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THE EFFECTS OF EFFICIENCY ON BANKS' MARKET RISK: EMPIRICAL EVIDENCE FROM CHINA

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ABSTRACT

This article investigates the effect of efficiencies on market risk using a sample of Chinese commercial banks from 2000 to 2015 using different measures of market risk; the Value at Risk (VaR) and Expected Shortfall (ES). The cost and profit efficiencies are estimated by the Stochastic Frontier Analysis (SFA) on the 12 biggest banks listed on the Shanghai Stock Exchange. In testing the effect between efficiency and market risk, this study applied four different models to uncover the relationship between VaR and ES as measures of market risk on cost and profit efficiencies. Utilising a panel data analysis, the results show that different banks efficiencies affect market risk measures differently. While bank cost efficiency reduces market risk, increase in profit efficiency increase market risk. The analysis in this study helps explain the unconvincing evidence of an inefficiencies-risk connection in the bank sector. Bank regulators and managers may need to focus on the cost and profit efficiencies-related initiatives to better manage the market risk. These findings provide bank managers with more understanding of bank risk and serve as an underpinning for bank supervision efforts aimed at strengthening the joint risk management of efficiency-market risks.

Keywords: market risk, Stochastic Frontier Analysis, Expected Shortfall, Value at Risk

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INTRODUCTION

The advancement in the banks' financial instruments is complex, fragile and interconnected around the world (Remolona & Shim, 2015). The advancement has opened the door for a myriad of risk exposures to the banks, especially market risk. Market risk is the possible loss caused by the unexpected movements in financial instruments or portfolios, such as stock price, exchange rate, interest rate, credit spreads or commodity price (Scandizzo, 2016). The bank market risk, if not managed properly, may lead to a reduction of earnings or valuation of the bank, resulting in capital loss. Due to the interconnected nature of banks' financial instrument, this loss will cause a multiplier effect of losses in other banks, thus affecting the stability of the entire banking industry. Owing to this fragile nature of market risk, the management of the banks' market risk has become top priority for banking supervision (Segoviano & Goodhart, 2009; BCBS, 2011).

The interrelationship between risks and bank efficiency has received much attention in banking literature, especially after the 1997 Asian financial crisis and the 2008 Great Recession (Phan et al., 2018; Asongu & Odhiambo, 2019). The hypotheses offer by Berger and DeYoung (1997) in their seminal paper explain the contradicting views on the effect of efficiency and risk in the banking sector. Saeed and Izzeldin (2016) found that their paper supports the skimping hypotheses – efficiency has a positive impact on market risk. A positive sign on the efficiency-market risk can be explained from the profit efficiency outlook. Higher market risk arising from higher profit efficiency could be due to the banks undertaking profit-orientated initiatives. Such as offering high-risk financial instruments at the same time leveraging their trading portfolios. The initiatives increased the exposure to bank market risk. On the other hand, efficiency might inversely affect banks' market risk – moral hazard hypotheses (Tan et al., 2017). The believers of this view argue that benefits or savings from efficiency can be directed towards improving capital buffers which will be able to absorb more risk exposure, lessen the risk, create higher safety, and strengthen the banking industry. The above evidence suggests that debatable issues exist regarding the efficiency-risk relationship in the banking sector, therefore such debatable conclusions of efficiency-market risk warrant further studies to be examined.

The objectives of this study are threefold. First, we examine the bank market risk, cost and profit efficiencies using China as our sample. China is selected because it is the largest emerging market in the world (Kim et al., 2015). Second, credit growth rates in the countries have been more volatile, which may raise concerns about the stability of the financial system. According to Bloomberg

News dated 11 November 2019, aggregate financing in China was 618.9 billion yuan (USD88 billion), which compares to about 2.27 trillion yuan in September and 737.4 billion yuan in the same month of 2018 (Bloomberg, 2019). Besides, our sample also contains four of China's banks that are global systemically important banks (G-SIBs) which may lead to the increasing role of bank lending. Therefore, it is necessary to analyse the effect of efficiency and market risk which are important towards banking stability. Finally, we empirically analyse whether different types of efficiency (cost and profit) affect the different measures of market risk Value at Risk (VaR) and Expected Shortfall (ES). The scarcity of studies that analyse the impact of different measures of efficiency and market risk begs the issue to be examined further.

LITERATURE REVIEW

Bank Market Risk

The importance of managing banks' risk in particular after a series of the financial crisis has attracted increasing research interest on the banks' risk determinants (Mohd Amin & Abdul-Rahman, 2020; Abdul-Rahman et al., 2019; Othman et al., 2018; Abdul-Rahman et al., 2018a; 2018b; Tamadonnejad et al., 2017; 2016; Abdul-Rahman et al., 2017; Yaakub et al., 2017; Mohd Pauzi et al., 2017). Over the decade since the 2008 financial crisis, the literature on banking and finance has seen renewed interest in many areas, including the finance-loan growth nexus, effectiveness of supervision, development of risk indicators and efficiency of banks. Studies such as Alexius et al. (2014) have examined determinants of market risk focusing on the role of transaction volume and interest differential for Swedish interbank premium over the period 2007–2011. The results show the significance of these two variables as the main determinants for the interbank market risk premium. Banerjee et al. (2016) examine the effects of derivatives usage on capital market risk measures in Indian banks over the period 1997–2005. The authors constructed the capital market risk measures by using 2-Index Model. Their findings suggest that most of their determinants are significantly related to the capital market risk.

Htay and Salman (2014) explore the correlation between bank risks in Malaysia. Using five banks in Malaysia from 2002 to 2011, the authors examine the relationship between operating, liquidity, credit and market risks. The standard deviation of the quarterly stock return is used to measure market risk. The results are inconclusive. Ab-Hamid et al. (2017) measured bank market risk using ES.

The findings show that the average bank market risk in Malaysia is fluctuating and in decreasing trend throughout the sample period. The results showed that Malaysian banks were more resilient from the repercussion of the Great Recession in 2008 eliciting lesser losses compared to the impact of the global economic slowdown in 2001.

Kassi et al. (2019) examine the effect of market risk on the financial performance of 31 non-financial companies listed on the Casablanca Stock Exchange (CSE) over the period 2000–2016. They used the degree of financial leverage, the book-to-market ratio, and the gearing ratio as the indicators of market risk. Employing the pooled Ordinary Least Squares (OLS) model, the fixed effects model, the random-effects model, the difference-GMM and the system-GMM models, the results show that the different measures of market risk have significant negative influences on the companies' financial performance. The elasticities are greater following the degree of financial leverage compared with the book-to-market ratio and the gearing ratio. In most cases, the firm's age, the cash holdings ratio, the firm's size, the debt-to-asset ratio, and the tangibility ratio have positive effects on financial performance, whereas the debt-to-income ratio and the stock turnover hurt the performance of these non-financial companies. Therefore, decision-makers and managers should mitigate market risk through appropriate strategies of risk management.

Using the sample from emerging and developed markets from 2002 to 2009, Low et al. (2015) examine the impact of quality governance on equity market risk. The authors use standard deviation and semi-deviation of equity return to measure market risk. The findings document the significant impact on emerging markets but no significant impact on developed markets. Sorwar et al. (2016) compare the market profiles for Islamic and conventional banks around the world over the period of 2000–2013. Using VaR and ES as the market risk measures, the findings suggest Islamic banks are less risky than conventional banks.

Researchers have also used VaR and ES methods in multiple ways, such as:

1. Focusing to construct measurements model based on the financial distributions (Mbairadjim et al., 2014).
2. Using the bootstrap technique to build a financial framework (Hong et al., 2014).
3. Examining the market portfolios (Chen et al., 2014).

4. Forecasting the financial distributions using variations of Autoregressive Conditional Heteroscedasticity (ARCH) models (Aloui & Ben, 2015).

Bank Efficiency using Stochastic Frontier Analysis (SFA)

The methods used to measure efficiency can be divided into the parametric (Stochastic Frontier Analysis, SFA) and non-parametric (Data Envelopment Analysis, DEA) approaches. Berger and Humphrey (1997) reviewed 130 studies of financial institutions' frontier efficiency in 21 countries. They found:

1. The efficiency estimation techniques can be grouped into parametric and non-parametric models with the number of studies moderately close to each other (60 and 69).
2. Banks with non-parametric approaches gave higher inefficiency results compared to parametric approach.
3. The parametric and non-parametric approaches rank the same set of institutions differently.

Another review from Bhatia et al. (2018) also supported the usage of the parametric method.

Using cost and profit efficiency measures, Aysan et al. (2011) examine the efficiency effects on profitability for Turkish bank from 2002 to 2007. Their findings could not find any significant relationship between efficiency and profitability. Sharma et al. (2012) estimate the technical efficiency of Indian banks from 2005 to 2006 and 2009 to 2010. Their findings show that the growth in technical efficiency depends on fixed assets and deposits.

Abdul-Majid et al. (2011) analyse Malaysian banks focusing on the determining impact of conventional and Islamic banking on efficiency, economies of scale and productivity over the period of 1996–2002. Using cost efficiency, their findings explain that the differences in operating characteristics have different effects on cost. Rozzani and Rahman (2013) explore the efficiency determinants for conventional and Islamic banks in Malaysia over the period of 2008–2011. Using profit efficiency as the dependent variable, their results indicate that the operational cost has a significant effect on profit efficiency for both types of banks.

Louati and Boujelbene (2015) examine the market power and efficiency-stability relationship in Islamic and conventional banks in Middle East and North Africa (MENA), and South-East Asia from 2005 to 2012. Using Lerner indicator in the translog SFA method, the authors find that the increase in competition in Islamic banking increases the overall banking stability. Using cost efficiency, Ding et al. (2015) study the factors that influenced efficiency on banks in China from 2005 to 2013. Their results show that the reserve requirement, the interest rate spread, open market operations, and operations of shadow banking is affecting the cost-efficiency.

From the literature review, many efficiencies types of research use a variety of frameworks. Researchers have ample tools at their disposal to choose from between the production and intermediation approaches, functional forms, efficiency concepts (cost, profit and technical), and one-step or two-step procedures (Khalib et al., 2016; Ab-Hamid et al., 2018a; 2018b). Variability also occurred due to differences in the sample size, countries, period, several inputs and outputs and control variables. All factors above contributed to heterogeneity in efficiency results in banking literature (Aiello & Bonanno, 2018). Acknowledging the differences, this study examines the differences in the efficiency and bank market risk model using two different concepts of efficiency, cost and profit.

Bank Efficiency (SFA) and Bank Risk-Taking

There are two main hypotheses arguing the impact of efficiency on risk in the banking industry. They are bad management and moral hazard hypotheses (Berger & DeYoung, 1997). The bad management hypothesis (Williams, 2004) argues that a lower level of efficiency leads to higher costs as incompetent managers do not adequately control their expenses efficiently. The reduction in efficiency will lead to an increase in banks' risk because of credit, operational, market and reputational problems. On the other hand, the moral hazard hypothesis (Jeitschko & Jeung, 2005) argues that banks with lower levels of efficiency may take excessive risk-taking action when the liability of the risk can be transferred to a third party. This action arising from the informational friction and the agency problem tend to make bank managers take on higher risk.

Liadaki and Gaganis (2010) study the relationship between efficiency and stock performance for European banks over the period 2002–2006. The authors estimate the cost and profit efficiencies by using SFA approaches while the stock performance by using monthly returns. The results show that the profit efficiency has positive and significant effects on stock performance while the cost efficiency has no effects on stock performance.

Another research was done by Fiordelisi et al. (2011) on European banks from 1995 to 2007. The authors examine the relationship between bank efficiency, capital and risk by using Granger-causality method. The cost, revenue and profit efficiencies are estimates using SFA, the risks are proxies by two methods; expected default frequency and non-performing loans while capital is measured by equity to capital ratio and the book value. Among the results are higher levels of cost and revenue efficiencies lead to higher risk and higher capital leads to higher cost-efficiency.

By using Australian banks from 1985 to 2008, Shamsuddin and Xiang (2012) investigate the effects of technical, cost and profit efficiency on banks market value. Using SFA method to estimates the efficiency and yearly excess of individual bank stock returns, the findings show that all efficiencies measures effects banks market values. Similarly, Vardar (2013) examines the effects of efficiency on bank stock performance in the transition European countries from 1995 to 2006. Using cost and profit efficiencies derived from SFA while bank stock performance measured by monthly cumulative stock returns, the empirical results show that the profit efficiency has positive and significant impacts on stock performance while the cost efficiency has negative and significant impacts on stock performance.

Using Islamic and conventional banks from 2002 to 2010, Saeed and Izzeldin (2016) test the relationship between default risk and efficiency. Both cost and profit efficiencies are derived from SFA while the default risk is measured by distance to default. Using vector autoregressive technique (VAR), the analysis shows that the increase in cost and profit efficiencies leads to higher risks. On the efficiency and market risk, the authors find a positive association between the two variables.

As for the market risk, the Basel Committee on Banking Supervision (BCBS) has shifted the bank market risk measurement method from VaR to ES in the aftermath of the Great Recession (BCBS, 2016). Since the ES is the latest method for measuring bank market risk, only a few studies have tested the effectiveness of the ES method.

DATA AND METHODOLOGY

We used data of type A shares from the 12 biggest banks in China from 2000 to 2015. This study selected top-tier listed banks to reduce the heterogeneity effects among the banks. The selected banks are listed on the Shanghai Stock Exchange and four of the banks are global systemically important banks (G-SIBs). Besides efficiency, this study also examines other bank-specific variables to be included in the model as control variables. The variables are:

1. Natural log of total assets (SZ) (Demirguc-Kunt et al., 2013).
2. Ratio of total equity to total assets (CP) (Beltratti & Stulz, 2012).

3. Ratio of Non-performing Loan to Total Loan (NPLL) (Klomp & Haan, 2012).
4. Ratio of Non-interest Income to Revenue (NI) (Akhigbe et al., 2012).
5. Return on Average Assets (ROAA) (Akhigbe et al., 2012).
6. Ratio of marketable securities to total assets (MS) (Akhigbe et al., 2012).

The banks' financial data are collected from the BankScope database. The annual reports are used either when data are unavailable or for cross-references.

Table 1 presents the variables' description, expected sign, and data sources for all variables used in this study, and Table 2 summarises the variables' statistics.

Table 1
Variable description, expected sign and data sources

Variable	Description	Expected sign
	Efficiency (SFA) model	
Cost	Total interest expense + total non-interest expenses	
Profit	Profit before tax	
Output 1 (y_a)	Total loans	Positive
Output 2 (y_b)	Other earnig assets + other operating income	Positive
Price of labour (*wl*)	Personnel expenses/total assets	Positive
Price of physical capital (*wk*)	Other operating expenses/fixed assets	Positive
Price of deposits (*wd*)	Total interest expense/deposits and short-term funding	Positive
	Market risk model	
MR	Market risk measured using VaR and ES	
CEF	Cost efficiency estimated using SFA	Negative
PEF	Profit efficiency estimated using SFA	Positive
SZ	Natural log of toal assets	Positive
CP	Total equity/total assets	Negative
NPLL	Non-performing loan/total loan	Positive
NI	Non-interest income/revenue	Positive
ROAA	Return on average assets	Negative
MS	Marketable securities/total assets	Negative

Table 2
Summary statistics for market risk and efficiency models

Variable	No. of observation	Mean	SD	Min	Max
Efficiency (SFA) model					
Cost (mil)	183	113063	128627	351	542427
Profit (mil)	183	64679	89140	17	405555
Output 1 (y_a) (mil)	183	2091150	2513862	1997	11652812
Output 2 (y_b)	183	1483297	1609301	6091	6954521
Price of labour (wl)	183	0.00476	0.00131	0.00064	0.00823
Price of physical capital (wk)	183	0.62213	0.26521	0.18381	1.60323
Price of deposits (wd)	183	0.02008	0.00662	0.01044	0.05369
Market risk model					
VaR	117	−0.03220	0.01387	−0.07960	−0.01032
ES	117	−0.05132	0.02106	−0.10473	−0.01628
Cost Efficiency	117	0.93095	0.03860	0.78270	0.98310
Profit Efficiency	117	0.77812	0.12215	0.37190	0.97210
SZ	117	14.82757	1.25388	11.76660	16.91600
CP	117	0.05550	0.01463	0.02200	0.09800
NPLL	117	0.01528	0.01316	0.00380	0.10600
NI	117	0.17695	0.07645	0.02260	0.38690
ROAA	117	0.01032	0.00303	0.00360	0.01480
MS	117	0.20440	0.06967	0.07580	0.49310

This study employs a two-stage procedure for empirical analysis. In the first stage, the dependent variables—the market risk—are measured by using the VaR and ES methods. The cost and profit efficiency are estimated using SFA, and other banks specific variables are calculated using financial ratios. In the second stage, the unbalanced panel data is used to regress the results from market risk measurements (VaR and ES), cost and profit efficiency scores and other bank-specific variables.

Bank Market Risk

The data used for VaR and ES derived from the daily stock price. The daily stock price data is collected from the Wall Street Journal, Yahoo Finance, Google Finance and Morningstar websites.

VaR

Following Dowd (2005), the VaR confidence level is α and $p = 1 - \alpha$, where p is the probability of worst outcome and qp is the p-quantile of a stock returns over some holding period. The VaR of the stock at the confidence level, α and at a certain holding period is equal to:

$$VaR = -qp \tag{1}$$

The VaR is simply the negative of the qp quantile of the stock returns distribution.

ES

The ES is the expected loss when the financial loss is greater than the VaR calculations. It calculates the expected value of the loss at the extreme end of the distribution when the VaR has failed to calculate it. Following Dowd (2005), if the loss distribution is discrete, the ES is the average of the worst 100 $(1 - \alpha)$ percent of losses:

$$ES_{\alpha} = \frac{1}{1-\alpha} \sum\nolimits_{p=0}^{n} p^{\text{th}} \text{ largest lost} \times \text{probability of } p^{\text{th}} \text{ largest lost} \tag{2}$$

Bank Efficiency (SFA)

This study estimates bank efficiency by employing the parametric method known as SFA. The parametric method was chosen because the model separates between statistical noise and efficiency estimations. The non-parametric method such as Data Envelopment Analysis (DEA) is not considered because it lumped together all types of disturbances and assumed it as inefficiency (Berger & Humphrey, 1997).

Cost Efficiency

This study collected and analysed the data of 247 banks of 12 developed and developing economies in East Asia and the Pacific area from 2003 to 2012 to find the empirical evidence for these relationships. Using a stochastic frontier approach (SFA) to estimate bank cost efficiency, we found that there are significant relationships among risks, cost efficiency and environmental factors, but they are in different levels when comparing between developed and developing economies, or between the periods of the pre- and post-2008 financial crisis. On the measures of efficiency, Lotto (2018) used operating expense over operating income. It refers to what occurs when the right combination of inputs such as staff, technology and process are used in production while ensuring that costs are maintained at the desired level to improve productivity. The cost-efficiency in this study can be obtained by estimating a cost function with a composite error term. Aigner et al. (1977) and Meeusen and Broeck (1977) specify a composite error term to the deterministic frontier to separate inefficiency and random error. The single equation stochastic cost function model can be written as:

$$\ln TC_i = f(Y_i, W_i; \beta) + v_i + u_i \tag{3}$$

where $\ln TC_i$ is the logarithm of the total costs for the i-th bank. It represents the minimum cost of producing outputs Y_i with input prices W_i, β is a vector of unknown parameters: $v_i \sim i.i.d.N(0, \sigma_v^2)$ is a two-sided error term captures measurement error and statistical noise, and $u_i \sim i.i.d.N^+(0, \sigma_u^2)$ is a one-sided positive error term capture the effects of cost inefficiency relative to the frontier. The model incorporates the calculation of measurement error and statistical noise using maximum likelihood estimators. The total variance is $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and the Gamma ratio is $\gamma = \sigma_u^2/(\sigma_u^2 + \sigma_v^2)$ $\gamma = \sigma 2/(\sigma 2 + \sigma 2)$. The ratio has a value between 0 and 1.

A hypothesis test of $\gamma = 0$ serves as a test of the existence of the one-sided error for the half- normal model (Kumbhakar et al., 2015).

The cost-efficiency SFA model takes the following form:

$$\begin{aligned} \ln TC = {} & \alpha_0 + \sum_{i=1}^{m} \alpha_i \ln y_i + \sum_{j=1}^{J} \beta_j \ln w_j \\ & + \frac{1}{2}\left[\sum_{i=1}^{m}\sum_{k=1}^{m} \delta_{ik} \ln y_i \ln y_k + \sum_{j-1}^{J}\sum_{h=1}^{J} \theta_{jh} \ln w_j \ln w_h\right] \\ & + \sum_{i=1}^{m}\sum_{j=1}^{J} \rho_{ij} \ln y_i \ln W_j + v_i + u_i \end{aligned} \tag{4}$$

Symmetric restrictions require $\delta_{ik} = \delta_{ki}$ and $\theta_{jh} = \theta_{hj}$. Because the cost function is homogeneous with degree one in the input prices, it must satisfy the following additional parameter restrictions:

$$\sum_j \beta_j = 1; \sum_j \theta_{jh}\ 0\ \forall\ h, \sum_j \rho_{ij} = 0$$

Following Boucinha et al. (2013), this study adopts the translog form which is the commonly used functional form in the bank efficiency literature as the structure of production technology and adopt the intermediation approach. Following Srairi (2010), this study considers two outputs: (i) total loans, y_a, and (ii) other earning assets, y_b, (inter-bank funds, investments securities and other investments) and three inputs: price of labour (*wl*) measured as personnel expenses divided by the total assets, price of physical capital (*wk*) measured by operating expenses minus personnel expenses divided by fixed assets, and the price of deposits (*wd*) measured as total interest expenses divided by total funding. To satisfy linear homogeneity in input prices, all variables are normalised by the price of deposit.

Profit Efficiency

The alternative profit function is adopted to measure the profit efficiency. The alternative profit function is similar to cost function. It uses the same translog specification and independent variables as the cost function with one difference. The dependent variable is replaced by $\ln PE_i = \ln(PF_i + |PF_i^{min}| + 1)$, where PF_i is the profit before tax of the -ith bank. The term $\theta = |PF_i^{min}| + 1$ indicates the absolute minimum value of net profits overall banks in a given year plus 1. The term θ is a constant added to every bank's profit so the natural logarithm is a positive number since the minimum profits can be negative. The composite error term is $v_i - u_i$. Inefficiency term enters the frontier with a negative sign because inefficiency reduces profits below the best practice bank frontier. The measure of profit efficiency is defined as $PE_i = \exp(-u_i)$. The efficiency scores take a value between 0 and 1 with values closer to one indicating a fully efficient bank.

Bank Market Risk Model

This study examines the link between bank market risk and efficiency. Based on the efficient market hypothesis, this study would expect a semi-strong form to reflect all the information publicly available which also include efficiencies (Kirkwood & Nahm, 2006). This study uses the standard market model with efficiency and other bank-specific variables. Bank market risks are regressed against the determinants using panel data. Since there is a bidirectional relationship between the independent variables, as shown by Berger and Humphrey (1997), panel data analysis is suitable for this study. Following De Haan and Poghosyan (2012) and Papadamou and Tzivinikos (2013), the proposed model is:

$$\begin{aligned} \mathrm{MR}_{it} = {} & \beta_0 + \beta_1 \mathrm{EF}_{it} + \beta_2 \ln \mathrm{SZ}_{it} + \beta_3 \ln \mathrm{CP}_{it} + \beta_4 \ln \mathrm{NPLL}_{it} \\ & + \beta_5 \ln \mathrm{NI}_{it} + \beta_6 \ln \mathrm{ROAA}_{it} + \beta_7 \ln \mathrm{MS}_{it} + \varepsilon_{it}, \\ & [i = 1, \dots, N;\ t = 2000, \dots, 2015] \end{aligned} \tag{5}$$

where MR = Market Risk, EF = Efficiency, SZ = Size, CP = Capital, NPLL = Non-performing Loan, NI = Non-interest Income, ROAA = Return on Average Assets, and MS = Marketable Securities. The error term can be further broken down into: $\varepsilon_{it} = \mu_i + \lambda_t + u_{it}$: where μ_i is called the individual-specific effect, λ_t is called the time effect, and $u_{it} \sim N(0, \sigma_u^2)$ denotes the well-behaved error term.

Based on the proposed model, this study produces four models to examine the effects. There are:

1. Model 1: VaR and Cost Efficiency.
2. Model 2: ES and Cost Efficiency.
3. Model 3: VaR and Profit Efficiency.
4. Model 4: ES and Profit Efficiency.

From each model, there are three competing models in panel data: Pooled OLS (POLS), Fixed Effects (FE), and Random Effects (RE). Three tests are conducted to select the correct panel data model: Poolability F-Test, Breusch-Pagan LM test and Hausman's specification test.

RESULTS AND DISCUSSION

Bank Market Risk

From Figure 1, the mean of bank market risk in China fluctuates throughout the sample period. The highest recorded of losses, –6.1% (VaR) and –8.6% (ES), are in 2008 due to the Great Recession. The lowest, –1.6% (VaR) and 2.3% (ES), are in 2012. The market risk increased again in 2015, to –4.3% (VaR) and –7.1% (ES).

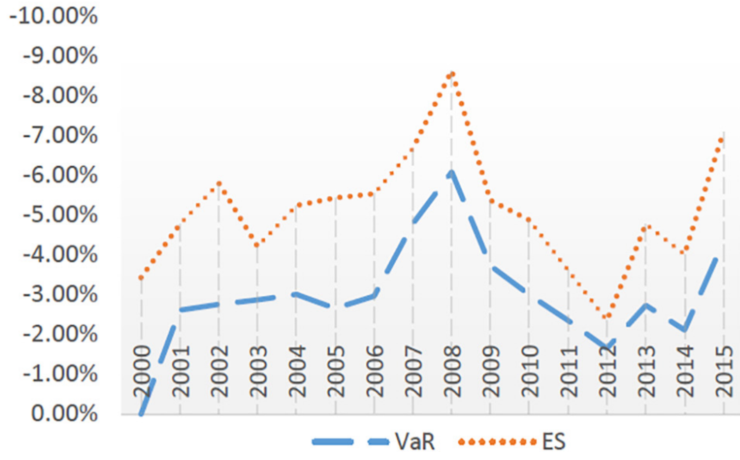

Figure 1. Bank market risk (VaR and ES)

Bank Efficiency

For cost frontier estimation, from the 14 regressors, eight are statistically significant. The gamma value is 0.90. The log-likelihood value is high (214.90) and statistically significant at the 1% level. The sigma-squared is significant at 1% level. The high and significant value of the log-likelihood function and significant value of sigma-squared indicates highly significant parameter estimates. The estimation results show a positive and significant relationship between the two outputs (total loans and other earning assets). This means that higher outputs lead to higher costs. The coefficient for the price of inputs (price of labour and price of fund) are also positive and significant. It shows that the high price of inputs leads to higher costs. The elasticity of the price of labour (0.98) is higher than the elasticity of the price of fund (0.55). This suggests that banks should focus more on personnel expenses compared to interest expenses to control the cost. The coefficient for combinations of the outputs γ_{11}, γ_{22} and γ_{12} are also significant (5%, 10% and 5%, respectively). Both γ_{11} and γ_{22} are positive, while γ_{12} is negative. This shows that the combinations between different output prices reduce efficiency. The coefficient of the double input price for labour (δ_{ll}) is significant, at 1%. The results indicate that *wl* contributes more than does *wf*.

For profit frontier estimation, from 14 variables, only five are statistically significant. The gamma value is 0.98. The log-likelihood value is 8.69 and statistically significant at the 1% level. The sigma-squared is significant at the 1% level. The significant value of the log-likelihood function and significant value of sigma-squared indicates significant parameter estimates. The estimation results show a positive and significant value for other earning assets output. This means that higher other earning assets outputs lead to higher profits. The coefficient for the price of fund is negative and significant. It shows that the high price of fund leads to lower profit efficiency. Its own outputs' combination (γ_{22}) reduces the profit efficiency, as it has a negative value and is significant at the 10% level. The coefficient for *wf* is negatively significant at 1%. This indicates that the increase in *wf* reduces the profit efficiency, while the combination of its price (δ_{ll}) increases efficiency by being positively significant, at 1%. The coefficient of cross input prices (δ_{lf}) is significant at 1% and has a negative value. This means that the combination of the input price reduces profit efficiency.

Table 3 reports the estimation results for the cost and profit efficiencies model.

Table 3
Estimation results for the cost and profit efficiencies

Variables	Parameters	China	
		Cost efficiency	Profit efficiency
Constant	α_0	5.54219 (0.47480)	1.77772 (1.15682)
$\ln y_1$	α_1	0.51427* (0.19146)	−0.51636 (0.57824)
$\ln y_2$	α_2	0.36249*** (0.19204)	1.17904** (0.58356)
$\ln wl$	β_1	0.98532* (0.20796)	0.88741 (0.56851)
$\ln wf$	β_f	0.55601* (0.20796)	−1.41397* (0.45011)
$\ln y_1 \ln y_1$	γ_{11}	0.28630** (0.12209)	−0.26860 (0.28055)
$\ln y_2 \ln y_2$	γ_{22}	0.21947*** (0.11868)	−0.58412*** (0.30929)
$\ln y_1 \ln y_2$	γ_{12}	−0.24115** (0.11897)	0.44212 (0.28865)
$\ln wl \ln wl$	δ_{ll}	0.20421* (0.06388)	0.48151* (0.15850)
$\ln wf \ln wf$	δ_{ff}	0.04175 (0.05381)	0.22093 (0.21138)

(*continue on next page*)

Table 3 (*continued*)

Variables	Parameters	China	
		Cost efficiency	Profit efficiency
ln *wl* ln *wf*	δ_{lf}	−0.06738 (0.05460)	−0.51612* (0.14002)
ln y_1 ln *wl*	θ_{1l}	−0.01535 (0.06341)	−0.16370 (0.16704)
ln y_1 ln *wf*	θ_{1f}	−0.05179 (0.05428)	−0.19684 (0.13949)
ln y_2 ln *wl*	θ_{2l}	−0.01088 (0.05841)	0.13979 (0.15683)
ln y_2 ln *wf*	θ_{2f}	0.04759 (0.05106)	0.06278 (0.14778)
Log-likelihood		214.90044	8.69662
Variance components:	$\sigma^2(u)$ =	0.01303* (0.00288)	0.17150[a]* (0.03230)
	$\sigma^2(v)$ =	0.00136** (0.00062)	0.00342 (0.00397)
Gamma		0.90549	0.98045
LR test of the one-sided error		11.89803*	20.39412*

Notes: Standard error in parentheses. * Significant level at 1%; ** Significant level at 5% and *** Significant level at 10%.

From Figure 2, cost efficiency for China's bank is mostly stable and relatively higher than profit efficiency. Cost-efficiency in China is not affected by the Great Recession in 2008 (96%). Cost efficiency in China is showing an upward trend from 2009 until 2015. Whereas profit efficiency is fluctuating throughout the sample period. The graph shows that the profit efficiency in China is affected by the Great Recession when it fell from 78% in 2007 to 73% in 2008. The profit efficiency is showing a downward trend from 2010 until 2015.

Figure 2. China cost and profit efficiencies

Bank Market Risk Model

To decide which is the best model for the bank market risk, each model is estimated with three-panel data methods: (i) POLS, (ii) FE and (iii) RE. From the three tests: (i) Poolability F-test, (ii) Breusch-Pagan LM test, and (iii) Hausman's specification test conducted to select the best model, we found that POLS method is preferred by Models 1, 3 and 4, while Model 2 preferred FE method. Table 4 shows the results from preferred models.

Table 4
Bank market risk model results

Variables	China			
	Cost efficiency		Profit efficiency	
	Model 1 VaR and CE	Model 2 ES and CE	Model 3 VaR and PE	Model 4 ES and PE
Constant	−0.00819 (0.03779)	0.29915 (0.11530)	−0.14059 (0.02351)	−0.18834 (0.03650)
CE (VaR)	−0.10759* (0.03085)			
CE (ES)		−0.23144* (0.05810)		
PE (VaR)			0.03002* 0.01143)	
PE (ES)				0.03303*** (0.01774)
ln SZ	0.00654* (0.00189)	−0.00889 (0.00686)	0.00783* 0.00193)	0.00942* (0.00300)
CP	−0.18944 (0.14094)	−0.11110 (0.26983)	−0.25084*** (0.14227)	−0.36401 (0.22085)
NPLL	0.21284*** (0.10860)	−0.34830 (0.28350)	0.21552*** (0.11311)	0.36904** (0.17559)
NI	0.00006 (0.02020)	0.07108*** (0.04193)	0.02020 (0.02054)	0.03279 (0.03189)
ROAA	−0.08983 (0.69909)	0.81227 (1.35352)	−0.93907 (0.81885)	−0.01652 (1.27116)
MS	−0.06199* (0.01866)	−0.06184*** (0.03205)	−0.07059* (0.01870)	−0.09505* (0.02903)
Adjusted R^2	0.2580	NA	0.2243	0.1897
R^2 – within	NA	0.2671	NA	NA
R^2 – between	NA	0.3174	NA	NA
R^2 – overall	NA	0.0290	NA	NA
F-Test	1.16	1.69***	0.73	1.14
LM Test	1.12	0.39	5.42	0.83
Hausman-Test	9.57	12.63***	0.00	9.10

Notes: Standard Error in parenthesis; * Significant level at 1%; ** Significant level at 5% and *** Significant level at 10%; NA = Not Applicable.

DISCUSSION

China has a significant and negative sign for both cost-efficiency models (Models 1 and 2). The negative effects of cost efficiency on bank market risk in China are in line with the studies conducted in the U.S. Kwan and Eisenbeis (1997) found that the increased in cost efficiency lowers the bank risk-taking. There are two similarities in data used in this study and Kwan and Eisenbeis (1997) study: (i) the relatively small sample of banks and (ii) large size of banks. In this study, there are four global systemically important banks in China. With the large size of banks, the economies of scale could easily be achieved. The negative relationship findings also supported by Yin et al. (2013). The authors argue due to its size, the Chinese banks are more efficient in transforming inputs into lending assets. Also, the bank's managers could take more risk because the risk can easily be leverage due to its bigger size. Tan and Anchor (2017) findings also show that the efficiencies of Chinese commercial banks are significantly and negatively affected by risk. The findings supported the moral hazard hypothesis.

China also has significant but positive value for both profit efficiency models (Models 3 and 4). As for the positive effects of profit efficiency on bank market risk, banks usually offer more financial instruments to achieve higher profits. Thus, by offering more financial instruments, the bank has increased its exposure to bank market risk. As indicated by Liadaki and Gaganis (2010), the change in profit efficiency has significant and positive effects on stock prices. This result is in line with Tan and Floros (2018) and Fang et al. (2019) findings. These results supported the skimping hypothesis.

As for the other bank-specific variables, our models show that the increase in the size of the banks increases the market risk (Models 1, 3 and 4). As for the positive effect, China has larger banks than can leverage its size to have economies of scale and economies of scope. The Bigger bank can leverage better compared to smaller banks. With the leverage, it will be able to offer more financial instruments and thus increases the risk. This will be positive effects of size on bank risk (Dietrich & Wanzenried, 2014).

The significant and negative sign of capital ratio in Model 3, supports the capital absorption hypothesis (Akhigbe et al. 2012). According to Akhigbe et al. (2012), the capital absorption hypothesis explains that the probabilities of a bank with high capital to fail are lower during the financial crisis because it has more capital to absorb the losses compared to the low capital bank.

The increase in non-performing loan increases the market risk (Models 1, 3 and 4). As banks offer more financial instruments, it increases bank exposure to the risk. The positive and significant relationship between non-performing loans and risk is supported by Papadamou and Tzivinikos (2013). For a significant and positive sign of non-interest income, the results are in line with DeYoung and Rice (2004) study. The authors empirically find that even though the non-interest income had increased to more than 40% in banks operating income, the increase has resulted in the positive relationship between risk and return trade-offs. In contrast, the increase in marketable securities reduces the market risk in all models. Bank invest in short to medium term marketable securities such as subordinated notes and debentures (SND) to diversify its portfolios. Investing in large amounts of marketable securities provides liquidity for banks and its signal a lower likelihood of financial distress (Sironi, 2003). The results supported Sironi (2003) proposition of SND are negatively related to bank risk.

CONCLUSION

This paper studies the effects of cost and profit efficiencies on bank market risk. This study is important since market risk has become a top priority for banking regulation and supervision after the Great Recession. We use SFA to estimate cost and profit efficiencies, VaR and ES to measures market risks and use panel data of 12 biggest banks listed on the Shanghai Stock Exchange over the period 2000–2015.

For the first objective, the findings for bank market risk reveal there are significant differences between VaR and ES methods to measure bank market risk. The results from ES relatively higher than VaR. It means that there are losses that could be captured better using ES compared to VaR. As for efficiency, the results from cost-efficiency estimations are higher compared to profit efficiency. This means that there is a lot of opportunities for China to improve its profit efficiency compared to its cost-efficiency. The downward trend of the profit efficiency could trigger the banking supervisors and managers to take necessary actions.

For the second objective, we find a significant and negative relationship between the cost efficiency and market risk while the significant but positive relationship between profit efficiency and market risk. As each type of efficiency focus on a specific dimension, in this case, cost and profit, it does affects differently to the market risk.

Our results extend Kwan and Eisenbeis (1996) paper by showing that there is a relationship between bank market risk and efficiency in the Chinese market. The results show that the improvement in cost efficiency reduces market risk, while the improvement in profit efficiency increases market risk. Since there are differences in the effects of efficiencies on bank market risk, the banking supervisors and managers may need to formulate specific policies and strategies on cost efficiency-related initiatives to manage the market risk better.

This study has uncovered some elements from the fragile nature of market risk. As the bank market risk has become a top priority for banking supervisors, the findings could facilitate formulations of appropriate tools to improve monitoring of bank market risk. As this study limits the effects of efficiency on market risk by using 12 banks in China as a sample, more research could be done to validate the findings. The effects could be explored further by comparing different types of markets, such as developed and emerging markets, or different bank size categories in different countries. Other methods also could be used to estimates efficiencies such as advanced non-parametric method or combination between DEA and SFA methods.

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