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## Is bank competition detrimental to efficiency? Evidence from China

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Zuzana Fungáčová, Pierre Pessarossi and  
Laurent Weill

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Zuzana Fungáčová<sup>#</sup>, Pierre Pessarossi<sup>+</sup> and Laurent Weill<sup>\*</sup>

## Is bank competition detrimental to efficiency? Evidence from China

### Abstract

This paper addresses the relationship between bank competition and efficiency by computing Lerner indices and cost efficiency scores for a sample of Chinese banks over the period 2002-2011. Granger-causality tests are performed in a dynamic GMM panel estimator framework to evaluate the sign and direction of causality between them. We observe no increase in bank competition over the period, even as cost efficiency improves. In a departure from the empirical literature showing that competition negatively granger-causes cost efficiency for Western banks, we find no significant relation between competition and efficiency. This suggests that measures to increase bank competition in the Chinese context are not detrimental to efficiency.

JEL Codes: G21, D40

Keywords: bank, competition, efficiency, China

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# 1 Introduction

The general view in the economic literature is that bank competition promotes economic growth (e.g. Claessens and Laeven, 2005). In China, however, the banking industry dominates the financial system (Allen et al., 2012). Just five state-owned banks held 47% of total banking sector assets at the end of 2011 (CBRC Annual Report, 2012).<sup>1</sup> The dominance of state banks presents obvious questions concerning competitiveness in the Chinese banking industry and the ability of the Chinese financial system to support economic growth of core industries over the long run. Yet academic assessments of bank competition in China remain impressively scarce. A rare exception is the study of Yuan (2006), who measures competition over the period 1996-2000. Competition, measured by a non-structural aggregate measure for the Chinese banking industry, is surprisingly shown to be perfect.

As competition often relates to banking system efficiency, the dominance of the five largest state-owned banks also raises the corollary issue of efficiency of the Chinese banking industry. Berger, Hasan, and Zhou (2009) note the lower efficiency of state-owned banks may reflect their dominant market position.

In this paper, we provide new evidence on the relationship between competition and efficiency in the Chinese banking industry by considering recent data on a large sample of Chinese banks between 2002 and 2011. This work has three objectives.

Our first aim is to measure the level and the evolution of banking competition in China over the past decade. This is of particular interest for the analysis of the banking industry. First, it provides information on the degree of competition for Chinese banks relative to other countries. Second, it assembles evidence on the evolution of bank competition in China during a decade marked by profound reforms of the Chinese banking industry, especially concerning the large state-owned banks. These reforms include a transfer of non-performing loans to asset management companies, bank recapitalization, and the entry of minority foreign strategic investors in several banks. China's accession to the WTO in 2001 allowed foreign banks access to the banking system, albeit market share held by foreigners remains very low. Our analysis helps assess the market power of banks over the decade. We check whether large state-owned banks differ in market power relative to other

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<sup>1</sup> The "Big Four" (Industrial and Commercial Bank of China, Agricultural Bank of China, China Construction Bank, and Bank of China), plus the Bank of Communications. We refer to these in our analysis as the "Big Five."

banks. This provides information about the effects on competition from the persistence of large state-owned banks and the entry of foreign banks.

Our second aim here is to investigate the efficiency of Chinese banks in recent years. Several studies analyze bank efficiency in China (e.g. Chen, Skully, and Brown, 2005; Fu and Heffernan, 2007; Ariff and Can, 2008; and Berger, Hasan, and Zhou, 2009) but they rely on datasets from the 1990s and early 2000s. We update the discussion of efficiency of Chinese banks by looking at the situation after reforms in the banking industry. One topic of particular interest is whether large state-owned banks still suffer from lower efficiency than their counterparts.

The third aim is to investigate the relationship and causality between competition and efficiency in the Chinese banking industry as these characteristics of market structure are seen as related in other contexts. The intuitive “quiet life” hypothesis suggests that competition promotes higher efficiency. The theoretical “efficient-structure” hypothesis (Demsetz, 1973), in contrast, predicts a negative impact of efficiency on competition, as more efficient banks would benefit from lower costs and thus gain higher market shares. Furthermore, the specific characteristics of bank competition may negatively influence efficiency as reduced competition lets banks benefit from economies of scale in monitoring borrowers and through longer-term customer relationships.

The sign and direction of causality of the relationship between competition and efficiency in the Chinese banking industry have normative implications for bank regulators. If we find evidence showing a positive impact of bank competition on efficiency, the policy conclusion would be that regulators should favor pro-competitive policies in the Chinese banking industry as it promotes economic gains through greater consumer welfare and efficiency of Chinese banks. On the other hand, a finding that efficiency negatively impacts bank competition in line with literature on other countries (e.g. Casu and Girardone, 2009) would imply that bank regulators face a trade-off and should moderate their application of pro-competitive policies. In addition, the observation of a detrimental impact of efficiency on competition that accords with the “efficient-structure hypothesis” would imply pro-competitive policies have little relevance.

Fu and Heffernan (2009) analyze the interrelationships of profitability, cost efficiency, and market structure indicators (concentration indices and market share) for Chinese banks between 1985 and 2002. They find no relation between cost efficiency and market structure indicators. However, their study provides limited evidence relevant to our

research question; market structure indicators are relatively crude measures of competition compared to measures based on the new empirical Industrial Organization (IO) approach such as the Lerner index. Furthermore, the relation is not analyzed within the dynamic panel framework and not tested for Granger-causality.

We analyze the relation and causality between competition and efficiency in the Chinese banking industry by computing Lerner indices to measure competition in line with recent studies on bank competition (e.g. Carbo et al., 2009; Turk-Ariss, 2010). We perform Granger-causality tests to check the direction of causality. Following Pruteanu-Podpiera, Schobert, and Weill (2007) and Casu and Girardone (2009), we embed Granger-causality estimations in Generalized Method of Moments (GMM) dynamic panel estimators designed to handle autoregressive properties in the dependent variable when lagged values are included as explanatory variables. Both papers analyze this issue for samples of European banks. They provide evidence in favor of a negative relation between competition and efficiency, that results from a detrimental impact of competition on efficiency. These results contradict the intuitive notion that competition is positively related to efficiency. We thus ask if a similar conclusion is warranted for the Chinese banking industry.

The rest of the article is structured as follows. Section 2 briefly describes the recent evolution of the Chinese banking industry and surveys the literature related to the relation between competition and efficiency, as well as banking in China. Section 3 discusses data and methodology. Section 4 discusses the results. Section 5 concludes.

## 2 Background

### 2.1 The evolution of the Chinese banking industry

The Chinese banking sector has gone through significant reforms in recent decades. Before 1978, the People's Bank of China (PBC) operated in a mono-banking environment. Today, all major Chinese banks measured by assets have staged successful initial public offerings and are listed. They all meet Basel I capital adequacy requirements and are moving to meet Basel II requirements. Four Chinese banks rank among the world's ten largest banks.<sup>2</sup> The banking sector constitutes the most important part of the financial system in China. Bank

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<sup>2</sup> As of mid-September 2012, four of the world's ten largest banks in terms of market capitalization were Chinese (KPMG, 2012).



loans are the main source of external funding, accounting for 75% of all external funding sources at the end of 2010.<sup>3</sup>

China's banking sector reforms were part of the broader economic reforms and were implemented gradually. Initially, a two-tier banking system was introduced so that the PBC retained its central bank functions as commercial operations were transferred to four specialized state-owned banks.<sup>4</sup> These new state-owned banks started to perform the main financial intermediation functions in the mid-1980s after they were allowed to accept deposits and grant loans. At the same time, the establishment of several new banks was permitted.

During the second phase of reforms, which were launched in 1994, the Chinese government had to respond to growing asset quality deterioration of large state-owned banks. Three policy banks were established with the objective of separating policy lending from commercial lending. In 1995, the Commercial Bank Law of China officially granted the "Big Four" banks commercial bank status. In 1998, the first round of state-bank recapitalization to deal with the stock of non-performing loans (NPLs) took place. The following year, the first transfer of NPLs to asset management companies occurred. New banks also entered the market during this period. For example, Minsheng Banking Corporation (China's largest private bank) was created in 1996. In December 2001, China entered WTO and committed to opening up its banking system to foreign banks over the next five years.

The third phase of reforms involved getting the large state-owned commercial banks in shape for initial public offerings and listing. The goal of the overhauls was to strengthen balance sheets by transferring NPLs off the books and then recapitalizing each bank. The listing of ABC in 2010 was the final IPO for the four commercial banks. ABC was listed on both the Shanghai and Hong Kong exchanges.

Despite the reforms and the entry of foreign investors, China's banking sector remains mostly in state hands. The large state-owned commercial banks are still the main providers of nationwide wholesale and retail banking services, even if their share of assets in the banking sector overall declined from 58% in 2003 to 47% in 2011. The second largest group of banks in China consists of 12 joint-stock commercial banks. Their share,

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<sup>3</sup> People's Bank of China (2010), *The People's Bank of China Monetary Policy Report*.

measured in terms of banking sector assets, increased from about 11% to over 16% between 2003 and 2011 (mostly at the expense of the large state-owned banks).

The third tier of the banking sector is composed of city commercial banks. These traditionally operate in local markets within a particular administrative region, even if the regulation that once limited their regional scope has been abolished. Another group of banks operating in China are rural financial institutions. They include traditional institutions like rural commercial banks, rural cooperative banks, and rural credit cooperatives, as well as new rural financial institutions such as village or township banks, lending companies, and rural mutual cooperatives. 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 1.5% in 2003 and was just below 2% at the end of 2011, when there were 40 locally incorporated foreign banks and 94 foreign bank branches in China. Foreign owners have also been allowed to hold minority stakes in certain state-owned banks since 1996.

## 2.2 The relation between competition and efficiency in banking

Despite the dearth of theoretical literature on the link between competition and efficiency, the sentiment of Caves (1980, p. 88) that economists have “a vague suspicion that competition is the enemy of sloth” is widespread. We identify three strands of thought on the relationship of competition and efficiency in the literature.

The “quiet life” hypothesis that increased competition enhances cost efficiency derives from the idea that monopoly power allows managers to grab a share of the monopoly rents through discretionary expenses or a reduction of their efforts. Hicks (1935) suggests that monopoly power allows firms to relax their efforts. Nonetheless, the existence of a monopoly rent does not explain its appropriation by managers. Owners of monopolistic firms can exert the same control of managerial effort than those of competitive firms, and might thus prevent this appropriation.

Leibenstein (1966) bolsters Hicks’ argument by explaining why inefficiencies inside firms (X-inefficiencies) exist and why they are reduced by the degree of competition in product markets. He explains that X-inefficiencies come from imperfections in the in-

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<sup>4</sup> 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).

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ternal organization of firms creating information asymmetries between owners and managers. Competition reduces these inefficiencies in two ways. First, it provides incentives for managers to exert more effort to avoid the personal costs of bankruptcy. Second, a greater degree of competition provides owners with better knowledge to assess the performance of their firm (and managers) relative to other firms. Following Leibenstein's work, some papers have proposed a formalization of his ideas (e.g. Hart, 1983; Scharfstein, 1988).

The "efficient-structure" hypothesis, proposed by Demsetz (1973), predicts that cost efficiency reduces competition. It contradicts the "quiet life" view in terms of both sign and direction of causality. Here, the best-managed firms have the lowest costs and consequently the largest market shares. This leads to a higher level of concentration. As concentration can be considered an inverse measure of the competition, a negative link between competition and efficiency is expected.

Finally, we have the "banking specificities" hypothesis, which suggests that competition has a detrimental impact on cost efficiency. While the first two views are not specific to banking markets, the theoretical literature suggests that the banking industry is unique in how it operates. Developed by Pruteanu-Podpiera, Weill, and Schobert (2008), the starting point of this hypothesis is the observation of the imperfect competition structure of banking markets, which is stressed in most studies analyzing bank competition (e.g. Carbo et al., 2009). The theoretical literature on banking suggests that this market structure may be the result of information asymmetries in the lending relationship. These asymmetries provide banks and regulators with the incentives to implement certain mechanisms to solve the resulting issues such as moral hazard. Banks gain useful information, for example, through establishing long-term relationships with their customers to gain information on them. However greater bank competition among banks may reduce the length of the customer relationships.

This hypothesis is complemented by Diamond (1984), who shows that banks, unlike investors, have a comparative advantage in the *ex post* monitoring of borrowers through economies of scale resulting from their monitoring role.

By increasing the number of competitors on a banking market, competition can increase costs to the lender seeking to maintain economies of scale in the face of customer relationships of shorter duration. As a consequence, competition hampers the cost efficiency of banks.

The empirical literature offers only a few studies on the relation between competition and efficiency in banking. The first wave of studies includes works investigating the link between cost efficiency and market structure indicators (market share or concentration indices). These papers analyze the relationships among profitability, cost efficiency, and market structure indicators to test hypotheses concerning the relation between cost efficiency and market structure indicators, as well as those that relate profitability to both characteristics. They do not analyze the relevance of the “quiet life” hypothesis, but check whether cost efficiency and market structure influence profitability. Most of these studies concern banking industries of Western countries. For example, Berger (1995) looks at US banks, while Goldberg and Rai (1996) examine European banks. These studies typically show a positive relation between cost efficiency and market share (or cost efficiency and concentration). As higher concentration and greater market share are both associated with lower competition, they support the view of a negative relation between competition and cost efficiency.

The study by Fu and Heffernan (2009) is of particular interest for our discussion. In line with the above-mentioned studies, it analyzes the interrelationships between profitability, cost efficiency, and market structure indicators on China. The investigation is performed on a sample of 187 observations (14 banks) from 1985 to 2002. While cost efficiency is measured by employing the stochastic frontier approach, market structure is represented by the market share, the Herfindahl index, and the share of the four largest banks. The authors alternatively perform regressions of market structure indicators on cost-efficiency scores and cost-efficiency scores on market structure indicators. No relation between market structure indicators and cost efficiency is found in any of the estimated regressions.

These works provide the first empirical investigation of the relation. Nevertheless, they rely on structural measures of competition that suffer from limitations we describe below. Moreover, they do not use dynamic panel estimators to analyze this relation. Finally, causality is only considered by including variables as right-side and left-side variables in the regressions; no Granger-causality test is performed.

The second wave of empirical works includes studies that consider non-structural measures of competition. Weill (2004) analyzes the relation between cost efficiency and the H-statistic obtained with the Rosse-Panzar model to measure competition for Western European banks. He finds a negative relation between competition and efficiency. Maudos

and Fernandez de Guevara (2007) employ the Lerner index to measure market power of European banks in their analysis of this relation. They support the view of a negative relation between competition and efficiency. Solis and Maudos (2008) perform a similar analysis for Mexican banks by considering separately the Lerner index for deposits and loans. While they observe a negative link between competition and efficiency on the deposit market, they find an opposite result for the loan market.

The third wave of empirical studies includes attempts to measure competition by employing non-structural measures and performing Granger-causality tests to check the sign and direction of causality between competition and efficiency. Pruteanu-Podpiera, Schobert, and Weill (2007) analyze the relation between competition and efficiency for a sample of Czech banks. Competition is measured by the Lerner index. Granger-causality tests are performed to check the sign and type of causal relation between competition and efficiency. Granger-causality estimations are embedded in GMM dynamic panel estimators. Competition is found to negatively Granger-cause efficiency, but efficiency does not Granger-cause competition. Casu and Girardone (2009) perform a similar investigation for banks from the five largest EU countries. They observe limited support for a negative impact running from competition to efficiency, but find no evidence of reverse causality. Both works corroborate the results of earlier studies that show a negative relation between competition and efficiency. Moreover, as causality runs from competition to efficiency, they suggest that this relation is better explained by the “banking specificities” hypothesis than the “efficient-structure” hypothesis.

All in all, the theoretical literature provides conflicting arguments with respect to the sign and direction of causality between competition and efficiency. The empirical literature tends to support a negative relation.

### 2.3 Competition and efficiency in Chinese banking

Bank competition in China has received surprisingly little academic treatment. We are aware of only two publications that analyze this issue.

Yuan (2006) measures competition with the non-structural H-statistic, relying on the sample of 15 banks covering the period from 1996 to 2000. His purpose was to establish the level of bank competition in China before it joined the WTO. Notably, he obtains measures of the H-statistic quite close to one, which he interprets as evidence the Chinese

banking industry was near a state of perfect competition at that time. Comparing this study with other works using the H-statistic (e.g. Carbo et al., 2009), it appears these H-statistic values for China are much higher than values generally found for other banking industries. However, Yuan's (2006) study was conducted on a limited sample of banks. Furthermore, the level of bank competition may well have changed after China joined the WTO.

Fu (2009) also analyzes bank competition in China with the non-structural H-statistic, but employs a larger sample of 76 banks and covers a more recent period (1997 to 2006). Her results indicate monopolistic competition in the Chinese banking industry and an increase in bank competition after China joined the WTO in 2001.

Beyond these studies, the recent Global Finance Development Database from the World Bank provides a large set of measures on financial systems for the period 1960-2010.<sup>5</sup> The GFDD includes a yearly mean Lerner index for Chinese banks from 1997 to 2010. The mean Lerner index falls from 0.39 to 0.26 between 1997 and 2001, suggesting enhanced bank competition between 1997 and 2001. The mean Lerner index falls from 0.39 to 0.26 and then rises from 0.26 to 0.38 between 2001 and 2010, suggesting a reduction in bank competition between 2001 and 2010. While these measures help assess bank competition in China, the GFDD methodological information on the computation of the Lerner index is limited as the database only mentions that "it compares output pricing and marginal cost." Moreover, the yearly mean Lerner index does not allow distinguishing between different types of banks in China, nor does it indicate how many Chinese banks are included in the calculation. Indeed, all we know is that Lerner indices of the GFDD were computed from Bankscope data.

Thus, despite the insights of the above studies, they provide limited information on comparison of market power across types of banks and the evolution of bank competition over time. The H-statistic only provides an aggregate measure of competition for the banking industry, i.e. the overall degree of bank competition in China. While it conceivably could provide specific measures of competition for groups of banks, this would be difficult in the case of China where the groups are small. Moreover, as pointed out by Shaffer (2004), the H-statistic is not a continuous measure of bank competition, but a diagnosis on the type of competition. As a consequence, it only indicates whether the banking market is

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<sup>5</sup> For more details see <http://data.worldbank.org/data-catalog/global-financial-development>

in monopolistic competition, monopoly, or perfect competition. It is unsuited to assessing the evolution of bank competition over time.

In contrast, bank efficiency in China has been tackled in several studies. Chen, Skully, and Brown (2005) study the impact of the 1995 bank deregulation on cost efficiency of Chinese banks. Measuring the cost efficiency of 43 Chinese banks over the period 1993-2000 with nonparametric data envelopment analysis (DEA), they conclude that large state-owned banks and small joint-equity banks are more efficient than medium-sized joint-equity banks. The mean yearly cost efficiency scores range from 42.6% to 58.2%, suggesting large inefficiencies in the Chinese banking industry.

Fu and Heffernan (2007) measure cost efficiency of Chinese banks over the period 1985-2002 with the stochastic frontier approach. Their sample includes 14 banks (four state-owned banks and ten joint-stock commercial banks). They provide evidence that joint-stock commercial banks are more efficient than state-owned banks. The mean efficiency scores in this study range between 40 and 52%, depending on the distributional assumptions. These findings further support the view of strong inefficiencies in the Chinese banking industry.

Ariff and Can (2008) extend the analysis of efficiency of Chinese banks by analyzing profit efficiency. They estimate cost efficiency and profit efficiency of 28 Chinese commercial banks over the period 1995-2004 by employing DEA. They show that joint-stock banks are more cost efficient and profit efficient than state-owned banks. They also observe mean cost efficiency levels of 79.8%, i.e. significantly higher than profit efficiency levels ranging between 43.9% and 50.5% depending on the profit frontier specification.

Berger, Hasan, and Zhou (2009) focus on the impact of ownership on bank efficiency in China. They perform their analysis on 38 Chinese banks over the period 1995-2003 and estimate cost efficiency and profit efficiency using the stochastic frontier approach. Their main findings 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 are 89.7% for cost efficiency and of 47.6% for profit efficiency.

The conclusions of studies on bank efficiency in China are consistent in two respects. First, they agree that ownership affects efficiency; in particular, large state-owned banks tend to be less efficient. Second, there is no consensus in estimations of inefficiencies in the Chinese banking industry; various mean cost efficiency levels are reported. This

could be the result of different observation periods, or the size and composition of samples. In any case, our sample of Chinese banks is larger than any of these earlier studies, and hopefully provides a more comprehensive view on the efficiency of Chinese banks.

## 3 Data and methodology

### 3.1 Data

We use bank-level financial statement data for Chinese banks provided by Bankscope, a financial database maintained by Bureau Van Dijk. Whenever there are missing values or variables, we hand-collect the corresponding data from the annual reports of the bank from their websites. Our final sample comprises of 451 observations for 76 Chinese banks. The data includes all major commercial banks in China. We cover the period from 2002 to 2011. Naturally, the distribution of the observations during the sample period reflects the availability of data influenced, for example, by the intentions of banks to list their shares.<sup>6</sup>

The banks in our sample can be divided into five categories. Following the development in the banking sector and the classification of banks by the Chinese Banking Regulatory Commission (CBRC),<sup>7</sup> we identify (1) the large state-owned commercial banks, i.e. the Big Four, plus Bank of Communications (the “Big Five”), (2) joint-stock commercial banks, (3) city commercial banks, (4) foreign banks, and (5) other banks. The descriptive statistics of the main variables are presented in Table 1.

### 3.2 Lerner indices

Tools used to measure bank competition can be divided into the traditional IO and the new empirical IO approaches. The traditional IO approach proposes tests of market structure to assess bank competition based on the Structure Conduct Performance (SCP) model. The SCP hypothesis argues that greater concentration causes less competitive bank behavior and leads to higher bank profitability. Thus, competition can be measured by concentration

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<sup>6</sup> The data for 2011 was not available for all the banks in June 2012 when our dataset was collected.

<sup>7</sup> Details concerning this classification are available in the 2011 CBRC Annual Report and at <http://www.cbrc.gov.cn/chinese/jrjg/index.html>.



indices such as the market share of the largest banks, or by the Herfindahl-Hirschman index.

The new empirical IO approach provides non-structural tests to circumvent the problems of competition measures based on the traditional IO approach. Non-structural measures do not infer the competitive conduct of banks from an analysis of market structure, but rather measure bank behavior directly.

Following the new empirical IO approach, we compute the Lerner index, an individual measure of competition for each bank and each year. The Lerner index has commonly been computed in recent studies on bank competition (e.g. Carbo et al., 2009; Fang, Hasan, and Marton, 2011). The Lerner index is defined as the difference between price and marginal cost, divided by price.

The price here is the average price of bank production (proxied by total assets), namely the ratio of total revenues to total assets, following e.g. Carbo et al. (2009). The marginal cost is estimated on the basis of a translog cost function with one output (total assets) and three input prices (price of labor, price of physical capital, and price of borrowed funds). Turk-Ariss (2010) applies the same specification of inputs when calculating the Lerner index for banks in developing countries. We estimate one cost function for all periods in which we include bank fixed effects. Symmetry and linear homogeneity restrictions in input prices are imposed. The cost function is specified as follows:

$$\ln TC = \alpha_0 + \alpha_1 \ln y + \frac{1}{2} \alpha_2 (\ln y)^2 + \sum_{j=1}^3 \beta_j \ln w_j + \sum_{j=1}^3 \sum_{k=1}^3 \beta_{jk} \ln w_j \ln w_k + \sum_{j=1}^3 \gamma_j \ln y \ln w_j + \varepsilon \quad (1)$$

where  $TC$  denotes total costs,  $y$  total assets,  $w_1$  the price of labor (ratio of personnel expenses to total assets),<sup>8</sup>  $w_2$  the price of physical capital (ratio of other non-interest expenses to fixed assets),  $w_3$  the price of borrowed funds (ratio of interest paid to total funding). Total cost is the sum of personnel expenses, other non-interest expenses, and interest paid. The indices for each bank have been excluded from the presentation for the sake of simplicity. The estimated coefficients of the cost function are then used to compute the marginal cost (MC):

<sup>8</sup> As our dataset does not provide numbers of employees, we use this proxy variable for the price of labor, following Maudos and Fernandez de Guevara (2007).

$$MC = \frac{TC}{y} \left( \alpha_1 + \alpha_2 \ln y + \sum_{j=1}^3 \gamma_j \ln w_j \right) \quad (2)$$

Once marginal cost is estimated and price of output computed, we can calculate the Lerner index for each bank and obtain a direct measure of bank competition.

### 3.3 Efficiency scores

Cost efficiency measures how close a bank's cost is to its optimal cost when producing the same bundle of outputs. Several methods are used in the literature to measure efficiency with frontier approaches. They are all based on the estimation of a cost frontier, but they mainly differ in the assumptions made to disentangle the distance from the frontier between an inefficiency term and a random error. We adopt the stochastic frontier approach, which has been widely used in the literature to estimate cost efficiency scores (e.g. Berger, Hasan, and Zhou, 2009; Fu and Heffernan, 2009).

The stochastic frontier approach disentangles inefficiency from random error by assuming a normal distribution for the random error and a one-sided distribution for the inefficiency term. The basic model assumes that total cost deviates from the optimal cost by a random disturbance,  $v$ , and an inefficiency term,  $u$ . Thus, the cost function is  $TC = f(Y, P) + \varepsilon$  where  $TC$  represents total cost,  $Y$  is the vector of outputs,  $P$  the vector of input prices, and  $\varepsilon$  the error term (the sum of  $u$  and  $v$ ).  $u$  is a one-sided component representing cost inefficiencies, i.e. the degree of weakness of managerial performance.  $v$  is a two-sided component representing random disturbances, reflecting bad (good) luck or measurement errors.  $u$  and  $v$  are independently distributed.  $v$  is assumed to have a normal distribution. We assume a gamma distribution for the inefficiency term  $u$  following Greene (1990). Following Jondrow et al. (1982), bank-specific estimates of inefficiency terms are calculated using the distribution of the inefficiency term conditional to the estimate of the composite error term  $\varepsilon$ . Greene (1990) provides the estimate of the cost inefficiency term with a gamma distribution.<sup>9</sup>

We estimate a system of equations composed of a translog cost function and its associated input cost share equations, derived using Shephard's lemma. The system of

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<sup>9</sup> See Kumbhakar and Lovell (2000) for further details on Stochastic Frontier Analysis.

equations is estimated using the Iterative Seemingly Unrelated Regression (ITSUR) estimation technique. Standard symmetry constraints are imposed. Homogeneity conditions are imposed by normalizing total costs, price of labor, and price of physical capital, by the price of borrowed funds. Following Weill (2009) among others, we consider two outputs in the cost function: total loans and other earning assets. We follow the intermediation approach for the specification of inputs and outputs. This approach assumes that the bank collects deposits to transform them with labor and capital into loans. Thus, the complete model is the following:

$$\begin{aligned} \ln\left(\frac{TC}{w_3}\right) &= \beta_0 + \sum_m \alpha_m \ln y_m + \sum_n \beta_n \ln\left(\frac{w_n}{w_3}\right) + \frac{1}{2} \sum_m \sum_j \alpha_{mj} \ln y_m \ln y_j \\ &+ \frac{1}{2} \sum_n \sum_k \beta_{nk} \ln\left(\frac{w_n}{w_3}\right) \ln\left(\frac{w_k}{w_3}\right) + \sum_n \sum_m \gamma_{nm} \ln\left(\frac{w_n}{w_3}\right) \ln y_m \\ &+ \varepsilon \end{aligned} \quad (3)$$

$$S_n = \partial \ln\left(\frac{TC}{w_3}\right) / \partial \ln w_n = \beta_n + \sum_k \beta_{nk} \ln\left(\frac{w_k}{w_3}\right) + \sum_m \gamma_{nm} \ln y_m + \eta_n \quad (4)$$

where TC is total costs,  $y_m$   $m^{\text{th}}$  bank output ( $m=1,2$ ),  $w_n$   $n^{\text{th}}$  input price ( $n=1,2$ ),  $w_3$  the price of borrowed funds,  $S_n$  the input cost share<sup>10</sup> ( $n=1,2$ ), and  $\eta_n$  an error term ( $\eta_n$  is independent from  $\varepsilon$ ). For simplicity in presentation, the indices for each bank have been dropped. The model is estimated for all years so that we estimate one common cost frontier over the entire period. We include time dummy variables in the cost frontier.

### 3.4 The relation between competition and efficiency

A key issue of this paper is to study the relation between competition and efficiency of Chinese banks. We aim at investigating the sign of the relation but also the direction of causality between competition and efficiency.

Building on the work of Pruteanu-Podpiera, Weill, and Schobert (2009) and Casu and Girardone (2009), we perform Granger-causality tests with GMM techniques. We estimate the following equations:

$$Lerner Index_{i,t} = f(Lerner Index_{i,lag}, Efficiency_{i,lag}) + \varepsilon_{i,t} \quad (5)$$

$$Efficiency_{i,t} = f(Lerner Index_{i,lag}, Efficiency_{i,lag}) + \varepsilon_{i,t} \quad (6)$$

Indice  $i$  represents the bank, while indice  $t$  denotes the year. *Efficiency* is the cost efficiency score. *Lerner Index* is the value of the Lerner Index, and  $\varepsilon_{i,t}$  is the error term.

The first equation tests whether changes in efficiency temporally precede variations in market power, while the second equation evaluates whether changes in market power temporally precede variations in efficiency. We use two lags and estimate an AR(2) process for competition and efficiency variables. This number of lags is chosen according to the number of years available. Casu and Girardone (2009) also employ two lags in their study using yearly data.

Granger-causality is tested by a joint test in which the sum of the coefficients of the lagged explaining variable is tested to be significantly different from zero. The sum of these coefficients gives the overall measure of the effect of the explaining variable. The addition of the lagged dependent variables to the predicting variables creates econometric problems induced by unobserved bank-specific effects and joint endogeneity of the explanatory variables. To address these issues, we use GMM estimators for dynamic panel models developed by Arellano and Bover (1995) and Blundell and Bond (1998). We use the two-step system GMM estimator with Windmeijer's (2005) corrected standard error. We include dummy variables for years.

Following Pruteanu-Podpiera, Weill, and Schobert (2009) and Casu and Girardone (2009), we do not include control variables in our estimations. We stress, however, that we have performed our estimations also by including a variable for bank size, defined by the logarithm of total assets. This inclusion does not affect our findings.<sup>11</sup>

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<sup>10</sup>  $S_n$  is equal to the expenses for the input  $n$  divided by total costs.

<sup>11</sup> The results of these additional estimations are available on request.

## 4 Results

This section presents the empirical results. We first display the estimates of Lerner indices and efficiency scores to provide insights on the evolution of competition and efficiency in the Chinese banking system. We then discuss the results concerning the relation between competition and efficiency for Chinese banks.

### 4.1 Lerner indices and efficiency scores

We first provide the estimates of competition and efficiency for Chinese banks over our period of study. These estimates indicate the level and evolution of both characteristics over time.

The development of the mean Lerner indices by years is displayed in Table 2. They are presented for all banks as well as for different types of banks by considering separately the “Big Five” banks, joint-stock commercial banks, city commercial banks, and foreign banks. Several trends can be identified. First, we observe that the average Lerner index over the period is 37.8%, with yearly mean Lerner indices between 27.7% and 42.1%. Comparison of these values with those obtained for other countries suggests that Chinese banks possess extremely high market power. Carbo-Valverde et al. (2009) observe mean Lerner indices ranging from 11% to 22% for EU countries with an EU mean of 16%. Berger, Klapper, and Turk-Ariss (2010) obtain a mean Lerner index of 22% for a sample of banks from 23 developed countries. When considering emerging markets, Fungáčová, Solanko, and Weill (2010) find Russian banks have a mean Lerner index of 21.4%. Our finding supports the view of a low degree of competition in the Chinese banking industry.

Second, we observe some discrepancies in bank competition between different types of banks. Over the period, the mean Lerner indices are 38.9% for the Big Five banks, 34.1% for joint-stock commercial banks, 40.9% for city commercial banks, and 29.9% for foreign banks. Thus, the ranking by type of banks in terms of market power shows that foreign banks have the lowest market power, followed by joint-stock commercial banks, and the Big Five banks. City commercial banks have the highest market power. The relatively high market power of large state-owned banks is likely explained by competitive advantage from the absence of a formal deposit insurance scheme. The finding for foreign banks reflects the fact that these banks have only recently entered the Chinese market, as well as

in line with the view that foreign banks are enhancing competition in China's banking markets.

Third, the evolution of the mean Lerner index over the period does not indicate increased competition in the Chinese banking industry. As the samples are smaller for the early years of our study, it is difficult to make general comments on the trend from 2002 to 2011. Indeed, the changes in the Lerner index may result from changes in the composition of our sample. Nonetheless, we stress that the yearly mean Lerner index ranges between 27.7% and 32.3% in the period 2002-2006, and between 37.5% and 42.1% during 2007-2011 when the number of observations is sufficient. Moreover, while the size of the sample remains comparable between 2007 and 2011, we see no reduction of the Lerner index over the period.

Thus, we do not observe generally enhanced competition in the last decade. Our findings comport with the observation of the OECD (2010, p.77) that "there has been limited change in the concentration of the banking sector." At first glance, it is somewhat remarkable that China's accession to WTO has not led to greater competition in the banking industry. However, this result is far less surprising if we consider the limits imposed on new competitors (OECD, 2010). Moreover, the share of foreign banks in the total assets of the Chinese banking sector has not significantly increased over time, oscillating around 2% over the past decade, hitting 1.5% in 2003 and 1.9% in 2011 (CBRC, 2012).

We turn to the analysis of the efficiency scores for Chinese banks. The mean efficiency scores are presented in Table 3. They are presented for all banks and for each type of bank. Several findings are fairly striking.

First, the average efficiency score over the period is 74.6%, with yearly mean efficiency scores between 67.2% and 78.2%. Thus, over the entire period banks were able on average to reduce their costs by a quarter for the given level of output. These cost efficiency levels are globally comparable to other countries, in particular emerging countries. Bonin, Hasan, and Wachtel (2005) obtain a mean cost efficiency score of 70% for transition countries. Weill (2009) finds means of cost efficiency between 61% and 90% for EU countries.

Second, the comparison of mean efficiency scores across types of banks shows that Big Five banks are the least efficient banks with the mean score of 68.4% for the sample period. City commercial banks and joint-stock commercial banks have mean efficiency scores of 72.8% and 76.8%, respectively. Foreign banks are the most efficient banks with a

mean efficiency score of 84.6%. These findings accord with former studies of Chinese banks conducted on smaller samples. Fu and Heffernan (2007) and Ariff and Can (2008) also find evidence for higher efficiency of joint-stock commercial banks in comparison to the large state-owned banks. Berger, Hasan, and Zhou (2009) similarly conclude to lower efficiency of large state-owned banks and greater efficiency of foreign banks. Our results thus confirm the persistence of the influence of bank ownership on efficiency in China in recent years. State ownership still exerts a detrimental impact and foreign ownership is still beneficial.

Third, the evolution of efficiency scores shows an upward trend. Again, one needs to be cautious about general statements on the evolution over the full period as the number of banks in the sample is much smaller in the first half of the period. Nevertheless, we observe an almost continuous improvement of efficiency over the years. The mean efficiency score rises from 67.2% in 2002 to 71.7% in 2006, and then further increases from 74.1% in 2007 to 78.2% in 2011. Our results indicate an improvement in cost efficiency of the Chinese banks over the years. This finding is in line with Herd, Hill, and Pigott (2010), who stress that performance of Chinese banks has considerably increased in the recent years thanks to closures of unnecessary branches, efforts to cut labor, and investments supporting more efficient banking operations.

## 4.2 The relation between competition and efficiency

We present the results on the relation between competition and efficiency for Chinese banks in Table 4. The results suggest that the total impact of the Lerner index on cost efficiency is not significant, i.e. that changes in market power do not Granger-cause changes in cost efficiency. This finding is inconsistent with the “quiet life” hypothesis that market power has a negative impact on cost efficiency. It is also inconsistent with the “banking specificities” hypothesis, whereby the impact should be positive. This finding differs from that observed by Pruteanu-Podpiera, Weill, and Schobert (2008) and by Casu and Girardone (2009) for samples of European banks. It is also at odds with most literature on the link between market power and cost efficiency in the banking industry.

At the same time, we observe that the total impact of cost efficiency on the Lerner index is not significant. From a theoretical perspective, this does not accord with the “efficient-structure” hypothesis, which predicts a positive influence of cost efficiency on mar-

ket power. Arellano and Bond AR(2) tests are not significant in both specifications indicating no presence of autocorrelation in level,<sup>12</sup> and rendering the GMM estimator inconsistent. Moreover, the Hansen J-test of over-identifying restrictions does not reject the null hypothesis of exogeneity of the instruments.

In other words, these results support the absence of *any* relation between market power and cost efficiency for Chinese banks. This finding differs from the results generally observed for other countries. On the other hand, Fu and Heffernan (2009) reach a quite similar conclusion when analyzing the link between efficiency and market structure characteristics (concentration, market share) in the Chinese banking industry.

The “banking specificities” hypothesis may hold a possible explanation for our result, which suggests that, unlike in other countries, bank competition is not detrimental to efficiency in China. This hypothesis, which explains why competition hampers efficiency in banking as observed in studies of Western countries, is based on the existence of information asymmetries in the relationship between the bank and the borrower that give banks an incentive to implement mechanisms for solving the problems stemming from this relationship. They must perform a monitoring of borrowers for which economies of scale exist, and they have to establish long-term relationships to obtain information on borrowers. Consequently, competition has a negative influence on cost efficiency of banks by increasing costs of the lending activity, owing to the need to pursue economies of scale in the face of shorter customer relationships.

This hypothesis may play a lesser role in China in comparison to the developed countries as it relates to the importance of information asymmetries in the relationship between bank and borrower. Unlike Western banks, Chinese banks are likely to suffer less from such information asymmetries. One reason is that the structure of loans of Chinese banks is biased toward loans to large state-owned companies (Herd, Hill, and Pigott, 2010). For such big borrowers, information asymmetries are much lower than for small and medium-sized enterprises (SMEs). SMEs are particularly rationed in terms of credit in China, while they belong to the companies for which opaqueness plays a key role in the lending relationship.

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<sup>12</sup> We do not even find autocorrelation for the AR(1) process.



### 4.3 Robustness checks

We conduct robustness checks to confirm the validity of our empirical results on the relation between competition and efficiency.

First, we use an alternative technique to measure efficiency. We have adopted the stochastic frontier approach to estimate the cost efficiency frontier as it is standard in the literature. Nonetheless, a few researchers investigate the robustness of efficiency scores with different techniques (e.g. Bauer et al., 1998). Their main conclusion is that the choice of the technique can influence the distribution of efficiency scores. Thus, we adopt an alternative technique to calculate efficiency scores: the time-varying WITHIN model proposed by Cornwell, Schmidt, and Sickles (1990). This technique has been rarely applied in works on bank efficiency (e.g. Esho, 2001; Weill, 2009). Nevertheless, as this model relies on the panel data, it is of particular interest for our research. By using panel data, the WITHIN model does not require distributional assumptions on the inefficiency term and the random disturbance. The term  $\varphi_{it}$  is modeled as follows:

$$\varphi_{it} = \theta_{1i} + \theta_{2i} t + \theta_{3i} t^2, \quad (7)$$

where  $\varphi_{it} = \varphi - u_{it}$ ,  $i$  indexes bank,  $t$  represents time,  $\varphi$  the intercept in the cost function, and the  $\theta$ s are cross-section bank-specific parameters.

We compute the coefficient of correlation between efficiency scores obtained by the stochastic frontier approach and those calculated using the WITHIN model: it is significantly positive and equals 0.51. This confirms that, even if the efficiency scores obtained by relying on these two techniques are not fully correlated, there is a high positive relation between them.

We report the results of estimations including efficiency scores computed with the WITHIN model in Table 5. We again observe no relation between the Lerner index and cost efficiency in any direction. The total impact of the Lerner index on cost efficiency is not significant, as well as is the case for the total impact of cost efficiency on the Lerner index. Hence, these results corroborate those obtained with the efficiency scores based on the stochastic frontier approach.

We next employ the difference GMM estimator, which considers instruments as lags of the levels of the explanatory and dependent variables (Hansen, 1982; Arellano and

Bond, 1991). Two studies in the banking literature compare the results of the difference GMM estimator and the system GMM estimator (e.g. De Haas and Lelyveld, 2010). In their analysis of the relation between competition and efficiency, Casu and Girardone (2010) report results for both estimators. We report the results of estimations with the difference GMM estimator in Table 6. Our conclusion does not change: there is no significant impact of cost efficiency on market power, or of market power on cost efficiency.

Third, we compute four more robustness checks.<sup>13</sup> As our estimation results could be influenced by the choice of the lag length on the dependent and independent variable, we include a three-year lag on the dependent and independent variables. We further check the possibility of an instantaneous Granger causality by including the independent variable at time  $t$  in the regression.<sup>14</sup> We also divide the sample in two sub-samples for the period before and after the financial crisis. One might argue that the relationship between competition and efficiency was temporarily disrupted by the financial crisis and the drastic increases in lending observed in the Chinese banking sector. The first sub-sample includes observations from 2002 to 2007; the second includes observations from 2008 to 2011. In all of these three robustness tests, we are unable to find evidence of a causal relationship between competition and efficiency or the reverse.

Finally, to check whether the chosen GMM dynamic panel methodology influences our results, we perform simple regressions of efficiency scores on Lerner indices using bank and year fixed effects with and without controlling for bank size. The Lerner index is never significant, whereas bank size is statistically significant when included.

Similar to the baseline results, the AR2 test is not significant in any of the robustness test specifications, which indicates no evidence of autocorrelation in level. The Hansen J-test does not reject the null hypothesis of exogeneity of instruments.

All in all, our results and the robustness checks support the absence of any relation between market power and cost efficiency for Chinese banks.

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<sup>13</sup> These results, available upon request, are not reported here for the sake of brevity.

<sup>14</sup> The test has the following form:  $Y_{i,t} = f(Y_{i,lag}, X_{i,t}, X_{i,lag}) + \varepsilon_{i,t}$

## 5 Conclusion

In this paper we analyze the relationship between competition and efficiency for Chinese banks, computing Lerner indices to measure competition and estimate cost efficiency scores for 76 Chinese banks over the period 2002-2011. This issue has a particular importance in China where the market structure of the banking industry remains dominated by five state-owned banks which are characterized by low efficiency.

Our main findings on bank behavior can be summarized as follows. First, bank competition did not increase during that period under review. Second, competition differs depending on the type of banks. Foreign banks have on average the lowest Lerner index. Third, Chinese banks have improved their efficiency in the recent years. Fourth, differences in efficiency across types of banks persist with the lowest efficiency scores going to the Big Five state-owned banks and the highest to foreign banks. This finding agrees with the observations of Berger, Hasan and Zhou (2009) for 1994-2003.

Our investigation to identify a link between competition and efficiency showed no significant relation. Neither the effect of the Lerner index on cost efficiency, nor the effect of cost efficiency on the Lerner index is significant. This finding rejects the intuitive “quiet life” hypothesis that competition favors efficiency. It also differs from the earlier literature that found a negative relation between competition and efficiency. Thus, it appears that banking competition is not detrimental to efficiency in China.

From a normative perspective, our findings suggest that pro-competitive policies in the Chinese banking industry do not affect the cost efficiency of banks. On the one hand, this means that policies favoring cost efficiency of banks should be separately designed. On the other hand, Chinese authorities might not suffer from the trade-off resulting from a negative impact of competition on efficiency. Indeed, the observation of such detrimental impact as found in other countries would have led to a trade-off between the benefits from lower banking prices and losses from lower efficiency due to tighter competition.

Our research is an initial step toward understanding of the effects of bank competition in China. Taking into account the implications for financial stability, further work is needed to investigate the influence of bank competition on financial stability in this country.

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Table 1 Descriptive statistics

	Obs.	Mean	Median	Std.dev.	Min.	Max.
Total assets (RMB million)	451	884 700	89 798	2 229 502	3 819	15 500 000
Price of funds (interest expenses/total funding)	451	0.014	0.013	0.006	0.001	0.048
Price of labor (personnel expenses/total assets)	451	0.005	0.005	0.002	0.001	0.014
Price of physical capital (other noninterest expenses/fixed as- sets)	451	0.910	0.604	1.122	0.055	12.867
Total costs (RMB million)	451	20 260	1 892	50 483	50	329 388

Table 2 Development of Lerner index

This table displays the main statistics for Lerner indices.

		All banks			Big Five			Joint-stock commercial banks			City commercial banks			Foreign banks		
Year	Obs.	Mean	Std.dev.	Obs.	Mean	Std.dev.	Obs.	Mean	Std.dev.	Obs.	Mean	Std.dev.	Obs.	Mean	Std.dev.	
2002	10	0.277	0.086	2	0.230	0.154	7	0.282	0.075	1	0.343	-	0	-	-	
2003	12	0.295	0.072	3	0.319	0.066	7	0.267	0.073	1	0.330	-	1	0.386	-	
2004	17	0.323	0.094	5	0.323	0.114	9	0.289	0.072	2	0.434	0.094	1	0.399	-	
2005	26	0.320	0.101	5	0.335	0.117	10	0.281	0.088	7	0.348	0.077	1	0.477	-	
2006	37	0.338	0.102	5	0.346	0.116	11	0.302	0.093	16	0.360	0.090	1	0.463	-	
2007	61	0.405	0.122	5	0.443	0.014	11	0.377	0.069	33	0.442	0.127	6	0.291	0.130	
2008	76	0.376	0.114	5	0.401	0.061	11	0.338	0.101	43	0.396	0.102	8	0.330	0.180	
2009	76	0.375	0.100	5	0.439	0.050	11	0.380	0.051	43	0.393	0.084	8	0.253	0.151	
2010	75	0.421	0.098	5	0.482	0.035	11	0.418	0.043	42	0.447	0.078	8	0.251	0.097	
2011	61	0.400	0.075	5	0.449	0.047	10	0.422	0.060	31	0.406	0.062	5	0.305	0.093	
Total	451	0.378	0.107	45	0.389	0.099	98	0.341	0.090	219	0.409	0.095	39	0.299	0.135	



Table 3 Development of efficiency scores

This table displays the main statistics for efficiency scores. Efficiency scores are estimated with stochastic frontier approach. All scores are in percent.

Year	All banks			Big Five			Joint-stock commercial banks			City commercial banks			Foreign banks		
	Obs.	Mean	Std.dev.	Obs.	Mean	Std.dev.	Obs.	Mean	Std.dev.	Obs.	Mean	Std.dev.	Obs.	Mean	Std.dev.
2002	10	67.23	6.90	2	65.06	6.76	7	67.16	7.64	1	72.06	-	0	-	-
2003	12	69.88	5.75	3	62.22	2.32	7	71.14	3.26	1	76.31	-	1	77.66	-
2004	17	69.17	6.17	5	66.24	4.95	9	70.26	5.28	2	67.25	12.23	1	77.93	-
2005	26	71.46	5.97	5	66.64	4.20	10	73.37	4.83	7	70.37	6.02	1	81.34	-
2006	37	71.73	8.70	5	57.15	13.49	11	76.07	3.54	16	72.12	4.82	1	75.96	-
2007	61	74.06	10.53	5	66.89	4.73	11	78.82	3.31	33	70.24	11.39	6	86.43	3.67
2008	76	73.57	10.91	5	67.88	5.45	11	79.00	3.60	43	70.10	11.49	8	86.81	4.69
2009	76	75.68	9.60	5	72.97	4.19	11	81.14	4.11	43	73.58	9.44	8	85.58	3.36
2010	75	77.28	8.21	5	76.47	3.36	11	81.82	3.86	42	74.88	8.76	8	85.51	3.36
2011	61	78.24	9.16	5	78.44	3.82	10	82.76	3.29	31	76.84	10.19	5	80.63	13.54
Total	451	74.56	9.54	45	68.45	8.38	98	76.81	6.38	219	72.84	10.00	39	84.56	6.16

Table 4 Main estimations

We use the two-step GMM estimator with Windmeijer (2005)'s corrected standard error (reported in brackets). Efficiency scores are estimated with stochastic frontier approach. \*, \*\*, \*\*\* denote a p-value below 10%, 5%, or 1%, respectively. Arellano-Bond tests for autocorrelation (AR1/AR2) have a null hypothesis of no autocorrelation and are applied to the differenced residuals. The Hansen J-test has a null hypothesis of "the instruments as a group are exogenous."

	Dependent variable	
	Efficiency	Lerner index
Efficiency <sub>t-1</sub>	0.415 (0.413)	0.00335 (0.00448)
Efficiency <sub>t-2</sub>	0.208 (0.270)	-0.00237 (0.00261)
Efficiency <sub>t-1</sub> = Efficiency <sub>t-2</sub> = 0	chi2(2) = 11.30*** Pr > chi2 = 0.004	chi2(2) = 0.83 Pr > chi2 = 0.66
∑ Efficiency coefficients	0.624*** (0.227)	0.001 (0.003)
Lerner Index <sub>t-1</sub>	-17.82 (38.61)	0.470* (0.270)
Lerner Index <sub>t-2</sub>	10.44 (15.00)	0.0568 (0.148)
Lerner Index <sub>t-1</sub> = Lerner Index <sub>t-2</sub> = 0	chi2(2) = 0.50 Pr > chi2 = 0.78	chi2(2) = 4.83* Pr > chi2 = 0.09
∑ Lerner Index coefficients	-7.374 (33.007)	0.527** (0.240)
Constant	33.34 (23.52)	0.0974 (0.273)
Observations	299	299
Number of banks	76	76
P-value AR1/AR2	0.708/0.474	0.182/0.987
P-value Hansen test	0.181	0.658

Table 5 Robustness check: Efficiency scores estimated with the WITHIN model

We use the two-step GMM estimator with Windmeijer (2005)'s corrected standard error (reported in brackets). \*, \*\*, \*\*\* denote a p-value below 10%, 5%, or 1%, respectively. Arellano-Bond tests for autocorrelation (AR1/AR2) have a null hypothesis of no autocorrelation and are applied to the differenced residuals. The Hansen J-test has a null hypothesis of "the instruments as a group are exogenous."

	Dependent variable	
	Efficiency	Lerner index
Efficiency <sub>t-1</sub>	1.200*** (0.235)	0.00174 (0.00169)
Efficiency <sub>t-2</sub>	-0.575*** (0.135)	-0.00157 (0.00240)
Efficiency <sub>t-1</sub> = Efficiency <sub>t-2</sub> = 0	chi2(2) = 30.25*** Pr > chi2 = 0.000	chi2(2) = 1.06 Pr > chi2 = 0.59
∑ Efficiency coefficients	0.625*** (0.207)	0.0002 (0.002)
Lerner Index <sub>t-1</sub>	22.08 (24.61)	0.669** (0.302)
Lerner Index <sub>t-2</sub>	5.644 (9.506)	-0.114 (0.175)
Lerner Index <sub>t-1</sub> = Lerner Index <sub>t-2</sub> = 0	chi2(2) = 2.55 Pr > chi2 = 0.28	chi2(2) = 5.70* Pr > chi2 = 0.06
∑ Lerner Index coefficients	27.728 (20.842)	0.554** (0.239)
Constant	19.32 (12.67)	0.141 (0.199)
Observations	299	299
Number of banks	76	76
P-value AR1/AR2	0.210/0.649	0.185/0.782
P-value Hansen test	0.798	0.592

Table 6 Robustness check: Difference GMM estimator

We employ the difference GMM estimator. Robust standard errors are reported in brackets. Efficiency scores are estimated with stochastic frontier approach. \*, \*\*, \*\*\* denote a p-value below 10%, 5%, or 1%, respectively. Arellano-Bond tests for autocorrelation (AR1/AR2) have a null hypothesis of no autocorrelation and are applied to the differenced residuals. The Hansen J-test has a null hypothesis of “the instruments as a group are exogenous.”

	Dependent variable	
	Efficiency	Lerner index
Efficiency <sub>t-1</sub>	0.188 (0.445)	-0.00271 (0.00265)
Efficiency <sub>t-2</sub>	-0.342 (0.451)	0.000928 (0.00222)
Efficiency <sub>t-1</sub> = Efficiency <sub>t-2</sub> = 0	chi2(2) = 4.06 Pr > chi2 = 0.13	chi2(2) = 2.62 Pr > chi2 = 0.27
∑ Efficiency coefficients	-0.153 (0.857)	-0.002 (0.004)
Lerner Index <sub>t-1</sub>	-85.00 (67.25)	0.452 (0.540)
Lerner Index <sub>t-2</sub>	-95.61 (72.21)	0.00836 (0.610)
Lerner Index <sub>t-1</sub> = Lerner Index <sub>t-2</sub> = 0	chi2(2) = 0.771.75 Pr > chi2 = 0.41	chi2(2) = 10.50*** Pr > chi2 = 0.005
∑ Lerner Index coefficients	-180.613 (138.153)	0.461 (1.140)
Observations	223	223
Number of banks	76	76
P-value AR1/AR2	0.134/0.857	0.098/0.706
P-value Hansen test	0.759	0.144

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