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WORLD FINANCIAL CRISIS AND EMERGING MARKET BANK PERFORMANCE: A BANK EFFICIENCY STUDY

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SIEMS EMERGING MARKET BRIEF

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ABSTRACT

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The ongoing global financial crisis has caused great turmoil in the developed world's banking sector, and as of this writing (September 2011), most of the developed world is still struggling to recover from the crisis. As a result, the emerging market banks, represented by the BRIC banks, are increasing in importance in the global banking market. We investigated bank performance and its relationship to bank characteristics and macroeconomic factors using a sample of major banks in the BRIC countries during 2003–2009 and found that the BRIC banks increased in efficiency due to the rapid economic growth and rising GDP in these countries. The presence of foreign-owned banks also played a role in promoting the overall efficiency of the banking sector; however, the presence of large state-owned banks had a negative impact on efficiency. Finally, the relatively high level of bank capitalization and loan loss reserves helped to improve the efficiency level of the BRIC banks before and during the global financial crisis.

I.
INTRODUCTION

Banks are usually the cornerstone of a country's financial system, especially in the emerging markets (EMs) where the equity and bond markets are not well developed. The ongoing global banking crisis further underscores the importance of the banking sector in the process of economic development. While most of the developed world is still struggling to recover from the global banking crisis, the banking sector in the BRIC countries (namely, Brazil, Russia, India, and China) was relatively less affected by the financial crisis. In addition, there have been fewer cases of major bank failures in the BRIC countries whose economies were either not as affected by the crisis (such as China) or recovered much faster than their developed counterparts (such as Brazil). This not only contributed to the global economic recovery from the 2007–2008 recession but also has served to increase the importance of the EM banks in the global banking system. For instance, as of July 2011, among the top 10 banks in the world ranked according to market capitalization, 4 are from emerging markets (table 1). In addition, according to Bloomberg data, 44% of the top 100 banks are EM banks, an increase from 21% and 30% in 2002 and 2007, respectively. A recent report published by *The Banker* shows that a high proportion of the banks surveyed in 2010 indicate that the EM economies will be the main driver of the future growth of the world banking industry (Ghosh, 2010). Consequently, the performance of the major EM banks in the years before and during the 2007–2008 financial crisis, represented by the BRIC countries, has recently received greater attention. From the research point of view, the global financial crisis provides a natural experiment that provides us with a rare opportunity to examine how well the EM banks performed and what factors explain their performance.

44% of the top 100 banks in the world are EM banks in 2011, an increase from 21% and 30% in 2002 and 2007, respectively

TABLE 1. TOP-10 BANKS IN THE WORLD (BY MARKET CAP., US$ BILLION, JUNE 2011)			
Rank	Bank Name	Country	Market Cap.
1	Industrial & Commercial Bank Of China	China	248.6
2	China Construction Bank	China	225.5
3	HSBC Hldgs Plc	UK	182.3
4	JPMorgan Chase	US	161.1
5	Agricultural Bank Of China	China	144.3
6	Bank Of China	China	143.3
7	Wells Fargo & Co	US	138.9
8	Citigroup Inc	US	111.2
9	Bank Of America	US	109.7
10	Banco Santander	Spain	97.8
Source: Bloomberg, 2011.			

This study attempts to investigate the following significant questions about the major banks in the BRIC countries: How did the BRIC banks perform in the years immediately before and during the global financial crisis? What factors explain their performance over that period? For instance, did the presence of foreign-owned banks in the BRIC countries have a negative impact on the performance of the BRIC banks during the financial crisis? What is the impact of the macroeconomic environment on bank efficiency in these countries? We utilize a sample of 947 bank observations, covering the major banks in the BRIC countries for the period of 2003–2009. We find that the performance of the BRIC banks shows great variation both within and across countries and that the banking sector of the BRIC countries was negatively affected by the global financial crisis. Comparatively, China was the least affected, while Russia was affected the most (a 29% decline in efficiency from 2007 to 2008). Brazil and India exhibited a steady level of efficiency until the financial crisis, but the efficiency declined during the crisis. They are still recovering in the early post-crisis period. The analysis of inefficiency factors reveals that Brazil and China have an institutional and macroeconomic environment that is more conducive to the profit efficiency of its banking sector. The higher ratio of foreign-owned banks and the relatively low level of state-owned banks contributed to the bank efficiency levels. Furthermore, the BRIC banks increased in efficiency due to the rapid economic growth and the rising GDP per capita in these countries. Public listings, high capital levels, and loan loss reserves are found to have a significantly positive impact on BRIC banks' efficiency levels, while the NPL ratio and the degree of reliance on interbank borrowing have a negative effect on their efficiency levels.

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II. BASIC PERFORMANCE MEASURES

BASIC INDICATORS OF BANK PERFORMANCE: A PRE-LIMINARY EXAMINATION

As a preliminary examination, figure 1 exhibits the trend of some basic indicators (e.g., profitability) of the major banks in BRIC countries between 2003 and 2009. It is clear from the figure that Brazilian banks recorded relatively high profitability in terms of both the return on average assets (ROAA) and return on average equity (ROAE) at the beginning of the period. However, their average profitability declined afterward (especially in 2007) and then recovered in 2008 and 2009. The profitability of Indian banks is basically stable throughout the period, as is Chinese banks' profitability since 2005. Russian banks had the highest level of ROAA and ROAE during the period of 2005–2006, but their average profitability has declined continuously since then. The Russian economy experienced the greatest economic contraction by far during the crisis, which probably explains much of this deterioration. We have also calculated a simple measure of bank capitalization, and its trend is plotted in figure 1. On average, Russian banks have the highest ratio of equity to total assets,[1] while China has the lowest.

One simple measure of the quality of banks' loan portfolio is the non-performing loan (NPL) ratio. For the period of 2003–2009, Indian banks have the lowest average NPL ratio (3.48%), while Brazilian banks have the highest (9.87%). However, the value of this variable is affected by each country's regulatory rules and loan categorization system. For instance, China uses a relatively lax rule to count NPLs; therefore, the NPL ratio for Chinese banks may be underestimated. Furthermore, figure 1 shows the comparison of loan loss reserves among the BRIC countries. China and In-
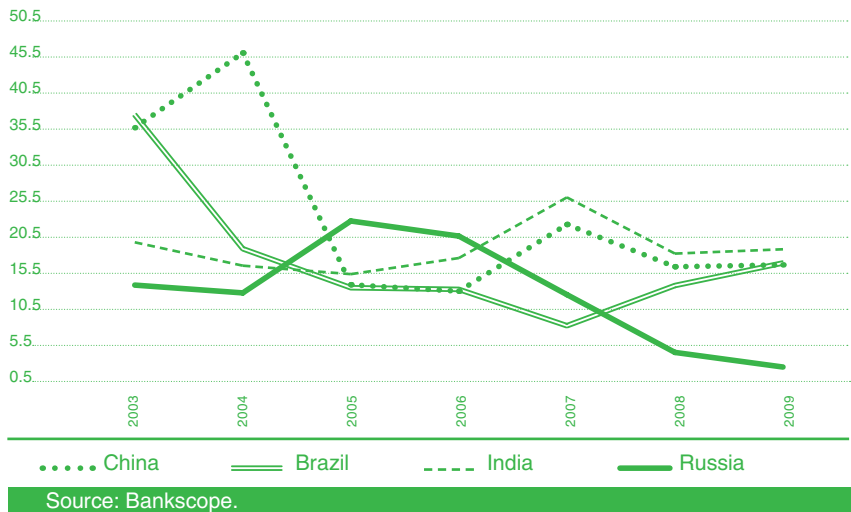

FIGURE 1. Basic Indicators of Bank Performance in BRIC Countries (2003–2009) Return on Average Assets (ROAA)
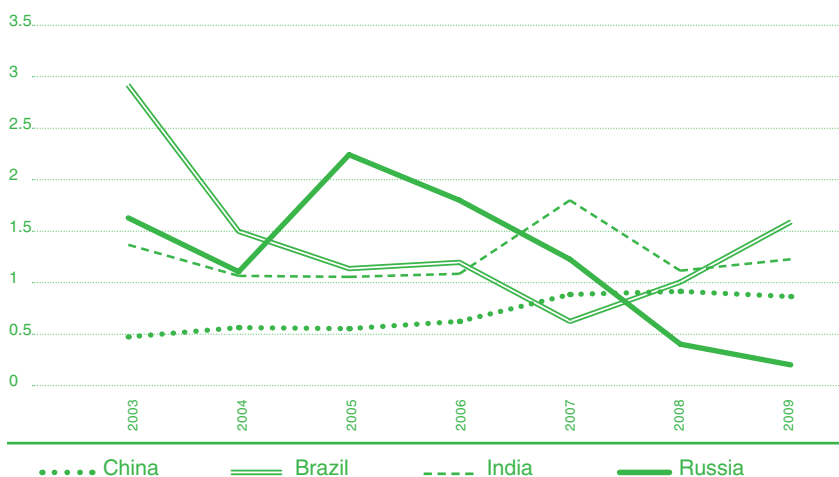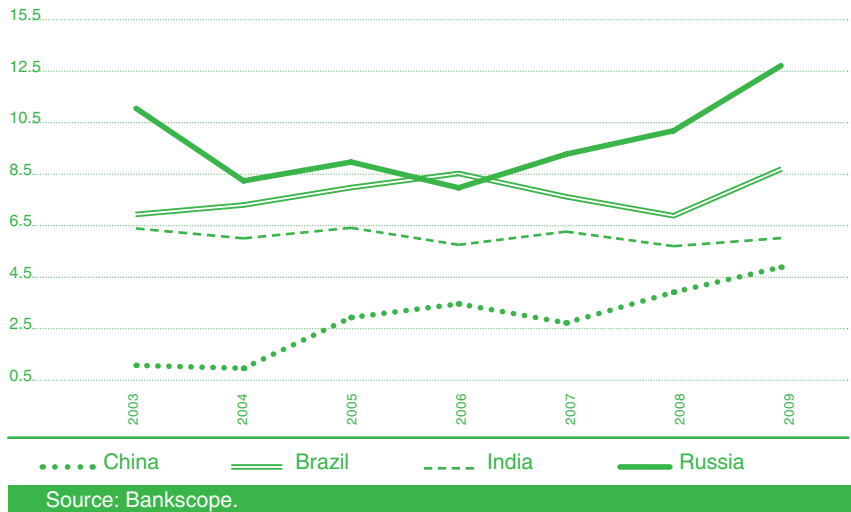
Source: Bankscope.

[1]   The assets measurement is not adjusted for risk.

FIGURE 1. Basic Indicators of Bank Performance in BRIC Countries (2003–2009) Return on Average Equity (ROAE)

Source: Bankscope.

FIGURE 1. Basic Indicators of Bank Performance in BRIC Countries (2003–2009) Equity/Total Assets

Source: Bankscope.

dia have the lowest loan loss reserves to total loans ratio among the group, which is approximately 20% of that of Russian banks.

MEASURING BANK EFFICIENCY

Although the banks' financial performance can be partially revealed by simply looking at the various financial ratios (e.g., ROAA, ROAE, etc.), such investigations quite often lead to conflicting conclusions that can be misleading, given that the market contains inefficiencies and the price informa-

FIGURE 1. Basic Indicators of Bank Performance in BRIC Countries (2003–2009) Loan Loss Reserve/Gross Loans
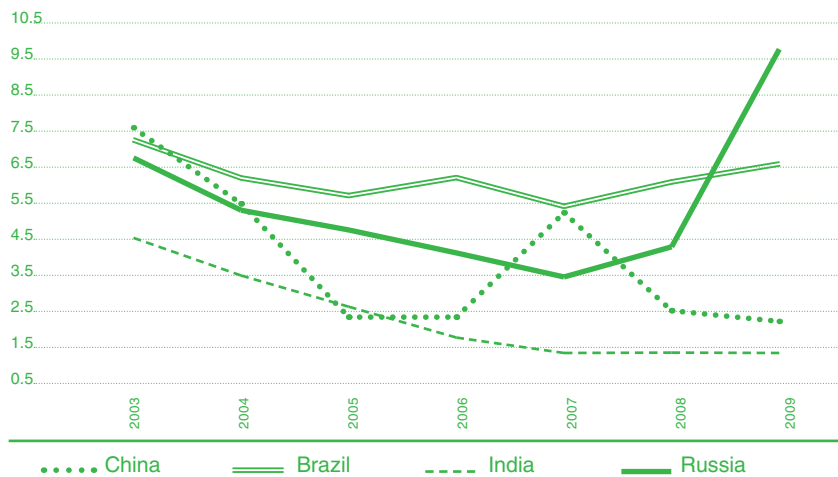
Source: Bankscope.

tion is sometimes unreliable. Therefore, it is important to further investigate how efficient the banks are in allocating economic resources. A *stochastic frontier approach* is commonly employed for bank efficiency analysis. Such an approach is especially appropriate in efficiency studies of emerging markets, in which problems related to measurement error and an uncertain economic environment are more likely to prevail (please see the appendix for a detailed description of the model and methodology).

A bank's efficiency level can be affected by both bank-specific characteristics (such as its capital level and nonperforming loans) and the macroeconomic environment (such as the rate of economic growth or the level of development of its capital markets). In the analysis of factors that affect banks' efficiency levels, we considered a large set of macroeconomic factors and bank-level characteristics. The primary macro factors of interest include the following: market structure of the banking sector as measured by the bank concentration level, degree of development of the country's capital market as measured by the importance of its stock market, share of state-owned banks in the country's banking sector, share of foreign-owned banks in the banking sector, GDP and its growth rate, and net interest spread. In addition, we considered a large set of bank-level risk factors and indicators of the banks' asset structure. These variables include bank size, the bank's listing status, the ratio of nonperforming loans (NPLs) to total loans, the ratio of loan loss reserves to NPLs, the leverage ratio (equity/total assets), the loans to deposits ratio, reliance on interbank borrowing, and the ratio of securities to total earning assets (including cash and deposits, reserves at the central bank, deposits at other financial institutions, reverse repurchase agreements, and total loans and securities).

III. EMPIRICAL RESULTS: BANK EFFICIENCY SCORES

We focus on the major banks in the BRIC countries: (1) banks included in the *Bankscope* database during 2003–2009; (2) banks that *The Banker* included in the list of the 1000 biggest banks during the same period. We have a total of 947 bank-year observations (table 2) over 2003–2009, which includes a period of rapid global economic expansion and deep financial crisis. All of the bank-level data items are obtained from the *Bankscope*. Information about the country-level variables is from various sources, including the World Bank, IMF, Beck (2010), and Barth et al. (2003; 2008) (see note from table 3).

Table 3 reports the summary statistics of the major financial ratios of banks from each of the BRIC countries during 2003–2009. The variable values of the input/output factors are converted to 2005 price levels with the GDP deflator and measured in millions of U.S. dollars. Descriptive information about the country-level macroeconomic indicators is also reported in table 3. Comparatively speaking, Russia and India have higher degrees

TABLE 2. SAMPLE DISTRIBUTION (2003-2009)								
	2003	2004	2005	2006	2007	2008	2009	Total
Brazil	15	15	15	15	15	15	13	103
India	26	27	28	30	29	29	29	198
Russia	21	26	29	33	33	32	32	206
China	59	60	60	64	65	66	66	440
Total	121	128	132	142	142	142	140	947
Source: Bankscope.								

of reliance on the capital markets, while China relies more on the banking sector as its major credit provider. Although India is largely a market-based economy, the share of state-owned banks in its banking sector is the highest among the BRIC countries (75%), while China is a close second (67%). Russia has the lowest share of state-owned banks (37%), followed closely by Brazil (41%). Brazil has the most open banking sector among the BRICs, as reflected by its relatively high share of foreign-owned bank participation (23%). Conversely, foreign banks play a very limited role in the remaining BRIC countries, with those market shares averaging only 1.6%, 7%, and 8.5% for China, India, and Russia, respectively.

Our estimation model calculates an efficiency score for each individual bank in the BRIC countries over time. Table 4 reports the weighted average bank efficiency scores for each country during 2003–2009, which were derived by weighting banks' total assets. China's banking sector scored the lowest efficiency level among the BRIC countries at the beginning of the period (2003) but scored the highest by 2009, averaging 87% over this period. Not surprisingly, the entire banking sector of the BRIC countries was

negatively affected by the 2007–2008 global financial crisis, and efficiency scores dropped precipitously. Comparatively, China was the least affected (a 2% reduction from 2007 to 2008); Russia recorded the highest reduction in banks' profit efficiency right after the financial crisis (a 29% decline from 2007 to 2008), and its efficiency remained at depressed levels in the early post-crisis period (i.e., through 2009). Among the four BRIC countries, Russia exhibited the highest volatility in overall efficiency of its banking system. Brazil and India exhibited a steady level of efficiency until the financial crisis, but their efficiency declined during the crisis. They are still recovering in the early post-crisis period.

TABLE 3. DESCRIPTIVE STATISTICS

	Full Sample			Brazil		
	Mean	S.D.	N	Mean	S.D.	N
Operating Income*	1486.27	3710.57	947	3400.29	4477.16	103
Net Interest Income*	1131.46	2994.92	947	2441.72	3112.78	103
Total Non-Interest Operating Income*	354.82	933.83	947	958.57	1455.29	103
Total Interest Expense*	960.89	2155.65	947	2519.59	3142.31	103
Total Non-Interest Expenses (incl. provision)*	1038.76	2488.44	947	2546.82	3387.19	103
Importance of stock market	1.1412	0.8442	947	1.1904	0.3527	103
Market concentration (%)	54.5501	18.2841	947	25.4966	15.6257	103
Share of state-owned banks (%)	59.1087	14.7718	947	40.8748	4.9344	103
Share of foreign banks (%)	6.5776	6.6256	947	23.1767	3.7382	103
Ln (GDP)	14.2113	0.6217	947	13.7898	0.2685	103
GDP growth rate (%)	8.2291	4.1936	947	3.6474	2.1619	103
Net interest spread (%)	8.0800	10.5463	947	37.8086	3.5407	103
Bank size (ln assets)	9.0174	1.6575	947	9.6192	1.4936	103
Public	0.4699	0.4994	947	0.4757	0.5019	103
Equity/Assets (%)	8.2030	7.8374	947	9.5672	4.3968	103
NPL ratio (%)	5.7784	7.7614	947	9.8690	6.9079	103
Loan loss reserve/NPL (%)	153.16	188.17	947	73.23	16.58	103
Net loan/Total customer deposits (%)	122.7311	160.8952	947	110.9627	69.2841	103
Security/Total earnings assets (%)	26.1071	15.5938	947	51.1665	17.4320	103
Interbank borrowing (%)	25.0043	25.0475	947	50.0946	19.7020	103

Note: * - Values in million US dollars (2005 price level); ROAA – return (operation profit) on average assets; ROAE – return (operation profit) on average equity; NPL – non-performing loans; the calculation of GDP and private credit by deposit money banks/GDP) and the structure size (the ratio of two ratios: STOCK MARKET CAPITALIZATION / GDP and private credit by deposit money banks/GDP). The higher t *Bank Regulation and Supervision Database* of the World Bank) and is calculated as the percentage of the assets held by the five largest banks of the country as of the end of 2001 and 2005 respectively; "Sh 2005; "Share of foreign banks" is from Barth et al. (2003, 2008) and is calculated as percentage of the bank assets held by the banks 50% or more foreign owned as of year-end 2001 and 2005; GDP, GDP

TABLE 4. BANK EFFICIENCY SCORE (WEIGHTED AVERAGE, 2003-2009)

	China	Brazil	India	Russia
2003	0.8212	0.8750	0.8839	0.8994
2004	0.8029	0.8808	0.8611	0.8960
2005	0.8819	0.8840	0.8599	0.9221
2006	0.8849	0.8733	0.8555	0.9021
2007	0.9119	0.8699	0.8495	0.8855
2008	0.8956	0.7754	0.7896	0.6317
2009	0.9213	0.8551	0.8172	0.6850
Average (2003-09)	0.8743	0.8591	0.8452	0.8317

Note: The calculation of the bank efficiency score is based on the regression model (2) in Appendix Table 2 and the weighted average of the efficiency score is reported using banks' total assets as weight.
Source: SIEMS own calculation.

India			Russia			China		
Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
977.77	1753.57	198	826.17	1814.89	206	1576.09	4572.23	440
570.30	921.55	198	492.90	1304.19	206	1376.21	3886.59	440
407.47	936.53	198	333.27	713.79	206	199.88	802.80	440
1070.54	1679.74	198	442.03	976.61	206	789.60	2297.06	440
691.01	1301.26	198	638.52	1445.97	206	1029.61	2877.24	440
1.8528	0.6606	198	2.0166	0.4916	206	0.3997	0.2421	440
41.3259	1.8386	198	43.4311	0.4837	206	72.5078	1.9730	440
74.5195	0.6260	198	37.3932	1.4511	206	66.6091	0.7810	440
6.9986	0.2514	198	8.4845	0.2419	206	1.6098	0.3544	440
13.6765	0.1727	198	13.6302	0.1724	206	14.8228	0.2913	440
7.9836	1.5764	198	4.8015	5.5622	206	11.0168	1.7302	440
4.8847	0.6300	198	6.5088	1.0146	206	3.2943	0.1681	440
9.4371	1.0947	198	8.1768	1.4375	206	9.0813	1.8436	440
0.9798	0.1410	198	0.3447	0.4764	206	0.2977	0.4578	440
6.1797	1.9256	198	16.9141	11.8716	206	4.7158	3.2120	440
3.4814	2.8042	198	4.5795	7.5405	206	6.4157	9.0142	440
69.69	19.67	198	284.37	278.31	206	142.34	141.50	440
73.7887	30.1246	198	290.1516	280.9938	206	69.1268	15.6618	440
35.1036	6.8604	198	15.9914	13.3011	206	20.9284	9.5354	440
11.1260	11.8811	198	54.1719	25.8502	206	11.7203	8.7008	440

lculation of "importance of stock market" follows Beck (2010, *Financial Structure Dataset*, the World Bank) and is the average of the structure activity (the ratio of two ratios: stock market total value traded/ he higher the value of this variable, the more market-based the countries' financial system is (more reliance on capital market); "Banking market concentration" is obtained from Barth et al. (2003, 2008, ctively; "Share of state-owned banks" is from Barth et al. (2003, 2008) and is calculated as the percentage of the bank assets held by the banks 50% or more government owned as of year-end 2001 and DP, GDP growth rate and the net interest spread are all from the *International Financial Statistics of IMF* (2009).

IV. EMPIRICAL RESULTS: WHAT EXPLAINS BRIC BANKS' PERFORMANCE?

What explains the differences in efficiency among the BRIC banks? We conducted an analysis of inefficiency factors (see table 2 in the appendix for the main regression results) and noted several interesting observations: (1) The overall country factor (e.g., institutional development, economic development, etc.) for India and Russia indicates a significant negative impact on the bank efficiency level in the two countries. This may reflect the relatively poor institutional environment, small size of the overall economy (GDP), slower GDP growth rate, and lower importance of the banking sector in Russia's financial development. In India, a high share of state-owned banks in its banking sector and a low share of foreign-owned banks contribute to the bank efficiency level. (2) Brazil and China have an institutional and macroeconomic environment that is relatively conducive to the profit efficiency of its banking sector. Among the country factors, the higher ratio of foreign-owned banks, lower level of bank concentration, and relatively low share of state-owned banks contribute the most to the efficiency level of Brazilian banks. In addition, both the level and pace of economic development (GDP per capita and GDP growth rate) help to promote the efficiency level. China's banking sector benefits from the large domestic market and its rapid GDP growth. Stock market development has a negative impact on banking sector efficiency, probably because it competes with banks in financial intermediation. More than any other country, China benefits from the country's heavy reliance on its banking system in allocating financial resources. (3) The estimation results show that both the banking market concentration level and the share of state-owned banks have a statistically significant and negative impact on banks' efficiency level, while the net interest spread does not significantly affect bank efficiency.

Public listings, banks' capital level, and loan loss reserve ratio are found to have a significantly positive impact on banks' efficiency levels, while the NPL ratio and the degree of reliance on interbank borrowing have a negative effect on banks' efficiency levels. Interestingly, bank size has no statistically significant effect on bank efficiency levels in the BRIC countries. This could be because our sample consists largely of big banks in the BRIC countries.

> Brazil and China have an institutional and macroeconomic environment that is relatively conducive to the profit efficiency

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V.
FURTHER
DISCUSSION

To summarize, we find that the impact of the global financial crisis on the BRIC countries varies across the countries, with China being the least affected and Russia the most affected. Furthermore, BRIC banks increased in efficiency due to the rapid economic growth and the rising GDP per capita in these countries. Foreign-owned banks help to promote the overall performance of the banking sector. Finally, the relatively high level of bank capitalization and loan loss reserves helped the BRIC banks to improve their performance and cope with the global financial crisis.

Our research has important implications for the BRIC countries and for general EMs as well. In India, banking sector deregulation since the 1990s led to an increase in domestic private and foreign bank entry and improvements in the efficiency of government-owned banks. The Indian banking sector has also benefitted greatly from the acceleration in India's economic growth over the past eight years (averaging 8%). Nonetheless, the process of deregulation has moved forward slowly. One example is the government policy on foreign acquisition of domestic banks. The regulation does not allow foreign banks to own controlling stakes in domestic banks, which restricted the expansion of foreign banks in India. According to the dataset compiled by Barth et al. (2003–2008), the share of foreign banks in terms of bank asset holdings was only 8% in India. Despite the bank deregulation, the share of state-owned banks was 74.53%, the highest level among the BRIC countries. The slow progress of banking sector deregulation and the strong presence of state-owned banks resulted in significant difficulty in bank consolidation in India. To boost banking consolidation in the country, the Indian government recently indicated that it will allow new banks (including foreign banks) to enter the banking sector. This may be a positive step in pushing forward the stalled banking consolidation and reform process and may increase future bank efficiencies.

The process of deregulation and bank consolidation has moved forward slowly in India

Before the onset of the economic crisis, the Russian banking industry was one of the most efficient (by our yardstick) among the BRICs. This all changed during and following the financial crisis. The efficiency score of the Russian banking sector suffered the most among the BRIC countries during this period. The recovery of the Russian banking sector has been slow since 2009 despite decent GDP growth. On the positive side, Russian banks are generally well capitalized with sizable loan-loss provision buffers, so the medium-term prospects for the Russian banking sector is actually reasonably healthy. Moreover, the share of state-owned banks in Russia is low (37%), which is probably healthy over the long-run for the domestic banking sector. For the Russian commercial banks to meet the future challenges successfully, the country's macroeconomic and institu-

tional environment needs to be further improved. Our results indicate that the current macroeconomic and institutional environment in Russia poses a major hurdle to the efficiency level of the banking sector. Compared to the other BRIC countries, Russia has a relatively low ranking in its legal framework and bureaucracy.

Among the BRIC nations, Brazil probably has the most developed financial infrastructure to support a relatively efficient banking sector. It also has the highest level of openness in its banking market, as illustrated by the relatively large share of foreign banks in terms of bank assets holdings (23%). The efficiency score of the banking sector declined during the global financial crisis but recovered afterward. Average capital adequacy ratios are well above the regulatory requirements, and the majority of private sector banks returned to profitability in 2010. A strong economy has helped; Brazil had GDP growth of 7.5% in 2010. Nonetheless, the Brazilian banking sector needs to pay attention to the rapidly rising loan-to-deposit ratio (as a result of the fast credit expansion in the past decade) and heavy reliance on foreign funds and interbank borrowings. While a high loan-to-deposit ratio may enhance banks' profitability in the short run, it may create concerns for the banks' liquidity position and stability in the long run, especially since the interbank bank market and foreign funds can dry up quickly in times of internal and external shocks. Another concern is the current and potential nonperforming loans (NPLs) buildup in the Brazilian banking sector. The NPL ratio was already high (10.34% in 2009) in Brazil, compared to that of other BRIC countries. The rapid expansion of bank credit since the 2000s led to easy credit for consumers, and borrowing costs are now much lower than they were several years ago. The debt burdens of the borrowers have been building up, and delinquencies are now rising at a very fast pace. The consumer debt service burden, which stood at 24% of disposable income in 2010, is now expected to rise to 28% in 2011. This compares with a 15% rate for the "overburdened" U.S. consumer and a mid-single–digit reading for other emerging markets such as China and India (according to the *Financial Times*).

Our study indicates that the Chinese banks performed relatively well in terms of efficiency, and their average efficiency score rose steadily over an eight-year period, even during the world financial crisis. However, these results need to be interpreted with caution,

The recovery of the Russian banking sector has been slow since 2009 despite decent GDP growth, but the medium-term prospects for the Russian banking sector is actually reasonably healthy

The Brazilian banking sector needs to pay attention to the rapidly rising loan-to-deposit ratio (as a result of the fast credit expansion in the past decade) and heavy reliance on foreign funds and interbank borrowings

as the methodology used in this study cannot capture the impact of the banks' current operations on their future performance. Although an important goal of China's banking reform was to force the commercial banks to operate on business principles, the lending decisions of these banks are frequently influenced by government policies and subject to state intervention. During the eruption of the global financial crisis in 2008, the Chinese government took aggressive measures to stimulate the economy. To help the government achieve its policy goals, the major commercial banks implemented a very loose credit policy and flooded the credit market with more than RMB 10 trillion (about USD 1.6 trillion) in new loans. To date, there have been no formal reports on the credit risk associated with the massive, state-directed lending binge. However, it is likely that many of these loans are risky, as illustrated by the frequent news reports about troubled projects or impending defaults. As a result, the NPL ratio of Chinese banks, now officially listed as only 1.9% (as of July 2011), is expected to rise rapidly over the next several years, which will affect the level of profit efficiency of these banks.

> The NPL ratio of Chinese banks, now officially listed as only 1.9% (as of July 2011), is expected to rise rapidly over the next several years as a result of the very loose credit policy during 2007-2008

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APPENDIX

THE STOCHASTIC FRONTIER APPROACH TO ESTIMATE BANK EFFICIENCY

The main methodology to measure bank performance in this paper is based on a *stochastic frontier approach* which is commonly employed for bank efficiency analysis. Such an approach is especially appropriate in efficiency studies of emerging markets, in which problems related to measurement error and an uncertain economic environment are more likely to prevail (Fries and Taci, 2005). Following previous studies (e.g., Jiang et al., 2009; Wang and Schmidt, 2002), we adopt the estimation procedure proposed by Battese and Coelli (1995) and use a one-step maximum likelihood regression model. The output distance function[2] is defined as: $D_0(x, y) = \min\{\theta : (y/\theta) \in P(x)$. Following Lovell et al.(1994), $D_0(x, y)$ is non-decreasing, positively homogeneous and convex in the output vector y and non-increasing in the input vector x. If y falls inside the production possibility set $P(x)$, then $D_0(x, y)$ is less than one. If y falls on the boundary of the production possibility set, then $D_0(x, y)$ is equal to one. More specifically, for a firm producing m outputs using n inputs, an output distance function in a translog form is usually given by (e.g., Jiang et al., 2009):

$$\ln D_o(x^t, y^t, t) = \alpha_0 + \sum_{k=1}^{n} \alpha_k \ln x_k^t + \sum_{j=1}^{m} \beta_j \ln y_j^t + \frac{1}{2}\sum_{k=1}^{n}\sum_{h=1}^{n} \alpha_{kh} \ln x_k^t \ln x_h^t + \frac{1}{2}\sum_{j=1}^{m}\sum_{l=1}^{m} \beta_{jl} \ln y_j^t \ln y_l^t$$

$$+ \sum_{k=1}^{n}\sum_{j=1}^{m} \gamma_{kj} \ln x_k^t \ln y_j^t + \varphi_t t + \frac{1}{2}\varphi_{tt} t^2 + \sum_{k=1}^{n} \xi_{kt} \ln x_k^t t + \sum_{j=1}^{m} \tau_{jt} \ln y_j^t t,$$

where x is input, y is output (multiple inputs, multiple outputs) and t is time. As $D_o(x^t, y^t, t)$ is homogeneous of degree 1 in y, we obtain the following constraints:

$$\sum_{j=1}^{m} \tau_{jt} = 0 (j = 1, 2, ...M), \quad \beta_{jl} = \beta_{lj} \text{ and } \alpha_{kh} = \alpha_{hk}.$$

Under these constraints, we can derive the following equation for individual firm i:

$$\ln D_{oi}^t - \ln y_{mi}^t = \alpha_0 + \sum_{k=1}^{n} \alpha_k \ln x_{ki}^t + \sum_{j=1}^{m-1} \beta_j \ln(y_{ji}^t)^* + \frac{1}{2}\sum_{k=1}^{n}\sum_{h=1}^{n} \alpha_{kh} \ln x_{ki}^t \ln x_{hi}^t$$

$$+ \frac{1}{2}\sum_{j=1}^{m-1}\sum_{l=1}^{m-1} \beta_{jl} \ln(y_{ji}^t)^* \ln(y_{li}^t)^* + \sum_{k=1}^{n}\sum_{j=1}^{m-1} \gamma_{kj} \ln x_{ki}^t \ln(y_{ji}^t)^* + \varphi_t t_i + \frac{1}{2}\varphi_{t} t_i^2$$

$$+ \sum_{k=1}^{n} \xi_{kt} \ln x_{ki}^t t + \sum_{j=1}^{m-1} \tau_{jt} \ln(y_{ji}^t)^* t + v_i^t,$$

where $(y_{ji}^t)^* = y_{ji}^t / y_{mi}^t (j = 1, 2, ... m - 1)$. By definition, $\ln D_{oi}^t \leq 0$. We further

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[2] A major advantage of the distance function approach is that it can be applied in the case of multiple inputs, multiple outputs or absence of price information when the traditional dual approach is inapplicable (Jiang et al., 2009).

APPENDIX TABLE 1. DESCRIPTIONS OF INPUT AND OUTPUT FACTORS IN THE REGRESSION MODEL

	Profit Efficiency Model
Input factors	Total interest expenses, total non-interest expenses (= Total non-interest expenses (overheads)+ loan impairment charge, as reported in *Bankscope*)
Output factors	Operating Income (=Net Interest Income+Total Non-Interest Operating Income)

Note
1. Operating Income = Net Interest Income+Total Non-Interest Operating Income 2. Pre-Impairment Operating Profit = Operating Income - Total Non-Interest Expenses(overheads) 3. Operating Profit = Pre-Impairment Operating Profit - Loan Impairment Charge - (Securities and Other Credit Impairment Charges)
4. All values adjusted to 2005 price level (million US dollars).

define $u_i^t = -\ln D_{oi}^t$: i.e. $u_{i,}^t$ follows a non-negative truncated normal distribution. In addition, $v_i^t \sim N(0, \sigma_v^2)$: i.e., v_i^t follows a standard normal distribution. u_i^t and v_i^t are independent. This is the standard setting of a stochastic frontier model[3].

How to define and measure the inputs and outputs of a bank is an important issue in the bank efficiency research. The two basic methods are the production and the intermediation approach. We use the latter[4] in this study. The definitions of the input and output factors are presented in Appendix Table 1. The definitions of the input and output factors are presented in Appendix Table 1.

Following Battese and Coelli (1995), we further analyze the determinants of u_i^t. The inefficiencies (u_i^t) can be further decomposed as $u_i^t = z_i^t \delta + e_i^t$, where z_i^t denotes the exogenous factors that affect the technical inefficiency term, δ denotes the coefficients of these factors and e_i^t is a random variable, which is independently distributed as truncations of a normal distribution $N(0, \sigma_u^2)$ (here, $e_i^t \geq -z_i^t \delta$). This means that u_i^t is independently distributed as non-negative truncations of a normal distribution $N(\mu_i^t, \sigma_u^2)$, in which $\mu_i^t = z_i^t \delta$, indicating that μ_i^t , the expected value of u_i^t , is influenced by different factors with a constant variance.

Appendix Table 2 presents the estimation results using two different models. In regression model (1), we use country dummy variables to capture the country factor using China as the benchmark while seven country-level macroeconomic indicators are included in model (2). It is clear from Appendix Table 2 that the signs of the first-order coefficients are as ex-

[3] Simultaneous equation bias may exist when both inputs and outputs are included in the distance function as regressors. After the normalization procedure, output ratios may be treated as exogenous (Coelli and Perelman, 1996).
[4] Berger and Humphrey (1997) argue that under the production approach, financial institutions are thought of as primarily carrying out services for account holders. These institutions perform transactions and process documents for customers, including loan applications, credit reports, checks and other payment services, and insurance services. Under this approach, output is best measured by the number and type of transactions or documents processed over a given period. Unfortunately, such detailed transaction flow data are typically proprietary and not publically available. As a result, data on the stock of the number of deposit or loan accounts serviced or insurance policies outstanding are used instead. Also, only physical inputs such as physical capital, labor and their cost as well as operating expenses (excluding interest expenses) are used. In contrast, under the intermediation approach, financial institutions are thought of as primarily intermediating funds between savers and investors. Because service flow data are not usually available, the flows are typically assumed to be proportional to the financial value of the accounts, such as the dollar amount of loans, deposits or insurance policy premiums as well as the value of other earning assets. The input of funds and their interest costs should also be included in the analysis together with physical inputs. As service flows to depositors are proportional to the value of deposits, if we treat deposits as both input and output, then interest expenses are usually used as costs. In addition, the interest expense-to-deposit ratio is used as the price of the input and the value of deposits as the output.

APPENDIX TABLE 2. MAIN REGRESSION AND ANALYSIS OF INEFFICIENCY FACTORS

	Regression (1)		Regression (2)	
Main regression	Coefficient	t-value	Coefficient	t-value
Interest expenses	-0.3199	-7.19	-0.3228	-6.96
Non-interest expenses	-0.5259	-9.39	-0.5280	-9.66
Interest expenses square	-0.0308	-2.20	-0.0338	-2.30
Non-interest expenses square	-0.1005	-4.70	-0.1061	-5.39
Interest expenses × non-interest expenses	0.0551	3.54	0.0601	4.03
Time	-0.0473	-1.75	-0.0469	-1.78
Time × time	-0.0014	-0.23	0.0002	0.04
Interest expenses ×time	0.0106	1.38	0.0087	1.14
Non-interest expenses ×time	-0.0065	-0.72	-0.0057	-0.67
Constant	-0.9621	-8.95	-0.9475	-9.82
Inefficiency Analysis				
Brazil	-0.4904	-1.09	--	--
India	2.3010	10.39	--	--
Russia	1.3468	4.56	--	--
Importance of stock market	--	--	1.2296	10.79
Banking market concentration	--	--	3.7007	5.55
Share of state-owned banks	--	--	4.6829	4.39
Share of foreign banks	--	--	-3.2775	-2.70
Log (GDP)	--	--	-1.0089	-6.09
GDP growth rate	--	--	-9.4557	-3.02
Net interest spread	--	--	1.3269	0.72
Bank size (=log (assets))	0.0394	0.79	0.0090	0.18
Public listing or not	-1.9917	-13.38	-1.8036	-12.73
Equity/assets	-7.7909	-15.25	-6.7086	-15.04
NPL ratio	7.4852	9.86	7.1897	11.20
Loan loss reserves/NPL	-0.0028	-4.40	-0.0020	-3.82
Net loan/Total customer deposits	-0.0708	-1.19	-0.1158	-2.62
Security/Total earning assets	-0.5215	-1.20	-0.4536	-1.12
Reliance on interbank borrowing (=(Total funding- Customer Deposits)/ Total funding)	1.9550	2.61	2.7214	5.31
Constant	-5.1814	-10.73	4.3525	2.95
Sigma-squared	0.8341	18.19	0.8395	12.64
Gamma	0.9500	218.01	0.9501	161.10
Log likelihood	-110.48	-101.71		
LR test	863.47	881.00		
No. of observations	947	947		

Note: NPL – non-performing loans; the calculation of "importance of stock market" follows Beck (2010, *Financial Structure Dataset*, the World Bank) and is the average of the structure activity (the ratio of two ratios: stock market total value traded/GDP and private credit by deposit money banks/GDP) and the structure size (the ratio of two ratios: STOCK MARKET CAPITALIZATION / GDP and private credit by deposit money banks/GDP). The higher the value of this variable, the more market-based the countries' financial system is (more reliance on capital market); "Banking market concentration" is obtained from Barth et al. (2003, 2008, *Bank Regulation and Supervision Database* of the World Bank) and is calculated as the percentage of the assets held by the five largest banks of the country as of the end of 2001 and 2005 respectively; "Share of state-owned banks" is from Barth et al. (2003, 2008) and is calculated as the percentage of the bank assets held by the banks 50% or more government owned as of year-end 2001 and 2005; "Share of foreign banks" is from Barth et al. (2003, 2008) and is calculated as percentage of the bank assets held by the banks 50% or more foreign owned as of year-end 2001 and 2005; GDP, GDP growth rate and the net interest spread are all from the *International Financial Statistics* of IMF (2009).

pected, and that most are highly significant at the 1% level. Both regression models have a high γ value, indicating the high significance level (1% level) of the overall model fit. This is further confirmed by other model tests.

The lower panel of Appendix Table 2 reports the results of the analysis of inefficiency factors. The "dependent" variable is a measure of the inefficiency level of banks. Therefore, a positive coefficient in the regression shows that the factor is negatively associated with banks' efficiency level. In the regression model (1), we include country dummies to capture the differences in institutions, culture, etc. among the BRIC countries, using China as the benchmark. In the regression model (2), seven country-level variables are included to investigate their influences on the bank efficiency level in each country.

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