and *BP*. The value of c_1 indicates that increased competition enhance bank performance. This result rejects the Hypothesis 1.

In step 2, the coefficient of *Competition* on *TGR* is positive and significant (a=0.0433, p<0.01). This positive value of a supports Hypothesis 3 and indicates that increased competition is helpful to support bank innovation activities.

In the last step, c_2 represents the direct effect of competition on bank performance. The value of c_2 is positive but not significant (c_2=0.0718). While b represents the effect of *TGR* on *BP*, with a positive and significant value (b=1.9167, p<0.01). This positive value for b suggests a positive relationship between *TGR* and *BP.* In other words, financial innovation activities enhance bank performance. This result rejects Hypothesis 2 and suggests a positive relationship between innovation and bank performance.

Based on the test procedure mentioned in Figure 3, this paper concludes that innovation plays as a full mediator between competition and bank performance. This conclusion provides support for Hypothesis 4.

In addition, as a control variable, the coefficient of *Equity ratio* is positive. This result indicates the equity ratio has a positive relationship with bank performance. Equity ratio is a reverse measure of banks' debt pressure, which equals the ratio of total shareholders' equity to total assets. A high equity ratio normally indicates that the bank is expanding. It also leads to scale merit and diversification, both of which enhance bank performance.

The coefficient of the other control variable (i.e., *GDP growth rate*) is negative, showing that *GDP* growth rate has a negative relationship with bank performance. Specifically, a booming economy means more loan demands to banks. The increased total amount of loans leads to increased total amount of non-performing loans. It is

harmful to bank performance.

6. Conclusion

Most previous literature mainly focus on the effect of market structure on bank performance. By introducing innovation as a mediator, this paper demonstrates a new method to test the relationship between competition and bankperformance in Chinese banking industry. The authors use a sample of 14 Chinese commercial banks within a period from 2004 to 2017. Two indicators are applied here for measuring competition and innovation. The competition indicator (i.e., *Boone Index*) analyzes the cost elasticity of performance by capturing the link between competition and efficiency. And the innovation indicator (i.e., Technology Gap Ratio, *TGR*) represents the gap between current technology level and the potentially available technology level over the whole period. The Structural Equation Model (SEM) is employed to examine the mediating effect of innovation.

Although a comprehensive reform is placed to facilitate the liberalization in Chinese banking industry, government still plays a leading role in Chinese banking system. Therefore, market competition is restrained by excessive government interventions. The empirical result of Boone index also shows that competition in Chinese banking industry is not fierce.

The other conclusion is that the technology level of Chinese banks is still low. According to the definition of *TGR*, the technology level of Chinese banks is far below the potentially available technology level over the whole period, which suggests the possibility of a dramatic improvement of technology. Therefore innovation activities should be encouraged urgently to improve the technology level of banks.

The mediating effect of innovation is tested by employing Structural Equation Model (SEM). The authors discover that competition has positive effect on both bank performance and innovation. These results suggest that competition will enhance bank performance and facilitate banks' innovation activities. Meanwhile, the positive coefficient of innovation shows that the improvement of technology will enhance bank performance.

Of the most importance, c_2 in step3 is not significant. Based on the test procedure of mediating effect, the authors conclude that innovation plays a full mediating effect between competition and bank performance.

Last but not least, the coefficient of equity ratio is positive. It also shows that equity ratio has a positive relationship with bank performance. It could result from scale merit and diversification, which are derived from banks' expansions. While the coefficient of *GDP* growth rate is negative, it shows that *GDP* growth rate has a negative effect on bank performance. The authors deduce that better economic environment leads to more investment opportunities for investors and more loan demands for banks. Ultimately, increased total amount of loans results in increased total amount of non-performing loans.

The results of the empirical works illustrate a chained relationship among competition, innovation and performance in Chinese banking industry. Competition

did not directly affect bank performance. However, it affects performance through innovation as a mediator. Increased competition facilitates banks' innovation activities and raises the technology level. In turn, it enhances bank performance.

Because the Chinese government still plays a leading role in banking system, it is vital to make policies conservatively and thoroughly. For policy makers, they ought to consider the impact of their decisions comprehensively to avoid consequent problems. In addition, it is urgently and vitally suggested for bank managers to support financial innovation actively. Because innovation improves the technology level of bank, and in turn, enhances bank performance.

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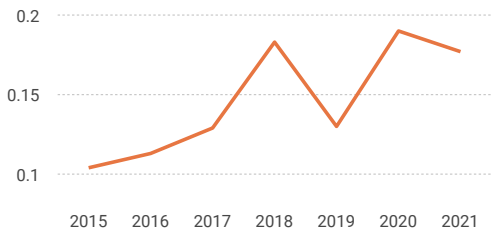

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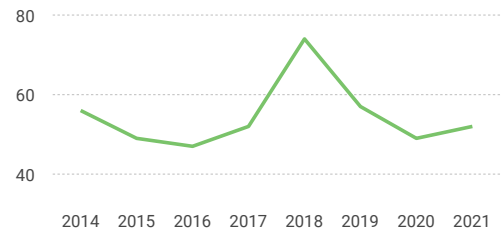

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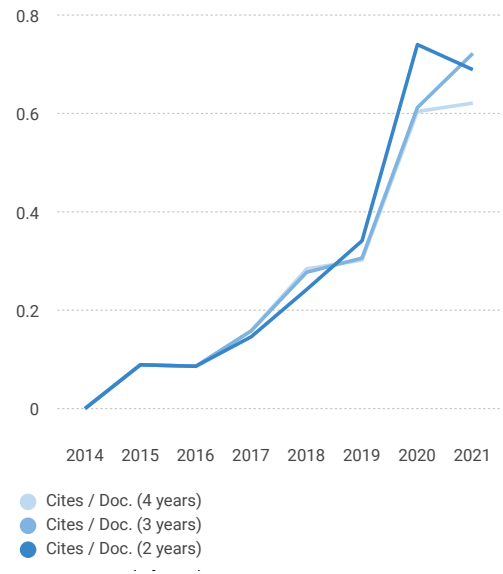

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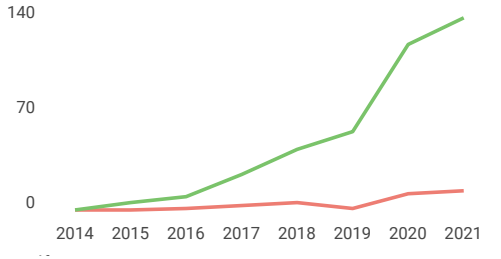

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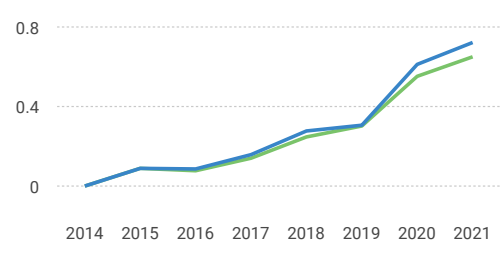

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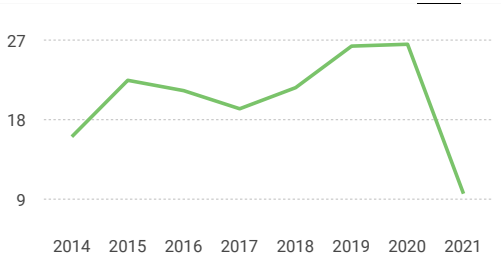

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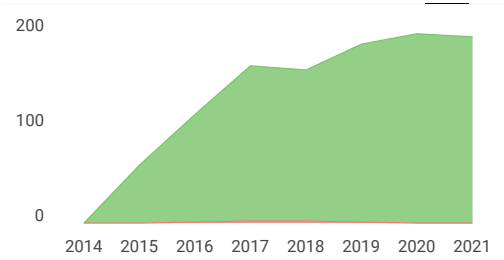

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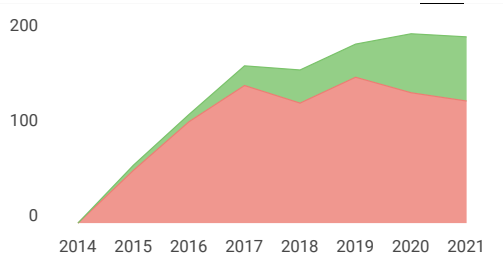

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