Are Chinese Big Banks Really Inefficient?
Distinguishing Persistent from Transient Inefficiency

Zuzana Fungáčová[1]
Bank of Finland

Paul-Olivier Klein[2]
University of Strasbourg

Laurent Weill[3]
EM Strasbourg Business School, University of Strasbourg

Abstract

There is large evidence that the five largest state-owned banks in China (the Big Five) suffer from low cost efficiency. The objective of this paper is to investigate how overall inefficiency of Chinese banks is decomposed between persistent inefficiency and transient inefficiency. While persistent efficiency reflects structural problems, transient efficiency is associated with short-term events. We use the model from Kumbhakar, Lien and Hardaker (2014) based on the stochastic frontier approach to measure persistent efficiency and transient efficiency for a large sample of 170 Chinese banks over the period 2008-2015. We find that Big Five banks have lower cost efficiency on average than other Chinese banks, which results from lower persistent cost efficiency. Big Five banks do not significantly differ in transient efficiency from other Chinese banks over the period, even if their transient efficiency is more volatile. Our findings support the view that major structural reforms need to be implemented to enhance efficiency of Big Five banks.

JEL Codes: C23, D24, G21.
Keywords: bank, efficiency, China, transient and persistent efficiency.

[1] Bank of Finland Institute for Economies in Transition (BOFIT), Snellmaninaukio, P.O. Box 160, FI-00101 Helsinki. Email: zuzana.fungacova@bof.fi
[2] Institut d'Etudes Politiques, Université de Strasbourg, 47 avenue de la Forêt Noire, 67082 Strasbourg Cedex. Email: paul-olivier.klein@unistra.fr
[3] Corresponding author. Institut d'Etudes Politiques, Université de Strasbourg, 47 avenue de la Forêt Noire, 67082 Strasbourg Cedex. Email: laurent.weill@unistra.fr

1. Introduction

Bank efficiency is crucial for the bank-based Chinese financial system. Cost efficiency of banks which measures the ability of banks to produce with minimal costs is associated with better managerial performance and allows banks to charge lower loan rates to borrowers. Furthermore, greater cost efficiency of banks has been shown to enhance financial stability (Berger and DeYoung, 1997; Podpiera and Weill, 2008) and to favor economic growth (Lucchetti, Papi and Zazzaro, 2001; Hasan, Koetter and Wedow, 2009).

The cost efficiency of the Chinese banks has been largely investigated. The main conclusion is that the five largest state-owned banks (the Big Five), which account for about 40% of the banking system's assets, suffer from low efficiency (Berger, Hasan, and Zhou, 2009, Fungáčová, Pessarossi and Weill, 2013). It indicates that these banks could hamper financial development and financial stability. This further leads to policy implications including the reduction of the market share of the Big Five or implementation of significant changes in their governance to enhance their efficiency.

However literature has so far considered only overall inefficiency of Chinese banks. This inefficiency can be further decomposed into its persistent and its transient part. Persistent inefficiency accounts for the presence of structural problems in the bank which can include poor organization or weak management, while transient inefficiency is related to non-systematic problems which only matter in the short term like for instance an economic downturn.

In order to decide about well-designed policy measures it is necessary to identify the proportions of persistent and transient inefficiency in the overall inefficiency of Chinese banks. Reducing persistent inefficiency implies major changes that affect management, organization, or even operating environment such as a change in government support. On the other hand, transient inefficiency can only be a temporary consequence of cyclical events and can be reduced through one-time adjustments like short-term changes in inputs.

Thus, finding lower efficiency of Big Five banks mainly caused by lower persistent efficiency would support the view that these banks need a significant reform or else their role in the financing of the economy should be clearly reduced. In case the inefficiency of Big Five banks is mainly transient, these banks are not a persistent cause of lower efficiency of the Chinese banking system and do not require profound changes.

The objective of this study is to provide the first efficiency analysis of Chinese banks decomposing overall efficiency between persistent efficiency and transient efficiency. This enables us to refine the former results on Chinese banks. We measure the persistent efficiency and transient efficiency of Chinese banks by applying the recent model from Kumbhakar, Lien and Hardaker (2014).

Their approach uses panel data to decompose overall efficiency between persistent efficiency and transient efficiency. It relies on a three-step procedure based on the use of the random effects model and the stochastic frontier approach.

This model provides a major improvement to the commonly used stochastic frontier models in the literature on bank efficiency. Panel data have the main advantage of providing the possibility to control for the bank heterogeneity due to unobserved time-invariant covariates. However, former approaches based on the stochastic frontier approach use panel data models which either view inefficiency as time-invariant (Schmidt and Sickles, 1984; Berger, 1993) or mix firm effects with inefficiency (Battese and Coelli, 1992, 1995). By utilizing Kumbhakar, Lien and Hardaker (2014)'s model, we disentangle persistent efficiency from transient efficiency while controlling for random bank-specific effects.[4]

We consider a large dataset of 170 banks for the period 2008-2015, including Big Five, joint-stock commercial banks, city commercial banks, rural banks and foreign banks. We rely on the panel nature of our dataset to examine whether the conclusion of lower efficiency for Big Five is observed for both persistent and residual efficiency.

Our paper contributes to the analysis of the efficiency of Chinese banks and the results enable us to evaluate the gap in efficiency of Big Five banks. It also contributes to the literature on bank efficiency by expanding the applications of the stochastic frontier model allowing the decomposition between persistent and transient efficiency. We are only aware of one recent work by Badunenko and Kumbakhar (2017) decomposing persistent and transient efficiency in the banking industry. Their study examines the effects of regulation on the different types of banks in India.

The rest of the article is structured as follows. Section 2 reviews the related literature. Section 3 presents data and methodology. Section 4 displays the main estimations. Section 5 concludes.

2. Related literature

We first describe the Chinese banking industry. We then review the main literature on efficiency of Chinese banks.

[4] Two recent papers provide alternative ways to estimate the model: Tsionas and Kumbhakar (2014) use a Bayesian approach and Filippini and Greene (2014) utilize a maximum simulated likelihood approach.

2.1 Chinese banking industry

There were many significant reforms implemented gradually in the Chinese banking sector in the last decades. This development is in line with the transformation of the Chinese economy as a whole. Prior to the reforms that started in 1978 the People's Bank of China (PBC) was the only bank performing both central bank and commercial bank functions. Currently the major banks in China are publicly listed and rank among the world's largest banks. Chinese banking sector has been growing very fast and the bank assets more than tripled between 2008 and 2016. They account for over 310% of GDP[5] ranking the Chinese banking system as one of the largest in the world (IMF, 2017). Bank loans serve as the main source of external financing for Chinese firms.

The reforms were implemented in several stages. First, a two-tier banking system was created. PBC retained its central bank functions and commercial operations were transferred to four specialized state-owned banks: Agricultural Bank of China (ABC), the Bank of China (BoC), the People's Construction Bank of China (which changed its name in 1996 to China Construction Bank, or CCB), and the Industrial and Commercial Bank of China (ICBC). They were allowed to accept deposits and grant loans and started to function as financial intermediaries in mid-1980s. Nowadays together with the Bank of Communications (BOCOM) these banks constitute the group of the largest banks (Big Five).

The second phase of reforms started in 1994 when the government needed to respond to growing asset quality deterioration of large state-owned banks. In order to separate policy lending from commercial lending three policy banks were created. To deal with the non-performing loans, the first round of state-bank recapitalization was implemented in 1998 and afterwards the first transfer of NPLs to asset management companies occurred a year later. There was an effort to stimulate competition and many new banks were allowed to enter the market including national level joint-stock commercial banks as well as city credit cooperatives and city cooperative banks. In 2001 China entered WTO and committed to opening up its banking system to foreign banks over the next five years.

The third stage of reforms aimed at creating sound governing structure and at strengthening banks' balance sheets of the largest state-owned banks. Starting in 2005, they were gradually transferred into joint-stock companies in order to prepare them for initial public offerings. The listings were done gradually and ABC's listing in 2010 was the final IPO for the four largest banks.

There has been progress in gradual liberalization of the financial system in recent years. The interest rates were liberalized; lending rates in 2013 and finally in October 2015 the interest rate ceiling

[5] The corresponding number for advanced economies is about 283% and emerging ones 95%.

on deposits of less than one year was eliminated. It seems that following these changes the credit pricing has improved as the share of loans well above or below the benchmark rate has increased (OECD, 2017). The pricing below the benchmark rate might however be related to SOEs lending. Another move in the liberalization process was the introduction of the deposit insurance system in May 2015. Nevertheless, more recently PBC has introduced different measures that provide selective liquidity support and thus do not support the move towards more market-based mechanisms (OECD, 2017).

Despite the implemented reforms and the entry of foreign investors, China's banking sector remains mostly in state hands. Different state authorities are involved depending on the type of bank. According to the banks' ownership structure the CBRC (China Banking Regulatory Commission) classifies banks into several groups. The first one consists of the Big Five banks. These are the largest state-owned banks that have been transferred into joint-stock companies and publicly listed in the last decade and thus in addition to the state as majority owner they all have private and foreign minority owners. These banks provide nationwide wholesale and retail services, and have strong focus on funding state-owned enterprises. The China Banking Regulatory Commission (CBRC) reports that the big state-owned banks held 41 % of all commercial banking system assets in 2014. Despite their impressive growth their share has been gradually decreasing; in 2004 it still stood at 57 %.

The second group of banks consists of joint-stock commercial banks that also operate nationwide. They are usually mid-sized banks with mixed ownership, and are relatively new banks as the youngest of them were established in the early 2000s. Joint stock banks largely operate typical commercial banking business and they also target SMEs. These banks accounted for 18 % of Chinese banking sector assets at the end of 2014, an increase by 6 % in comparison to 2004.

The "small-size" end of the market is represented by banks operating regionally which include city commercial banks and rural commercial banks, as well as small local banks such as rural cooperative banks, rural credit cooperatives, and village and township banks. City commercial banks are a product of shareholding reform of former urban credit cooperatives and until 2006 they could operate within their headquarter city. They were originally created to carry out local government lending operations and some of these banks are still owned by local governments. These banks are important in providing financing to small and medium-sized enterprises. Their share in the banking sector has doubled within ten years, reaching 10 % at the end of 2014. Rural banks mainly serve the rural population and usually operate within a small township or village.

Foreign banks do not account for a significant part of the banking sector assets. Their share has not changed significantly during the last decade as it stood at about 2 %.

2.2 Efficiency in Chinese banking

Bank efficiency of Chinese banks has been investigated in several studies. Chen, Skully, and Brown (2005) investigate the impact of the 1995 bank deregulation on cost efficiency of Chinese banks. They estimate cost efficiency of 43 Chinese banks over the period 1993-2000 with nonparametric data envelopment analysis (DEA). They find that large state-owned banks and small joint-stock commercial banks are more efficient than medium-sized joint-stock commercial banks. The mean yearly cost efficiency scores for the whole sample range from 42.6% to 58.2%.

Fu and Heffernan (2007) estimate cost efficiency of Chinese banks over the period 1985-2002 by employing the stochastic frontier approach. Their sample contains 14 banks (four state-owned banks and ten joint-stock commercial banks). They show that joint-stock commercial banks are more efficient than state-owned banks. The mean efficiency scores range between 40% and 52%, depending on the distributional assumptions.

Ariff and Can (2008) extend the analysis of efficiency of Chinese banks to profit efficiency. They measure cost efficiency and profit efficiency of 28 Chinese commercial banks over the period 1995-2004 with DEA. Mean cost efficiency for Chinese banks is 79.8%, which is significantly higher than mean profit efficiency ranging between 43.9% and 50.5% depending on the profit frontier specification. They also find greater cost efficiency and profit efficiency for joint-stock commercial banks than for state-owned banks.

Berger, Hasan, and Zhou (2009) study how ownership influences bank efficiency in China. They estimate cost efficiency and profit efficiency on a sample of 38 banks over the period 1995-2003 with the stochastic frontier approach. Their key conclusions are that the Big Four state-owned banks are the least efficient and the foreign banks are most efficient. This result stands for both cost efficiency and profit efficiency. The mean efficiency scores for the whole sample are 89.7% for cost efficiency and 47.6% for profit efficiency.

Fungacova, Pessarossi and Weill (2013) investigate the relation between bank competition and cost efficiency on a sample of 76 Chinese banks (including Big Five banks, joint-stock commercial banks, city commercial banks, foreign banks, and few other banks) over the period 2002-2011. To this end, they utilize the stochastic frontier approach to measure cost efficiency scores. While observing an average efficiency score of 74.6% over the period for all Chinese banks, they show that Big Five banks are the least efficient banks while foreign banks are the most efficient ones. In addition, they find no significant relation between bank competition and cost efficiency.

Dong et al. (2016) study cost and profit efficiency of Chinese banks for the 2002-2013 period. They use the stochastic frontier model from Battese and Coelli (1995) and consider a sample of 142 banks including Big Five banks, joint-stock commercial banks, city commercial banks, and foreign

banks. They extend the analysis of Berger, Hasan and Zhou (2009) to a greater sample and more recent data. They obtain mean efficiency scores of 69.7% for cost efficiency and 68.5% for profit efficiency and they find that Big Five banks are the least cost efficient banks while foreign banks are the most efficient ones. Cost efficiency of Big Five banks is significantly lower than the efficiency of all other groups and the gap in cost efficiency is persistent over the period. On the other hand, Big Five banks and joint-stock commercial banks are the most profit efficient. The authors point out an improvement in profit efficiency for Chinese banks over the period of study, while for cost efficiency there was a strong increase between 2002-2006 and 2007-2009 followed by stabilization between 2007-2009 and 2010-2013.

To sum up, the analysis of former literature on bank efficiency in China shows that ownership affects efficiency with a consensual view that Big Five banks are less cost efficient than other banks. We extend this literature by disentangling persistent efficiency and transient efficiency for our sample of Chinese banks which is larger than any dataset employed in the earlier studies.

3. Data and methodology

3.1. Methodology

In this section, we describe the methodology we use to calculate the efficiency scores. We aim to disentangle the persistent from the transient inefficiency of Chinese banks. While persistent inefficiency is stable over time, transient inefficiency varies across time for each bank. Distinguishing persistent from transient inefficiency has long been considered as unfeasible by the literature –an issue known as the "Greene problem" (Greene, 1980). Recent developments made by Kumbhakar, Lien and Hardaker (2014) have overcome this issue. Starting with the error-terms of panel data, they build a methodology to disentangle persistent and transient inefficiency. They start with the standard cost function for panel data:

$$\log c_{it} = h(\boldsymbol{y}_{it}, \boldsymbol{w}_{it};\, \boldsymbol{\theta}) + a_i + \epsilon_{it} \qquad (1)$$

where $i = 1, \dots, n$ denotes the i^{th} bank and $t = 1, \dots, T_i$ denotes the time period in which bank i is observed, c_{it} measures the total cost of the bank i at time t, $\boldsymbol{y}_{it}$ denotes the vector of outputs, $\boldsymbol{w}_{it}$ the vector of input prices and $h(.)$ is the cost function. a_i is the error-term for the bank i over all the time periods and ϵ_{it} is the error-term for the bank i in time period t.

Kumbhakar, Lien and Hardaker (2014) use the two error-terms to distinguish between persistent and transient inefficiency. They first divide the fixed error-term a_i in a random part which accounts for exogenous events affecting bank's costs (v_{0i}) and an inefficient part which can be attributed to the bank's cost inefficiencies (u_{0i}):

$$a_i = v_{0i} + u_{0i} \quad (2)$$

By definition, u_{0i} is fixed over time. Hence, it represents the fixed inefficiency, or persistent inefficiency, of bank *i*. Second, they divide the variable error-term ϵ_{it} in a random part which accounts for exogenous events affecting bank's costs (v_{it}) and an inefficient part which can be attributed to the bank's cost inefficiencies (u_{it}):

$$\epsilon_{it} = v_{it} + u_{it} \quad (3)$$

By definition, u_{it} changes over time. Hence, it represents the variable inefficiency, or transient inefficiency, of bank *i*. Overall, the cost function becomes:

$$\log c_{it} = h(\boldsymbol{y}_{it}, \boldsymbol{w}_{it};\ \boldsymbol{\theta}) + v_{0i} + u_{0i} + v_{it} + u_{it} \quad (4)$$

The error term now consists of four different components. The first component v_{0i} captures banks' latent heterogeneity which is constant over time. The second component u_{0i} captures the long-run/persistent/time-invariant inefficiency of the bank i. The third component v_{it} captures random shocks affecting the bank i at each period t. The fourth component u_{it} captures time-varying inefficiency.

We rely on the methodological approach developed in Kumbhakar, Wang and Horncastle (2015, p.275-276) to estimate the cost function (4). Their approach is based on three steps. First, a standard cost function for panel data is estimated as in (1) –*i.e.* with a fixed error-term a_i and a variable error-term ϵ_{it} .

We employ a translog cost frontier with random effects at the bank level. In line with Fungacova, Pessarossi and Weill (2013), we use the intermediation approach for the specification of input prices and outputs. This approach assumes that bank generates loans by collecting deposits and transforms them with labor and capital. We consider two outputs, loans (*y1*) and other earning assets *(y2)*. We use three inputs prices. Our first input price is the price of labor (*w1*) which is the ratio of personnel

expenses to total assets (*w1*). The second input price is the price of physical capital (*w2*), computed as the ratio of other non-interest expenses to fixed assets. The last input price is the price of borrowed funds (*w3*), defined as the ratio of interest paid to total funding. Homogeneity conditions are obtained by scaling the price of labor and the price of physical capital by the price of borrowed funds. The explained variable is Total Cost (*TC*), which corresponds to the sum of personnel expenses, other non-interest expenses, and interest paid. We estimate the following translog cost-function:

$$\ln\left(\frac{TC}{w_3}\right) = \beta_0 + \sum_m(\theta_m \ln y_m) + \sum_n\left(\beta_n \ln\frac{w_n}{w_3}\right) + \frac{1}{2}\sum_m\sum_j(\theta_{mj} \ln y_m \ln y_j) + \frac{1}{2}\sum_n\sum_k(\beta_{nk} \ln\frac{w_n}{w_3}\ln\frac{w_k}{w_3}) + \sum_n\sum_m(\gamma_{nm} \ln\frac{w_n}{w_3}\ln y_m) + a_i + \epsilon_{it} \quad (5)$$

where $m = 1, 2$ and $j = 1, 2$ denote the outputs and $n = 1, 2, 3$ and $k = 1, 2, 3$ denote the inputs prices. In this specification a_i captures the bank's random effect and ϵ_{it} is the classical random noise. This first step gives the predicted value of a_i and ϵ_{it}, respectively α_i and ε_{it}.

In the second step, we use the predicted value ε_{it} obtained in (5) to estimate the time-varying inefficiency u_{it}. We assume that v_{it} is a random noise i.i.d $N(0, \sigma_v^2)$ and u_{it} is $N^+(0, \sigma_u^2)$. We estimate u_{it} in (3) with a standard stochastic-frontier technique. We obtain a prediction of the bank's time-varying inefficiency $\hat{u}_{it}$ using the Jondrow et al. (1982) procedure. The residual cost efficiency (RCE) is calculated as in Battese and Coelli (1988): $RCE = \exp(u_{it}|\varepsilon_{it})$.

In the third step, we retrieve the bank's persistent inefficiency. For this, we split the bank's random-effect α_i predicted in (5) in two components, the banks' latent heterogeneity v_{0i} and the bank-specific time invariant inefficiency u_{0i}. Again, We assume that v_{0i} is a random noise i.i.d $N(0, \sigma_{v_0}^2)$ and u_{it} is $N^+(0, \sigma_{u_0}^2)$ and we estimate u_{0i} in (2) using the standard stochastic-frontier technique. We obtain a prediction of the bank's time-invariant inefficiency $\hat{u}_{0i}$ using the Jondrow et al. (1982) procedure. The persistent cost efficiency (PCE) is calculated as in Battese and Coelli (1988), $PCE = \exp(u_{0i})$.

Finally, the overall cost efficiency (OCE) is obtained as the product of the persistent and transient cost efficiency, that is $OCE = PCE \times RCE$.

3.2. Data

Our analysis is based on yearly bank-level financial statement data of Chinese banks from Bankscope database. We supplement missing values or variables with hand-collected data from the annual reports of the relevant bank's website. This way we construct a unique dataset containing a

total of 984 observations for 168 banks covering the period between 2008 and 2015. These banks account for the vast majority of Chinese banking sector's assets. We prefer not to include earlier time periods because the data is only available for limited number of banks. To put our dataset into perspective; Berger, Hasan and Zhou (2009) use a 39-bank sample in their efficiency analysis, and Dong et al. (2016) a 142-bank sample in their investigation of cost and profit efficiency.

The banks in our sample are divided into several categories by accounting for their ownership structure. This division is based on the classifications used by the CBRC. The descriptive statistics of the main variables used in the analysis are provided in Table 1 and Table 2.

4. Results

This section is devoted to the presentation of empirical results. Table 3 provides the estimated coefficients for the cost frontier. We display the mean efficiency scores per year and per type of banks in Table 4. Both transient, and persistent efficiency scores are reported. We further provide differences in efficiency scores between Big Five banks and other types of banks with significance tests for overall, transient, and persistent efficiency respectively in Tables 5, 6, and 7.

We start by commenting the scores for the whole sample of banks. First, the average overall efficiency score is 82.76%. This mean cost efficiency score is higher than what has been found in most former works. Fungacova, Pessarossi and Weill (2013) obtain an average score of 74.6% and Dong et al. (2016) find an average score of 69.7%. It is however lower than the mean efficiency score of 89.7% obtained by Berger, Hasan and Zhou (2009).

Second, we observe that transient efficiency and persistent efficiency levels are very similar for the whole sample. Their means over the period are respectively 90.81% and 91.07%. Therefore, the overall conclusion for Chinese banks is that they suffer as much from persistent inefficiency as from transient inefficiency.

Third, the evolution of transient efficiency over time does not show high volatility over time. Yearly mean scores for transient efficiency range between 90.03% and 91.37%. In addition, there is no clear trend for transient efficiency since there is no gradual rise or fall over the period. As a consequence, overall efficiency of Chinese banks has been very stable over the period.

We focus now on the efficiency of Big Five banks for which several conclusions emerge. Big Five banks have lower overall efficiency than most other types of banks. While Big Five banks have an average overall efficiency of 81.84%, the average overall efficiency is 83% for rural commercial banks, 85.18% for joint-stock commercial banks, and 85.43% for foreign banks. As shown in Table 5,

overall efficiency is significantly lower for Big Five banks than for joint-stock commercial banks and for foreign banks. Only city commercial banks are less efficient than Big Five banks with an average overall efficiency of 81.27% but this difference is not statistically significant.

The comparison of overall efficiency across types of banks confirms the general conclusion that Big Five banks have low cost efficiency relative to other types of banks. In line with Berger, Hasan and Zhou (2009), Fungacova, Pessarossi and Weill (2013) and Dong et al. (2016), we find that Big Five banks[6] are less efficient than joint-stock commercial banks and foreign banks. Our results slightly differ from former literature on the comparison between Big Five banks and city commercial banks: we conclude to better efficiency for Big Five banks while Fungacova, Pessarossi and Weill (2013) and Dong et al. (2016) find the opposite. However, these studies have relied on different time periods, which can explain the differences in their conclusions. All in all, since we use more recent and more accurate data than former studies, our findings tend to confirm the persistence of low efficiency of Big Five banks.

Nevertheless the key question is to determine if the low efficiency of Big Five banks mainly comes from persistent inefficiency or from transient inefficiency. We find that persistent inefficiency dominates transient inefficiency for Big Five banks. Namely mean persistent efficiency is 89.83% to be compared with 91.10% for mean transient efficiency. Consequently low overall efficiency of Big Five banks results more from persistent inefficiency than from transient inefficiency. This result is supported by the analysis of the differences in transient efficiency and in persistent efficiency between Big Five banks and other types of banks as reported in Tables 6 and 7. Over the period, Big Five banks do not have significantly lower transient efficiency than any other type of banks. However they have significantly lower persistent efficiency than joint-stock commercial banks and foreign banks. Hence the weak performance of Big Five banks in cost efficiency relative to other types of banks comes from low persistent efficiency. Low persistent efficiency indicates the presence of structural problems in these banks. Our results support the view that major changes should be implemented to enhance the efficiency of the large state-owned banks.

The analysis of yearly transient efficiency scores uncovers that transient efficiency is particularly volatile for Big Five banks. Namely, mean transient efficiency scores range from 86.58% to 93.37%. It has to be stressed that this range for yearly transient efficiency scores is much higher than for all other types of banks. The greater volatility of transient efficiency for Big Five banks than for other types of banks makes overall efficiency of these banks more volatile. The key implication is

[6] Berger, Hasan and Zhou (2009) consider a group of Big Four banks.

that this result suggests that Big Five banks are particularly affected by short-term events that might be related for example to window guidance.

When analyzing the results for other types of banks, we point out that persistent efficiency is higher than transient efficiency for joint-stock commercial banks, foreign banks, and rural commercial banks. Only city commercial banks are more hampered by persistent inefficiency than by transient inefficiency which is similar to the results for Big Five banks.

In a nutshell, we find that Big Five banks are less efficient than joint-stock commercial banks, rural commercial banks, and foreign banks. This lower efficiency mainly comes from low persistent efficiency, suggesting that structural changes have to be implemented to improve efficiency. In addition, transient efficiency is particularly volatile for Big Five banks, which tends to show greater dependence on short-term shocks and leads to higher volatility for these banks over time.

5. Conclusion

This study provides a new contribution to the analysis of the efficiency of Chinese banks. A common finding in this literature has been the low cost efficiency of Big Five banks. Such finding has major implications since these banks have a large market share in the Chinese banking industry, meaning that their weak cost efficiency can contribute to slowing down of economic growth.

In this study we investigate how overall inefficiency of Chinese banks is decomposed between persistent inefficiency and transient inefficiency. We uncover whether the low efficiency of Big Five banks mainly comes from persistent efficiency revealing structural problems or from transient efficiency associated with short-term events.

We obtain several insightful results. First, transient efficiency and persistent efficiency levels are of the same order of magnitude for all Chinese banks, meaning that overall efficiency is equally decomposed between both of these components. Second, Big Five banks have on average lower overall efficiency than other Chinese banks. This weakness of Big Five banks comes from lower persistent efficiency. In addition to the fact that Big Five banks have greater transient efficiency than persistent efficiency, we find that persistent efficiency is lower for Big Five banks than for other banks while no difference is observed for transient efficiency. Third, transient efficiency is more volatile for Big Five banks than for other banks. It suggests that these banks are more sensitive to short-term events.

Our main conclusion is that the efficiency problem of Big Five banks in China is mainly a persistent efficiency problem. High volatility of transient efficiency for Big Five banks suggests that the analysis of overall efficiency can be blurred by transient efficiency which can be temporary high and then gives the impression that overall efficiency of Big Five banks is satisfactory in the short-term.

However low persistent efficiency of Big Five banks supports the view that major reforms aimed at enhancing their efficiency should not be postponed. These reforms can be associated to privatization, changes in governance, or reduction of state support which might still contribute to higher incentives for wasting resources. Further research is necessary to assess the efficiency impact of these different measures.

References

Ariff, M., Can, L., 2008. Cost and Profit Efficiency of Chinese Banks: A Non-Parametric Analysis. China Economic Review 19, 2, 260-273.

Badunenko, O., Kumbakhar, S., 2017. Economies of Scale, Technical Change and Persistent and Time-Varying Cost Efficiency in Indian Banking: Do Ownership, Regulation and Heterogeneity Matter? European Journal of Operational Research 260, 789-803.

Battese, G.E., Coelli, T.J., 1992. Frontier Production Functions, Technical Efficiency and Panel Data: With Application to Paddy Farmers in India. Journal of Productivity Analysis 3, 153-169.

Battese, G.E., Coelli, T.J., 1995. A model for technical inefficiency effects in a stochastic production frontier for panel data. *Empirical Economics* 20, 2, 325-332.

Berger A., 1993. Distribution-Free Estimates of Efficiency in the U.S. Banking Industry and Tests of the Standard Distributional Assumptions. Journal of Productivity Analysis 4, 261-292.

Berger, A., DeYoung, R., 1997. Problem Loans and Cost Efficiency in Commercial Banks. Journal of Banking and Finance 21, 849-870.

Berger, A., Hasan, I., Zhou, M., 2009. Bank Ownership and Efficiency in China: What Will Happen in the World's Largest Nation? Journal of Banking and Finance 33, 1, 113-130.

Chen, X., Skully, M., Brown, K., 2005. Banking Efficiency in China: Application of DEA to Pre- and Post-Deregulations Era: 1993-2000. China Economic Review, 16, 229-245.

Dong, Y., Firth, M., Hou, W., Yang, W., 2016. Evaluating the Performance of Chinese Commercial Banks: A Comparative Analysis of Different Types of Banks. European Journal of Operational Research 252, 1, 280-295.

Filippini, M., Greene, W., 2016. Persistent and Transient Productive Inefficiency: A Maximum Simulated Approach. Journal of Productivity Analysis 45, 187-196.

Fu, X., Heffernan, S., 2007. Cost X-Efficiency in China Banking Sector. China Economic Review, 18, 35-53.

Fungáčová, Z., Pessarossi, P., Weill, L., 2013. Is Bank Competition Detrimental to Efficiency? Evidence from China. China Economic Review 27, 121-134.

Greene, William H., 1980, On the estimation of a flexible frontier production model, Journal of Econometrics 13, 101–115.

Hasan, I., Koetter, M. Wedow, M., 2009. Regional Growth and Finance in Europe: Is There a Quality Effect of Bank Efficiency? Journal of Banking and Finance 33, 8, 1446, 1453.

IMF, 2017. People's Republic of China Staff Report for the 2017 Article IV Consultation, July 2017.

Jondrow, J., Lovell, C.A.K., Materov, I., Schmidt, P., 1982. On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model. Journal of Econometrics 19, 233-238.

Kumbhakar, S., Lien, G., Hardaker, J., 2014. Technical Efficiency in Competing Panel Data Models: A Study of Norwegian Grain Farming. Journal of Productivity Analysis 41, 2, 321-337.

Kumbhakar, S., Wang, H., Horncastle, A., 2015. A Practitioner's Guide to Stochastic Frontier Analysis Using Stata. Cambridge University Press.

Lucchetti, R., Papi, L., Zazzaro, A., 2001. Bank's Inefficiency and Economic Growth : A Micro-Macro Approach. Scottish Journal of Political Economy 48, 4, 400-424.

OECD, 2017. OECD Economic Surveys: China. March 2017.

Podpiera, J., Weill, L., 2008. Bad Luck or Bad Management? Emerging Banking Market Experience. Journal of Financial Stability 4, 135-148.

Schmidt, P., Sickles, R., 1984. Production Frontiers and Panel Data. Journal of Business and Economic Statistics 2, 4, 367-374.

Tsionas, M., Kumbhakar, S., 2014. Firm Heterogeneity, Persistent and Transient Technical Inefficiency: A Generalized True Random-Effects Model. Journal of Applied Econometrics 29, 110-132.

Table 1
Descriptive statistics

This table provides descriptive statistics of the variables used in the frontier estimation. Total Costs (*tc*) is the sum of personal expenses, interest expenses and other expenses. All variables are in millions CNY.

	All	Mean	Median	Std Dev.	Min.	Max.
Total Costs (*tc*)	984	18 299	2 325	59 868	4	476 525
Gross Loans (*y1*)	984	390 346	41 203	1 346 053	98	11 900 000
Other Earning Assets (*y2*)	984	329 773	41 528	1 038 162	163	8 638 760
Personal Expenses/Assets (*w1*)	984	0.01	0.01	0	0	0.03
Operating Expenses/Assets (*w2*)	984	2	0.77	6.11	0	155.93
Interests/Total Funding (*w3*)	984	0.01	0.01	0.03	0	1.07

Table 2
Descriptive statistics by bank type

This table provides descriptive statistics of the variables depending on the bank type. Total Costs (*tc*) is the sum of personal expenses, interest expenses and other expenses. All variables are in millions CNY.

	N	Mean	Median
Big Five Banks			
Total Costs (*tc*)	40	270 608	255 797
Gross Loans (*y1*)	40	6 138 315	6 035 720
Other Earning Assets (*y2*)	40	4 743 255	5 051 629
Personnel Expenses/Assets (*w1*)	40	0.01	0.01
Operating Expenses/Assets (*w2*)	40	0.48	0.44
Interests/Total Funding (*w3*)	40	0.01	0.01
Joint-Stock Commercial Banks			
Total Costs (*tc*)	92	43 420	36 807
Gross Loans (*y1*)	92	918 876	784 837
Other Earning Assets (*y2*)	92	839 852	631 380
Personnel Expenses/Assets (*w1*)	92	0.01	0.01
Operating Expenses/Assets (*w2*)	92	0.95	0.85
Interests/Total Funding (*w3*)	92	0.01	0.01
City Commercial Banks			
Total Costs (*tc*)	504	3 713	2 116
Gross Loans (*y1*)	504	65 257	35 992
Other Earning Assets (*y2*)	504	75 720	41 119
Personnel Expenses/Assets (*w1*)	504	0.01	0
Operating Expenses/Assets (*w2*)	504	0.92	0.62
Interests/Total Funding (*w3*)	504	0.02	0.01
Rural Commercial Banks			
Total Costs (*tc*)	123	4 409	2 486
Gross Loans (*y1*)	123	82 166	55 781
Other Earning Assets (*y2*)	123	79 825	39 267
Personnel Expenses/Assets (*w1*)	123	0.01	0.01
Operating Expenses/Assets (*w2*)	123	0.72	0.51
Interests/Total Funding (*w3*)	123	0.01	0.01
Foreign Banks			
Total Costs (*tc*)	221	1 622	889
Gross Loans (*y1*)	221	28 053	13 526
Other Earning Assets (*y2*)	221	27 208	14 964
Personnel Expenses/Assets (*w1*)	221	0.01	0.01
Operating Expenses/Assets (*w2*)	221	5.88	3.67
Interests/Total Funding (*w3*)	221	0.01	0.01

Table 3
Cost Frontier

Panel translog cost frontier with random-effects at the bank-level. Definition of the variables is provided in the methodological section. We follow the approach of Kumbhakar, Lien, and Hardaker (2014) and divide the efficiency in a persistent and transient part. *, **, and *** denote an estimate significantly different from 0 at the 10%, 5%, and 1% level, respectively.

	log(tc/w3)
log(y1)	0.514***
	(6.04)
log(y1)²	0.197***
	(18.37)
log(y2)	0.335***
	(4.92)
log(y2)²	0.148***
	(12.02)
log(y1) × log(y2)	-0.163***
	(-14.76)
log(w1/w3)	0.429***
	(4.72)
0.5 × log(w1/w3)²	0.249***
	(14.79)
log(w2/w3)	0.013
	(0.25)
0.5 × log(w2/w3)²	0.032***
	(9.45)
0.5 × log(w1/w3) × log(w2/w3)	-0.054***
	(-3.32)
log(y1) × log(w1/w3)	0.039***
	(4.04)
log(y1) × log(w2/w3)	-0.026***
	(-3.41)
log(y2) × log(w1/w3)	-0.021*
	(-1.81)
log(y2) × log(w2/w3)	0.022***
	(3.20)
Constant	2.615***
	(3.99)
Transient Error component	
usigmas	
Constant	-4.120***
	(-32.94)
Persistent Error Component	
usigmas	
Constant	-4.181***
	(-40.98)
N	984
N of groups	168
Chi²	33517***
R² Within	0.95
Residuals Skewness	1.43***

Table 4
Efficiency Measures

This table provides the efficiency scores of the banks over the years and depending on the bank type. We follow Kumbhakar, Lien, and Hardaker (2014) and divide the efficiency in a persistent and transient part.

Years	All			Big 5		
	Overall	Transient	Persistent	Overall	Transient	Persistent
2008	0.8254	0.9049	0.9118	0.7775	0.8658	0.8983
2009	0.8334	0.9137	0.9118	0.815	0.9077	0.8983
2010	0.8326	0.9123	0.9122	0.8306	0.9248	0.8983
2011	0.8297	0.9085	0.9130	0.7989	0.8885	0.8983
2012	0.8349	0.9129	0.9125	0.8320	0.9264	0.8983
2013	0.8265	0.9089	0.908	0.8387	0.9337	0.8983
2014	0.8180	0.9003	0.9083	0.8261	0.9195	0.8983
2015	0.8242	0.9057	0.9100	0.8281	0.9215	0.8983
Total	**0.8276**	**0.9081**	**0.9107**	**0.8184**	**0.911**	**0.8983**
	Joint-Stock			Foreign		
	Overall	Transient	Persistent	Overall	Transient	Persistent
2008	0.8524	0.9138	0.9332	0.8622	0.9146	0.9423
2009	0.8652	0.9272	0.9332	0.8666	0.9191	0.9428
2010	0.8681	0.9303	0.9332	0.8575	0.9107	0.9411
2011	0.856	0.9193	0.9310	0.8549	0.911	0.9384
2012	0.8541	0.9199	0.9283	0.8512	0.9070	0.937
2013	0.8553	0.9215	0.9280	0.8458	0.9060	0.9341
2014	0.8331	0.8973	0.9283	0.8421	0.9033	0.9318
2015	0.8332	0.8974	0.9283	0.8612	0.9199	0.9364
Total	**0.8518**	**0.9155**	**0.9304**	**0.8543**	**0.911**	**0.9375**
	CCB			RCB		
	Overall	Transient	Persistent	Overall	Transient	Persistent
2008	0.8110	0.9073	0.8936	0.8105	0.8756	0.9251
2009	0.8180	0.9126	0.8956	0.8283	0.8921	0.9283
2010	0.8118	0.9077	0.8941	0.8512	0.9165	0.9286
2011	0.8109	0.9050	0.8957	0.8519	0.9183	0.9278
2012	0.8267	0.9173	0.9009	0.8211	0.8992	0.9013
2013	0.8129	0.9051	0.8972	0.8320	0.9128	0.9052
2014	0.8057	0.8964	0.8984	0.8246	0.9105	0.9070
2015	0.8071	0.8967	0.8999	0.8270	0.9143	0.9059
Total	**0.8127**	**0.9055**	**0.8971**	**0.83**	**0.9078**	**0.912**

Table 5
Overall Efficiency

This table provides the difference in the overall efficiency scores of the Big 5 banks over the years. Significance is tested with a test of student. *. **. and *** denote significant difference at the 10%, 5%, and 1% level respectively.

	Big5 - Joint-Stock	Big5 - CCB	Big5 - RCB	Big5 - Foreign	Big5 - All
2008	-0.0749***	-0.0335	-0.033	-0.0847***	0.0505
	(-7.68)	(-1.03)	(-1.21)	(-3.08)	(1.67)
2009	-0.0501***	-0.0029	-0.0133	-0.0516**	0.0193
	(-5.17)	(-0.11)	(-0.63)	(-2.53)	(0.74)
2010	-0.0375***	0.0188	-0.0207	-0.0269	0.0021
	(-3.49)	(0.75)	(-0.96)	(-0.99)	(0.08)
2011	-0.0571**	-0.012	-0.053**	-0.056**	0.0321
	(-2.73)	(-0.43)	(-2.4)	(-2.58)	(1.28)
2012	-0.0222	0.0053	0.0108	-0.0192	0.0031
	(-1.60)	(0.18)	(0.15)	(-0.50)	(0.08)
2013	-0.0166	0.0258	0.0067	-0.0071	-0.012
	(-1.04)	(0.78)	(0.12)	(-0.24)	(-0.33)
2014	-0.007	0.0203	0.0014	-0.016	-0.0066
	(-0.40)	(0.76)	(0.04)	(-0.58)	(-0.24)
2015	-0.0051	0.0209	0.0011	-0.0331	-0.0028
	(-0.28)	(0.82)	(0.03)	(-1.55)	(-0.11)
Total	-0.0335***	0.0057	-0.0116	-0.0359***	-0.0102
	(-5.77)	(0.56)	(-0.79)	(-3.73)	(0.97)

Table 6
Transient Efficiency

This table provides the difference in the transient efficiency scores of the Big 5 banks over the years. Significance is tested with a test of student. *. **. and *** denote significant difference at the 10%, 5%, and 1% level respectively.

	Big5 - Joint-Stock	Big5 - CCB	Big5 - RCB	Big5 - Foreign	Big5 - All
2008	-0.048***	-0.0415	-0.0098	-0.0488*	0.0413*
	(-4.49)	(-1.6)	(-0.44)	(-2.02)	(1.74)
2009	-0.0195**	-0.005	0.0156	-0.0114	0.0063
	(-2.77)	(-0.30)	(0.90)	(-0.61)	(0.39)
2010	-0.0055	0.0171	0.0083	0.0141	-0.013
	(-1.22)	(1.22)	(0.51)	(0.62)	(-0.81)
2011	-0.0308*	-0.0165	-0.0297*	-0.0225	0.0208
	(-2.18)	(-0.91)	(-1.87)	(-1.43)	(1.35)
2012	0.0064	0.0091	0.0272	0.0194	-0.0141
	(1.33)	(0.41)	(0.48)	(0.59)	(-0.46)
2013	0.0122*	0.0286	0.0209	0.0277	-0.0258
	(2.04)	(1.21)	(0.63)	(0.95)	(-1.02)
2014	0.0222	0.0231	0.009	0.0162	-0.0191
	(1.72)	(1.43)	(0.65)	(0.79)	(-1.15)
2015	0.0241*	0.0248	0.0072	0.0016	-0.0164
	(2.02)	(1.40)	(0.62)	(0.10)	(-1.00)
Total	-0.0045	0.0055	0.0032	0	0.0029
	(-1.03)	(0.79)	(0.32)	(0)	(-0.4)

Table 7
Persistent Efficiency

This table provides the difference in the persistent efficiency scores of the Big 5 banks over the years. Significance is tested with a test of student. *. **. and *** denote significant difference at the 10%, 5%, and 1% level respectively.

	Big5 - Joint-Stock	Big5 - CCB	Big5 - RCB	Big5 - Foreign	Big5 - All
2008	-0.0349**	0.0047	-0.0268	-0.0441***	0.0143
	(-2.86)	(0.20)	(-1.81)	(-3.72)	(0.68)
2009	-0.0349**	0.0027	-0.03*	-0.0446***	0.0142
	(-2.86)	(0.12)	(-2.13)	(-3.88)	(0.70)
2010	-0.0349**	0.0042	-0.0303*	-0.0429***	0.0146
	(-2.86)	(0.19)	(-2.16)	(-3.14)	(0.72)
2011	-0.0328**	0.0025	-0.0295*	-0.0401**	0.0153
	(-2.71)	(0.12)	(-2.04)	(-2.59)	(0.76)
2012	-0.0301**	-0.0027	-0.0031	-0.0387**	0.0149
	(-2.38)	(-0.13)	(-0.07)	(-2.34)	(0.62)
2013	-0.0297**	0.001	-0.0069	-0.0358*	0.0109
	(-2.24)	(0.05)	(-0.17)	(-1.97)	(0.44)
2014	-0.0301**	-0.0002	-0.0087	-0.0335*	0.0117
	(-2.38)	(-0.01)	(-0.23)	(-1.79)	(0.48)
2015	-0.0301**	-0.0016	-0.0076	-0.0382**	0.0136
	(-2.38)	(-0.08)	(-0.2)	(-2.23)	(0.57)
Total	-0.0321***	0.0012	-0.0138	-0.0392***	-0.0135*
	(-7.67)	(0.15)	(-1.17)	(-7.1)	(1.69)