Efficiency and productivity of Chinese national and regional banks

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Efficiency and Productivity of Chinese National and Regional Banks

By

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A Doctoral Thesis. Submitted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy of Loughborough University.

Abstract

This thesis investigates the performance of Chinese commercial banks by evaluating their efficiency and productivity. Beginning with cost efficiency analysis of Chinese commercial banks over the time period 2002 to 2014. The thesis then analyses the efficiency and productivity of regional banks, specifically urban commercial banks. Based on geographical characteristics of regional banks, the spatial parameters are added in the production function in order to capture spatial spillovers. A new spatial total factor productivity index to measure productivity is introduced. The results indicate that the efficiency of Chinese commercial banks increased in the pre- and post-crisis period but dropped during the financial crisis. In addition, the results suggest that the joint-stock and regional banks are more efficient than other type of banks in China. Another notable result is the significant positive spatial relationship in the production process of the Chinese regional banks. Overall productivity has increased from 2013 to 2016, which is mainly improved by the return to scale changing.

Keywords, Chinese banking, Efficiency, Productivity, Regional Banking, Spatial Analysis, Stochastic Frontier Approach

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Chapter 1 - Introduction

1.1 Motivation

In 2015, China created $10.87 trillion GDP compared to $17.95 trillion GDP of the USA[1]. China is currently the second largest economy in the world. The economy of China has experienced a high growth rate over the past 40 years; GDP in 2014 was more than ten times larger compared to GDP in 1995. There have been boom developments in China's financial markets; the volume of financial markets has increased since 2005 and the Chinese financial markets contributed 7 per cent of overall GDP in 2014[2] (details in appendices). The Chinese financial system has evolved from a single bank into a diversified financial market with both banking and non-banking institutions.

The Chinese financial system had only one bank conducting financial business before 1978: the People's Bank of China. During 1978 to 1984, four state-owned banks were established, specialised to undertake banking business from the People's Bank of China; this made the People's Bank of China become the true central bank of China. Meanwhile, the first trust and investment companies and foreign bank representative offices were founded.

[1] Source from World Bank national account data http://databank.worldbank.org/data
[2] Source from National Bureau of Statistic of China http://data.stats.gov.cn/english

These initial reform actions indicated the opening of the financial markets in China. From 1985 to 1996, other types of banks were established: development banks were founded to take over policy-lending business from state-owned banks (providing financial services for state-owned enterprises under plan a of national economic development); new joint-stock commercial banks aimed to compete with state-owned banks; regional banking was also formed to provide financial services for local enterprises and individuals. Numerous non-banking financial institutions were founded, and capital markets became available to the public after the opening of the Shanghai Stock Exchange and Shenzhen Stock Exchange. The banking industry expanded its customer base and the financial market began providing a range of different financial services.

From 1997 to 2007, the developing banking industry revealed several problems. For example, state-owned commercial banks carried a high volume of non-performance loans inherited from the previous specialised and policy-lending businesses. Therefore, the State Council formed regulatory commissions for each financial industry to supervise the operations of financial institutions and asset management companies were founded to deal with non-performing loans. State-owned commercial banks also started to list on the stock exchange to increase capital and improve governance. The financial market diversified further with a gold market, money market, and foreign exchange market. After joining the World Trade Organization in 2001, the financial market became more welcoming to foreign participants. There were more foreign investors in the market and foreign banks started local businesses. A modern financial system was formed in China. After 2008 the banking and insurance industries started merging. The State Council also merged the Banking Regulatory Commission and Insurance Regulatory Commission together as a new department to supervise both industries. The regional banks (i.e., urban credit cooperatives) were all transformed into urban commercial banks. The new commercial banking format provided better profitability and risk management. Private banks also joined the financial market, with five private bank licences issued by Banking Regulatory Commission in 2014. With developing technology, more and more customers and retail stores accepted mobile payments and transactions. Online banking became a convenient and stylish way to bank in Chinese.

Regional banks are financial institutions that serve small- and medium-sized local enterprises and individuals. In China, the urban commercial bank is a type of regional bank; this industry has grown tremendously in the last two decades. The total assets of overall urban commercial banking have grown from 1,462 billion RMB to 22,680 billion RMB from 2003 to 2015, constituting 11.38 per cent of Chinese banking total assets in 2015, up from 5.29 per cent in 2013[3]. Now, as the third largest type of commercial bank in China, urban commercial bank is an essential part of the economy and a crucial research area.

[3] Source from Chinese Banking Regulatory Commission annual report 2006-2015 and detail display in Table 2.5.

Through the evolution of the Chinese financial system, the Chinese banking industry has change tremendously in last 40 years. The banking industry plays a vital role in the financial system and the whole economy. To observe Chinese banks efficiency, this thesis can investigate the significance of reform actions and learn lessons from the best practice. As the world's second largest economy, mainland China has 31 administrative regions and it covers 9.6 million square kilometres[4]. There is unbalanced economic development among these regions. Differing levels of regional economy require various financial services. As the third largest type of bank in china, urban commercial bank becomes more and more important to the Chinese banking industry. However, there is limited research on urban commercial banks' efficiency and productivity. Previous research measures the efficiency and productivity of urban commercial banks by traditional methods. Based on the geographical characteristics of urban commercial banks, traditional efficiency and productivity measurements might create biases in the result. Considering spatial parameters into the analysis can make the results more convincing and accurate. Therefore, this thesis first reviews Chinese commercial banks' cost efficiency and then analyses the efficiency and productivity of Chinese regional banks by estimating spatial production frontier.

[4] Source from website of the central government of China http://www.gov.cn/test/2005-05/25/content_17358.htm.

1.2 Contribution

To contribute to the current research, this thesis extends the efficiency analysis of both national and regional banking in China. It estimates the cost efficiency performance of majority Chinese commercial banks (158 banks) in the post-WTO[5] period (2002 to 2014) and examines the impact of major events on the efficiency of Chinese commercial banks. The results provide an insight to the costliest inputs and display the performance difference of ownership categories. This thesis also introduces a spatial analysis of the efficiency and productivity of Chinese regional banks (urban commercial banks). The analysis focuses on the post-market restructure period of urban commercial banks. This methodology can identify the spatial dependence and spillover among regional banks. The results confirm a positive spatial relationship between Chinese urban commercial banks and provide a more accurate way to estimate the efficiency and productivity of regional banking.

1.3 Outline

This thesis includes six chapters. Chapter 2 introduces details of the Chinese financial system and the development of Chinese urban commercial banks. Chapter 3 applies a cost efficiency analysis of majority commercial banks in

[5] World Trade Organization is the global organization dealing with the rules of trade between nations, China joined WTO in 2001.

China using a stochastic frontier approach. Although the literature on banking production and efficiency is well established (e.g., Bonin et al., 2005a, Boubakri et al., 2005 and Clarke et al., 2005), there is a lack of research on regional banking particularly on Chinese regional banks. Chapter 4 extends research on Chinese urban commercial bank by utilising spatial methodology. Building on the research in Chapter 4, Chapter 5 investigates the productivity of urban commercial banks. Chapter 6 concludes the thesis by synthesising the findings of previous chapters.

Chapter 2 - Evolution of the Chinese Financial System and Development of Urban Commercial Banks

2.1 Introduction

The Chinese financial system has evolved from a single banking system into a diversified financial system, including banking institutions, non-banking institutions, foreign exchange markets, money markets, gold markets, and capital markets. Based on China's economic open-up policy and several financial reforms, the Chinese financial system has developed significantly in last 40 years.

This chapter provides an overview of the Chinese financial system by identifying participants, evolution processes and the characteristics of each phase. Section 2.2 describes the four phases of financial system evolution. Section 2.3 provides background information of urban commercial banks. Section 2.4 is a conclusion.

2.2 Overview of the Chinese Financial System since 1978

Before 1978, there was only one bank in the Chinese banking industry: the People's Bank of China. It served as both a central bank and a commercial bank. In this mono-banking system, the People's Bank of China handled all types of financial transactions (Allen et al., 2007). The People's Bank of China belonged to the Ministry of Finance at this time. There has been a significant evolution of the Chinese financial system since the Chinese economic reform in 1978. The process of financial system evolution can be separated into four phases:

1) The first phase of initial financial reform 1978-1984;
2) The second phase of deepening and commercialisation 1985-1996;
3) The third phase of banking modernisation and expansion 1997-2007;
4) The last phase of the financial innovation 2008-present.

2.2.1 The Reform of the Financial System Restructuring (1978–1984)

During this reform period, the People's Bank of China (PBOC) was separated from the Ministry of Finance[6]. Three specialised state-owned banks were founded to take over part of the PBOC's commercial banking business at the

[6] Source from the Institute of Contemporary China Studies, http://www.hprc.org.cn/

end of 1979: the Agricultural Bank of China, the People's Construction Bank of China, and the Bank of China. The Agricultural Bank of China focused on rural banking businesses. The People's Construction Bank of China was set up for fixed-asset investment especially in large urban construction projects and changed its name to the China Construction Bank in 1996. The Bank of China mainly deal with foreign exchange business (Yang, 2002). In 1984, the Industrial and Commercial Bank of China was established to take over the rest of the commercial banking business from the PBOC (Allen et al., 2007).

These four specialised banks operated under the government's plan of national economic development, which provided services for state-owned enterprises in designated industries. These four state-owned banks (commonly known as the 'Big Four' banks) became oligopoly banking institutions with no competition across their specialised field. In this reform period, the 'Big Four' banks acted as government agents and provide financial services to state-owned enterprises regardless of their profitability (Jiang et al., 2009). Therefore, these banks accumulated a large number of non-performing loans. Addtionally, the 'Big Four' banks had to employ a certain number of the People's Liberation Army[7] members who had completed their tours of duty. This circumstance caused an over-employment problem in the 'Big Four' banks (Wang et al., 2014).

[7] People's Liberation Army is the name of the armed forces of China

After the ‘Big Four’ banks undertook all commercial and policy banking business from PBOC, the PBOC turned into the real central bank for China; it regulated and supervised all specialised banks, non-bank financial institutions, and insurance companies (Chen et al., 2005a). The central bank kept the name of PBOC, and its major goals were maintaining price stability, enforcing strict supervision of financial systems, conducting clearance and issuing bank notes (Jiang et al., 2009). The ‘Big Four’ banks and the PBOC constituted the two-tiered banking system in China.

The China International Trust and Investment Corporation—the first trust and investment company in China—was founded in 1979. As a growing market, the trust and investment companies worked as an investment channel for projects that state-owned banks could not fund traditionally including foreign investment. The trust and investment companies were formed by banks, state-owned enterprises, provinces government and state ministries, but with lack of supervision. The trust and investment companies were able to offer high interest rates and invested in diverse industries, such as imports, exports, property and equity markets (Chen et al., 2005a). In 1979, the Export-Import Bank of Japan set up the first foreign bank representative office in Beijing, but was a non-profit institution (Zou and Ouyang, 2008). In order to attract foreign and domestic investment, China set Special Economic Zones in several cities that had special economic policies and flexible governmental measures. Foreign banks had been allowed to open operational branches in selected

Special Economic Zones since 1982. However, the Chinese government was still conservative in allowing foreign banks to conduct financial services during this reform period (Berger et al., 2009).

2.2.2 Reforms of Institutional Restructuring, Deepening, and Banking Commercialisation (1985-1996)

The aim of the reform in this period was to transform the policy-oriented banking industry into a market-oriented banking industry (Jiang et al., 2009). After 1986, a batch of national and regional joint-stock commercial banks were established. Different from state-owned banks, their main goal was profit maximisation (Chang et al., 2012). In this way, the Chinese government attempted to change the oligopoly situation of the 'Big Four' banks. The Bank of Communication was founded as the first national state-owned joint-stock commercial bank in 1986 (Zou and Ouyang, 2008).

The government removed the restriction that specialised state-owned banks must only serve their respective designated industries; thus, all 'Big Four' banks could expand their scope of business to other industries (Chen et al., 2005a). The foreign banks' restriction was relaxed in 1994; 23 cities were opened to foreign banks. In addition, the Chinese government permitted first deposits and loans business with Chinese enterprises in RMB[8] in Shanghai Special Economic Zones in 1996 (Berger et al., 2009).

There were three development banks founded in 1994 to take over the policy-lending business from state-owned banks (Berger et al., 2009). These three development banks consisted of the China Development Bank, the Agricultural Development Bank of China, and the Export-Import Bank of China. The China Development Bank provided loans for larger national construction projects under the National Economic Development Plan of China. The goal of the Agricultural Development Bank of China was to provide financial service for agricultural policy. The Export-Import Bank of China deal with financial activities for national trade policy (Zou and Ouyang, 2008).

This banking restructure was intended to increase comprehensive competition of the commercial banking industry. However, those three development banks could not undertake all previously policy-lending business. Because of limitation of branch networks and low capital level. Therefore, the 'Big Four' banks had to continue their policy-lending business for a while until the development banks matured (Chen et al., 2005a).

[8] RMB is official currency of China, its full name being 'renminbi'.

The regulatory law of the banking industry also enacted from this reform period. The Central Bank Law was passed in 1995 and confirmed the legal basis of the People's Bank of China's autonomy to formulate policy and supervise the financial system. It also reduced the local government's power of credit allocation. In the same year, the Commercial Bank Law was enacted to transform state-owned banks from policy-oriented banks into market-oriented banks, thus encouraging state-owned banks to operate their business based on market principles (Berger et al., 2009). The Commercial Bank Law required commercial banks to separate security and trust business from banking services. In the meantime, the Law of Negotiable Instruments, Insurance Law, and General Monetary Rule were promulgated, providing a legal environment for non-banking financial institutions and money markets development (Zou and Ouyang, 2008).

In addition, many non-banking financial institutions (such as insurance companies, trust and investment companies, and credit cooperatives) were founded in this reform period. However, lack of regulation and supervision lead to defaults and closures of several trust and investment companies in the late 1990s. There were restrictions on trust and investment companies to operate as commercial banks, but with still less restriction and monitoring (Hong and Yan, 1997). Rural credit cooperatives[9] and urban credit cooperatives were founded to diversify the banking system and were mainly focused on small and

[9] Rural Credit Cooperatives were initially supervised by the Agriculture Bank of China instead of the central bank.

medium-sized enterprises and individuals (Chen et al., 2005a). In 1996, rural credit cooperatives and urban credit cooperatives started a regional merger and transformed into the rural commercial bank and urban commercial bank. In 1986, the State Council approved the People's Bank of China resuming the business of postal saving and remittance (Zou and Ouyang, 2008).

The Chinese capital market and money market also grew in this period. Two domestic stock exchange—the Shanghai Stock Exchange and Shenzhen Stock Exchange—were established in 1990 and growth was fast in the following decades. The Shanghai Stock Exchange focused on large enterprise stock trading and the Shenzhen Stock Exchange paid attention to small and medium enterprise stock trading[10]. Following capital market development, the first Chinese bankruptcy law was passed in 1986 (Allen et al., 2007). With respect to the money market, the Chinese Foreign Exchange Trade Centre was set up as a national inter-bank borrowing centre in 1994 in Shanghai. It provided foreign exchange trading business, inter-bank offering rate (SHIBOR[11]), and bond trading clearing business (Zou and Ouyang, 2008).

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[10] Shanghai and Shenzhen Stock Exchange webpage: http://www.sse.com.cn/, http://www.szse.cn/.
[11] Full name of SHIBOR is 'Shanghai Interbank Offered Rate'.

2.2.3 Banking Modernisation and Financial Market Expansion Reforms (1997-2007)

In order to deal with the problem of large non-performing loans of state-owned banks, the Ministry of Finance of China injected 270 billion RMB into state-owned banks by issuing long-term government bonds in 1998 (Jiang et al., 2009). There were four asset management companies[12] (state-owned) established to off-load non-performing loans from the 'Big Four' banks in 1999 (Zou Ouyang, 2008). These four companies bought 1.4 trillion RMB non-performing loans from the 'Big Four' banks' total loans at face value (Berger et al., 2009). However, the Chinese banking industry still had a series of problems such as poor profitability and weak risk management. The State Council injected another $45 billion into the Bank of China and China Construction Bank in 2003, and $15 billion into the Industrial and Commercial Bank of China in 2005 (Jiang et al., 2009). These activities were called the 'pilot state-owned bank-overhaul program' increasing capital instead of writing off non-performing loans (Berger et al., 2009).

The government improved its regulatory system by setting up specialised authorities. In 1998, the State Council combined all securities offices of the People's Bank of China (PBOC) to set up the Securities Regulatory Commission. It aimed to regulate and supervise all securities business. In the

[12] Their full names are Xinda, Dongfang, Changchen, and Huarong.

same year, the Insurance Regulatory Commission was founded to take over the insurance regulation from PBOC. Finally, the Banking Regulatory Commission—established in 2003—took over authority to supervise the banking industry from PBOC. The new external monitoring of banking asset quality was implemented and the central bank (PBOC) only focused on monetary policy (Zou and Ouyang, 2008). The Chinese government set up a professionalisation sub-sector regulatory system for financial markets.

There was fast expansion in the capital and money markets in this reform period. China joined the World Trade Organization in 2001. It attracted many investors—including overseas investors and institutions—to the Chinese financial market. The Securities Regulatory Commission issued the Qualified Foreign Institutional Investor program in 2002; the program selected global institution investors (based on their performance) to invest in the RMB denominated capital market. In order to meet market requirements, the Shanghai Gold Exchange was formed to provide a platform for national gold trading in 2002. China Financial Futures Exchange was founded in 2006 following by development of financial derivatives market in Shanghai. The money market has developed a range of businesses, such as inter-bank borrowing, paper markets, certificates of deposit, and revise repo services (Zou and Ouyang, 2008). Some Qualified Foreign Institutional Investors also entered the asset management industry and operated in joint ventures with Chinese companies in 2003 (Allen et al., 2007).

In the bond market, there was a total of 2,877 billion RMB of government bonds at the end of 2005. Policy bonds[13] reached 1,782 billion RMB in the same year. On the other hand, corporate bonds only took a small part of the market. The mutual funds were first established in 1998 and there were 268 open-end and 85 close-end funds at the end of 2006. The total net assets of all mutual funds were 8.6 trillion RMB by the same year (Allen et al., 2007).

There was high rate growth in the stock market until it met the peak in 2000. The market moved in another direction as a major correction and half of the market capitalisation was lost in the following five years. In this valley period, the Shenzhen Stock Exchange operated a Small and Medium Enterprise board market for high-tech industries in 2004[14], reducing the entry restrictions of the capital market for small and medium companies. By the end of 2006, most of capital market losses were recovered, reaching new heights in 2007 (Allen et al., 2007).

The banking industry was gradually opened to external competitors. The PBOC allowed eight foreign licensed banks to obtain local currency funding in 1998. In the follow year, foreign banks were permitted to conduct RMB business with Chinese enterprises (Berger et al., 2009). After 2006 all foreign banks were allowed to operate RMB business and were treated as equally with domestic

[13] This refers to bonds issued by development banks and operated under Ministry of Finance supervision.
[14] Source from Shenzhen Stock Exchange website, http://www.szse.cn.

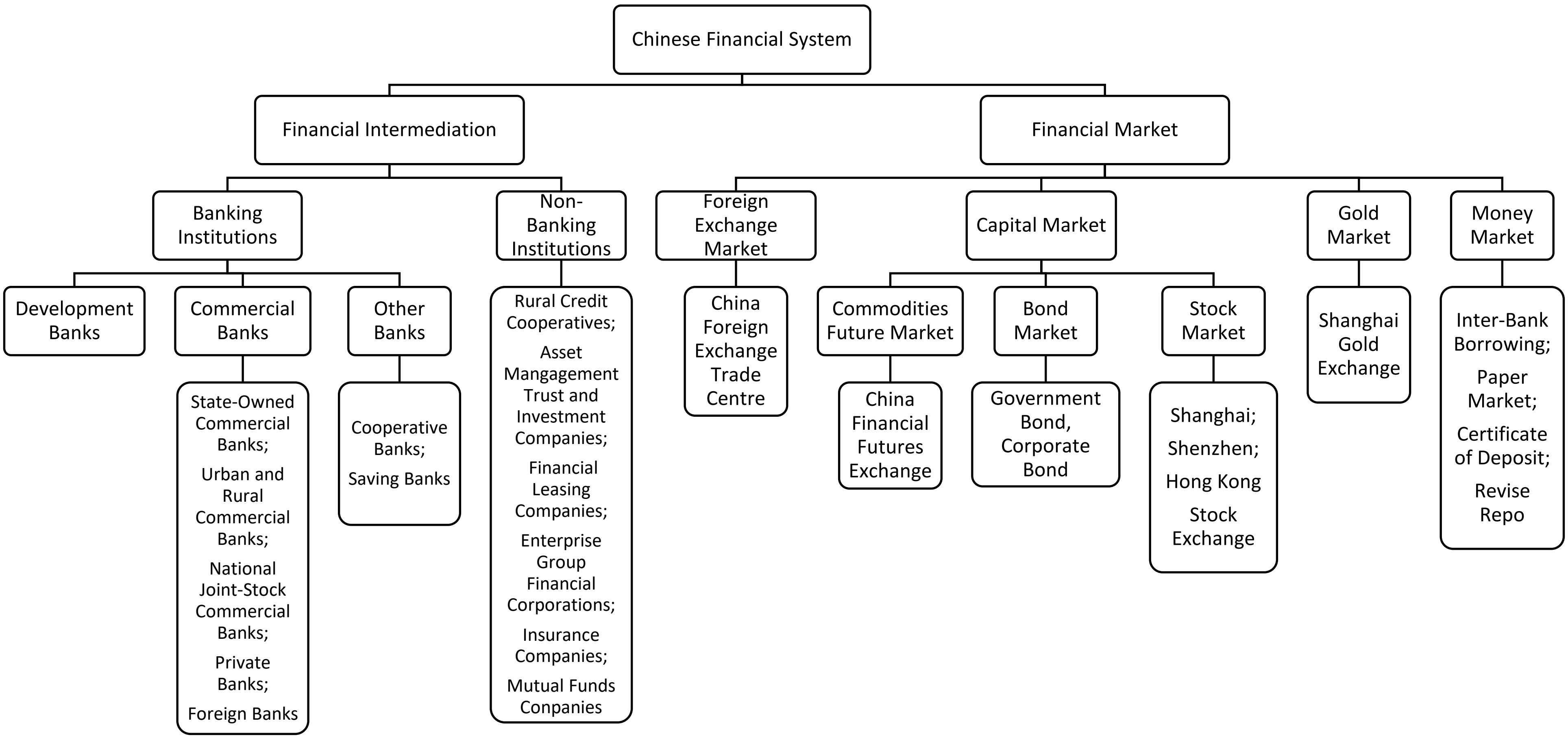
banks (Wang et al., 2014). The first six foreign banks were HSBC, Bank of East Asia, the Standard Chartered Bank, Citibank, Hang Seng Bank, and the DBS bank. After China joined the World Trade Organization, foreign investors were encouraged to buy equity share of Chinese domestic banks. All major international banks and large financial institutions had an interest in this market and invested in all types of domestic banks (Jiang et al., 2009); these improved the Chinese domestic banks' internal governance and capital size.

To compete with both foreign banks and other domestic banks, the 'Big Four' banks had to improve their management and competitiveness. The government provided a large number of foreign exchange reserves to state-owned banks to refuel their capital fund and ameliorate capital structure (Wang et al., 2014). The summary from the National Financial Work Conference indicated that the state-owned banks had to reform as a stock-listed commercial bank structures in order to achieve modern governance and external monitoring in 2002. Then, the China Construction Bank, Bank of China, and Industrial and Commercial Bank of China successively issued Initial Public Offering on the Hong Kong and Shanghai Stock Exchange from 2005 to 2007 (Bin, 2007). Banks started to provide more services for customers, such as customer credit services, payment options, and credit cards (Zou and Ouyang, 2008). The new commercialised structure supported the competition of state-owned banks in the new banking environment of China.

With the growth of the capital markets, banks started to get involved in capital markets. The China Construction Bank received a permit to operate derivatives business in 2004. In the following year, the Banking Regulatory Commission allowed banks to set up their own subsidiary mutual fund companies (Zou and Ouyang, 2008). All financial sectors started to integrate with one another. With the fast growth of post saving business, the Banking Regulatory Commission approved the establishment of the Postal Saving Bank of China in 2007 (Zou and Ouyang, 2008). In this reform period, there were liberalisation policies on interest rates and fewer restrictions on ownership takeovers and Merger and acquisitions in the banking industry. Banks received greater freedom and geographical scope of operation. The Central Bank Law and Commercial Bank Law were also revised to align with the World Trade Organization agreement (Berger et al., 2009).

At this point, the modern financial system of China had been founded. Figure 2.1 provides a full map of the current financial system of China. As the figure demonstrates, the current Chinese financial system contains financial intermediation and a financial market. The financial intermediation has banking and non-banking institutions; the banking institutions include development banks, commercial banks, and other type of banks. The financial market has foreign exchange market, capital market, gold market, and money market; there are future, bond, and stock products available on capital market.

Figure 2.1 Overview Map of the Chinese Financial System



Source: Banking Regulatory Commission and Securities Regulatory Commission webpage.
http://www.csrc.gov.cn/pub/newsite/, http://www.cbrc.gov.cn/index.html

2.2.4 The Innovation of Financial Industry (2008-present)

The PBOC applied a moderately monetary policy after 2009 and increased the reserve rate for commercial banks to guarantee payment ability and control default risk. In the post-crisis period[15], the PBOC readjusted monetary policy to make the financial system synchronise with the national economy. In 2010, PBOC increased the reserve rate six times (0.5 per cent each time); the reserve rate reached 18.5 per cent by the end of that year (Li and Wang, 2012). To control interest rate, PBOC suggested a benchmark interest rate for deposits and lending. The banks' deposit rate had to follow the benchmark rate; the lending rate could float between 10 per cent to 70 per cent of the benchmark rate until 2012. In 2013, the PBOC opened the lending rate for market adjustments and the deposit rate was able to float based on the benchmark deposit rate (Li and Wang, 2015). The interest rate has gradually opened to market. With the first RMB bond issued in the Hong Kong's financial market in 2007, the RMB has been accelerating in internationalisation, with increasing international trading in RMB as currency (Zou and Ouyang, 2008). In December 2015, the International Monetary Fund was determined to add RMB into the Special Drawing Rights basket; RMB officially joined the basket in 2016[16].

[15] 'Post-crisis' refers to the period after the 2008 global financial crisis.
[16] International Monetary Fund webpage, http://www.imf.org/external/index.htm.

The insurance industry has rapidly expanded after 2010. The Insurance Regulatory Commission published 13 new policies that increased insurance businesses' range and made the insurance industry open to all other industries (Li and Wang, 2012). Following this, the banking and insurance industries began to overlap and merge. Many banks became involved in insurance business. For example, the Bank of China purchased a full share of Bank of China Insurance in 2009[17]. Furthermore, some insurance companies sought to invest in the banking industry. Ping An Insurance bought a16.76 per cent share of Shenzhen Development Bank in 2009. Shenzhen Development Bank then acquired Ping An Bank (a subsidiary bank of Ping An insurance) and changed its own name to Ping An Bank in 2012[18]. Banking and insurance businesses began mixed operations. Following this tendency, the government upgraded the regulation and supervision agencies for both industries. In 2018, the State Council merged the Bank Regulatory Commission and Insurance Regulatory Commission into a new department: the China Banking and Insurance Regulatory Commission[19].

China joined the Basel Committee on Banking Supervision in 2009, which meant that Chinese banking regulation policy must be kept abreast with the international standard. The Agriculture Bank of China was finally listed in both the Hong Kong and Shanghai Stock Exchange markets in 2010. Then, all the 'Big Four' banks finished their re-structural reforms and became state-owned joint-stock

[17] Information from Bank of China Insurance website, http://www.bankofchina.com/bocins.
[18] Information from Ping An Bank website, http://bank.pingan.com/index.shtml.
[19] Source from China Banking and Insurance regulatory Commission, http://www.cbrc.gov.cn/chinese/newIndex.html.

commercial banks (Li and Wang, 2012). The Urban Credit Cooperatives and Rural Credit Cooperatives were restructured and merged as urban commercial banks and rural commercial banks. As commercial banks, they could be regulated by the Banking Regulatory Commission, which improved operation monitoring and reduced risk. According to the Banking Regulatory Commission annual report, there was a total of 133 urban commercial banks and 655 rural commercial banks providing financial services for local medium and small enterprises and individuals in 2014. Based on loans and total assets, urban commercial banks and rural commercial banks were the third and fourth largest type of commercial bank in China. To increase internal governance and external monitoring, the structure of the Postal Saving Bank of China reformed from limited liability to joint stock in 2012. The Banking Regulatory Commission approved five private bank licences in 2014; one of the private banks—named MY bank—as already established and had started operating for business.

The major structure of the current Chinese banking industry includes five state-owned banks, three development banks, one post saving bank, 12 national joint-stock banks, five private banks, hundreds of urban commercial banks and rural commercial banks, and 41 foreign institutions. Table 2.1 shows details of Chinese banking institutions' loans from 2011 to 2014. The state-owned commercial banks produce more than half the loans on the market. However, the percentage of state-owned commercial banks is decreasing, which means their growth rate is smaller than other types of bank. The joint-stock commercial banks and development banks produce similar sizes of loan. The percentage of joint-stock commercial banks is increasing; the percentage of development banks is decreasing.

Urban and rural commercial banks have seen the biggest expansion of their business. The percentage of urban and rural commercial banks loans to whole market has increased from 7 per cent to 10 per cent. Foreign banks and other financial institutions produced nearly the same amount loans from 2011 to 2014. Table 2.2 summarises the total assets of Chinese banking institutions from 2011 to 2014. Similarly to loans, state-owned commercial banks have the biggest total assets, but their market share has decreased from 60 per cent to 51 per cent. Urban and rural commercial banks have seen the highest growth rate, followed by joint-stock commercial banks.

The total assets of other types of banks are slightly growing. Figure 2.2 describes the movement of total assets of the Chinese banking industry. As Figure 2.2 shows, the gap of urban and rural commercial banks between 2012 to 2013 and gap of joint-stock commercial banks between 2011 to 2012 are wider than gap of state-owned commercial banks between 2011 to 2014. Those two years were a time of major expansion for urban and rural commercial banks and joint-stock commercial banks. Overall, the Chinese banking industry is in an expansional state.

Table 2.1: Loans of Chinese Banking Institutions from 2011 to 2014 in USD (billion)

Type of bank	Loans bil. USD 2011	Percentage	Loans bil.USD 2012	Percentage	Loans bil. USD 2013	Percentage	Loans bil USD 2014	Percentage
State-owned commercial banks	4448.03	57%	5029.93	53%	5830.18	51%	6435.89	51%
Joint-stock commercial banks	1139.65	15%	1742.70	18%	1926.64	17%	2191.40	17%
Development banks	1293.22	17%	1516.40	16%	1770.45	16%	1987.69	16%
Foreign banks	118.22	2%	128.25	1%	147.66	1%	155.96	1%
Urban & Rural commercial banks	516.05	7%	778.86	8%	1211.50	11%	1296.45	10%
Other financial institutions	293.70	4%	358.71	4%	447.11	4%	456.62	4%
Total	7808.86	100%	9554.85	100%	11333.54	100%	12524.01	100%

Source: Bankscope.

'bil.' = billion

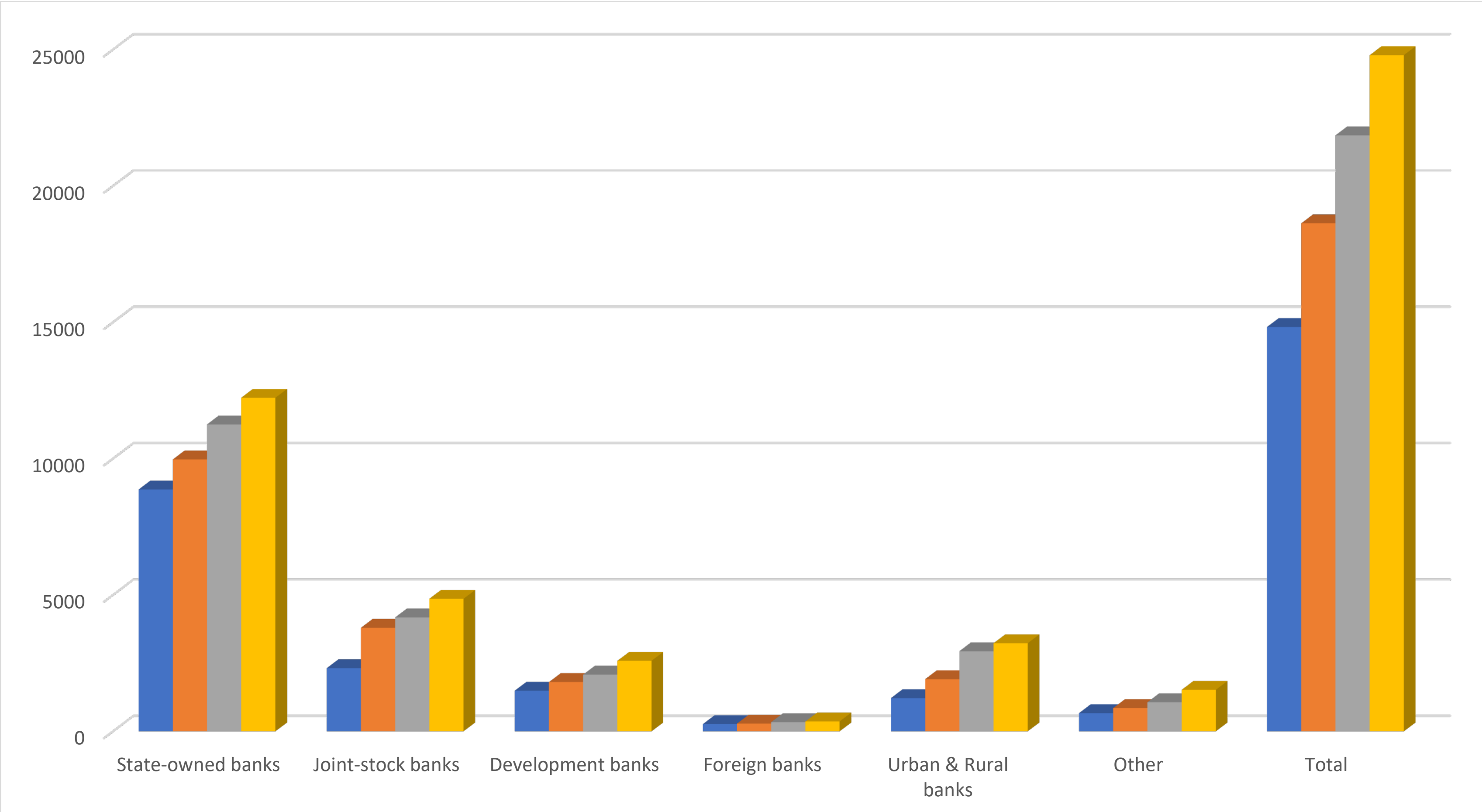
Table 2.2: Total Assets of Chinese Banking Institutions from 2011 to 2014 in USD (billion)

Type of bank	Total Assets bil. USD 2011	Percentage	Total Assets bil. USD 2012	Percentage	Total Assets bil. USD 2013	Percentage	Total Assets bil. USD 2014	Percentage
State-owned commercial banks	8868.14	60%	9970.96	54%	11254.31	51%	12232.05	49%
Joint-stock commercial banks	2315.62	16%	3796.97	20%	4175.49	19%	4859.34	20%
Development banks	1492.49	10%	1808.00	10%	2080.29	10%	2586.42	10%
Foreign banks	265.23	2%	286.40	2%	338.64	2%	363.85	1%
Urban & Rural commercial banks	1219.09	8%	1913.31	10%	2938.33	13%	3231.29	13%
Other financial institutions	669.34	5%	854.88	5%	1067.94	5%	1521.26	6%
Total	14829.90	100%	18630.52	100%	21855.00	100%	24794.22	100%

Source: Bankscope

'bil.' = billion

Figure 2.2: Comparison of Banking Sectors Total Assets From 2011 to 2014 in billion USD



Source: Bankscope

In 2009, a growth enterprise board was created on the Shenzhen Stock Exchange, called ChiNext; it was an over-the-counter market for innovation and fast-growing enterprises[20]. It provided a platform for high-tech companies to raise funds and encourage independent innovation. The Securities Regulatory Commission reported that the traders on the mainland and Hong Kong can invest in these two stock exchange markets[21]. This attracted more foreign investments into Chinese capital markets, which improved the capital market open level, investment liberalisation, and RMB internationalization. After unreasonable upward growth in 2008, the stock market fell back and was in downturn for the following five years. In 2014, the stock market recovered quickly (especially in small and medium enterprise boards) to reach new heights—the best in seven years—until the middle of 2015. In June 2015, the market fell back and decreased around 30% of the highest market[22].

The capital market—especially the stock market in China—shows an unbalanced fast growth; this might lead to a bubble growth, which would imply financial crisis. To deal with this, the Securities Regulatory Commission introduced a circuit breaker system in 2016, which would stop market trading for a 15-minute break if the market index increases or decreases 5 per cent on the same day. After the break, the stock market would close if the market index

[20] Shenzhen Stock Exchange webpage, http://chinext.szse.cn.
[21] Shanghai Stock Exchange webpage, http://www.sse.com.cn/aboutus.
[22] People's Daily webpage, http://www.people.com.cn.

continued to increase or decrease to 7 per cent[23]. The first trading day after the circuit breaker was introduced, the whole stock market went down—triggering a break—and then the whole market continued to decrease. The market closed earlier than regular trading time. On the fourth trading day, the stock market went down 5 per cent only 10 minutes after the market opened. After the first break of the day, the stock market crashed and closed in another 5 minutes[24] (the market opens for four hours on a regular trading day). Thus, all stock and future exchanges paused because of the circuit breaker system on the fifth trading day.

After 2012, the securities companies reached a new phase: beside traditional stockbroker business, they could now operate in new business such as wealth management and investment consultancy (Li and Wang, 2015). With this range of business, Chinese securities companies have expanded at high speed. Regarding the derivative market, asset-backed securitisations are available in Chinese financial market.

Also, there are many shadow banks (non-banking financial institutions that provide similar business to banks) and microcredit companies appearing during this period of the Chinese financial market. In 2012, there were 5,172 microcredit and middle-sized financial companies in Chinese financial market.

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[23] Shanghai Stock Exchange webpage, http://www.csrc.gov.cn.
[24] Details from People's Daily webpage, http://www.people.com.cn.

The balance of loans for these companies reached 470 billion RMB [25]. However, many of them went bankrupt and defaulted on customers' assets because of the lack of regulation. This highlights that the regulation system also needs to keep up with the fast development of the financial markets. The government introduced the Pilot Free Trade Zone,[26] which allowed for financial ideas and innovations to be operated in area that accelerated financial market internationalisation and liberalisation.

As an innovation of financial service, internet finance has gained popularity in China. It started with a product called Yu E Bao in 2013, which was an easy access service provided by Alipay. It consisted of a platform for purchasing currency fund that offered less complex purchase processes than traditional mutual fund trading platforms. Customers could make investment decisions from their smartphone or laptop. Alipay is a third-party electronic payment system. Alipay is founded in 2003 to reduce online shopping default risk. At first it only worked for its online shopping mall called Taobao. After that, it developed more services such as paying utility bills, purchasing mutual funds and insurance, credit payment and domestic and international money transfer[27]. In 2014, another mobile payment system called WeChat Pay was launched[28]. Based on convenience and obviating cash or bank card, most people use Alipay and WeChat Pay. These two payment solutions became part of the

[25] Hexun News, http://bank.hexun.com/2012-07-10/143389278.html.
[26] Area that to be used as testing economic and social reforms.
[27] Alipay website, https://www.alipay.com.
[28] WeChat Pay website, https://pay.weixin.qq.com/guide/index.shtml.

common lifestyle of modern China. The parent company of Alipay (Alibaba Group) combined mobile banking and mobile payments to set up the first private bank (MY Bank[29]) in China.

Tables 2.3 and 2.4 provide the main events of the Chinese financial system evolution. As the tables show, the first phase established four state-owned banks to set the People's Bank of China as a truly central bank. On the second phase, national and regional joint-stock commercial banks were founded to compete with state-owned banks. The stock market was available for public trading. The restructure of state-owned commercial banks happened on third phase; more diversified financial products were available on the financial market. With technology changing in the fourth phase, private banks were approved in China; the restriction of interest rate was gradually removed and there was a trend of mixed financial operations in the financial market. By reviewing the four major phases of financial reforms of China, the general process of how the Chinese financial system evolved from a single bank system into a modern financial system has been stated.

[29] MY Bank website, https://www.mybank.cn.

Table 2.3: Summary of Chinese Financial System Evolution

Period	Mission	Major Evens
1978-1984	Initial Financial Reform	• *'Big Four' banks established as state-owned specialised banks* • *People's Bank of China became a truly central bank* • *First trust and investment company established in 1979* • *First foreign bank representative office founded in 1979*
1985-1996	Deepening restructure and banking commercialisation	• *National and regional joint-stock commercial banks established* • *Three development banks established for government policy-lending in 1994* • *Central Bank Law and Commercial Bank Law passed in 1995* • *Rural and Urban Credit Cooperatives formed* • *Shanghai Stock Exchange and Shenzhen Stock Exchange established in 1990*

Notes: explanation of 'Big Four' banks is in section 2.1.1 and RMB is official currency of China, whose full name is renminbi

Table 2.4: Summary of Chinese Financial System Evolution (continued)

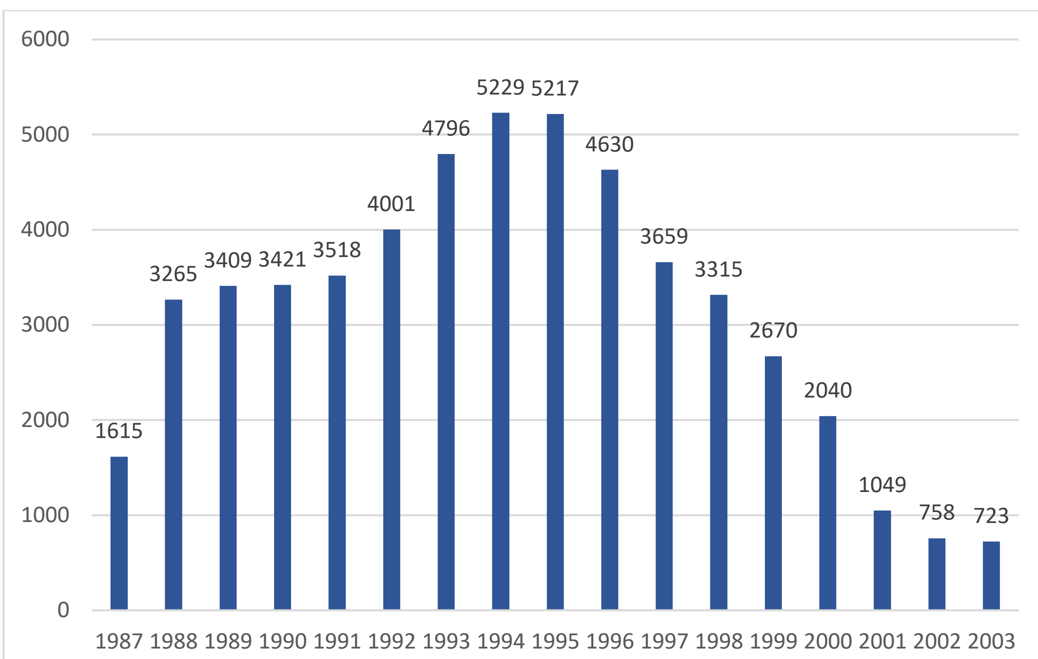
Period	Mission	Major Evens
1997-2007	Modernisation and expansion	• *Four state-owned asset management companies established to deal non-performing loans problem of state-owned banks* • *The first mutual funds formed in 1998* • *Securities Regulatory Commission, Insurance Regulatory Commission and Banking Regulatory Commission founded in 1998, 1998, and 2003* • *China joins in World Trade Organisation in 2001* • *'Big Four' banks listed on Hong Kong and Shanghai Stock Exchanges*
After 2008	Financial innovation and internationalisation	• *Growth Enterprise Board was created in the Shenzhen Stock Exchange which was called ChiNext.* • People's Bank of China *opened the loan rate to market adjustment in 2013* • *Shanghai-Hong Kong Stock Connect opened in 2014* • *Banking Regulatory Commission approved five private banks to start forming in 2014* • *RMB join in Special Drawing Rights in October 2016*

2.3 Background of Chinese Urban Commercial Banks

Chinese urban commercial banks were transformed from urban credit cooperatives, which were established following the Chinese economic opening-up policy of 1979. With fast growth of the national economy, urban credit cooperatives aimed to provide financial services to local small- and medium-sized companies and individuals. Due to inadequate regulation and restriction, urban credit cooperatives expanded rapidly. Figure 2.3 shows the number of urban credit cooperatives from 1987 to 2003. The number of urban credit cooperatives doubled from 1987 to 1988. Later from 1991 to 1995, there were 1,699 more urban credit cooperatives founded in these four years. Finally, the number of urban credit cooperatives reduced from 5217 to 723 from 1995 to 2003.

The first urban credit cooperative was founded in 1979 and by 1986 there were nearly 1,300 urban credit cooperatives in China. In 1986, the State Council issued provisional banking regulation rules to supervise urban credit cooperative business; the central bank issued provisional urban credit cooperative regulation rules to define the business area and property of urban credit cooperatives, as well as the standard to establish a credit cooperative. However, two years later—in 1988—the number of urban credit cooperatives rocketed to 3,265 with high-risk operating and a lack of self-monitoring. Most of the urban credit cooperatives contained a high volume of non-performing loans at that time. The central bank noticed the problem and agreed to increase the registered capital from 0.1 million to 0.5 million RMB (Men, 2011). The number of urban credit cooperatives remained stable at 3,518 in 1991. However, there was rapid growth of the economy in the following years and the GDP of China rose from 2,201 to 6,134 billion RMB during the period from 1991 to 1995. As a result, the number of urban credit cooperatives increased to 5,217 in 1995. Figure 2.4 provides the GDP of China from 1986 to 1995. In 1986, the GDP of China was 103.76 billion RMB. The GDP increased to 613.40 billion RMB by the end of 1995, which is nearly six times the GDP in 1986.

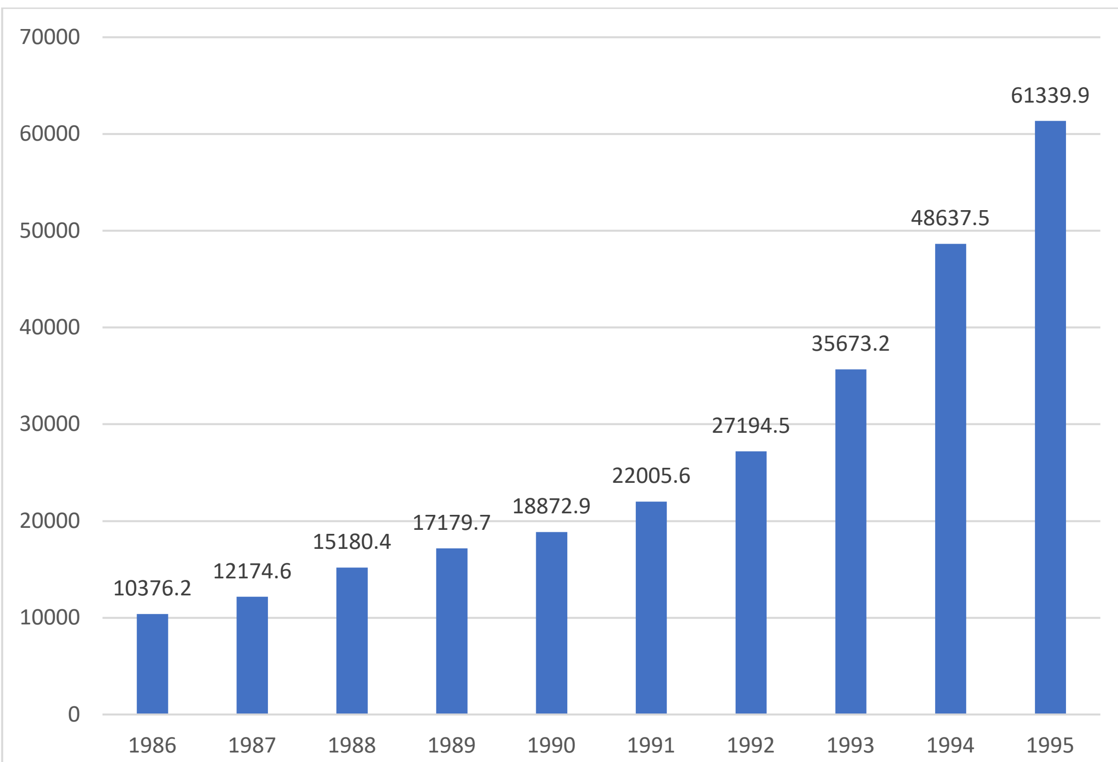
Figure 2.3 Number of Urban Credit Cooperatives in China from 1987 to 2003



Source: 1987 - 2003 Almanac of China's Finance and Banking

Despite their rapid growth, the urban credit cooperatives faced a large number of non-performing loans and payment crises due to the lack of supervision and an undeveloped financial system. To overcome those risks, the central bank stopped issuing licences to establish new urban credit cooperatives. The State Council merged urban credit cooperatives with rural credit cooperatives and other local financial institutions to establish the earliest urban cooperative bank in 1995. After that, all urban credit cooperatives were restructured into urban cooperative banks, and the central bank changed the name of urban cooperative banks to urban commercial banks in 1998 (Li, 2009).

Figure 2.4 Chinese National GDP from 1986 to 1995 (10 million RMB)



Source: National Bureau of Statistics of China

By undertaking business from credit cooperatives, the urban commercial banks were still designed to provide service to small- and medium-sized local enterprises and individuals. The new format gave these institutions unified standards, new governance and strong regulation. However, urban commercial banks were founded in the capital city of each provincial or prefecture level city, and could only operate within their administrative regions (Sun et al., 2013). After 2003, the China Banking Regulatory Commission undertook the duty of banking regulations and supervision from the central bank, and encouraged the urban commercial banks to explore cross-regionally. In 2005, the Bank of Shanghai and Bank of Beijing established branches in other provinces (Li, 2009). However, some urban commercial banks were too small to overcome the risk of non-performing loans and transform from urban credit cooperatives into urban commercial banks. Therefore, those banks within the same province merged as a new bank; for example, ten urban commercial banks in Jiangsu province were combined as the Bank of Jiangsu in 2006 (Li, 2009).

To improve self-management and governance, urban commercial banks attempted to attract foreign investors. The first case was the International Finance Corporation, which purchased 5 per cent in stock rights of the Bank of Shanghai in 1998 (Xie and Zhu, 2009). After that, many overseas investments flowed into Chinese urban commercial banks. The foreign investors required the urban commercial banks to change their governance to comply with international standard, which improved the banks' management. With expansion, urban commercial banks started to list in the stock market in order to raise capital. The Bank of Beijing, Bank of Nanjing, and Bank of Ningbo first issued IPO (Initial Public Offering) on the Shanghai Stock Exchange in 2007 (Xie and Zhu, 2009). By 2007, all urban commercial banks had disclosed their annual reports to public. All financial reports used new accounting standards based on requirement of Banking Regulatory Commission[30]. Going public attracted more private capital to join the urban commercial banks. In 2010, private capital accounted for 42.59 per cent of urban commercial banks' total capital and increased to 57.42 per cent in 2014[31]. Furthermore, two urban commercial banks set up representative offices overseas in 2010 (Bank of Beijing and Fudian Bank[32]).

By 2012, all the urban credit cooperatives had transformed into urban commercial banks. By the end of 2015, there were 133 urban commercial banks in the Chinese banking industry. Table 2.5 provides details of the total assets of urban commercial banks from 2003 to 2015. The total assets of urban commercial banks increased from 1,462 billion RMB to 22,680 billion RMB from 2003 to 2015. In the meantime, the total assets of urban commercial banks accounted for 11.38 per cent of the entire market, which has increased from 5.29 per cent. Urban commercial banks are currently the third largest commercial banks in China, and have become a vital part of the Chinese

[30] From China Banking Regulatory Commission annual report 2007.
[31] China Banking Regulatory Commission annual report 2010-2014.
[32] Information from China Banking Regulatory Commission annual report 2010.

banking industry. In response, the Banking Regulatory Commission pays more attention to urban commercial banks, and set up a monitoring department called the Urban Commercial Bank Supervision Department in 2015.

According to the administrative divisions of China, there are four direct-control municipalities, twenty-two provinces, and five autonomous regions in mainland China[33]. They are same level administrative areas. Each province or autonomous region has one capital city. Tables 2.6 and 2.7 provides details of the GDP, population, and number of urban commercial banks for each region. Most urban commercial banks set up headquarters in those capital cities and four direct-control municipalities. However, due to the different degrees of regional development, some provinces have more than 10 city commercial banks and some provinces only have two. For example, Shandong province (an eastern region) has an advanced economy compared to other western regions. In 2015, 98.5 million people live in Shandong province; it produced 6,300 billion GDP and had fourteen urban commercial banks in operation. In contrast, Qinghai (a western region) had only a population of 5.9 million and created 242 billion GDP in 2015. Qinghai province only has one urban commercial bank.

[33] Reference from Chinese government website http://www.gov.cn/test/2005-06/15/content_18253.htm.

Table 2.5 Total Assets of Urban Commercial Banks from 2003 to 2015

Years/Percentage	Urban commercial bank (in billion RMB)	Total banking industry (in billion RMB)
2003	1,462	27,658
%	5.29%	100%
2004	1,706	31,599
%	5.40%	100%
2005	2,037	37,470
%	5.44%	100%
2006	2,594	43,950
%	5.90%	100%
2007	3,341	53,116
%	6.29%	100%
2008	4,132	63,152
%	6.54%	100%
2009	5,680	79,515
%	7.14%	100%
2010	7,853	95,305
%	8.24%	100%
2011	9,985	113,287
%	8.81%	100%
2012	12,347	133,622
%	9.24%	100%
2013	15,178	151,355
%	10.03%	100%
2014	18,084	172,336
%	10.49%	100%
2015	22,680	199,345
%	11.38%	100%

Source: Chinese Banking Regulatory Commission annual report 2006-2015

The nature of how fundamental and widespread urban commercial banks have become to the Chinese banking system as a whole makes further research in this area worthwhile; investigation into their performance and comparison of their efficiency across regions is crucial.

2.4 Conclusion

The current financial system of China contains diversified markets and both banking and non-banking institutions. The banking industry has transformed from a single banking industry into an industry with multiple types of banks (commercial banks, development banks, saving banks, and cooperative banks). Commercial banks also grew up with multiple types of banks, including state-owned, joint-stock, regional, foreign and private commercial banks. The leading commercial banks (state-owned commercial banks) also accept foreign and private capital. It is interesting to observe the performance of those banks during the evolution process. The urban commercial bank is a type of regional bank which has a geographic characteristic; it has grown into the third largest commercial bank type in China. Therefore, it is worthwhile to investigate their efficiency, productivity, and spatial relationship.

Table 2.6 GDP, Population, and Number of Urban Commercial Banks for Different Regions in 2015

Region	GDP in billion RMB	Population in million	Number of UCB
Beijing	2,301	21.7	1
Tianjin	1,654	15.5	1
Hebei	2,981	74.3	11
Shanxi	1,277	36.6	6
Inner Mongolia	1,783	25.1	4
Liaoning	2,867	43.8	15
Jilin	1,406	27.5	1
Heilongjiang	1,508	38.1	2
Shanghai	2,512	24.2	1
Jiangsu	7,012	79.8	4
Zhejiang	4,289	55.4	14
Anhui	2,201	61.4	1
Fujian	2,598	38.4	4
Jiangxi	1,672	45.7	4
Shandong	6,300	98.5	14

Table 2.7 GDP, Population, and Number of Urban Commercial Banks for Different Regions in 2015 (continued)

Region	GDP in billion RMB	Population in million	Number of UCB
Henan	3,700	94.8	5
Hubei	2,955	58.5	2
Hunan	2,890	67.8	2
Guangdong	7,281	108.5	5
Guangxi	1,680	48.0	3
Hainan	370	9.1	1
Chongqing	1,572	30.2	2
Sichuan	3,005	82.0	12
Guizhou	1,050	35.3	2
Yunnan	1,362	47.4	3
Tibet	103	3.2	1
Shaanxi	1,802	37.9	2
Gansu	679	26.0	2
Qinghai	242	5.9	1
Ningxia	291	6.7	2
Xinjiang	932	23.6	5

Source: National Bureau of Statistics of China and Banking Regulatory Commission annual report 2014

Notice: UCB is an urban commercial bank

Chapter 3 - Analysis of Chinese Commercial Banks Cost Efficiency: Comparison of Different Ownership (2002-2014)

3.1 Introduction

3.1.1 Motivation and Research Question

As a crucial part of the Chinese financial system, the banking industry has evolved from a monopolised group of specialised banks into an industry with multiple types of bank, including a state-owned commercial banks, joint-stock commercial banks, regional banks, saving banks, development banks, private banks, cooperative bank and foreign banks. Until 2015, there were 4,262 banking institutions in China, with a total of 380 million employees[34]. Most previous studies of Chinese banking efficiency have focused on big banks such as state-owned commercial banks or joint-stock commercial banks (Chen et al., 2005a; Kumbhakar and Wang, 2007; Fu and Heffernan, 2007; Jiang et al., 2009). With the fast expansion of Chinese regional banks, it is also important to observe the performance of regional banks. China joined World Trade Organization in 2001, and Chinese banking industry underwent a global

[34] Source from Chinese Banking Regulatory Commission annual report 2015.

financial crisis and interest rate liberalisation. It is interesting to investigate how these events have impacted on Chinese banks' efficiency. There are two research questions in this chapter: 1) How efficient is the performance of Chinese commercial banks? 2) How has their performance changed in last 20 years?

3.1.2 Results and Outline

In order to observe the performance of Chinese banking under the tremendous evolution, this chapter reviews the cost efficiency of the majority of commercial banks in China from 2002 to 2014. The analysis covers 158 commercial banks, including state-owned, joint-stock, urban, rural and foreign banks. This chapter applies a cost function to deal with three prices of input, three outputs, and one quasi-fixed input. The analysis builds a cost frontier that includes time-varying and time-invariant models. There are also two standard panel-data models (fixed-effect and random-effect) for robustness. The results suggest that joint-stock, urban, and rural commercial banks have a similar—and high efficiency—performance; the foreign commercial banks rank after them; and the state-owned commercial banks have the lowest efficiency performance. The average efficiency result increases during the pre-financial crisis period (2002-2006) and decreases from 2006 to 2008. In the post-financial crisis period (after 2008), the average efficiency scores gradually rise.

This chapter consists of five sections. Section 3.2 provides a literature review of banking efficiency. Section 3.3 describes the data and methodology applied in this chapter. Section 3.4 provides the results of Chinese banking efficiency performance. The last section presents the conclusion.

3.2 Literature Review on Banking Efficiency

The definition of banking efficiency is how successful banks are in allocating their resources (inputs) to produce products (outputs) in order to achieve their target goals (Kumbhakar and Lovell, 2003). Frontier analysis and benchmarking is a method to evaluate the performance (efficiency) of a bank by comparing the inputs (banks use to process) and outputs (produce of bank). There are different measurements of efficiency such as minimisation of inputs or maximisation of profits.

Generally, the efficiency can be measured by two perspectives: technical efficiency and allocative efficiency (Kumbhakar and Lovell, 2003). Technical efficiency refers to the receipt of the maximum outputs by certain inputs (maximisation of production) or the minimisation of inputs through the given outputs (avoiding waste). From another perspective, allocative efficiency indicates the optimal circumstance of inputs and outputs under a fixed product price. Furthermore, banks might aim to minimise the costs at the certain outputs, maximise the revenue at the given inputs, or maximise profit by allocating the inputs and outputs. In these scenarios, the banks try to reach economic efficiency (cost, revenue, profit). The two major economic efficiency concepts are cost and profit efficiency (Berger and Humphrey, 1997).

The following content includes three sections. Section 3.2.1 provides the information about the literature working on the theory of factors impacting banking efficiency. Section 3.2.2 displays the empirical research on Chinese banking efficiency. Section 3.2.3 summarises previous literature on banking efficiency.

3.2.1 Factors Impacting Banking Efficiency

In previous studies, the major theoretical basis investigated two broad types of factors that impact on bank efficiency: internal and external factors. Internal factors refer to the elements of the bank itself, such as bank ownership, size, and productivity. The external factors focus on the environment factors, for instance, macroeconomic policy, technology growth and geographical distance. The following sub-sections introduce research on the effect of internal and external factors on banking efficiency.

3.2.1.1 Internal Factors

There are three major elements when considering internal factors: ownership, productivity, and bank size. As Lensink et al. (2008) state, to compare the efficiency between foreign and domestic banks, it is important to look at the quality of institutions in both the home and host countries. The research finds that if the governance distance of an institution's host and home countries becomes smaller, the foreign banks are more efficient than domestic banks. In developing countries, the foreign banks are generally more efficient than domestic banks. Private banks are more efficient than state-owned banks (Lensink et al., 2008). Altunbas et al. (2001) report that private owned banks are more efficient than mutual and public sector banks in the German banking industry, even though all sizes of public and mutual banks have slight cost and profit advantages over private commercial banks. According to Bonin et al. (2005a), banks with majority foreign ownership but without a strategic foreign owner are more efficient than domestic private banks. They provide measurement of costs and profit efficiencies in transition countries. In general, previous studies discovered that private commercial banks are normally more efficient than state-owned banks and foreign banks are more efficient than domestic banks.

Productivity is also an important element in bank performance. Koutsomanoli-Filippaki et al. (2009) test the productivity of Central and Eastern European countries. It documents that there was initially a decline in productivity for most Central and Eastern European countries, but an increase after 2000 due to the European Union accession. It confirms the completion of banking reforms in most countries. On the contrary, Casu et al. (2004) find productivity growth in the Italian and Spanish banking industry during the 1990s. For size to effect bank efficiency, Altunbas et al. (2000) investigate the scale economy and efficiency of Japanese banking, and their results suggest that the largest banks could be more efficient by decreasing outputs to reduce cost rather than improving X-efficiency. The definition of X-efficiency is that ratio of minimum cost of best-practice banks from a sample with same exogenous variable to actual cost (Berger and Mester, 1997). Altunbas et al. (2000) observe the cost characteristic of Japanese banks; they find that the optimal bank size is quite small by considering the risk and quality factors of the bank and that the level of financial capital has a strong impact on the scale efficiency.

3.2.1.2 External Factors

The economy and technology are frequently discussed in previous works when considering external factors. For example, the Kazakh's banks increased a huge number of bad loans during the world financial crisis and had a serious influence on the banks' cost, input distance and revenue frontiers (Glass et al, 2014b). Drake et al. (2006) state that the Hong Kong banking system had indeed been affected by macroeconomics, but has had varying degrees on different sizes of banks and different institutional sectors. Also, Kenjegalieva et al. (2009) investigate the macroeconomic environment influence on the efficiency of transition banks with a bootstrapped regression approach. The results state that the level of inefficiency of banks has been steadily increasing during the European Union negotiation period. Specifically in the earlier stages of the European Union negotiation period, the macroeconomic factors have had a significant effect on banking inefficiency in transition countries. Tabak et al. (2013) notice that local environment and constraints also affect the performance of banks. They prove that geographical distance has the effect of technical efficiency by estimating a geographically-weighted cost function.

Technology has had a big impact on the banking industry, such as in the introduction of online and mobile banking. It has changed the role of bank branches from a transaction-based to a sale-oriented role (Portela and Thanassoulis, 2007). Portela and Thanassoulis (2007) state that efficiency measurement of banks' branches is vital for banks, because banks' branches have become service and profit organisations. In order to measure banks' branches efficiency accurately, Eskelinen and Kousmanen (2013) develop a new approach called the intertemporal sales efficiency model. The contributions of the approach include explicit modelling of changing operational conditions and random noise. Bank efficiency has also benefited from productivity growth, a contribution of changing technology (Casu et al., 2004).

3.2.2 Empirical Efficiency Research on Chinese Banking

The banking industry in China has undergone a huge transformation since the Economy Opening-up policy of 1978. There are both internal and external factors that have changed the business activities of Chinese banking. With the development of the Chinese banking industry, overall efficiency has increased (Barros et al., 2011). The main events of the banking reform period—such as the privatisation of state-owned banks and joining the World Trade Organization (WTO)—have had a significant impact on banking performance.

Most of the previous research analyses how internal factors influence efficiency performance. There are mixed conclusions about the efficiency performance of Chinese banks and some literature provides contradictory results. The performance of banks with different ownership is different. Joint-stock commercial banks show a better performance in profitability than state-owned commercial banks (Jiang et al., 2009). Kumbhakar and Wang (2007) and Fu and Heffernan (2007) find similar results that joint-stock commercial banks are more efficient than state-owned banks. Opposingly, Chen et al. (2005a) conclude that the large state-owned banks and smaller banks are more efficient than medium joint-stock banks during the period 1993-2000.

Since joining the WTO, more foreign investors are involved within the Chinese financial market. Berger et al. (2009) compare the efficiency of foreign and domestic banks, and foreign banks were found to be the most efficient. The results indicate that Chinese banks can improve efficiency by acquiring foreign ownership. Jiang et al. (2009) support the view that foreign acquisition can contribute towards the efficiency of Chinese domestic banks in the long-term. Chinese domestic banks were also found to gain efficiency via privatisation (initial public offering), but this only had a short-term effect.

There are some other studies from different perspectives. For instance, from a productivity aspect, banks reach higher efficiency with the growth of productivity (Chang et al., 2012). Tan and Floros (2013) state that risk (loan-loss provision as a fraction of total loans) and technical efficiency have a positive relationship. There is a negative relationship between risk and level of capitalisation in the Chinese banking industry during the post-WTO period (2003 - 2009). On the other hand, Barros et al. (2011) indicate that when external effect factors are considered, overall banking efficiency improved after China entered the WTO. The economic environment and policies also affect banking performance. For example, the financial deregulation of 1995 improved cost efficiency both in the technical and allocative efficiency of Chinese banking (Chen et al., 2005a).

3.2.3 Conclusion

Despite increasing interest in the research of Chinese banking, most existing research concentrate on American and European banking. These researchers identify ownership, bank size, and the economy's effects on banks' efficiency. Other papers examine productivity and technology in relation to banking industry. Most of the literature on Chinese banking focuses on big banks and comparing the efficiency between different ownerships. The rising of regional banks has not been properly discussed in previous studies. Furthermore, most of these papers have researched periods before the 2008 global financial crisis. These researchers find the efficiency of banks improves upon participating in the WTO. The development of the Chinese banking industry involves many significant recent events, such as interest rate liberalisation, bank privatisation, and the development of derivative products. These highlight that investigation into banking performance needs to be timely and of interest to a wider audience, including academics, customers, policy makers, and industry stakeholders. There are tables summarising the literature of efficiency analysis in appendices. This chapter will measure the performance of the majority of Chinese commercial banks and cover the period of the 2008 global financial crisis and interest rate liberalisation.

3.3 Data and Methodology

3.3.1 Sample of Variables and Concept of Cost Efficiency

This study analyses data from 158 Chinese commercial banks from 2002 to 2014. Due to data availability, this is the longest research period I can reach. It is an unbalanced panel data sample collected from Bankscope, which was held by Bureau Van Dijk. It provides a wide range of data of banking financial statements covering 32,000 banks across the world[35]. The analysis uses the consolidated data for given banks if available; otherwise, the analysis uses unconsolidated data. The advantage of consolidated data is that it requires consistent accounting functions for a parent company and subsidiaries. Among total 158 commercial banks, there are five state-owned commercial banks, 12 national joint-stock commercial banks, 83 urban commercial banks, 25 rural commercial banks, and 33 solely foreign banks.

For input and output determination, this study uses an intermediation approach. Under this approach, banks are treated as financial intermediaries, meaning the mediator of funds (Sealey and Lindley, 1977). There are other input and output determination approaches—such as a profit approach, in which inputs and outputs are determined by its contribution to profit. There is also a

[35] Source from Bankscope webpage http://www.bvdinfo.com/en-gb/our-products/company-information/international-products/bankscope.

production approach, which treats banks as producers and in which all financial products (deposits, safekeeping, and cheque clearing) are outputs. The advantage of an intermediation approach is that it is more suited for frontier efficiency analysis. Therefore, for the selection of variables, this analysis has three input prices: price of labour (personal expenses/number of employees), price of capital (other operating expenses/ fixed assets) and price of deposits (interest expenses/deposits). For the quasi-fixed input, equity has been applied. There are three outputs: loans, other earning assets and other operating income. I applied two modifications on the data to make the sample fit this analysis. First, there are some negative data on other operating expenses and equity, and some data equal to zero on interest expenses and personal expenses. Therefore, those four variables have been shifted up with same unit to give them all a positive value. Second, there are limited data on personal expenses in the first nine years of the sample period. I use the last four years' personal expenses as a reference to calculate the annual personal expenses growth rate, then discount back using that growth rate to find the first nine years' personal expenses data.

Cost efficiency is a type of economic efficiency; it refers to the banks' attainable minimised cost at certain outputs or maximised outputs for given cost. As Kumbhakar and Lovell (2003) state, there are five main differences between cost and technical efficiency. First, the cost efficiency requires the input price, total cost and output quantities information. However, the technical efficiency only needs information of how banks used inputs and produced outputs. Second, the cost frontier can deal banks that have multiple outputs, while production frontier assumes banks only have one output. Third, all inputs are viewed as equal in an output-oriented stochastic production frontier. In a stochastic cost frontier, inputs and quasi-fixed inputs are contained under different situations. The fourth difference is that the cost efficiency requires the behavioural objective of banks, but technical efficiency does not need behavioural assumptions. Finally, the cost efficiency can be decomposed, but the technical efficiency cannot be decomposed.

Measurement of cost efficiency can be simply written as a cost function, as in Equation 3.1

$$CE(y,x,w)=\frac{c(y,w)}{C}=\frac{c(y,w)}{w^t x} \qquad (3.1)$$

In this function, the vector $\mathrm{y}=(y_1,\ldots.,y_m)\in R_+^m$ is the output of bank production and $\mathrm{x}=(x_1,\ldots.,x_n)\in R_+^n$ is the vector of input. The vector $\mathrm{w}=(w_1,\ldots.,w_n)\in R_+^n$ is the price of input. The $\mathrm{c(y,w)}$ refers to the cost frontier which means the best performing bank can be achieved. The item $w^t x$ indicates the actual cost of the observed bank, which we abbreviate as C. The level of cost efficiency is measured by the distance between the observed banks' actual cost and the best-practice cost frontier. The function of cost efficiency must satisfy following four properties:

1) $0 < CE(\mathrm{y,x,w}) \leq 1$, with $\mathrm{CE(y,x,w)} = 1 \Leftrightarrow \mathrm{x} = \mathrm{x(y,x)}$ so that $w^t x = c(y,w)$.
2) $\mathrm{CE(y,\lambda x,w)} = \lambda^{-1}\mathrm{CE(y,x,w)}$ for $\lambda > 0$.
3) $\mathrm{CE(\lambda y,x,w)} \geq \mathrm{CE(y,x,w)}$ for $\lambda \geq 1$.
4) $\mathrm{CE(y,x,\lambda w)} = \mathrm{CE(y,x,w)}$ for $\lambda > 0$

Therefore, the level of cost efficiency is limited between 0 and 1. The homogeneous degree of inputs is 1 and homogeneous degree of prices of input is 0, implying that if doubling of all inputs will double cost and halve cost efficiency; and if doubling of all prices of input, there will be no effect on cost efficiency. There is no decrease in outputs and the level of cost efficiency depends on prices of input change.

This analysis estimates cost efficiency for major commercial banks in the Chinese banking industry. In order to investigate the impact of the ownership on their performance, the banks are categorized into state-owned, joint-stock, urban, rural, and foreign commercial banks. All banks in the sample can be classified into these five categories. This analysis adds ownership as dummy variables into the models to observe the effect on efficiency. To interpret the cost order coefficients as elasticities to the sample mean, a mean-adjusted approach is used to update all of the data in the sample. The statistical summary of all variables is provided in Table 3.1. For the specification of models' estimation, there are three prices of input: w1, w2, and w3 which are the price of deposits, price of labour and price of capital, respectively. There are three outputs: y1, y2, and y3 which are total loans, other earning assets and other operating income, respectively. The quasi-fixed input (equity) has been denoted as z and total costs has been denoted as tc. As Table 3.1 displays, there are 899 observation units of each variable. The huge difference in size between Chinese commercial banks can be found in the table. For instance, the biggest commercial bank produces 1.8 billion USD loans and the smallest commercial bank only has 16,387 loans. At the same time, standard deviations for total cost, total loan, other earning assets, other operating income, and equity are unpredictably high. Equity, interest expenses, staff expenses, and other operating expenses have negative or zero value in the dataset. These four variables are shifted up to positive value in order to run the analysis. For this reason, the minimum values of price of deposit, price of labour, price of capital, and equity are very small.

Table 3.1 Summary Statistics of Variables (in USD)

Variable	Obs	Mean	Std. Dev.	Min	Max
Total cost (tc)	899	2,782,513	8,491,273	11,871	78,000,000
Price of Deposit (w1)	899	0.0175	0.0152	0.0002	0.3231
Price of Labour (w2)	899	0.1416	0.4494	0.0003	4.8318
Price of Capital (w3)	899	1.7148	3.3243	0.1265	55.3333
Total Loan (y1)	899	60,800,000	198,000,000	16,387	1,800,000,000
Other Earning Assets (y2)	899	50,100,000	153,000,000	5,400	1,300,000,000
Other Operating Income (y3)	899	44,44,488	2,595,435	3,717,139	26,600,000
Equity (z)	899	107,000,000	25,500,000	1	351,000,000

3.3.2 Cost Function

To estimate the cost efficiency level of observed banks, this chapter applies the cost function of a Stochastic Frontier Approach. Unlike production function, the cost function allows the model to deal with multiple outputs. Many Chinese commercial banks are listed in the stock market (state-owned banks, joint-stock banks, and several urban commercial banks). With these banks' size and range of product, the main goal of those banks is no longer expansion of their business; their major task is controlling costs. Therefore, the cost function is more appropriate in this analysis. The Stochastic Frontier Approach is a parametric frontier approach and its advantage is dealing with random errors when compared to a nonparametric frontier approach (Berger and Humphrey, 1997). The Stochastic Frontier Approach is presented by Aigner et al. (1977) and Meeusen et al. (1977). With the purpose of dealing with the statistical noise, they add a symmetric error term into the deterministic frontier. For a panel dataset, this analysis assumes that there are data available for bank i at time t. Equation 3.1 of cost efficiency can be reformulated as:

$$\mathrm{CE}_{it} = \frac{c(y_{it}, w_{it}; \beta) \cdot \exp\{v_{it}\}}{C_{it}} \qquad (3.2)$$

where $\mathrm{C}_{it} = w_{it}^{t} x_{it}$ indicates the bank total cost and now $\left[c(y_{it}, w_{it}; \beta) \cdot \exp\{v_{it}\}\right]$ becomes the stochastic cost frontier. Which $c(y_{it}, w_{it}; \beta)$ is the deterministic component for all banks and $\exp\{v_{it}\}$ is a specific random component of effect for any random shocks to each bank. The β represents a vector of technology parameter to be estimated. The vector y and vector w are still banks' produced outputs and prices of inputs. The equation follow properties as $\mathrm{CE}_{it} \le 1$, which $\mathrm{CE}_{it} = 1$ if, and only if, $\mathrm{C}_{it} = c(y_{it}, w_{it}; \beta) \cdot \exp\{v_{it}\}$ otherwise $\mathrm{CE}_{it} < 1$. This equation states that the cost efficiency of banks is the ratio of minimum cost achievable in an environment characterised by $\exp\{v_{it}\}$ to observed banks' cost.

Taking the cost frontier into log-linear Cobb-Douglas functional form, the single equation of stochastic cost function for a panel data set can be expressed as:

$$\ln C_{it} = \beta_0 + \beta_y \ln y_{it} + \sum_n \beta_n \ln w_{nit} + v_{it} + \mu_{it} \qquad (3.3)$$

where $\ln$ means logarithm of each vector. The error term $\varepsilon_{\mathrm{it}} = v_{it} + \mu_{it}$ is asymmetric, which v_{it} is part of the two-sided random statistical noise and u_{it} is the part of nonnegative cost inefficiency. It is positively skewed, since $\mu_{it} \geq 0$. The sum of technology parameter β_{n} should equal to one, which $\sum_{\mathrm{n}} \beta_n = 1$ in order to make sure that homogeneity of degree is +1 for the cost frontier in prices of input. By combining Equations 3.2 and 3.3, the estimation of cost efficiency becomes as follows:

$$\mathrm{CE}_{\mathrm{it}} = \exp\{-\mu_{it}\} \qquad (3.4)$$

In this chapter, there is more than one output to be analysed. To deal with the interaction of multiple outputs and prices of inputs, this chapter measures the Chinese banks' efficiency level by translog (transcendental logarithmic) form of cost function, as in the following equation:

$$
\begin{aligned}
\ln\left(\frac{C}{w_1}\right)_{it} &= \beta_0 + \sum_m \beta_m \ln \mathrm{y}_{mit} + \sum_{n+1} \alpha_{n+1} \ln\left(\frac{w_{n+1}}{w_1}\right)_{it} + \beta_z \ln z_{it} \\
&+ \frac{1}{2}\sum_m \sum_j \beta_{mj} \ln y_{mit} \ln y_{jit} + \frac{1}{2}\sum_{n+1}\sum_{k+1} \alpha_{n+1k+1}\left(\frac{w_{n+1}}{w_1}\right)_{it}\left(\frac{w_{k+1}}{w_1}\right)_{it} \\
&+ \frac{1}{2}\beta_{zz}(\ln z_{it})^2 + \sum_{n+1}\sum_m \alpha_{n+1m}\left(\frac{w_{n+1}}{w_1}\right)_{it} \ln y_{mit} + \sum_{n+1}\gamma_{n+1m}\left(\frac{w_{n+1}}{w_1}\right)_{it} \ln z_{it} \\
&+ \sum_m \beta_{mz} \ln y_{mit} \ln z_{it} + od_t + \nu_{it} + \mu_{it}
\end{aligned}
\qquad (3.5)
$$

The translog cost function presented by Christensen et al. (1973). Comparing to the Cobb-Douglas functional form, translog cost function can deal with multiple outputs without violating curvature conditions. Furthermore, the flexible form of translog cost function can allow input-orientation or output orientation technical inefficiency to interact with regressors. In Equation 3.5, C represents the total cost for bank i at time t. Beside a bank's produced outputs vector y_{it} and prices of inputs vector w_{it}, this equation also adds a quasi-fixed input vector z, which is the fixed input in short-term, but is variable in the long-term. The od_t represents ownership dummies in time period t. The item m indexes the three outputs and n refers to the three prices of input variables. The $\mu_{\mathrm{it}} \geq 0$ reflects the bank's cost inefficiency level and $\nu_{\mathrm{it}} \sim \mathrm{N}(0, \sigma_\nu^2)$ describes the effects of statistical noise. As mentioned before, the homogeneous of degree in price of input should be +1 in cost function. Therefore, the total cost and prices of input are divided by one of the prices of input w_1 in order to impose the requirement of this model. In this equation, I also add ownership dummies to observe the effect of ownership on the efficiency of banks.

To estimate banking efficiency scores under different ownership and dynamics of a sample period, this chapter applies two different stochastic frontier models: time-invariant and time-varying model. In order to support the test results, I also run two additional panel data models: fixed-effect model and random-effect model.

3.3.3 Time-Invariant Model

This model was first presented by Pitt et al. (1981). It provides efficiency analysis of panel data and assumes that cost of technology has been. So, Equation 3.3 can be rewritten as:

$$\ln C_{it} = \beta_0 + \beta_y \ln y_{it} + \sum_n \beta_n \ln w_{nit} + v_{it} + u_i \qquad (3.6)$$

where v_{it} is random noise term, $u_i \geq 0$ still represents cost inefficiency but only contains the producer effect, which has no time effect. In another words, this model has no allowance on cost technology changing during the research period. The parameters can be estimated by a Maximum Likelihood method but need additional distribution of two assumptions on error components:

(1) $v_{it} \sim N^{+}(0, \sigma_{v}^{2}).$

(2) $u_i \sim \mathrm{N}^{+}(0, \sigma^2) or \mathrm{N}^{+}(\mu, \sigma^2)$

3.3.4 Time-Varying Model

Based on an assumption of no technology changing, a time-invariant model is more suitable for short period efficiency analysis. However, for a long-term data sample—specifically in a fast-developing and highly competitive environment and industry—time effect on efficiency level is very important. This chapter applies a time-varying model to capture time effect. The time-varying model can separate the inefficiency term into time and produce effect components $\mathrm{u}_{\text{it}} = \beta_i \bullet u_t$. Therefore, the Equation 3.3 can be modified as:

$$\ln C_{it} = \beta_0 + \beta_y \ln y_{it} + \sum_n \beta_n \ln w_{nit} + v_{it} + \beta_i \bullet u_t \qquad (3.7)$$

With independence and distribution assumption on error terms, the time-varying parameters can be also estimated with the Maximum Likelihood method.

3.3.5 Fixed-effect Model

To support and check the previous two model results, we run two more panel data models. A fixed-effect model has the same assumption as the time-invariant model, in which the cost technology does not change over time. But a fixed-effect model assumes that the inefficiency term u_i is fixed and can be correlated with repressors or with random noise v_{it}. As u_i is fixed, it can be estimated as producer- specific intercept parameters. The Equation 3.3 can be re-demonstrated as:

$$\ln C_{it} = \beta_{0i} + \beta_y \ln y_{it} + \sum_n \beta_n \ln w_{nit} + v_{it} \qquad (3.8)$$

where $\beta_{oi} = (\beta_0 + u_i)$. The advantage of a fixed-effect model is that it has no requirement on error terms distribution assumption in comparison to the time-invariant and time-varying models. The parameters can be estimated by an Ordinary Least Squares method.

3.3.6 Random-effect Model

In comparison to the fixed-effect model on fixed term u_i, if one assumes that u_i becomes random and uncorrelated with the regressors and the noise v_{it}, then this is a random-effect model. The Equation 3.8 is still applied in a random-effect model; there is still no distribution assumption requirement for inefficiency term u_i, but the model assumes that u_i is random, with constant mean and variance, and it is nonnegative. The parameters of the random-effect model still can be estimated with an Ordinary Least Squares method.

3.4 Result and Discussion

3.4.1 Residual Skewness Test

To begin the analysis, we start with an Ordinary Least Squares (OLS) residual skewness test (Schmidt and Lin, 1984) for the validity of the stochastic frontier specification (Kumbhakar et al., 2015). Because this chapter applied cost function, I expect the residual should skew to the right, which means the skewness test result should be positive. This analysis runs the pooled OLS to get a result of residual skewness. As expected, the result shows a positive number of 1.234 for skewness. The skewness test is proof that positive skewness is significant (all test details are displayed in the appendices). Now, I can reject the null hypothesis of non-skewness of OLS residual and start running the stochastic frontier model.

3.4.2 Model Results

This chapter applies two stochastic frontier models—Time-Invariant and Time-Varying to measure efficiency levels of Chinese commercial banks under different ownership from 2002 to 2014. To support the results, this chapter also runs two additional panel data models: fixed-effect and random-effect. According to the monotonicity property of the cost function, an increase in price of input and the level of output lead to an increase in cost. The cost should be concave with price of input and non-increasing in quasi-fixed input. Therefore, I expect a positive relationship between price of input and total cost, and a positive relationship between output and total cost. Tables 3.2 and 3.3 provide the details of the estimated cost function parameter results from the above four models.

According to estimated results, the coefficients of all prices of inputs have a positive and significant relationship to total cost. For the prices of inputs, price of labour (w2) has the highest coefficient compared to the price of deposit (w1) and price of capital (w3). The labour cost is the costliest input for Chinese commercial banks. It is consistent with the interaction between prices of inputs and other variables. Most of the parameters involved with interaction of price of labour and other variables are significant, including the square of price of labour. Parameters of interaction involved with price of capital are not significant. This result meets the over-employment problem of state-owned banks that Wang et al. (2014) presents. For outputs loans (y1), other earning assets (y2), and other operating income (y3), loans have the highest impact on total cost. Therefore, improving cost control of producing loans can help Chinese commercial banks to reduce their total costs. The parameters involved with the interaction of loans with other variables are significant; the coefficient of square of loans is positive and significant, confirming that an increase in loans production will cost more for the bank. The coefficient of quasi-fixed input equity (z) is non-significant and the square of equity and interaction with other variables only displays one-star significance. In the research period, equity has no effect to total cost in Chinese commercial banks. All the ownership dummy variables present three-star significance. The different ownership of Chinese commercial banks has significant impact to banks' total cost.

Table 3.2 Estimated Parameters Results of Four Models

Variables	Time-Invariant		Time-Varying		Fixed-Effect		Random-Effect	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
w2	0.545***	0.006	0.544***	0.006	0.543***	0.007	0.544***	0.006
w3	0.074***	0.010	0.074***	0.010	0.085***	0.012	0.073***	0.010
y1	0.667***	0.016	0.664***	0.017	0.684***	0.021	0.653***	0.016
y2	0.267***	0.013	0.268***	0.012	0.246***	0.015	0.279***	0.012
y3	0.485**	0.240	0.492**	0.238	0.273	0.265	0.377	0.243
z	0.650	0.910	0.745	0.922	1.542	0.958	0.549	0.881
w2w2	0.044***	0.003	0.044***	0.003	0.043***	0.003	0.041***	0.003
w3w3	0.003	0.004	0.003	0.004	0.001	0.004	0.001	0.004
y1y1	0.015***	0.004	0.015***	0.004	0.017***	0.005	0.021***	0.004
y2y2	-0.006	0.004	-0.006	0.004	-0.004	0.005	-0.010**	0.004
y3y3	-0.142	0.195	-0.158	0.194	-0.027	0.206	-0.093	0.199
zz	0.012*	0.007	0.012*	0.007	0.012*	0.007	0.011	0.007
w2w3	0.008*	0.004	0.008**	0.004	0.006	0.004	0.013***	0.004
w2z	-0.587***	0.176	0.580***	0.174	0.545***	0.186	0.529***	0.174
w3z	-0.348	0.290	-0.342	0.288	-0.362	0.301	-0.343	0.295

Note: ***, **, and * represent statistically significance at 1%, 5%, and 10% level.

Table 3.3 Estimated Parameters Results of Four Models (continued)

Variables	Time-Invariant		Time-Varying		Fixed-Effect		Random-Effect	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
y1z	-0.570**	0.255	-0.585**	0.256	-0.685**	0.271	-0.535**	0.258
y2z	-0.222*	0.123	-0.224*	0.122	-0.278**	0.127	-0.168	0.117
y3z	1.300**	0.514	1.349***	0.515	1.268**	0.546	1.125**	0.515
w2y1	-0.003	0.005	-0.003	0.005	-0.007	0.005	0.002	0.005
w2y2	-0.009	0.007	-0.009	0.007	-0.008	0.007	0.018***	0.007
w2y3	0.181**	0.087	0.180**	0.086	0.170*	0.093	0.163*	0.088
w3y1	-0.026***	0.010	0.026***	0.010	0.034***	0.011	0.039***	0.010
w3y2	0.025**	0.010	0.025**	0.010	0.031***	0.012	0.039***	0.010
w3y3	0.244	0.157	0.248	0.156	0.239	0.165	0.258	0.161
socb	0.510***	0.051	0.499***	0.053			0.565***	0.066
jscb	0.178***	0.032	0.174***	0.033			0.128***	0.037
ucb	0.210***	0.022	0.210***	0.022			0.188***	0.022
rcb	0.164***	0.026	0.164***	0.026			0.124***	0.027
fb	0 (omitted)							
_cons	-0.465***	0.032	0.461***	0.031	0.208***	0.031	0.375***	0.030

Note: ***, **, and * represent statistically significance at 1%, 5%, and 10% level.

For the time-invariant model, the coefficient of price of labour (w2) is 0.545. It suggests that a 1 per cent increase in the price of labour will increase the total cost to the bank 0.545 per cent. The coefficient on the price of capital (w3) suggests that a 1 per cent increase in the price of capital will lead to only a 0.074 per cent increase in total cost. The sum of all prices of input parameters should equal to one, due to the homogeneity of degree assumption. Therefore, the coefficient of the price of deposit (w1) can be calculated by one minus the coefficient of price of labour and coefficient of price of capital, which is equal to 0.381. By comparing the coefficient of three prices of inputs, price of labour has major influence on the total cost of Chinese commercial banks and price of capital has the smallest impact.

By looking at parameters of output variables, loans (y1), other earning assets (y2), and other operating income (y3) all have positive and significant coefficients in the time-invariant model. The coefficients are 0.667, 0.267, and 0.485, respectively. These results imply that increasing 1 per cent of loans, other earning assets, or other operating income will increase the total cost by 0.667, 0.267, or 0.485 per cent, respectively. The coefficient of quasi-fixed input equity (z) is 0.65, but is non-significant. Thus, equity does not change the total cost for Chinese commercial banks. For the coefficients of the square of each price of input and output, price of labour and loans have three-star positive and significant results (0.044 and 0.015). This can be explained by the price of labour and loans being the costliest variables in prices of inputs and outputs. Furthermore, any interaction variables involved with price of labour or loans have a significant coefficient. Ownership dummy variables for state-owned, joint-stock, urban, and rural commercial banks have coefficients of 0.51, 0.178, 0.21, and 0.164, and they all have three-star significance. Therefore, the type of ownership has an effect on total cost for Chinese commercial banks. The time-varying model has a similar value of coefficient for each variable; the significance of coefficient for each variable is the same as the time-invariant model.

Fixed-effect and random-effect models are run for robustness. The value and significance of the coefficient for outputs, quasi-fixed input, interaction variables, and dummy variables are similar to the time-invariant and time-varying models. However, there is no significant relationship between the other operating income to total cost in the fixed-effect and random-effect models. Even for time-invariant and time-varying models, there is only two-star significance. This is because there are a certain number of banks in China that are still in an emerging stage. Beyond top leading banks in China, there are larger number of rural commercial banks and rural cooperatives banks providing financial services for local individuals and companies. These banks are in small size and focus on traditional banking business (transforming deposits to loans); there is not enough other operating business in these banks, leading to non-significance of other operating income to total cost.

3.4.3 Cost Efficiency

This chapter measures the cost efficiency of Chinese commercial banks from 2002 to 2014 by decomposing the error term. Table 3.4 summarises banks' efficiency under different ownership in a time-invariant model, providing a general picture of cost efficiency for Chinese commercial banks. In general, the average cost efficiency of Chinese commercial banks is 0.955. It is a high result, meaning that performance of cost control in the Chinese banking industry is good during the research period. The average cost efficiency of rural commercial banks is 0.969, which ranks first. Joint-stock and urban commercial banks have an average efficiency of 0.956 and are tied for second. Joint-stock commercial banks have a higher minimum efficiency score and urban commercial banks have a higher maximum efficiency score. Fu and Heffernan (2007) and Kumbhakar and Wang (2007) state that joint-stock commercial banks are more efficient than state-owned commercial banks. Foreign banks have a 0.947 for average efficiency and are therefore in third place. The state-owned banks only have a 0.863 average efficiency and rank in the last place—the same result as Berger et al. (2009).

Table 3.5 orders the efficiency results of the time-varying model into each year. As Table 3.5 shows, the number of banks increased from 2002 to 2013; there are 20 banks in 2002 and 115 banks in 2013 according to the research datasets. As mentioned in Chapter 2, some urban and rural commercial banks were founded in this period, leading to the increasing number of banks. Some of the urban and rural commercial banks were too small to handle operating risks; these banks merged to form new banks, which is the reason for the reduction in the number of banks to 99 in 2014. The average efficiency only drops 0.01 from 2002 to 2003, and then increases to 0.929 in 2006. During the global financial crisis, the average efficiency decreases to 0.91 in 2008. From 2009 to 2010 the average efficiency improves, reaching 0.917. There is 0.03 dip of average efficiency in 2011 and 2012. The average efficiency increases again to 0.917.

Table 3.4 Summary of Time-Invariant Model Efficiency Score for Different Ownership

Categories	Mean	Std. Dev.	Min	Max
Overall efficiency score	0.955	0.038	0.800	0.990
State-owned commercial bank	0.863	0.067	0.800	0.985
Joint-Stock commercial bank	0.959	0.020	0.922	0.984
Urban commercial bank	0.959	0.034	0.836	0.987
Rural commercial bank	0.969	0.016	0.911	0.982
Foreign bank	0.947	0.038	0.819	0.990

Table 3.5 Summary of Time-Varying Efficiency Scores for Sample Period

Year	No. of Bank	Mean	Std. Dev.	Min	Max
2002	20	0.920	0.056	0.804	0.988
2003	27	0.919	0.056	0.803	0.988
2004	30	0.923	0.054	0.805	0.988
2005	50	0.928	0.054	0.792	0.989
2006	72	0.929	0.049	0.795	0.990
2007	80	0.914	0.063	0.682	0.989
2008	61	0.910	0.069	0.686	0.990
2009	67	0.916	0.066	0.690	0.990
2010	86	0.917	0.061	0.694	0.990
2011	97	0.914	0.075	0.518	0.990
2012	95	0.914	0.075	0.524	0.991
2013	115	0.916	0.069	0.529	0.991
2014	99	0.917	0.071	0.534	0.991

The minimum efficiency decreases from 0.804 to 0.534. As discussed previously, there are some urban and rural commercial banks established by transforming from credit cooperatives. These urban and rural commercial banks must carry non-performing loans from former credit cooperatives. So, it is no surprises that the minimum efficiency keeps decreasing. On the contrary, the maximum efficiency increases from 0.988 to 0.991. Even though it is only a

0.03 difference, the best performing bank in China still maintains and improves its cost control during the research period.

To investigate the dynamics of the cost efficiency, I visualised the maximum, minimum and mean efficiencies of the time-varying model in Figure 3.1 and 3.2. As discussed in Table 3.5, the average cost efficiency of Chinese commercial banks has an upward trend from 2002 to 2006 and a downward trend from 2006 to 2008. After 2008, the average efficiency level slightly increases from 0.910 to 0.917 but has a little dip from 2010 to 2011. The Chinese banking industry has a modernisation and expansion period after 1997 (refer to Chapter 2, Section 2.2.3) and China joins the World Trade Organization in 2001. Foreign banks start entering the Chinese banking industry which increases competition. There is a gradual interest rate liberalisation during the research period. These events can explain why the average efficiency increases from 2002 to 2006. The global financial crisis of 2006 to 2008 causes a downward trend of average efficiency. Therefore, the world financial crisis has a negative effect on Chinese banking cost efficiency. In the post-crisis period, Chinese banks slowly recover their performance. The average efficiency increases from 0.914 to 0.917 from 2012. The removal of the restriction on loan interest rates in 2013 might help improve the Chinese commercial banks.

Figure 3.1 Dynamics of Overall Mean Efficiency for Sample Period

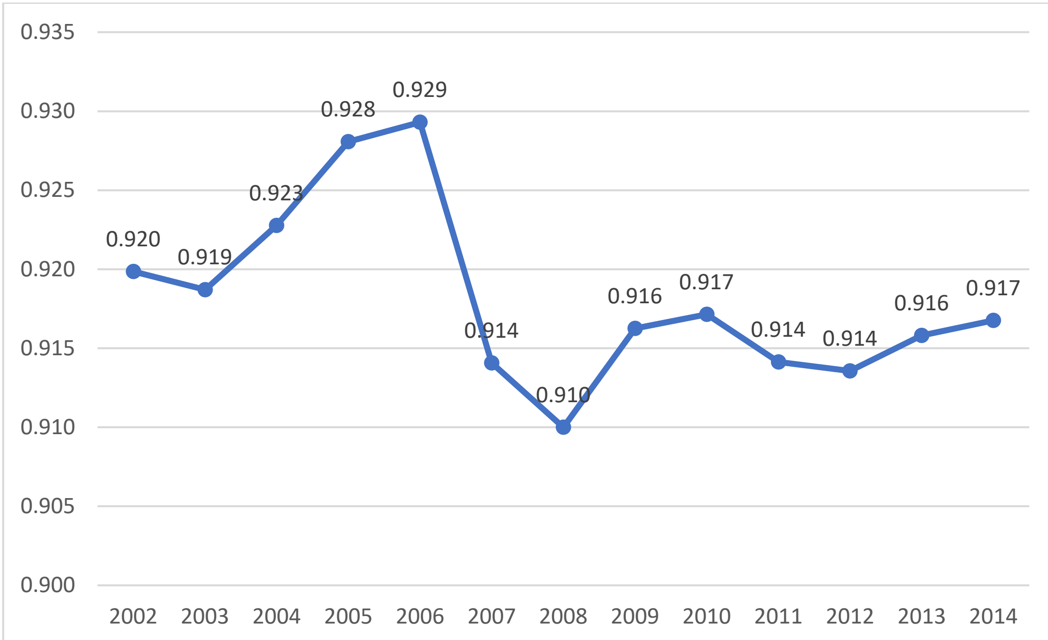


Figure 3.2 Dynamics of Overall Max, Min, and Mean Efficiency for Sample Period

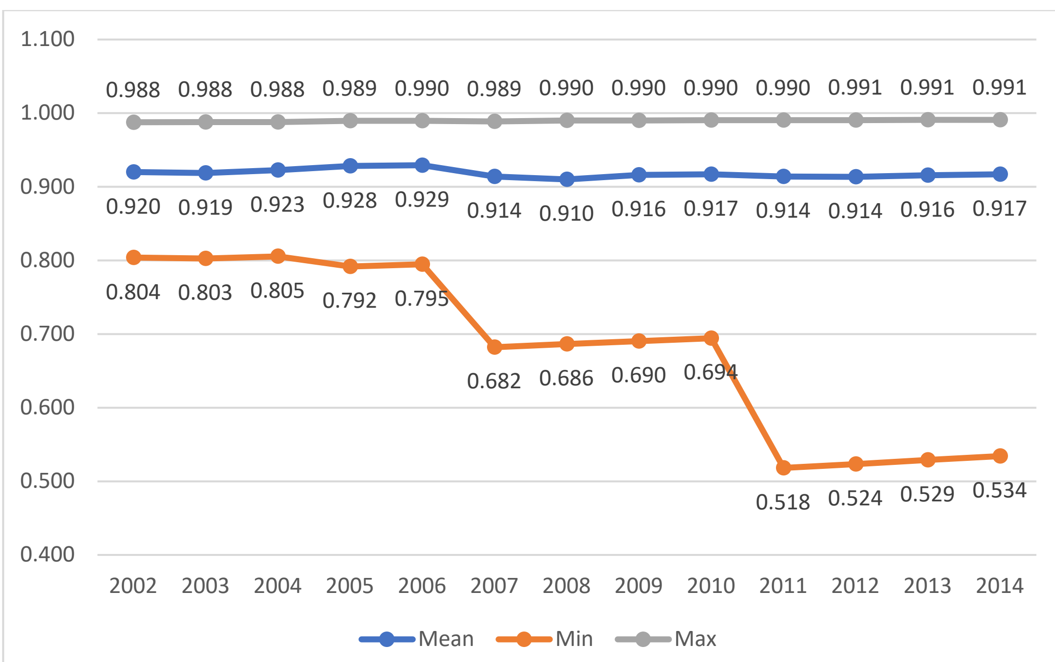


Figure 3.2 shows that the maximum efficiency is kept stable during the research period; the most efficient performance of the Chinese banks keeps stable. The minimum efficiency keeps decreasing, especially from 2007 to 2011. But the minimum efficiency has slight growth from 2011 to 2014. As the lower efficiency banks join the market, these banks also improve their cost efficiency. To view the efficiency trend under different ownership, Figures 3.3 to 3.12 provide the maximum, minimum and mean efficiency trends for state-owned, joint-stock, urban, rural, and foreign commercial banks from the time-varying model.

As Figure 3.3 presents, average efficiency of state-owned banks saw an uptrend from 2003 to 2006 and 2007 to 2014. State-owned commercial banks were listed in the stock market after 2005; improving monitoring and governance of state-owned commercial banks, thus leading to efficiency improvement. Interest rate liberalisation can also explain the uptrend. The state-owned commercial banks have problems with non-performing loans (detailed in Chapter 2, Section 2.2.3): this is the reason for the efficiency drop from 2002 to 2003. The State Council inject money to these banks in order to raise capital and overcome the risk from 2003 onwards (Jiang et al., 2009). Under the global financial crisis, the cost efficiency of commercial banks also deceases.

Figure 3.3 Dynamics of Mean Efficiency for State-owned Commercial Banks

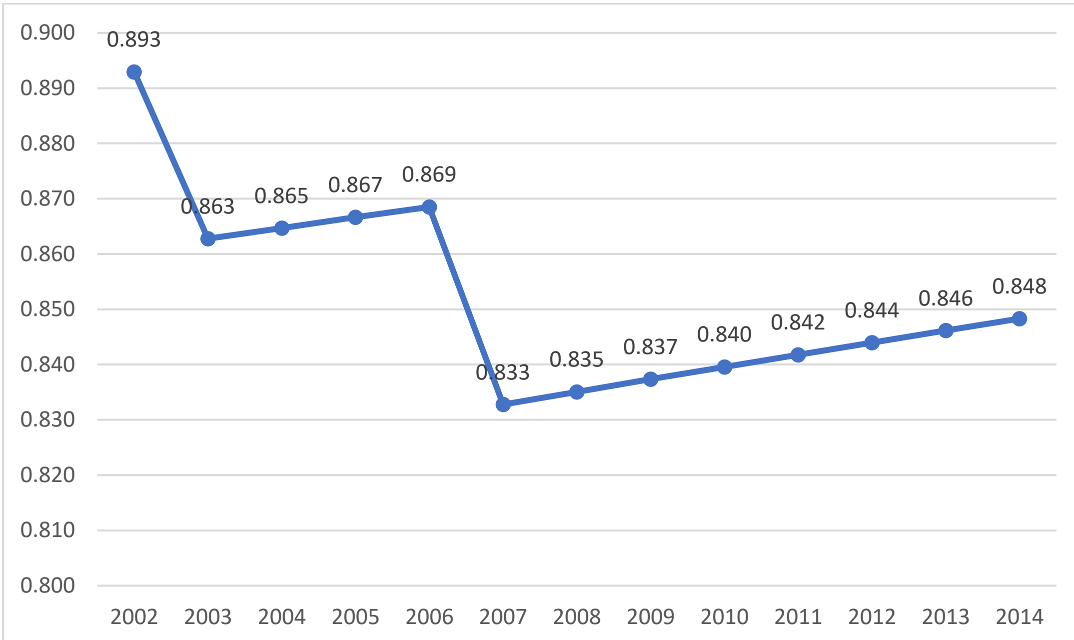
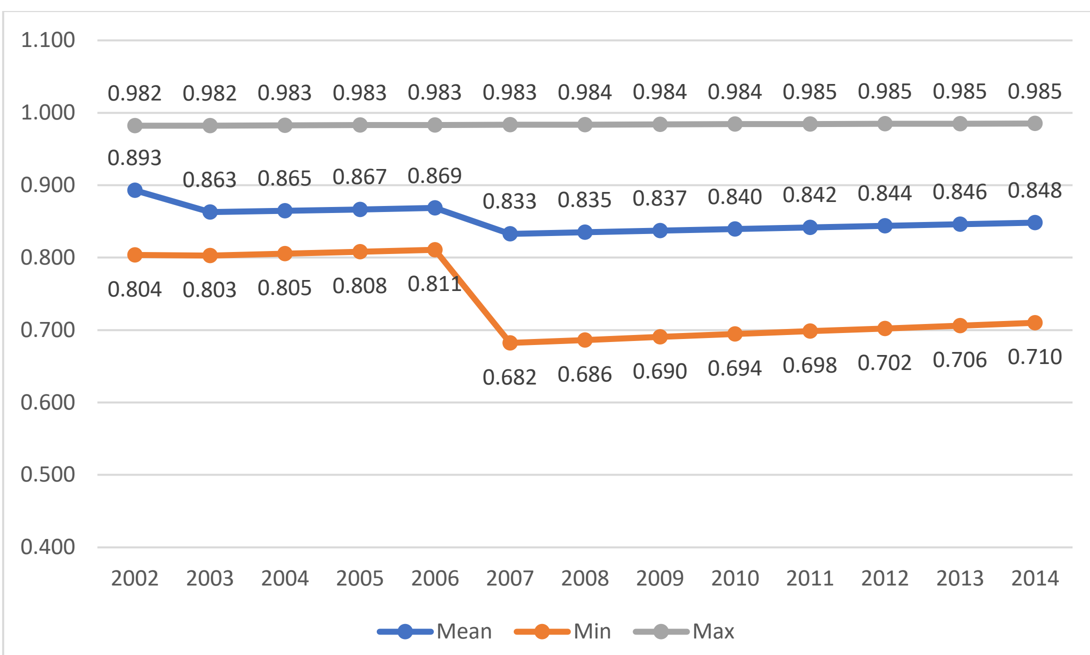


Figure 3.4 Dynamics of Max, Min, and Mean Efficiency for State-owned Commercial Banks



By looking at Figure 3.4, maximum efficiency of state-owned commercial banks is nearly unchanged. The minimum efficiency is stable from 2002 to 2006, but decreases from 2006 to 2007. The lowest efficient state-owned commercial banks are affected by the global financial crisis. However, they manage to improve their cost efficiency from 0.682 to 0.71 during 2007 to 2012.

Figure 3.5 shows the average efficiency of joint-stock commercial banks. There is a continuing uptrend in average efficiency of joint-stock commercial banks. Thus, joint-stock commercial banks did a good job to control cost. As Figure 3.6 displays, the most efficient joint-stock commercial bank increases cost efficiency from 2003 to 2004 and maintains stability afterward. The lowest efficient joint-stock commercial bank drops cost efficiency from 2003 to 2004, but improves efficiency from 2004 to 2008. The minimum efficiency is affected by the global financial crisis and decreases from 2009 to 2010. However, it slowly recovers from 0.888 to 0.894 during 2010 to 2014. Figures 3.7 and 3.8 present the efficiency of urban commercial banks.

The average efficiency of urban commercial banks has similar movement to the average efficiency of Chinese commercial banks overall. Joining WTO helps urban commercial banks attract foreign investors and increases average efficiency of urban commercia banks from 2002 to 2005. As with state-

Figure 3.5 Dynamics of Mean Efficiency for Joint-stock Commercial Banks

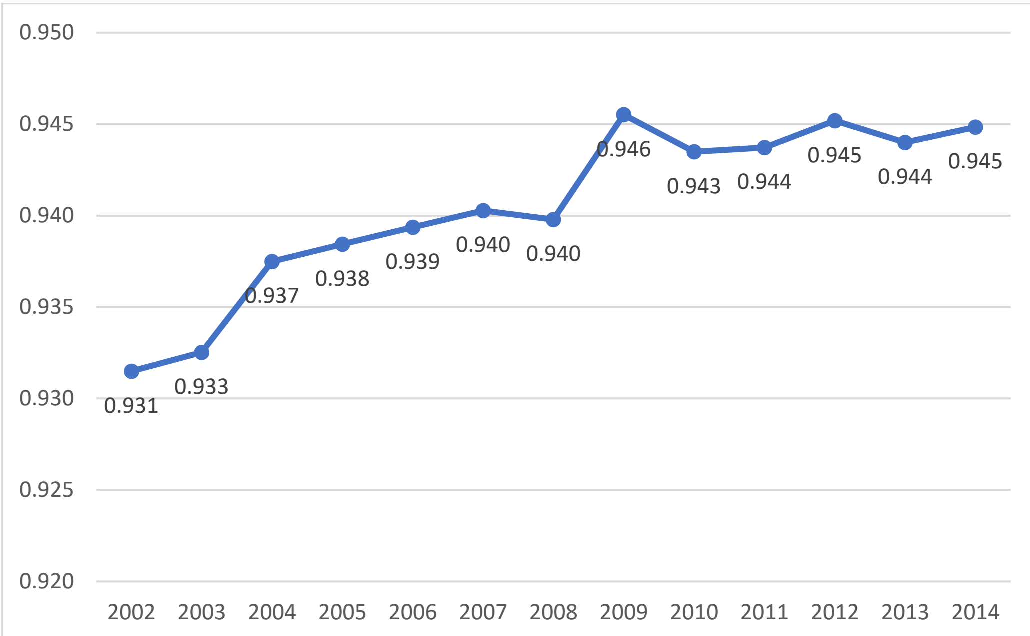


Figure 3.6 Dynamics of Max, Min, and Mean Efficiency for Joint-stock Commercial Banks

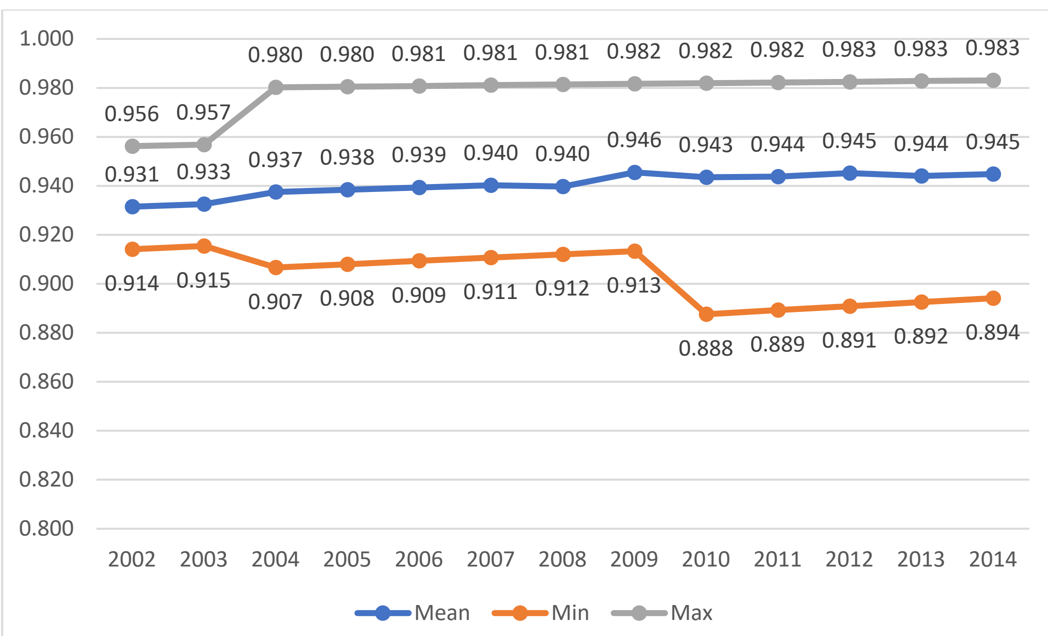


Figure 3.7 Dynamics of Mean Efficiency for Urban Commercial Banks

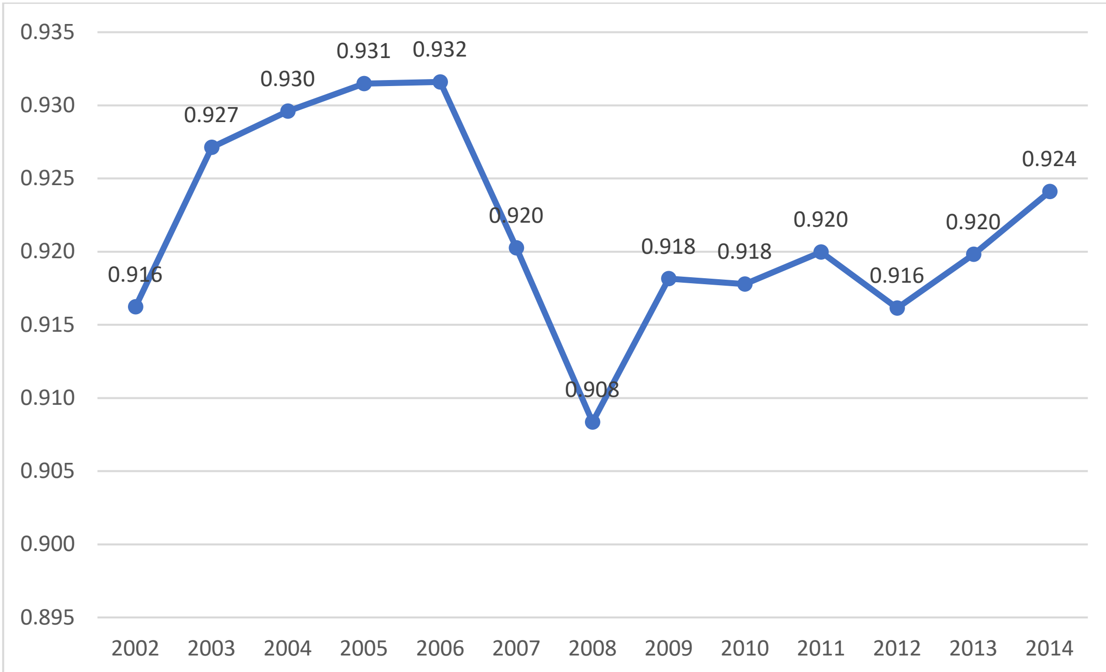
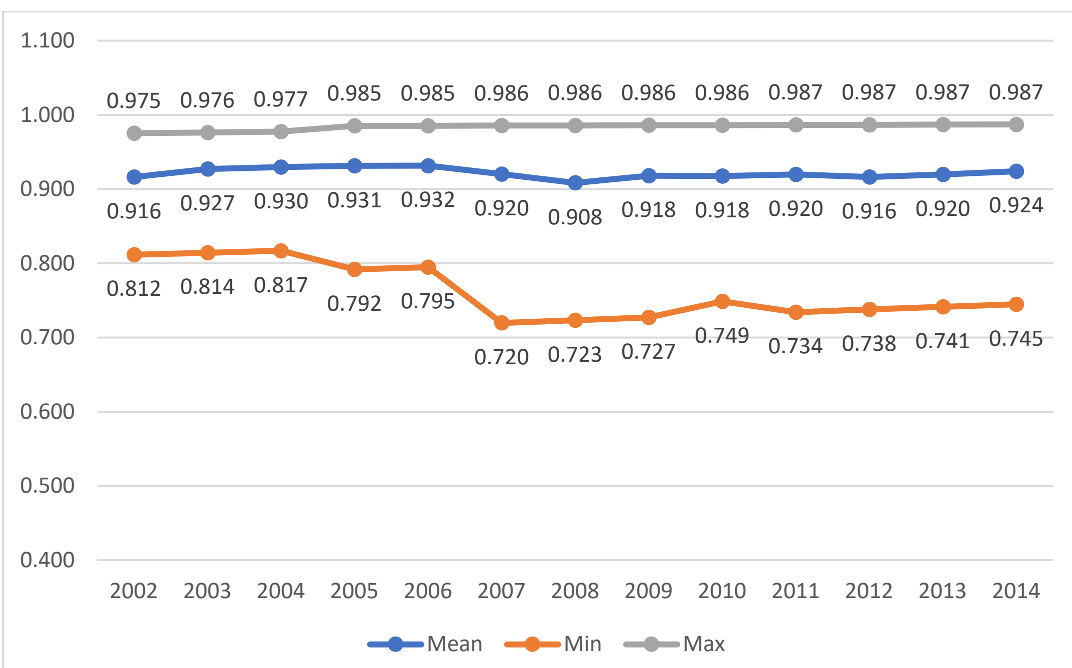


Figure 3.8 Dynamics of Max, Min, and Mean Efficiency for Urban Commercial Banks



owned and joint-stock commercial banks, urban commercial banks are also affected by global financial crisis. Several urban commercial banks are listed in the stock market, which helps to improve efficiency from 2008 to 2014. The maximum efficiency is moderately increased from 0.975 to 0.987. The minimum efficiency is stable from 2002 to 2005, but decreases from 2006 to 2007. After 2007, the minimum efficiency has a tiny improvement from 0.72 to 0.745.

The maximum, minimum, and average efficiencies of rural commercial banks have been shown in Figures 3.9 and 3.10. Similarly to state-owned, joint-stock, and urban commercial banks, the global financial crisis impacts rural commercial banks. The average efficiency of rural commercial banks continues to increase from 2002 to 2009, with a peak point of 0.957; the average efficiency decreases to 0.941 from 2009 to 2010. It then remains stable after 2010. The most efficient rural commercial bank improves cost efficiency from 0.918 to 0.977 during 2002 to 2005 and keeps increasing to 0.98 in 2014. The trend of minimum efficiency is similar to that of average efficiency; only has a small draw back (0.88 to 0.869) from 2004 to 2007.

In contrast to state-owned, joint-stock, urban, and rural commercial banks, the average efficiency of foreign banks initially decreased from 2002 to 2007. As Figure 3.11 shows, the average efficiency unexpectedly increases during the

Figure 3.9 Dynamics of Mean Efficiency for Rural Commercial Banks

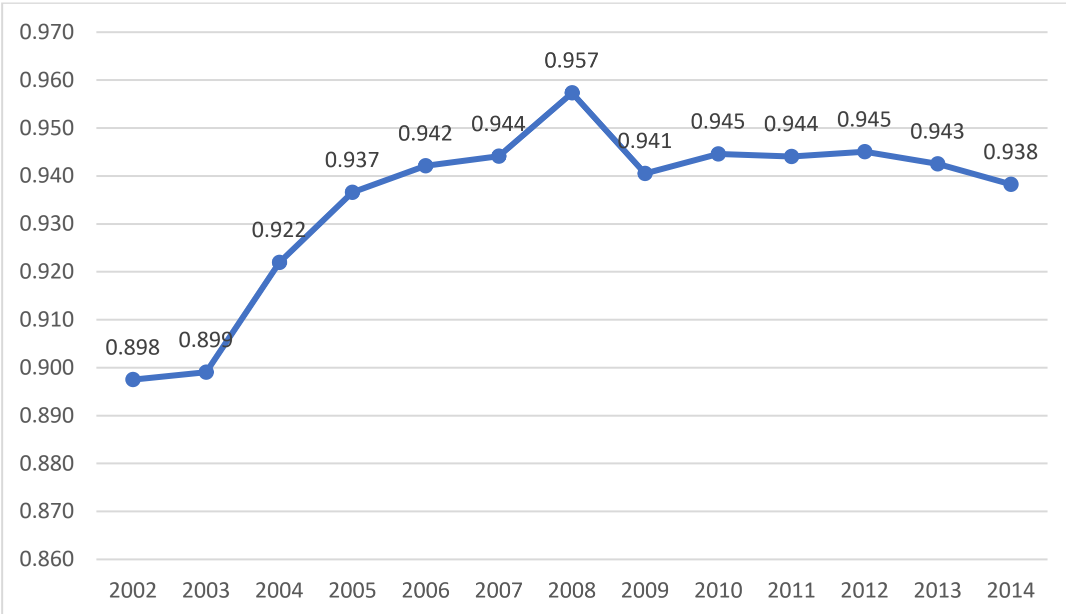
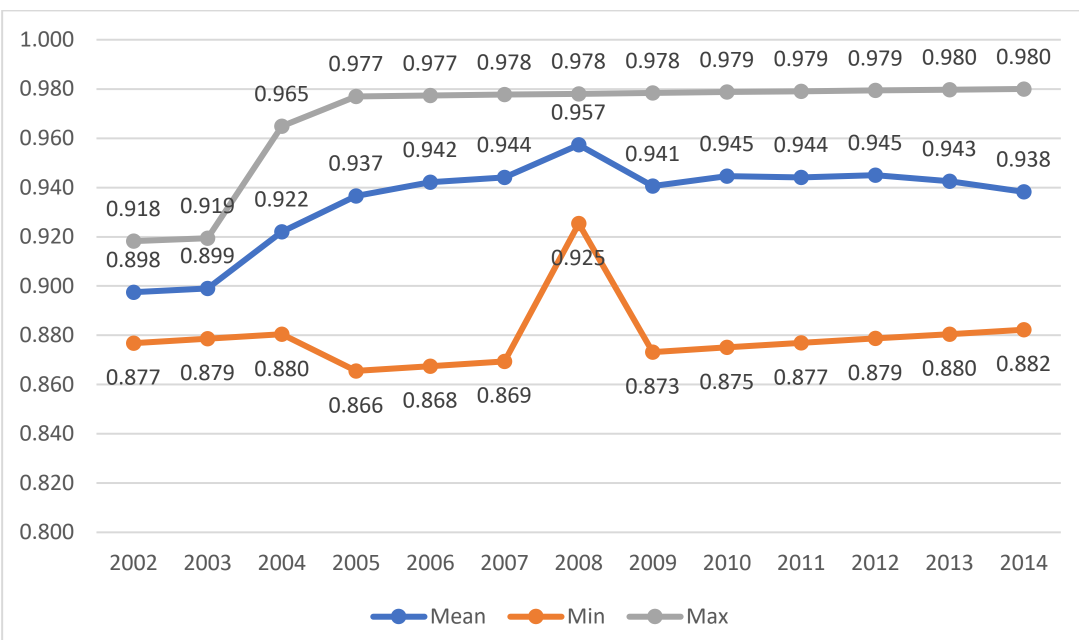


Figure 3.10 Dynamics of Max, Min, and Mean Efficiency for Rural Commercial Banks



global financial crisis period (2007 to 2009). However, the average efficiency decreases from 2009 to 2012 and then recovers a little bit. Figure 3.12 provides more sensible results. The maximum, minimum and average efficiencies of foreign banks are fairly close at the beginning of research period. The maximum efficiency gradually increases from 0.988 to 0.991. The minimum efficiency keeps decreasing from 2002 to 2009 and there is a big drop in minimum efficiency from 0.838 to 0.518 from 2009 to 2011 (right after the global financial crisis). The lowest efficiency foreign bank is hurt in the global financial crisis, but it slowly recovers its cost efficiency from 0.518 to 0.534 during 2011 to 2014. There are also dynamic trends of each bank under ownership categories in appendices.

3.5 Conclusion

In this chapter, I investigate the cost efficiency of Chinese commercial banks from 2002 to 2014. This chapter also observes the ownership impact on banking efficiency. Specifically, this chapter employs a Stochastic Frontier Approach to measure the cost efficiency of 158 Chinese commercial banks with Time-Varying and Time-Invariant models. I also apply additional panel data models (fixed-effect and random-effect models) for comparison and robustness check. The results demonstrate that all prices of input and outputs have a significant positive relationship to the total cost, except one output (other

Figure 3.11 Dynamics of Mean Efficiency for Foreign Commercial Banks

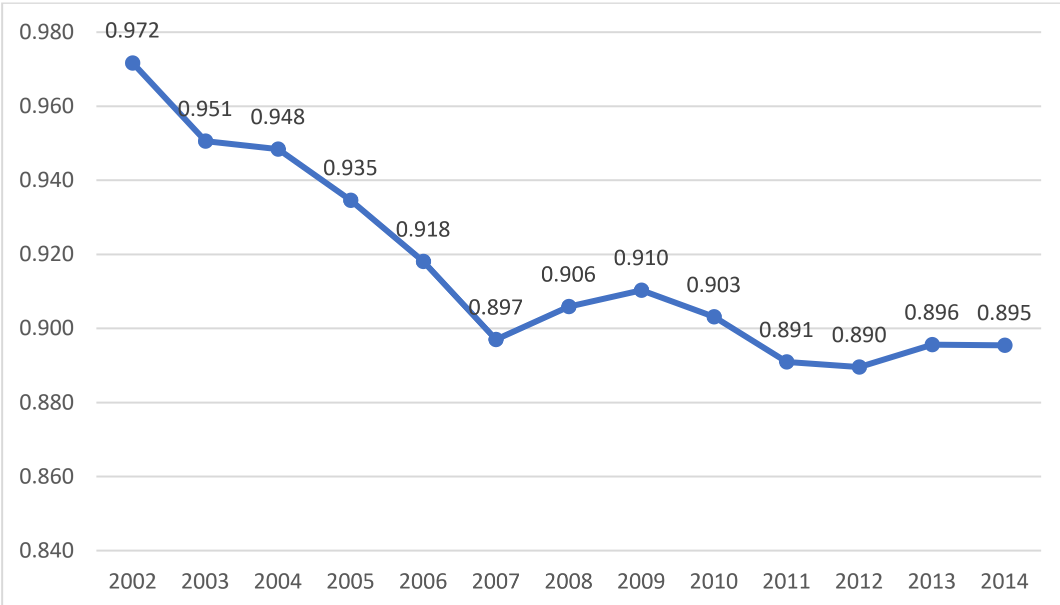
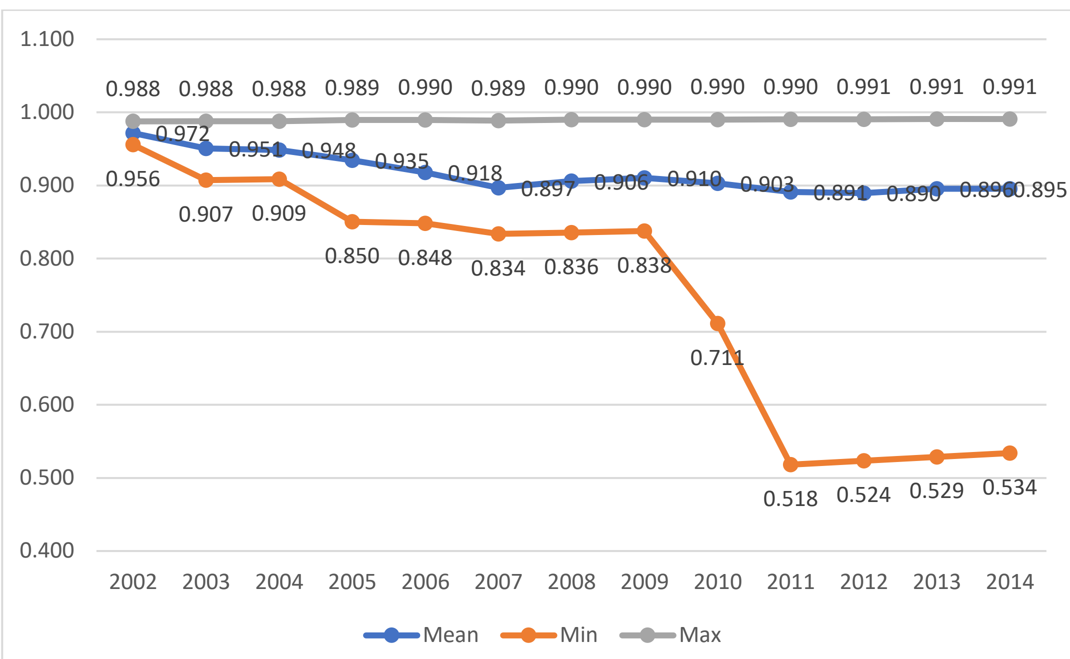


Figure 3.12 Dynamics of Max, Min, and Mean Efficiency for Foreign Commercial Banks



operating income). The developing banking industry in China—many banks are still mainly engaged in the traditional banking business—can explain the insignificant coefficient between operating income and total cost. Price of labour and loans have the highest influence on Chinese commercial banks' total cost. Additionally, there is no relationship between equity and total cost.

On average, the efficiency of all banks in the sample increases from 2002 to 2006. This can be explained by private and foreign investment entering the Chinese banking industry after China joined the World Trade Organization in 2001, after which there is an improvement in the competition of the Chinese banking industry. The world financial crisis drops down the overall average efficiency during 2006 to 2008. After 2008, there is a tendency towards moderate recovery of efficiency results, which can be credited to interest rate liberalisation. For different ownership categories, the state-owned commercial banks are the least efficient bank group, with an average efficiency score of 0.849. Joint-stock, urban and rural commercial banks have similar and high efficiency scores. Foreign commercial banks have lower efficiency than these three types of bank, but higher efficiency than state-owned commercial banks. This supports that the ownership affects bank efficiency and shows that state ownership leads to a disadvantage of cost control.

Chapter 4 - A Spatial Production Analysis of Chinese Regional Banks: Case of Urban Commercial Banks

4.1 Introduction

4.1.1 Motivation and Research Question

As second largest economy, mainland China has 31 administrative regions and covers 9.6 million square kilometres[36]. There is unbalanced economic development among these regions. The different levels of regional economy require various financial services. The urban commercial bank is one type of regional bank that provides financial services for local enterprises and individuals. The overall total assets of urban commercial banks have grown from 1,462 billion RMB to 22,680 billion RMB during 2003 to 2015, constituting 11.38 per cent of Chinese banking total assets in 2015, up from 5.29 per cent in 2003[37]. Now the third largest type of bank in China, urban commercial banks are an essential part of the economy and a crucial research area. The market restructure of transforming urban credit cooperatives into urban commercial

[36] Source from website of the central government of China http://www.gov.cn/test/2005-05/25/content_17358.htm.
[37] Source from Chinese Banking Regulatory Commission annual report 2016.

banks finished in 2012. The results of Chapter 3 indicate that urban commercial banks are more efficient than state-owned commercial banks. It is necessary to analyse the efficiency of urban commercial banks after the market restructure period.

Although the literature on banking production and efficiency is well established (e.g., Berger and Mester, 1997; Berger and Humphrey, 1997; Bonin et al., 2005b; Boubakri et al., 2005; Delis et al., 2017; Konara et al., 2019), there is a lack of research in regional banking, and particularly in Chinese urban commercial banks. There are currently no papers that attempt to analyse spatial dependence among urban commercial banks. Based on the geographical characteristic of urban commercial banks—whose main purpose is to provide business for local markets—it is worthwhile to investigate their spatial relationship. The research questions of this chapter are: 1) what is the impact of the market restructure on efficiency of urban commercial banks? and 2) is there any spatial relationship among urban commercial banks?

4.1.2 Results and Outline

This chapter investigates the performance and efficiency of 65 Chinese urban commercial banks across 18 Chinese provinces, four municipalities, and four autonomous regions (a total of 26 regions). They are same level administrative areas that do not overlap each other. This analysis focuses on the post-market restructure period from 2013 to 2015. This chapter utilises two methods to estimate results, including: 1) a spatial autoregressive production frontier with random effects, and 2) a spatial Durbin production frontier with random effects. Contributing to the existing literature, this chapter addresses the spatial relationship of Chinese urban commercial banks with adjacent regions' banks. By adding a spatial parameter into the modelling, the results provide a more accurate efficiency estimation. The model estimation results indicate that deposits have the greatest influence on output loans compared to other input variables. In addition, the results of both models provide strong evidence that loans of urban commercial banks have positive spatial relationships with the bank loans of their neighbouring regions. In addition, banks from contiguous regions have similar efficiency results. This chapter also finds that the regional market environment has an influence on the performance of local banks, though the results are mixed: for regions with less than three urban commercial banks, they have stable and relatively high average efficiency scores; for regions with more banks, there exist both higher and lower efficiency banks.

The rest of this chapter is organised as follows. Section 4.2 provides a literature review of regional banking, which looks at regional banking both outside and inside China's bank industry. Section 4.3 displays our sample dataset and methodology. This chapter provide model estimation results in Section 4.4. Section 4.5 concludes.

4.2 Literature Review for Regional Banking

Most research on banking investigates the European and U.S. banking industries. For example, Vander Vennet (2002) works on cost and profit efficiency in the European banking system. Recently, however, more and more literature focuses on developing countries (e.g. Bonin et al., 2005b; Boubakri et al., 2005; Clarke et al., 2005) with some studies focusing on banking in China (Fu and Heffernan, 2009; Chen et al., 2005a; and Lin and Zhang, 2009).

This section is separated into three parts. Sub-section 4.2.1 discusses literature of efficiency of national and regional banks outside Chinese banking. Sub-section 4.2.2 reviews studies of Chinese banking efficiency. Sub-section 4.2.3 provides a conclusion.

4.2.1 Literature outside the Chinese Bank Industry

Considering research that examines bank industries outside of the Chinese market, most focus on how ownership influences banking performance. Altunbas et al. (2001) report that private commercial banks are more efficient than public saving and mutual cooperative banks in the German banking industry, even though all sizes of public and mutual banks have slight cost and profit advantages over private banks. Bonin et al. (2005b) find that foreign banks have more efficacy than other banks in transition countries. Foreign investors provide a better service and have a positive impact on banks' profit efficiency. A similar result is found in Boubakri et al. (2005), which finds that long term privatisation can improve economic efficiency and reduce credit risk exposure to developing countries' banks. However, newly privatised banks, which are controlled by local industrial groups, have more opportunities to suffer credit risk and interest rate risk. Clarke et al. (2005) shows that privatisation improves banking performance and competition. However, there are many potential problems with banking privatisation, such as a minority share of state ownership in those banks; some governments restrict the privatisation process, foreign investors cannot participate in the privatisation process, and instead of direct sale to strategic investors, private shares are offed. By comparing efficiency between foreign and domestic banks, Lensink et al. (2008) states that it is important to look at the quality of institutions in both the home and the host countries; if the governance distance of an institution's host and home countries becomes smaller, the foreign bank is more efficient than the domestic bank. In contrast, Staub et al. (2010) find that state-owned banks are more cost efficient than foreign and foreign participation banks in Brazil. Konara et al. (2019) examine the effect of foreign direct investment to efficiency measurement; their results present that foreign competition benefits overall technical efficiency and scale efficiency, but has no benefit to pure technical efficiency, cost efficiency, and revenue efficiency.

Besides ownership, some literature focuses on the political effects on banking efficiency. Boehmer et al. (2005) research 101 developing countries' banks from 1982 to 2000 and report that political factors have a significant effect on banking privatisation. State-owned banks' privatisation is related to political conditions and has a higher opportunity to privatise if the government has greater accountability to voters. Furthermore, bank size is another factor for influencing banking efficiency. Vander Vennet (2002) finds that financial conglomerates are more revenue efficient than specialised banks in non-traditional banking business and that universal banks have higher cost and profit efficiency than non-universal banks. However, Vander Vennet (2002) concludes that the de-specialisation of banking might lead to a more efficient European banking system. Similarly, Berger and DeYoung (2001) finds that nationwide banks are more efficient than very small banks. Altunbas et al. (2000) investigate the scale economy and efficiency of Japanese banking, and their results suggest that the largest banks could be more efficient by decreasing output to reduce cost rather than improving X-efficiency. Regarding economic environment factors, Kenjegalieva et al. (2009) employ a bootstrapped regression approach to study the effect of macroeconomic environments on the efficiency of transition banks; their results state that the level of inefficiency of banks has steadily increased during the European Union negotiation period. In their earlier stages of the European Union negotiation period, the macroeconomic factors had a significant effect on the banking inefficiency in transition countries. Also, Kazakh's banks increased a huge number of bad loans during the world financial crisis. It has had a serious influence on the banks' cost, input distance and revenue frontiers (Glass et al, 2014a). Tabak et al. (2013) notice that local environment and constraints also affect the performance of banks. They prove that geographical distance has the effect of technical efficiency by estimating a geographically weighted cost function. In considering risk in banking performance, Fiordelisi et al. (2011) investigate the relationship of efficiency, risk, and capital in European banking. They demonstrate a negative relationship between efficiency and risk; and positive relationship between efficiency and capital. Delis et al. (2017) confirm the negative relationship between risk and efficiency in the U.S.; they also find that efficiency results depend on whether the model does or does not include a risk component.

Looking at the regional banking industry, Berger and DeYoung (2001) investigate 7,000 U.S. banks from 1993 to 1998. They find that the geographic scope has an impact on bank efficiency. If a bank expands into a close regional area, its efficiency will increase. On the contrary, if a bank affiliate moves further away from the origin, its efficiency will decrease. Collender and Shaffer (2003) provide information about why local banks behave differently from nation-wide banks, namely that they have different levels of access to local information, of commitment to local prosperity, of technology in risk management and of bank size. When comparing local and national banks in the U.S. from a customer perspective, local banks receive more positive evaluations on extra services, the bank's image and convenience (Kaynak and Harcar, 2005). Hasan et al. (2009) finds that there is a positive relationship between banking quality and economic growth across regions in 11 European countries, while Bos and Kool (2006) support that local market conditions as a environmental factor influences bank efficiency. Aside from the regional factors affecting bank efficiency, banks also have an influence on the local economy. Collender and Shaffer (2003) state that in the short run, bank liberalisation effects on local economic growth and out of market banks' mergers or acquisitions will not impair local economies; they will instead benefit the rural market. Moreover, Goodfriend (1999) finds that regional banks can facilitate central bank communications with the public. Beyond impaction factors of efficiency studies, some literature looks at research methodology; Wu et al. (2006) provide fuzzy logic into Data Envelopment Analysis which enables cross regional comparison.

4.2.2 Literature on the Chinese Banking Industry

When it comes to the Chinese banking industry, most literature studies the top-ranking banks, such as the big five state-owned commercial and 12 joint-stock commercial banks, with most research analysing the relationship between ownership and efficiency. Fu and Heffernan (2009) demonstrate that joint-stock banks had more X-efficiency than state-owned banks from 1985 to 2002, while Lin and Zhang (2009) supports that state-owned banks have less efficiency.

The definition of X-efficiency is that the ratio of minimum cost of best-practice bank from the sample to the same exogenous variable to actual cost (Berger and Mester 1997). The authors find that foreign shares or public listings can help to improve performance. A similar result is presented in Ariff and Can (2008), that joint-stock banks have more efficacy than state owned banks when looking at data from 1995 to 2004. On the other hand, Chen et al. (2005a) find that state-owned banks are more efficient than medium banks. One aspect on which most research agrees is that privatisation and foreign investors can improve banking performance in developing countries (Boehmer et al., 2005; Boubakri et al., 2005; Clarke et al., 2005).

Wang et al. (2014) study Chinese banking performance during the third period of banking reform and find that overall efficiency increases. However, they find that state-owned commercial banks are more efficient than the joint-stock commercial banks in the pre-reform period. Their results are inconsistent with other literature on Chinese banking. There are more foreign investments involved in the Chinese financial market since China joined the WTO. Berger et al. (2009) compare the efficiency of foreign and domestic banks, and foreign banks were found to be the most efficient. The results indicate that Chinese banks can improve efficiency by acquiring foreign ownership. Jiang et al. (2009) support the view that foreign acquisition can improve the efficiency of Chinese domestic banks in the long-term. Barros et al. (2011) indicate that overall banking efficiency improves after China entered the WTO, and that economic environment and policy also have an effect on the banking performance. Tan and Floros (2013) find that risk and technical efficiency have a positive relationship, and that there is a negative relationship between risk and level of capitalisation in the Chinese banking industry in the post-WTO period.

Besides ownership, there is also research which discusses bank size and the Chinese banking development process. Chen et al. (2005a) say that smaller banks are more efficient than medium-sized banks. But other literature—such as Ariff and Can (2008)—suggests that medium-sized banks are more efficient than small- and large-sized banks. Dobson and Kashyap (2006) discuss the advantages and disadvantages of Chinese banking reform. They state that there has been a substantial process of Chinese banking reform, but that the tensions of banking efficiency and social stability have remained and contributed to distortions. Finally, Ariff and Can (2008) argue that open markets, risk management and reduction of government capital can improve Chinese banking efficiency.

Drake et al. (2006) state that the Hong Kong banking system had been affected by macroeconomic factors—such as financial deregulation and the 1978-1979 South East Asian financial crisis—but to varying degrees based on different sizes of banks and different institutional sectors. Shyu et al. (2015) investigate banking efficiency in Taiwan, Hong Kong and Mainland China; they conclude that environmental conditions have significant impact on efficiency measurement. There is some literature on Chinese banking productivity; Kumbhakar and Wang (2007) analyse the impact of banking reform on banking productivity and find that productivity increases during 1993 to 2002. Similar to the result of efficiency, productivity improvement of joint-stock commercial banks is better than state-owned commercial banks. Change et al. (2012) continue work on Chinese banking productivity and find similar results that productivity in Chinese banking increases from 2002 to 2009; in addition, joint-stock commercial banks have higher productivity growth rates compared to state-owned commercial banks.

Regarding Chinese regional banking research, there is limited literature in this area in relation to banking efficiency. Ferri (2009) provides information about geographical factors and ownership factors, finding that city commercial banks in the east of China have better performance and that banks controlled by state-owned enterprises show less performance. Zhang et al. (2012) study 133 Chinese city commercial banks' relationships with law enforcement to the banks' risk-taking and efficiency from 1999 to 2008. The result shows that stronger law enforcement increases bank risk-taking in the region and that a better legal environment—such as the protection of intellectual property right—can improve the bank efficiency. In recent literature, Sun et al. (2013) research examines the relationship between strategic investors to city commercial banks efficiency. They find that strategic investors can improve the city commercial banks' efficiency but that there is a negative relationship between strategic investors and the level of regional economic development. There is also some literature that compiles regional banks with state-owned and joint-stock banks together as one Chinese banking market for analysis (Ariff and Can, 2008; Chen et al., 2005a; Lin and Zhang, 2009). Research on the ownership factor in Chinese bank efficiency is examined in Berger et al. (2009) and Jiang et al. (2009).

In addition to regional banking, there is a lot of literature focusing on the Chinese regional economy. Jin et al. (2005) provide the relationship between local governments and the local markets' development and find that the provincial government's strong fiscal incentive has a positive impact on the local economy, development and reform. Chen et al. (2005b) shows that the Chinese central government links the local official's turnover to local economic growth in order to incentivise the regional economy's development. Comparing the federalism between China and Russia, Blanchard and Shleifer (2001) argue that Chinese local governments must support new companies energetically, and that federalism has an important function in Chinese economy growth. Jin et al. (2005) also show evidence to support that Chinese federalism provides fiscal incentives for local governments, which contribute to market development.

4.2.3 Conclusion

To summarise, the well-established literature work on ownership, bank size, and political effect on banks' efficiency on European and U.S. banking. Compared to studies on national banks, studies on regional banks are limited and dominated by U.S. banking. Recent research pay attention to banking in developing countries, especially in China. Most of the literature on the Chinese banking industry looks at environmental factors' (ownership and size) impact on the efficiency of top-ranking banks (state-owned and joint-stock commercial banks); there is less work on regional banking, especially on Chinese urban commercial banks. There are some tables summarising the literature of national and regional banks efficiency in appendices.

To my best knowledge, there are only three papers that study the efficiency of Chinese urban commercial banks. However, there are some limitations to the existing research. Ferri (2009) only presents the performance of 20 banks within three regions and does not provide frontier efficiency analysis. The research period of the other two papers does not cover the time after the market restructure. Zhang et al. (2012) studies 133 urban commercial banks' efficiency with a distance function approach from 1999 to 2008. Sun et al. (2013) employs data envelopment analysis of 72 urban commercial banks during 2002 to 2010. None of these papers attempt to analyse spatial dependence among urban commercial banks. With the fast growth of urban commercial banks, it is worth investigating their efficiency in much greater detail. The chapter will address more accurate efficiency results of urban commercial banks by spatial production function; it will also attempt to analyse the spatial relationship of Chinese urban commercial banks.

4.3 Data and Methodology

4.3.1 Sample of Variables

The data sample consists of 65 Chinese urban commercial banks. These banks operate in 18 Chinese provinces, 4 municipalities, and 4 autonomous regions, which cover the majority of mainland China. However, due to data limitation, this sample excludes banks from five provinces[38]. The dataset consists of a balanced panel with a time span of 2013 - 2015 obtained from Orbis Bank Focus[39]. The model applied in this chapter requires a balanced dataset, but there are some merger and initial public offering activities during our research period that causing missing data. Therefore, this is biggest dataset I can collect. The choice of output and input variables is guided by the well-established intermediation approach to banking (Sealey and Lindley, 1997) which treats banks as fund intermediaries. The three inputs in the model specification are deposits, labour and fixed assets. The single output variable is loans. The

38 These five provinces are Hainan, Guizhou, Tibet, Shaanxi, and Qinghai.
39 Orbis Bank Focus is a worldwide database for 42,000 financial institutions information sourced by Bureau van Dijk. http://www.bvdinfo.com/en-gb/our-products/company-information/international-products/orbis-banks.

deposits variable is measured in monetary value. I use the number of employees as the labour variable in the modelling. However, the number of employees for some banks is missing one or two years of data. For those banks, I collected staff expenses and annual average financial industry wage of each region from the National Bureau of Statistics of China. Hence, this chapter can calculate the missing banks' number of employees by using staff expenses divided by the average annual wage to fill the dataset. The fixed assets are measured as long-term tangible pieces of property that banks own and use during their production process. Loans are the lending money from a bank to another party in return of future repayment of the principal amount and interest. I use mean-adjusted variables so that model coefficient results can be explained as elasticities at the sample mean. See Table 4.5 for a detailed description of the output and input variables and their summary statistics.

Loans is output y in the model estimation. There is a large different between the biggest and smallest urban commercial banks. The maximum loans in the sample are 747.9 billion RMB and the minimum loans are 9.7 billion RMB. There are 738.2 billion RMB difference loans between the biggest and smallest urban commercial banks. Three inputs to produce loans are deposits, labour, and fixed assets. They are noted as x1, x2, and x3 in model estimation. The difference in deposits between the biggest and smallest banks is wider than with loans. The biggest bank has 1593.9 billion RMB in deposits, while smallest bank only has 25.7 billion RMB in deposits. The labour difference is also large. The minimum labour is 511, but the maximum labour is 86,660. The standard deviation of fixed assets looks small; however, the biggest bank has 134 times the fixed assets compared to smallest bank.

Table 4.1 Summary Statistics of Data Variables

Variable	Model notation	Mean	Std. Dev.	Min	Max
Loans, in 100 million RMB	y	884.85	1,121.78	97.20	7,479.17
Deposits, in 100 million RMB	x1	1,991.90	2,454.77	257.16	15,939.10
Labour, number of employees	x2	6,459	9,462.89	511	86,660
Fixed assets, in 100 million RMB	x3	15.29	16.56	0.65	87.35

4.3.2 Spatial Production Function

The method of frontier efficiency analysis can be separated into non-parametric and parametric approaches. Data envelopment analysis (DEA)—as a non-parametric approach—is developed by Charnes et al. (1978) and wildly applied in efficiency measurement. However, the drawback of DEA is that it does not account for economic inputs and outputs; moreover, DEA does not deal with random errors in the model estimation (Berger and Mester, 1997). In contrast, stochastic frontier approach (SFA) allows economic variables and random error in the model. SFA is a parametric approach proposed by Aigner et al. (1977)

and Meeusen and van den Broeck (1977). But compared to DEA, SFA requires the assumption of inefficiency distribution (Berger and Humphrey, 1997).

Traditional DEA and SFA cannot deal with the spatial dependence of variables, and the result might lead to bias if spatial dependence exists within the research target. There is emerging literature on spatial stochastic frontier modelling that combines spatial econometrics with SFA. It began with adding a spatial parameter into frontier efficiency analysis with a distribution free approach. Druska and Horrace (2004) extend the cross-sectional model of Kelejian and Prucha (1999) by adding spatial correlation parameters into frontier framework with a fixed-effect model and measure time-invariant efficiency of Indonesian rice farms. Glass et al. (2013, 2014b) employ a similar model, but measure time-varying efficiency under SFA following Cornwell et al. (1990).

Later, Glass et al. (2016a) (GKS from hereon) combine SFA with spatial econometrics as a spatial autoregressive stochastic frontier and a spatial Durbin stochastic frontier for panel data. The spatial autoregressive stochastic frontier accounts for spatial lag of dependent variables, and the spatial Durbin stochastic frontier accounts for spatial lag of both dependent and independent variables. They calculate efficiency by assuming a half-normal distribution of inefficiency component and—following Schmidt and Sickles (1984)—obtain time-varying direct, asymmetric indirect and asymmetric total efficiencies. Glass et al. (2016b) develop the GKS model of latent heterogeneity by estimating a four error structure; they also introduce a spatial efficiency multiplier that separates asymmetric system efficiency from its own efficiency and asymmetric efficiency spillover from other units. At the same time, Tsionas and Michaelides (2016) also employ a spatial inefficiency model and the inefficiency term is spatial autoregressive in the Bayesian econometrics. Kutlu (2018) follows the GKS model and provides another way to measure efficiency under a spatial autoregressive stochastic frontier. The advantages of GKS model are allowing spatial lag of dependent and independent variables in model estimations; it can also capture spatial relationship and spillover within spatial context. The model proposed by Glass et al. (2016a, 2016b) can measure spatial relationships and spillover for research targets that carry with spatial dependence. Therefore, the model is suitable for regional banking analysis.

Instead of traditional production function, this chapter uses spatial production function (Glass et al., 2016a; 2016b) to measure the relationship between inputs and output(s). The reason this chapter employs a production function rather than cost or profit function is the nature of urban commercial banks; as emerging banks, urban commercial banks mainly focus on traditional banking business that transfers deposits into loans. The other operating income of urban commercial banks is 1.5 billion RMB compared to total loans of 112 billion RMB, which is only 1.3 per cent[40]. This chapter also looks at the spatial relationship between the different regions. The general production function can be written as:

$$y_{it} = f(x_{it};\beta) * TE_{it} \quad (4.1)$$

In this function, y_{it} is the vector of produced output from total N observed banks i, i = 1,…, N, at time period T, t = 1,…, T, x_{it} is vector of input which producer *i* used for process during time t, $f(x_{it};\beta)$ is the production frontier, β is a technology parameter to be estimated, and TE_{it} represents the output-oriented technical efficiency for each bank *i* over time t. In order to capture the effect of random shock or idiosyncratic error, Equation 4.1 can be rewritten as:

$$y_{it} = f(x_{it};\beta) * exp\{v_{it}\} * TE_{it} \quad (4.2)$$

where $exp\{v_{it}\}$ represents the idiosyncratic error. As we know $TE_{it} = exp\{-\mu_{it}\}$ and we can re-write the production function as:

---

[40] Data from Orbis Bank Focus.

$$y_{it} = f\left(x_{it};\beta\right) * exp\left\{v_{it}\right\} * \exp\{\mu_{it}\} \tag{4.3}$$

Then take $f\left(x_{it};\beta\right)$ into translog form (Christensen et al., 1973) so that the function is represented as:

$$\ln y_{it} = \alpha + \beta \sum_{h=1}^{H} \sum_{i=1}^{N} \ln x_{hit} + \tfrac{1}{2} \rho \sum_{h=1}^{H} \sum_{i=1}^{N} (\ln x_{hit})^2 + \lambda \sum_{h=1}^{H} \sum_{i=1}^{N} \ln x_{hit} \ln x_{(h+1)it} + v_{it} - \mu_{it} \tag{4.4}$$

where the random error is $\varepsilon_{it} = v_{it} - \mu_{it}$, v_{it} is the random noise component, and μ_{it} is the technical inefficiency component. It requires that $\mu \geq 0$, then there is $TE_{it} = \exp\{-\mu\} \leq 1$. The random noise component v_{it} assumed to be i.i.d. and symmetric and independently distributed with μ_{it}, therefore the random error ε_{it} is asymmetric. The vectors α, β, ρ, and λ are regression parameters which describe the relationship between inputs and outputs, h of x_{hit} indicates the different input variables h = 1,…,H, for each bank i during time t. For the spatial production function, spatial lags of the independent and dependent variables are added into traditional production function. Adding spatial lags of the dependent variable forms the spatial autoregressive production frontier model, and adding both spatial lags of the independent and dependent variables forms the spatial Durbin production frontier model. This analysis applies both methodologies. Therefore, this chapter can investigate the relationship of a bank's input and output variables relative to the banks operating in contiguous regions. For the spatial analysis, I create spatial contiguity matrix which covers all data regions. I give equal weights (which sum to one) for each region's neighbour and give zero value for the region itself and the non-neighbouring provinces.

4.3.3 Model

For the spatial stochastic production frontier estimation, this analysis applies both spatial autoregressive production frontier (SAPF) model and spatial Durbin production frontier (SDPF) model. The difference between these two models is that the SAPF model contains spatial lag of the dependent variables and the SDPF model contains lags of both dependent and independent variables. For SAPF model, Equation 4.4 can be rewritten as:

$$\begin{aligned} \ln y_{\mathrm{it}} &= \alpha + \beta \sum_{h=1}^{H} \sum_{i=1}^{N} \ln \mathrm{x}_{\mathrm{hit}} + \tfrac{1}{2} \rho \sum_{h=1}^{H} \sum_{i=1}^{N} (\ln x_{\mathrm{hit}})^2 + \\ & \lambda \sum_{h=1}^{H} \sum_{i=1}^{N} \ln x_{\mathrm{hit}} \ln x_{\mathrm{(h+1)it}} + \delta \sum_{\mathrm{k}=1}^{\mathrm{N}} \sum_{i=1}^{N} w_{ik} y_{kt} + v_{\mathrm{it}} + \kappa_{\mathrm{i}} - \mu_{\mathrm{it}} - \eta_i \end{aligned} \quad (4.5)$$

where $\delta \sum_{k=1}^{N} \sum_{i=1}^{N} w_{ik} y_{kt}$ is the spatial lag of the dependent variable, δ is the spatial parameter that needs to be estimated, w_{ik} indicates the spatial arrangement of each individual bank where $i \neq k$. For the SDPF model, I add spatial lags of independent variables into Equation 4.5, written as:

$$
\begin{aligned}
\ln y_{it} &= \alpha + \beta \sum_{h=1}^{H} \sum_{i=1}^{N} \ln x_{hit} + \tfrac{1}{2} \rho \sum_{h=1}^{H} \sum_{i=1}^{N} (\ln x_{hit})^2 + \\
&\lambda \sum_{h=1}^{H} \sum_{i=1}^{N} \ln x_{hit} \ln x_{(h+1)it} + \delta \sum_{k=1}^{N} \sum_{i=1}^{N} w_{ik} y_{kt} + \\
&\phi \sum_{j=1}^{N} \sum_{i=1}^{N} \sum_{h=1}^{H} w_{ij} x_{hjt} + v_{it} + \kappa_i - \mu_{it} - \eta_i
\end{aligned}
\qquad (4.6)
$$

where $\phi \sum_{j=1}^{N} \sum_{i=1}^{N} \sum_{h=1}^{H} w_{ij} x_{hjt}$ is spatial lag of independent variables, vector ϕ is spatial parameter, and—same as the SAPF model— w_{ij} indicates the spatial arrangement of each individual bank where $i \neq j$.

These two spatial models include four error components, which are $\varepsilon_{it}^{*} = \varepsilon_{it} + \varepsilon_i = v_{it} + \kappa_i - \mu_{it} - \eta_i$ where $\varepsilon_{it} = v_{it} - \mu_{it}$ is the time variant component and $\varepsilon_i = \kappa_i - \eta_i$ is the time invariant component. To deal with distributional assumption of the four error component, random effect has been used. Within

Equations 4.5 and 4.6, v_{it} is the standard idiosyncratic error based on unobserved heterogeneity of random effects. κ_{i} is time invariant random error of unit specific effect. μ_{it} is net time variant inefficiency and η_i is net time invariant inefficiency. Both of these two inefficiencies are assumed to be half-normally distributed. Then gross inefficiency is computed by combining these two inefficiencies, $\mathrm{GVI}=\mathrm{NVI}*\mathrm{NII}=\mu_{\mathrm{it}}*\eta_i$. The resulting inefficiency measure gross inefficiency, which is time variant inefficiency (Glass and Kenjegalieva, 2019). By separating inefficiency into NVI and NII components, this chapter can observe any effects caused by market restructure to short-run and persistent efficiency.

4.3.4 Elasticities of Spatial Production Model

It has been well-established that the fitted parameters for the exogenous repressors are not elasticities for a model that contains a spatial autoregressive variable. To deal with the effect of the spatial autoregressive variable for exogenous regressors, this analysis provides direct, indirect and total elasticities by using the fitted parameters from SAPF and SDPF model. The direct elasticity contains effects of feedback from the spatial matrix. It is measured the same way as non-spatial model elasticity.

There are two explanations of indirect elasticity: 1) average change of the dependent variable from remaining units in the sample following a change of an independent variable from one observed unit; 2) average change of the dependent variable from one observed unit following a change of an independent variable from remaining units in the sample. The sum of direct and indirect elasticities is total elasticity.

4.4 Results and Discussion

4.4.1 Residual Skewness Test

To begin the analysis, I first run an ordinary least squares (OLS) residual skewness test (Schmidt and Lin, 1984) for the validity of our model's stochastic frontier specification. Based on production function, I expect the residual should skew to the left, which indicates that the skewness test result should be negative. I run the pooled OLS first to get results for the residual skewness check. The residuals result shows an expected negative result (-0.73) for skewness. Thus, I can reject the null hypothesis of non-skewness of OLS residual. Details of residual and skewness test results are provided in the appendices.

4.4.2 Model Results

Table 4.2 provides details of the SAPF model and the SDPF model estimated results. Based on the monotonicity property of the production function (Kumbhakar and Lovell, 2003), an increase of inputs should lead to an increase in output. The output should be convex with respect to inputs. Therefore, I expect a positive relationship between input variables and the output variable.

The three input variables denoted as lx1, lx2, and lx3, are deposits, labour, and fixed assets respectively. Both the SAPF model and the SDPF model report positive and significant results for all input variables coefficients. This result supports the monotonicity properties of the production function at sample mean. Looking at the SAPF model results, the coefficient of deposits (lx1), labour (lx2), and fixed assets (lx3) are 0.738, 0.072, and 0.118 with significance. The values of coefficients under the SDPF model for these three variables are similar and same in significance level. Among input variables, deposits have the most impact on the banking production of output loans compared to the other two inputs. The coefficients of interaction variables have non-significance for both models except square labour (lx2x2). The coefficient of square labour of the SAPF model is -0.033 and -0.038 for the SDPF model. It indicates that urban commercial banks are inefficient in labour product. More labour involved will lead to a decrease in production. By looking back at the coefficient of labour, it is 0.072 of the SAPF model and 0.083 of the SDPF model. It implies the minor contribution of the labour to banks production. The SDPF model has spatial lags of independent variables. There are no significant coefficients of the spatial lag of independent variables except square deposits (wlx1x1). The coefficient of spatial lag of square deposits is 0.142 with one-star significance. This might imply that if deposits of an urban commercial bank have a large increase, their neighbour region's banks' loans will increase as well. The coefficient of the spatial lag of dependent variable δ is 0.183 of the SAPF model and 0.324 of SDPF model with significance. It describes that the spatial autoregressive dependence of loans across the 65 urban commercial banks exists. Therefore, by identifying the spatial dependence of urban commercial banks, the efficiency results provided by this chapter will be more accurate than a traditional production frontier.

The details of direct, indirect and total elasticities are presented in Table 4.3. The value and significance of direct elasticities for the SAPF and SDPF models are similar to their coefficients in Table 4.2.

Table 4.2 Spatial Production Model Estimated Result

Variables	Parameter	SAPF with Random Effect	SDPF with Random Effect
lx1	β_1	0.738***	0.716***
lx2	β_2	0.072**	0.083**
lx3	β_3	0.118***	0.121***
lx1x1	ρ_{11}	0.03	0.029
lx2x2	ρ_{22}	-0.033*	-0.038**
lx3x3	ρ_{33}	0.02	0.018
lx1x2	λ_{12}	0.019	0.026
lx1x3	λ_{13}	-0.039	-0.04
lx2x3	λ_{23}	0.002	0.007
_cons	α	-0.005	0.024
wlx1	ϕ_1		-0.181
wlx2	ϕ_2		-0.118
wlx3	ϕ_3		0.041
wlx1x1	ϕ_{11}		0.142*
wlx2x2	ϕ_{22}		0.078
wlx3x3	ϕ_{33}		-0.042
wlx1x2	ϕ_{12}		-0.117
wlx1x3	ϕ_{13}		-0.121
wlx2x3	ϕ_{23}		-0.092
rho	δ	0.183***	0.324**

Note: ***, **, and * represent statistically significance at 1%, 5%, and 10% level.

For indirect and total elasticities, the SAPF model has positive and significant in inputs variables, which satisfies the monotonicity property of production function. Only labour has no three-star significance level compared to deposits and fixed assets. Furthermore, the elasticities of interaction variables are also non-significant, except square labour of total elasticity. For the SDPF model, indirect elasticities are all non-significant. Therefore, the significant results of the total elasticities of the SDPF model were contributed by the direct elasticities.

Table 4.3 Direct, Indirect, and Total Elasticities for SAPF and SDPF Model

	SAPF			**SDPF**		
	Direct	Indirect	Total	Direct	Indirect	Total
lx1	0.740***	0.164***	0.905***	0.717***	0.096	0.814***
lx2	0.074**	0.017*	0.091**	0.082**	−0.148	−0.066
lx3	0.119***	0.026***	0.145***	0.124***	0.122	0.246*
lx1x1	0.030	0.006	0.036	0.034	0.196	0.230*
lx2x2	−0.033*	−0.007	−0.040*	−0.035*	0.116	0.082
lx3x3	0.025	0.006	0.031	0.021	−0.063	−0.042
lx1x2	0.022	0.005	0.027	0.025	−0.167	−0.143
lx1x3	−0.044	−0.010	−0.053	−0.048	−0.158	−0.206
lx2x3	−0.004	−0.001	−0.005	−0.002	−0.134	−0.136

Note: ***, **, and * represent statistically significance at 1%, 5%, and 10% level.

4.4.3 Net and Gross Efficiency Results

Based on the SAPF model and SDPF model estimation, there are three efficiency results for each model: Net Time-Variant Efficiency (NVE), Net Time-Invariant Efficiency (NIE), and Gross Time-Variant Efficiency (GVE). Table 4.4 here provides a summary of the efficiency results.

Table 4.4 Summary of Net and Gross Efficiency Results

Model	Mean	Std. Dev.	Min	Max
NVE of SAPF	93.09%	0.037	76.12%	98.22%
NIE of SAPF	82.38%	0.101	52.92%	95.49%
GVE of SAPF	76.76%	0.104	43.42%	93.03%
NVE of SDPF	93.22%	0.037	77.51%	98.08%
NIE of SDPF	82.45%	0.102	52.06%	96.18%
GVE of SDPF	76.93%	0.105	42.90%	92.68%

Note: NVE for Net Time-Variant Efficiency, NIE for Net Time-Invariant Efficiency, GVE for Gross Time-Variant Efficiency

Each type of efficiency results (NVE, NIE, and GVE) under the SAPF and SDPF models are close, and NIE and GVE results provide a much wider range of efficiency scores compared to NVE. For example, the average efficiencies of NVE, NIE, and GVE in the SAPF model are 0.93, 0.82, and 0.77 respectively. NVE represents short-run efficiency, NIE represents persistent efficiency, and GVE presents total efficiency. There is difference between short-run and long-run (persistent) efficiency. By looking at the minimum efficiency, NVE is 0.76 and NIE is 0.53 for the SAPF model. The lowest efficient bank has lower long-term efficiency than short-run efficiency. Therefore, the market contributes to short-ruin efficiency improvement of urban commercial banks. The maximum efficiencies of NVE, NIE, and GVE are 0.98, 0.95, 0.93. These are quite close, which means most efficient urban commercial banks keep their performance stable.

Figures 4.1 to 4.3 display the histogram of efficiency distribution for the SAPF model. As the figures demonstrate, short-run efficiencies (NVE) of Chinese urban commercial banks are concentrated around 0.95 and long-run efficiencies (NIE) are scattered between 0.6 to 0.95. This also confirms that the market restructure contributed to efficiency improvement in Chinese urban commercial banks. The total efficiency (GVE) is combination of short-run and long-run efficiency; it is concentrated around 0.8.

Figure 4.1 Histogram of NVE Result for SAPF Model

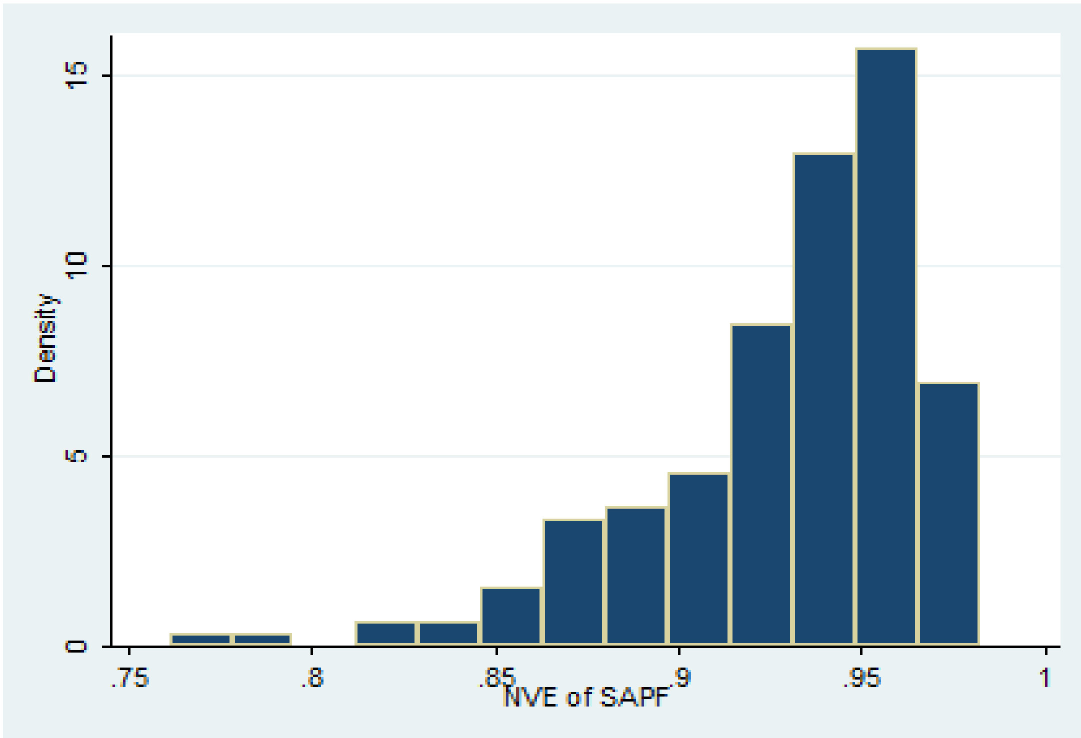


Figure 4.2 Histogram of NIE Result for SAPF Model

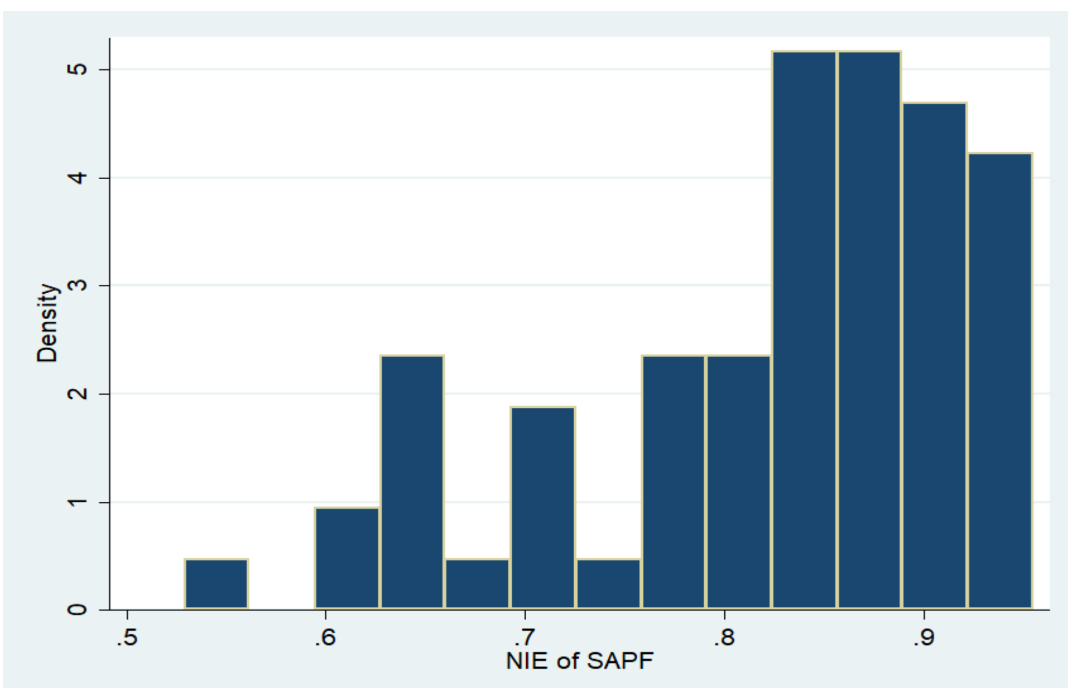
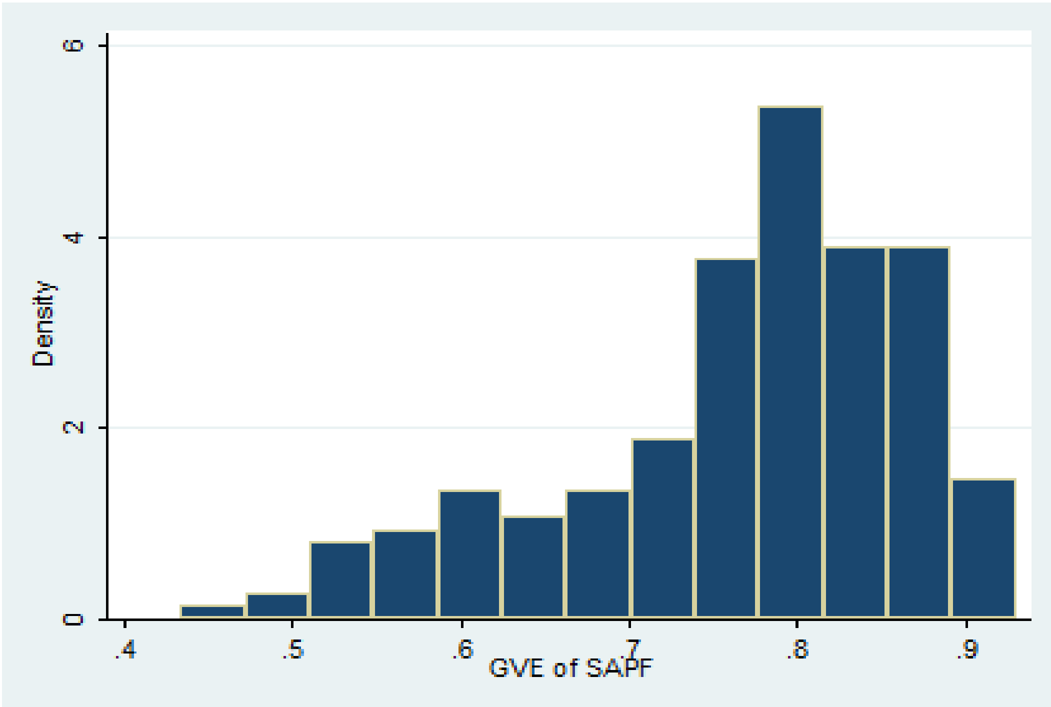


Figure 4.3 Histogram of GVE Result for SAPF Model



Figures 4.4 to 4.6 present the histogram of efficiency distribution for the SDPF model. The distribution state of the SDPF model is close to the SAPF model. The short-run efficiencies are concentrated around 0.95. However, compared to the SAPF model, the long-run efficiencies of the SDPF model are scattered between 0.7 to 0.95. The lower efficiency banks have higher efficiency scores under the SDPF model comparing to the SAPF model. The total efficiencies of the SDPF model are shifted up, concentrating around 0.85.

Figure 4.4 Histogram of NVE Result for SDPF Model

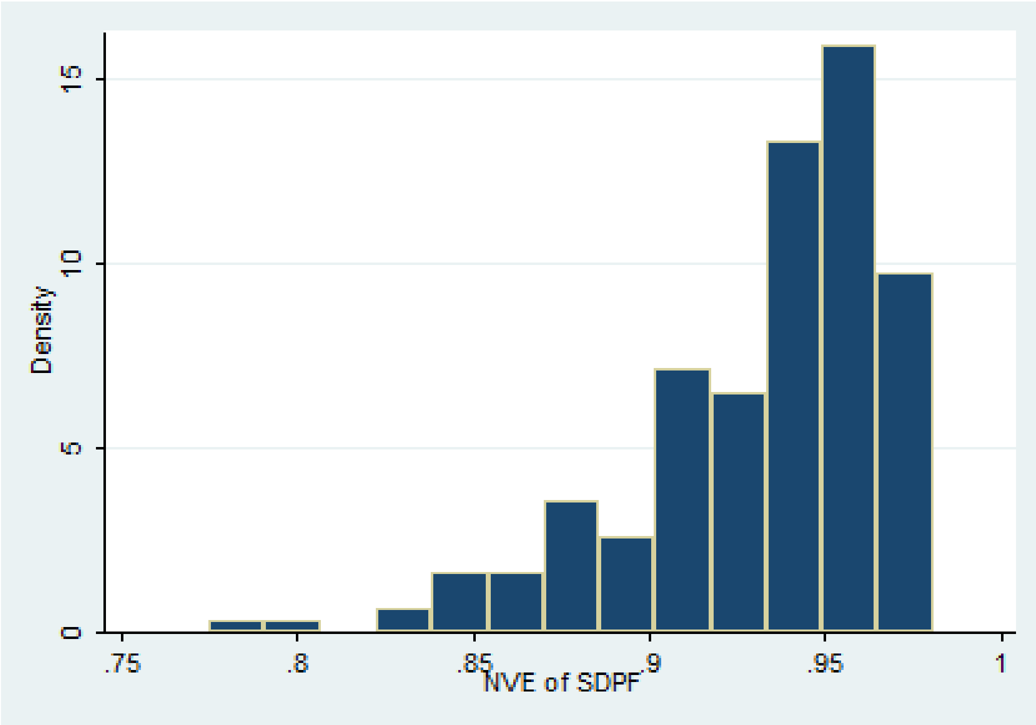


Figure 4.5 Histogram of NIE Result for SDPF Model

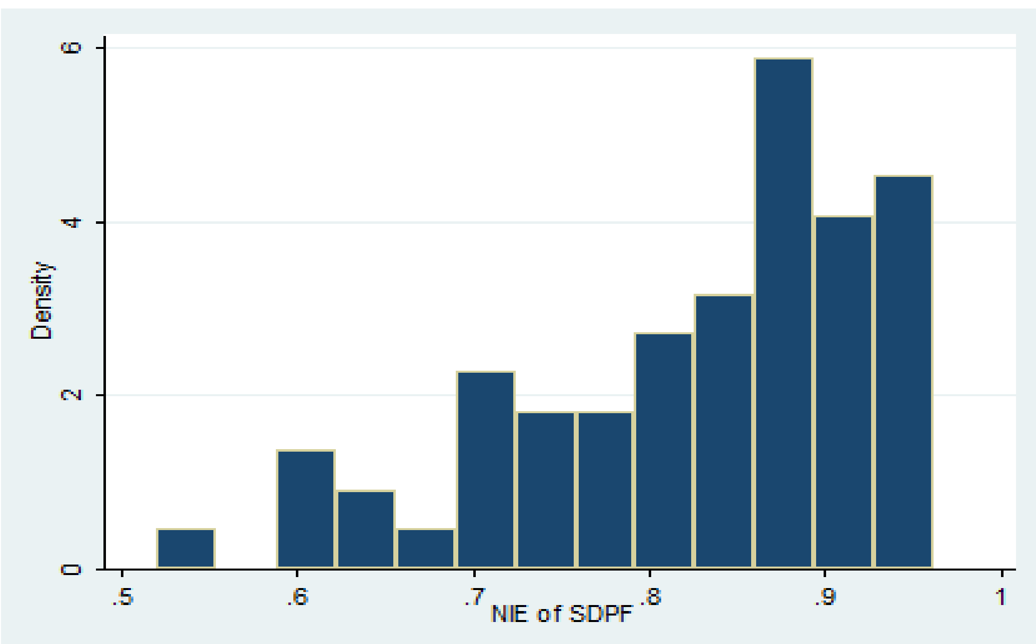
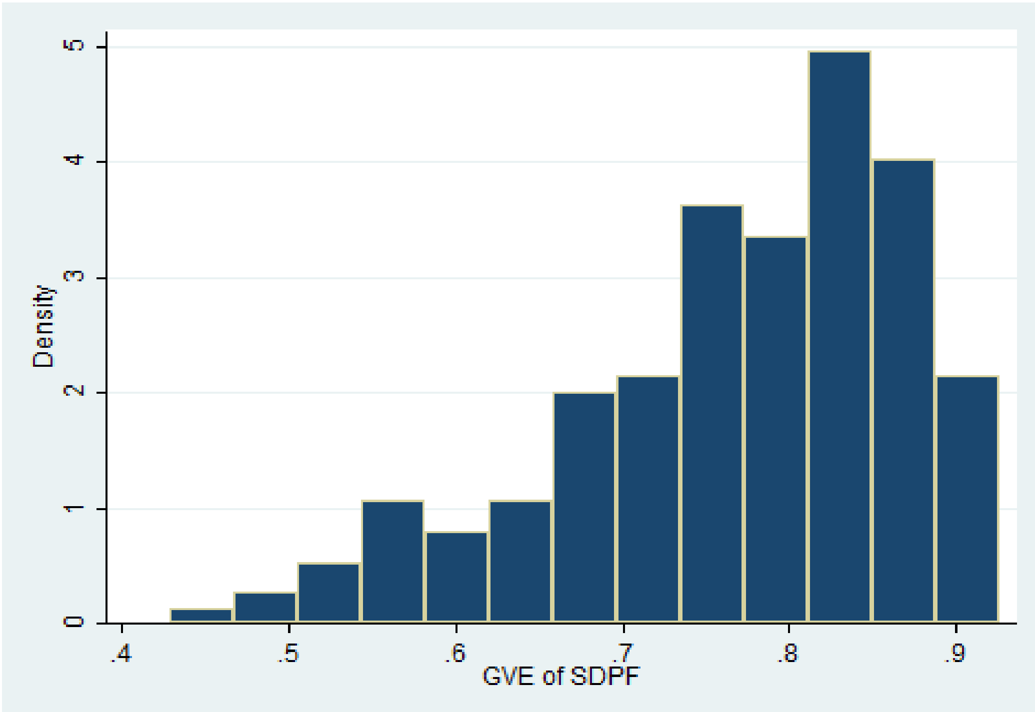


Figure 4.6 Histogram of GVE Result for SDPF Model



To illuminate the efficiency distribution of each region, Figures 4.7 and 4.8 show the geographical distribution of total efficiency on a Chinese map. Dark areas mean that the region has a higher efficiency score. The geographical distribution of total efficiency (GVE) is similar for the SAPF and SDPF models. As these figures display, most eastern regions have a darker colour than western regions. And eastern regions have advantage in economy, population, and number of urban commercial banks compared to western regions (details in appendices).

Figure 4.7 Geographical Distribution of GVE (SAPF) Model

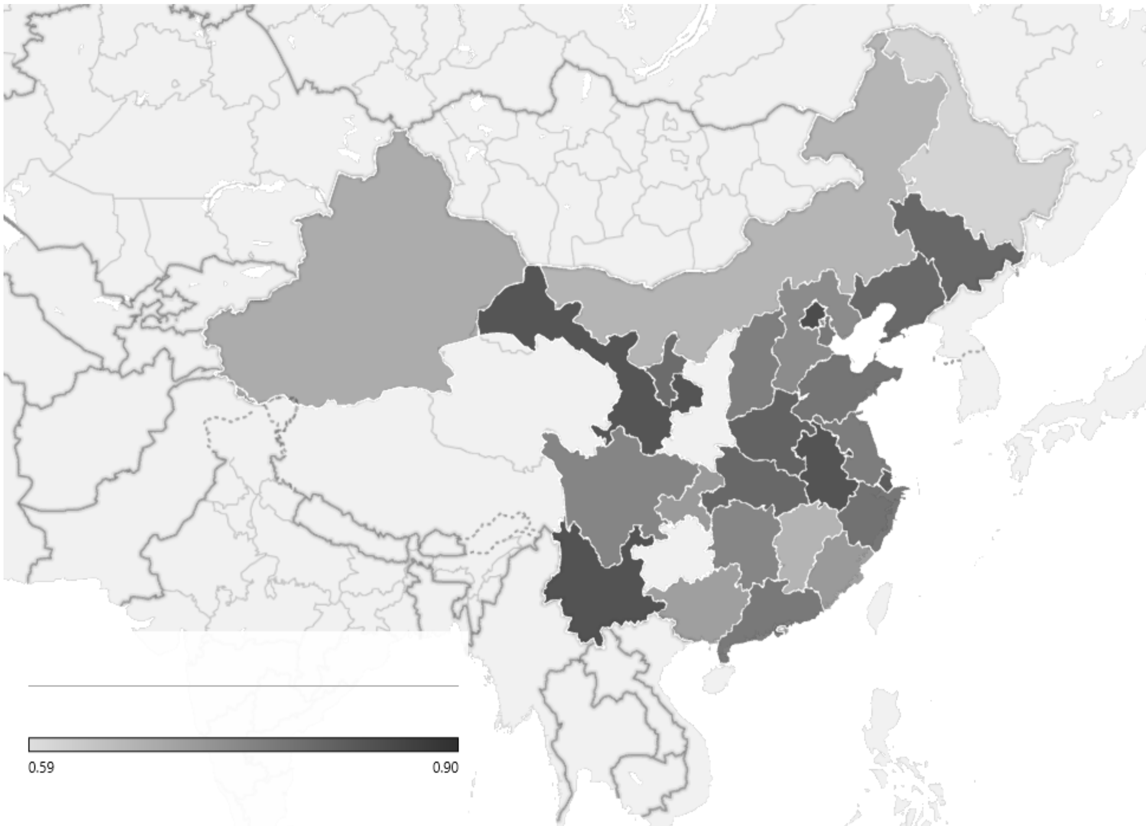
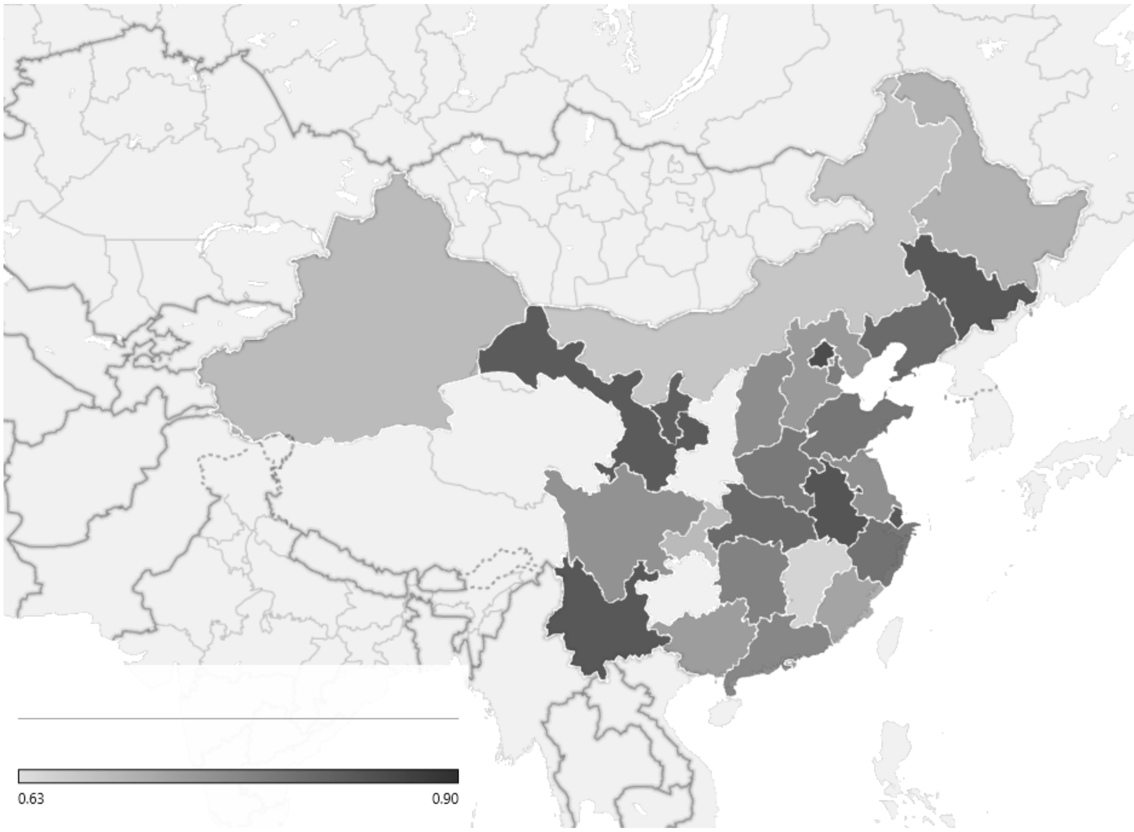


Figure 4.8 Geographical Distribution of GVE (SDPF) Model



To compare the efficiency of each region, Tables 4.5 to 4.7 give details of the efficiency result of the SAPF model for each region. The efficiency scores have been ordered from largest to smallest for mean, minimum and maximum, and respective rankings have been provided. Because of the data availability, some regions only display one bank in the sample. However, they contain more than one but less than three urban commercial banks in their region, except Shanxi and Xinjiang (Shanxi has six and Xinjiang has five urban commercial banks). The rest of the regions have more than three urban commercial banks (except Heilongjiang, Hunan, Guangxi, and Chongqing).

Table 4.5 Results of NVE of SAPF Models for Each Region

Region	No. of banks	Mean	Ranking	Min	Ranking	Max	Ranking
Beijing	<3	94.53%	1	91.88%	4	96.20%	19
Tianjin	<3	93.14%	14	87.64%	12	96.18%	20
Hebei	>3	92.92%	19	86.96%	15	97.69%	6
Shanxi	>3	93.53%	8	91.45%	6	95.52%	23
Inner Mongolia	>3	91.83%	25	85.10%	21	98.06%	2
Liaoning	>3	93.68%	6	90.76%	8	97.26%	11
Jilin	<3	93.77%	5	91.49%	5	95.92%	21
Heilongjiang	<3	91.80%	26	86.03%	17	97.32%	8
Shanghai	<3	93.56%	7	88.97%	11	97.20%	12
Jiangsu	>3	93.35%	10	89.16%	10	97.66%	7
Zhejiang	>3	93.29%	13	78.22%	25	97.74%	4
Anhui	<3	93.10%	15	85.91%	18	97.85%	3
Fujian	>3	92.74%	21	82.05%	24	96.45%	17
Jiangxi	>3	92.34%	24	82.71%	23	96.94%	14
Shandong	>3	93.50%	9	87.29%	14	96.52%	15
Henan	>3	93.32%	11	85.82%	19	97.28%	10
Hubei	<3	92.80%	20	87.48%	13	97.74%	5
Hunan	<3	93.00%	17	85.79%	20	96.43%	18
Guangdong	>3	92.50%	22	76.12%	26	98.22%	1
Guangxi	=3	92.41%	23	83.24%	22	97.31%	9
Chongqing	<3	93.02%	16	89.43%	9	96.48%	16
Sichuan	>3	93.29%	12	86.53%	16	97.07%	13
Yunnan	=3	94.48%	2	93.60%	2	95.03%	25
Gansu	<3	94.43%	3	93.93%	1	94.80%	26
Ningxia	<3	93.79%	4	92.61%	3	95.84%	22
Xinjiang	>3	92.99%	18	91.11%	7	95.41%	24

Table 4.6 Results of NIE of SAPF Models for Each Region

Region	No. of banks	Mean	Ranking	Min	Ranking	Max	Ranking
Beijing	<3	95.49%	1	95.49%	1	95.49%	1
Tianjin	<3	84.52%	14	84.52%	10	84.52%	20
Hebei	>3	79.44%	19	60.71%	25	90.23%	12
Shanxi	>3	82.66%	16	82.66%	12	82.66%	22
Inner Mongolia	>3	69.05%	24	67.00%	20	71.10%	24
Liaoning	>3	88.36%	9	82.83%	11	93.90%	6
Jilin	<3	88.79%	8	88.79%	7	88.79%	16
Heilongjiang	<3	63.99%	26	62.99%	23	64.99%	26
Shanghai	<3	91.97%	5	91.97%	5	91.97%	9
Jiangsu	>3	83.32%	15	75.97%	16	95.26%	3
Zhejiang	>3	86.23%	11	69.92%	19	95.30%	2
Anhui	<3	94.68%	2	94.68%	2	94.68%	4
Fujian	>3	75.72%	20	52.92%	26	88.17%	17
Jiangxi	>3	69.04%	25	63.17%	22	79.38%	23
Shandong	>3	85.39%	12	79.97%	13	91.58%	11
Henan	>3	90.42%	6	88.31%	8	91.69%	10
Hubei	<3	89.56%	7	89.56%	6	89.56%	13
Hunan	<3	81.13%	17	78.51%	15	83.75%	21
Guangdong	>3	85.03%	13	78.57%	14	93.93%	5
Guangxi	=3	74.51%	22	61.83%	24	89.55%	14
Chongqing	<3	75.69%	21	64.84%	21	86.55%	19
Sichuan	>3	81.04%	18	75.28%	17	89.26%	15
Yunnan	=3	93.73%	3	93.73%	3	93.73%	7
Gansu	<3	93.20%	4	93.20%	4	93.20%	8
Ningxia	<3	87.57%	10	87.57%	9	87.57%	18
Xinjiang	>3	70.73%	23	70.73%	18	70.73%	25

Table 4.7 Results of GVE of SAPF Models for Each Region

Region	No. of banks	Mean	Ranking	Min	Ranking	Max	Ranking
Beijing	<3	90.27%	1	87.74%	1	91.87%	3
Tianjin	<3	78.72%	13	74.07%	12	81.29%	20
Hebei	>3	73.96%	19	52.79%	24	86.87%	14
Shanxi	>3	77.31%	16	75.60%	10	78.95%	22
Inner Mongolia	>3	63.43%	25	57.01%	20	67.24%	25
Liaoning	>3	82.79%	9	75.58%	11	91.33%	4
Jilin	<3	83.25%	7	81.23%	6	85.16%	15
Heilongjiang	<3	58.75%	26	54.19%	22	61.65%	26
Shanghai	<3	86.04%	5	81.82%	4	89.40%	6
Jiangsu	>3	77.81%	15	68.31%	14	93.03%	1
Zhejiang	>3	80.50%	11	54.69%	21	91.09%	5
Anhui	<3	88.15%	3	81.34%	5	92.64%	2
Fujian	>3	70.43%	21	43.42%	26	84.05%	17
Jiangxi	>3	63.81%	24	53.42%	23	75.54%	23
Shandong	>3	79.85%	12	70.31%	13	88.00%	11
Henan	>3	84.38%	6	78.38%	8	89.20%	7
Hubei	<3	83.11%	8	78.34%	9	87.53%	12
Hunan	<3	75.47%	18	67.36%	15	80.26%	21
Guangdong	>3	78.68%	14	66.48%	16	89.09%	8
Guangxi	=3	68.96%	22	51.46%	25	86.96%	13
Chongqing	<3	70.47%	20	57.99%	19	83.50%	19
Sichuan	>3	75.64%	17	65.14%	17	85.16%	16
Yunnan	=3	88.56%	2	87.73%	2	89.08%	9
Gansu	<3	88.01%	4	87.55%	3	88.36%	10
Ningxia	<3	82.13%	10	81.10%	7	83.93%	18
Xinjiang	>3	65.77%	23	64.44%	18	67.48%	24

For short-run efficiency (NVE), Beijing (which has the biggest urban commercial bank: Bank of Beijing) has the highest average efficiency ranking. Ranking after Beijing are three western regions: Yunnan, Gansu, and Ningxia. These four regions have fewer urban commercial banks and the minimum efficiency raking of these four regions also rank in the top five. However, except Yunnan, Gansu, and Ningxia, the rest of the regions ranking in the top ten are all eastern regions. By looking at maximum efficiency results, regions with more urban commercial banks rank higher. For example, Guangdong ranks first and Inner Mongolia ranks second. But these regions with more banks have a lower ranking place of minimum efficiency. For long-run efficiency (NIE), Beijing ranks first in average, minimum, and maximum results. Yunnan and Gansu have average efficiency, ranking in third and fourth. The average efficiency ranking of Ningxia move to tenth. The ranking of minimum efficiency is similar to short-run efficiency. Ranking second and third in maximum efficiency are Zhejiang and Jiangsu—eastern regions. In fact, all eight of the top ten ranking regions of maximum efficiency are eastern regions. By looking at total efficiency (GVE), the ranking is similar to the long-run (NIE) ranking result. Beijing still ranks first on average and minimum efficiency. Except Yunnan, Gansu, and Ningxia, the rest of the top-ranking regions are eastern regions. For the SDPF model, Table 4.8 to 4.10 summarise the efficiency results and ranking for each region.

Table 4.8 Results of NVE of SDPF Model for Each Region

Region	No. of banks	Mean	Ranking	Min	Ranking	Max	Ranking
Beijing	<3	94.66%	1	93.02%	4	95.91%	20
Tianjin	<3	93.48%	10	89.08%	11	95.74%	21
Hebei	>3	92.93%	18	86.75%	17	97.91%	3
Shanxi	>3	93.59%	9	92.05%	6	95.31%	22
Inner Mongolia	>3	92.00%	26	83.93%	22	98.08%	1
Liaoning	>3	93.73%	8	90.65%	7	97.48%	9
Jilin	<3	94.13%	5	92.87%	5	96.58%	17
Heilongjiang	<3	92.30%	25	85.22%	20	97.66%	6
Shanghai	<3	93.91%	6	89.86%	9	97.22%	13
Jiangsu	>3	93.40%	12	89.47%	10	97.49%	8
Zhejiang	>3	93.41%	11	79.22%	25	97.64%	7
Anhui	<3	93.25%	15	86.31%	18	97.84%	4
Fujian	>3	92.88%	20	82.42%	24	96.55%	18
Jiangxi	>3	92.50%	24	83.83%	23	96.87%	14
Shandong	>3	93.73%	7	87.90%	13	96.65%	16
Henan	>3	93.05%	17	85.09%	21	97.47%	10
Hubei	<3	92.84%	21	87.61%	14	97.80%	5
Hunan	<3	93.38%	13	86.97%	15	96.27%	19
Guangdong	>3	92.64%	22	77.51%	26	98.06%	2
Guangxi	=3	92.88%	19	85.25%	19	97.30%	11
Chongqing	<3	92.50%	23	87.97%	12	97.25%	12
Sichuan	>3	93.32%	14	86.78%	16	96.80%	15
Yunnan	=3	94.45%	2	93.95%	1	94.92%	25
Gansu	<3	94.35%	3	93.94%	2	94.64%	26
Ningxia	<3	94.24%	4	93.68%	3	95.16%	24
Xinjiang	>3	93.14%	16	90.28%	8	95.24%	23

Table 4.9 Results of NIE of SDPF Model for Each Region

Region	No. of banks	Mean	Ranking	Min	Ranking	Max	Ranking
Beijing	<3	95.32%	1	95.32%	1	95.32%	2
Tianjin	<3	84.58%	13	84.58%	9	84.58%	20
Hebei	>3	78.12%	19	58.98%	25	90.31%	14
Shanxi	>3	80.94%	16	80.94%	13	80.94%	22
Inner Mongolia	>3	68.88%	25	67.10%	21	70.66%	25
Liaoning	>3	88.89%	9	82.95%	11	94.82%	3
Jilin	<3	92.95%	4	92.95%	4	92.95%	8
Heilongjiang	<3	73.01%	22	71.50%	18	74.52%	24
Shanghai	<3	93.35%	3	93.35%	3	93.35%	7
Jiangsu	>3	80.40%	17	71.61%	17	94.72%	5
Zhejiang	>3	87.45%	10	70.41%	19	96.18%	1
Anhui	<3	94.73%	2	94.73%	2	94.73%	4
Fujian	>3	75.74%	21	52.06%	26	89.61%	16
Jiangxi	>3	67.79%	26	62.21%	23	78.26%	23
Shandong	>3	86.36%	11	81.33%	12	92.32%	11
Henan	>3	86.26%	12	83.59%	10	88.27%	18
Hubei	<3	89.68%	8	89.68%	8	89.68%	15
Hunan	<3	83.69%	14	80.61%	14	86.78%	19
Guangdong	>3	83.10%	15	75.85%	15	93.64%	6
Guangxi	=3	77.61%	20	64.88%	22	92.46%	10
Chongqing	<3	71.12%	23	59.82%	24	82.41%	21
Sichuan	>3	79.85%	18	73.69%	16	89.18%	17
Yunnan	=3	92.81%	5	92.81%	5	92.81%	9
Gansu	<3	92.03%	6	92.03%	6	92.03%	12
Ningxia	<3	91.17%	7	91.17%	7	91.17%	13
Xinjiang	>3	70.37%	24	70.37%	20	70.37%	26

Table 4.10 Results of GVE of SDPF Model for Each Region

Region	No. of banks	Mean	Ranking	Min	Ranking	Max	Ranking
Beijing	<3	90.23%	1	88.67%	1	91.43%	5
Tianjin	<3	79.06%	13	75.34%	9	80.98%	20
Hebei	>3	72.75%	19	51.16%	25	87.26%	13
Shanxi	>3	75.76%	16	74.51%	11	77.15%	22
Inner Mongolia	>3	63.39%	25	56.32%	20	67.31%	25
Liaoning	>3	83.32%	8	75.20%	10	92.43%	2
Jilin	<3	87.49%	5	86.33%	4	89.78%	7
Heilongjiang	<3	67.40%	22	60.93%	19	71.41%	24
Shanghai	<3	87.66%	3	83.89%	6	90.76%	6
Jiangsu	>3	75.13%	17	64.24%	16	92.34%	3
Zhejiang	>3	81.75%	10	55.78%	21	92.20%	4
Anhui	<3	88.33%	2	81.77%	7	92.68%	1
Fujian	>3	70.58%	21	42.90%		85.55%	17
Jiangxi	>3	62.75%	26	52.73%	23	74.63%	23
Shandong	>3	80.94%	11	72.28%	13	88.67%	10
Henan	>3	80.26%	12	73.57%	12	86.04%	16
Hubei	<3	83.26%	9	78.57%	8	87.71%	12
Hunan	<3	78.16%	14	70.10%	14	82.91%	19
Guangdong	>3	77.02%	15	64.66%	15	88.89%	9
Guangxi	=3	72.19%	20	55.30%	22	89.61%	8
Chongqing	<3	65.84%	23	52.63%	24	80.15%	21
Sichuan	>3	74.56%	18	63.95%	17	85.15%	18
Yunnan	=3	87.66%	4	87.19%	2	88.09%	11
Gansu	<3	86.84%	6	86.45%	3	87.10%	14
Ningxia	<3	85.92%	7	85.41%	5	86.75%	15
Xinjiang	>3	65.55%	24	63.53%	18	67.02%	26

As Table 4.8 describes, Yunnan, Gansu, and Ningxia still rank top of average and minimum short-run efficiency. Nine regions of the top ten ranking of maximum efficiency are eastern regions. The ranking is similar to the SAPF model (Table 4.5). Same to ranking of long-run and total efficiency of the SDPF model, Beijing still ranks as first on average and minimum efficiency. And Yunnan, Gansu, and Ningxia are the only western regions in the top ten ranking. The ranking order of the SAPF and SDPF models are highly similar in short-run, long-run, and total efficiency.

The average efficiency scores have similar rankings for each region on both models' results. By looking at the number of banks and their ranking, if regions only have one urban commercial bank in the sample, they achieve a higher average and minimum efficiency score when compared to regions that have more urban commercial bank. The Bank of Beijing has the highest average efficiency in short-run, long-run, and total efficiency rankings. The next highest ranking of urban commercial bank regions—based on average efficiency—is located in the west of China and does not have a high level of GDP or population (see appendices for details) such as Yunnan, Ningxia, and Gansu. This is opposite to Ferri's (2009) result, where east region banks achieved higher efficiency.

The regions receiving the highest efficiency scores have more urban commercial banks. For example, Jiangsu has four urban commercial banks and its highest GVE result ranking is first, but its lowest result ranking is fourteenth under the SAPF model; a similar scenario occurs for Liaoning in the GVE results under the SDPF model—its highest result ranking is second, but lowest result ranking is Tenth. The same cases also apply to the NVE and NIE results. Those regions are located in the east of China, which has a high GDP compared to the western regions. Therefore, if regions have a relatively competitive environment, their urban commercial banks will achieve the highest efficiency levels. This result is in line with Bos and Kool (2006), where the authors find that the regional market environment has impact on bank performance. The advances of a regional economy have no positive impact on their regional bank efficiency.

For regions with less than three urban commercial banks, the efficiency results are stable during our sample years. This result matches with the current Chinese urban commercial bank industry problem. All Chinese urban commercial banks were transferred from urban credit cooperatives, which are non-profit institutions. There are a number of urban commercial banks that are less efficient and facing high risk; this has motivated the recent wave of merging and restructuring of those banks in order to achieve efficiency and reduce risk. For example, Huishang Bank was founded by merging six urban commercial banks and seven urban credit cooperatives within the region of Anhui province[41]. The highest GVE result of Huishang Bank ranks second under the results of the SAPF model and first under the SDPF model.

4.5 Conclusion

This chapter extends the research on Chinese regional banking, with a particular focus on urban commercial banks. I applied a spatial sutoregressive production frontier (SAPF) model and a spatial Durbin production frontier (SDPF) model to measure the performance and efficiency levels of 65 urban commercial banks from 2013 to 2015. This chapter provides a more acute efficiency analysis of Chinese urban commercial banks by identify the spatial dependence. The data sample covers most regions of mainland China and utilises three input variables (deposits, labour, and fixed assets) and one output (loans). Both the SAPF and SDPF models provide positive significant results that satisfy the monotonicity properties of the production function. This study addresses the relationship of Chinese urban commercial banks' output loans within the neighbouring regions and investigates the effect of regional market environment on bank performance. Among input variables, deposits have the most influences on output of loans in urban commercial banks. Most importantly, positive significant results on spatial lag of the dependent variable

[41] Source from Huishang Bank official website http://www.hsbank.com.cn/Channel/312285.

indicate that output loans of Chinese urban commercial banks have a positive spatial relationship with other banks in their neighbouring regions.

A similar case is found in efficiency results where banks from neighbouring regions have comparable efficiency scores. The average short-run efficiency is higher than long-term efficiency. The market restructure contributed to efficiency improvement of Chinese urban commercial banks. For regions with less than three urban commercial banks, the average efficiency is stable and relatively high. However, for regions which have more urban commercial banks in operation, there are both high and low efficiency performance banks. Thus, the regional market environment affects their efficiency performance. It also implies that a more competitive environment encourages higher efficiency performance. This result matches the historical problem of Chinese urban commercial banks, which inherited high non-performing loans from the urban credit cooperatives. There are many urban commercial banks with lower efficiency results. These results fit with the development processes of Chinese urban commercial banks where mergers and restructures take place to increase efficiency. The regions with less than three urban commercial banks have stable banks with relatively higher efficiency scores. Those efficiency results confirm the achievement of Chinese urban commercial banks' development, especially in recent merger activities.

Chapter 5 - Spatial Productivity of Chinese Regional Banks: Case of Urban Commercial Banks

5.1 Introduction

5.1.1 Motivation and Research Question

Chinese urban commercial banks are a type of regional bank that provides financial services for local enterprises and individuals. By looking at their total assets, urban commercial banks are currently the third largest commercial banks in China[42]. They are more efficient than state-owned commercial banks which are the biggest commercial banks in China (Ariff and Can, 2008; Lin and Zhang, 2009). Urban commercial banks play a vital role in the Chinese financial system and the economy.

Urban credit cooperatives were initially founded to provide financial service for local requirements. However, because of poor risk-management they generate a large number of non-performing loans. To deal with this problem, a market restructure started in the 1990s and finished in 2012, transforming urban credit

[42] Chinese Banking Regulatory Commission annual report 2016.

cooperatives into urban commercial banks. Based on the annual report of the China Banking Regulatory Commission, there are 133 urban commercial banks. It is therefore valuable to find the impact of the market restructure on the productivity of urban commercial banks. There are several works on the productivity of Chinese commercial banks, but they mainly focus on state-owned and joint-stock commercial banks. There is no research that tries to analyse the geographical characteristics of urban commercial banks and no research that considers their performance in the post market restructure period. The research questions of this chapter are: 1) how does productivity change after the market restructure period? 2) what drives productivity change in Chinese urban commercial banks?

5.1.2 Results and Outline

This chapters measures the productivity of 64 urban commercial banks operating in 26 regions during the post restructure period of 2013 to 2016. Based on the geographic characteristics of urban commercial banks, this chapter follows Glass and Kenjegalieva (2019) to apply a spatial total factor productivity index by using spatial autoregressive production function. The model decomposes the spatial total factor productivity index into efficiency change and return to scale change. The model can capture the spatial relationship of urban commercial banks and identify spatial direct (feedback) and spatial indirect (spatial spillovers) among these banks. The results indicate that there is positive spatial dependence in the production of urban commercial banks; productivity of urban commercial banks increases from 2013 to 2016 (mainly contributed by return to scale change). The efficiency is almost unchanged during the research period.

This chapter includes five sections. Section 5.2 reviews the literature of banking productivity across different countries. Section 5.3 provides data and a methodology of spatial total factor productivity. Section 5.4 shows model estimation and productivity results, and the last section is the conclusion.

5.2 Literature Review on Banking Productivity

The concept of productivity functions was initially proposed by Solow (1957); it provides a function of productivity growth with time derivative of production function, cost, or profit function. However, it does not provide measurement of productivity in index numbers. Later, Caves et al. (1982) combine the measurement of Malmquist (1953) with the function of Solow (1957) as a productivity index measurement function called the Malmquist productivity index. Now, the Malmquist productivity index has been applied with parametric and nonparametric method; it has been broadly applied in economic and banking research (Alam, 2001; Assaf et al., 2010; Casu et al., 2004; Chen, 2012).

Due to the nature of the methodology, banking productivity research focuses on different countries and geographic areas. A similarity across different regions is where there is banking with increasing productivity; most of the productivity gain is contributed by technology improvement (Park and Weber, 2006; Kenjegalieva and Simper, 2011; Casu et al., 2004).

The rest of this section has four parts. Sub-section 5.2.1 reviews literature on European banking productivity. Sub-section 5.2.2 discusses studies of U.S. banking productivity. Sub-section 5.2.3 provides information of research on Asian and Australian banking productivity. Sub-section 5.2.4 concludes the previous findings.

5.2.1 Productivity in European Banking

In the European banking industry, Casu et al. (2004) examines the productivity of 2,000 European banks from 1994 to 2000, with both parametric and non-parametric methods. Both methods provide positive improvement of productivity with a minor conflict during the research period and the productivity improvement mainly contributed by technology changing. Similarly, Fiordelisi and Molyneux (2010) show an increasing productivity result in European banking from 1995 to 2002 via the contribution of technology. They also state that the productivity change describes the variation of shareholder's value.

Recently, Casu et al. (2016) extend productivity research on European banking by looking at the impact of regulatory reform. They investigate productivity of eurozone countries' commercial banks from 1992 to 2014. The results still indicate a productivity improvement during the research period. The improvement is mainly contributed by technology. They also find that European banking converges to take the best available technology and that there are technological spillovers among European banking industries.

When looking at specific countries or regions, Grifell-Tatje and Lovell (1996) measure the productivity of Spanish savings banks after the 1980s deregulation period. The deregulation provides Spanish saving banks business expansion and mergers and acquisitions. However, business expansion and mergers do not contribute to the productivity of Spanish saving banks; the productivity of Spanish saving banks declines during the post-deregulation period. Later Kumbhakar et al. (2001) also examine the performance of Spanish savings banks in the post-deregulation period. They extend four more years data than Grifell-Tatje and Lovell (1996). Kumbhakar et al. (2001) find that the efficiency of Spanish savings banks decreases while the technical progress of Spanish savings banks has a high rate. The performance of Spanish savings banks in the post-deregulation period is slightly better. This result is contrary with Grifell-Tatje and Lovell (1996). Mendes and Rebelo (1999) investigate efficiency, technological change, and productivity in Portuguese banking deregulation. In the line with Grifell-Tatje and Lovell (1996), Mendes and Rebelo (1999) state that the efficiency of Portuguese banking does not improve based on increased competition; their result indicates a technological recess of Portuguese banking. Mendes and Rebelo (1999) suggests that Portuguese banking is facing an over-banking and over-branching situation.

Koutsomanoli-Filippaki et al. (2009) research productivity of Central and Eastern European countries' banking from 1998 to 2003. Because of institutional and structural reforms, banks' productivity increases that are due to technology are greater than the changes in productivity that are due to efficiency. Later Kenjegalieva and Simper (2011) extend research on the productivity of Central and Eastern European countries banking and find that technology could be affected by environment and risk management. Another example of technology improvement supporting a productivity increase is in Turkish banking. The productivity of 45 Turkish commercial banks increases between 2002 and 2010, even though their efficiency declines in this period (Assaf et al., 2013).

Merger and acquisition activities are valuable factors influencing productivity change. Productivity of UK building societies experiences significant improvement from merger activities during 1981 to 1993 (Haynes and Thompson, 1999). Haynes and Thompson, (1999) also find that a market with deregulation and competition can gain more productivity from merger activities.

On the opposite side, Rezitis (2008) finds no productivity increase in Greek banks from merger and acquisition activities from 1993 to 2004. Bernad et al. (2010) measure the impact of 17 merger activities on productivity of Spanish savings banks; the result displays that only half of the merger activities lead to improvement on banks' productivity and remaining activities have negative or no effect on their productivity. Beyond merger and acquisition, Grifell-Tatje and Lovell (1997) compare productivity between different types of bank. They demonstrate that Spanish commercial banks have a lower productivity growth rate than Spanish savings banks.

5.2.2 Productivity in U.S. Banking

In the United States, many researchers focus on the impact of banking deregulation in the 1980s to banking productivity. Most of the literature finds that deregulation increases banking productivity through technology improvement (Devaney and Weber, 2000; Alam, 2001; Tirtiroglu et al., 2005). Alam (2001) states that large U.S. commercial banks (with total assets over $500 million) received productivity gain from a different regulatory environment during the years 1980 to 1989; this increase is primarily gained with technology improvement of deregulation, rather than efficiency changing. Similarly, Mukherjee et al. (2001) finds that initial deregulation improves the productivity of large U.S. commercial banks by 4.5 per cent per year from 1984 to 1990. They also reveal that larger assets and the specialisation of product mix provides a higher banking productivity growth rate, but that higher equity to assets connects with a lower banking productivity growth rate. Devaney and Weber (2000) also demonstrate that the deregulation of state-wide branching improved the productivity of U.S. rural banking by 11.4 per cent from 1990 to 1993. Berger and Mester (2003) investigate the performance of U.S. banks by cost productivity and profit productivity in the deregulation period 1991 to 1997; they find that cost productivity worsens while profit productivity improvs during that research period. The result suggests that productivity measurement without considering revenues might mislead conclusions. For example, high cost investment might bring higher revenues, thus increasing profit.

Stiroh (2000) studies the performance of U.S. bank holding companies during 1991 to 1997 and finds that the productivity of U.S. bank holding companies increases during the research period. Benefits from the 1990s degranulation, technological change, financial innovation, and economics of scale contributed to productivity improvement. However, there is significant profit inefficiency in U.S. bank holding companies. So, the performance improvement of U.S. bank holding companies requires a reduction in profit inefficiency. Tirtiroglu et al. (2005) examine the impact of serial deregulation activities on U.S. banking productivity from 1971 to 1995. Overall, deregulation has a positive impact on long-run productivity of U.S. banking. Specifically, intrastate branching deregulation and market openness from interstate multibank holding company deregulation contributes to a positive effect on banking productivity growth.

However, unrestricted intrastate multibank holding company deregulation and interstate multibank holding company *de novo* branching deregulation create a negative effect on banking productivity. During the initial deregulation period, Humphrey (1991) finds that U.S. banking experienced a low rate of productivity growth during 1977 to 1987. This was due to a higher interest rate, a rise of money market mutual funds in the 1970s, and the increasing cost of bank loanable funds based on banking deregulation in the 1980s. Later, Humphrey (1992) tests the difference of banking productivity measurement on a flow and stock indicator selection. Flow means number of deposit and transactions and stock means value of deposit and loan balances. The productivity measurement results are different with flow and stock selection for output. Therefore, it is important to select output for banking productivity measurement.

Regarding the impact of bank size on productivity, Wheelock and Wilson (2009), Feng and Serletis (2009), and Feng and Zhang (2012) all find that large U.S. banks experience more productivity than other types of banks in the 1990s. Therefore, deregulation, an advance in information and financial technology changes have a differential effect on different size of banks (Wheelock and Wilson, 1999; 2009). Except for large commercial banks, other banks (with total assets less than $400 million) experience productivity losses or non-productivity growth during 1998 to 2005 (Feng and Serletis, 2009). Wheelock and Wilson (1999) also note that smaller banks (with total assets less $100 million) experienced a larger productivity decline during 1984 to 1993. Based on inefficiency rising (even with technology improvement), the smaller U.S. commercial banks experience decreasing productivity. Feng and Zhang (2012) discover that the productivity of U.S. large and community banks has suffered a downward trend in growth rate from 1997 to 2006.

Beyond deregulation and bank size, Fixler and Zieschang (1993) reveal merger activities contribute more to productivity gain in U.S. banking, even though there is no economics of scale from bank mergers. Fung (2006) discovers that there is conditional convergence among U.S. bank holding companies. This means that the initial difference of X-efficiency will create a permanent difference in the steady-state productivity of bank holding companies.

5.2.3 Productivity in Asian and Australian Banking

Previous research on Asian banking pays attention to how external factors affect banking productivity. Gilbert and Wilson (1998) examine the impact of Korean government deregulation on the financial market in 1980. They find that government deregulation specifically encourages the privatisation of a percentage of the banking industry, which improves Korean banking productivity from 1980 to 1994. This result meets Nakane and Weintraub (2005) research as well. Avkiran (2000) measures the productivity of four Australian trading banks and six regional banks in the deregulated period 1986 to 1995.

There is an initial decline in the productivity of Australian banks from 1988 to 1990, followed by a steady rise from 1991 to 1993. However, the overall productivity of Australian banks increases during the deregulation period. Avkiran (2000) states that technological progress has more contribution to productivity than technical efficiency, and that technological innovation is the way that Australian banking can pursue a technological process for productivity. Later, Park and Weber (2006) investigate the impact of the Korean financial liberalisation and the Asian financial crisis on banking productivity from 1992 to 2002. Like most of the literature results, technology changing from financial liberalisation provides a positive effect on productivity in Korean banking. Even though Korean banking becomes more inefficient in the pro-period of the Asian financial crisis, their productivity is still increasing. Banker et al. (2010) extend research on reform of the Korean banking system and find that the reform provides an uneven impact on the productivity of individual banks within the Korean banking industry. Conversely, Fujii et al. (2014) explore the effect of Indian banking restructure policy in the early 2000s to their banking productivity and notice that there is a downward shift in the production frontier of Indian banking with no increase in productivity. Hadad et al. (2011) investigate productivity of Indonesian banking from 2003 to 2007 by a monthly dataset. The results indicate that productivity change in Indonesian banks is driven by technological progress. Hadad et al. (2011) also examine risk management in Indonesian banks and find that balance sheet variables have an impact on Risk

Management Efficiency. Thus, by employing new technology on internal risk management enhancement, Indonesian banks can boost their productivity.

By looking at internal factors such as ownership, Leightner and Lovell (1998) measure productivity change in Thai banks from 1991 to 1994. Thailand experienced financial liberalization in early 1990s. The financial liberalization increases the competition of Thai banks, but the competition reduces profit of Thai banks. Leightner and Lovell (1998) find that objectives of bank, size of bank, and ownership of bank can affect bank productivity. For example, when bank objectives are applied, Thai banks have relatively rapid growth productivity. But when Bank of Thailand objectives are applied, the productivity of Thai banks declined and the productivity of foreign banks increased. Chen and Yeh (2000) investigate the productivity of Taiwan public and private commercial banks after deregulation in the early 1990s and find there is a slight increasing in banking productivity after deregulation. Chen (2012) also studies the risk-bearing behaviour of Taiwanese banking; the result states that adding risk as input into analysis provides a better bank frontier, and that public and private banks should receive a different technology set. The investigation also implies that Taiwanese public banks experience a higher productivity growth rate than private banks during the research period. In the meantime, Sufian (2011) demonstrates that the foreign banks have less productivity compared to domestic banks, and that publicly listed banks have more productivity than private banks in Malaysian banking.

There is small amount of literature investigating the productivity of Chinese banking. Kumbhakar and Wang (2007) examine the productivity of state-owned commercial banks and joint-stock commercial banks from 1993 to 2002. Their results show that the productivity of joint-stock commercial banks has a much higher growth rate than state-owned commercial banks. In a later period, Chang et al. (2012) and Matthews et al. (2009) provide similar results showing that joint-stock commercial banks have a stronger productivity gain than state-owned commercial banks. There are conflicting results when comparing productivity among state-owned commercial banks, joint-stock commercial banks, and urban commercial banks. Matthews and Zhang (2010) find that the growth rate of a Total Factor Productivity index is natural for state-owned commercial banks and joint-stock commercial banks, but it is positive for urban commercial banks during 1997 to 2007. However, Chang et al. (2012) state that joint-stock commercial banks reveal their highest growth rate in a Total Factor Productivity index among urban commercial banks and state-owned commercial banks. This conflict might be due to sample bias. Matthews and Zhang (2010) have 47 urban commercial banks in their research sample, whereas Chang et al. (2012) only have five.

Beside ownership, there are also other factors that can influence banking productivity, such as bank size, risk, and inflation rate (Sufian, 2011). Assaf et al. (2010) demonstrate that because of historical problems—large non-performing loans, poor restructuring, lack of management, and low market power—productivity of Shinkin banks in Japan receive no significant improvement during 2000 to 2006. Fung and Cheng (2010) examine convergence in banking productivity; they provide evidence of conditional convergence among the productivity of banks, which means different X-efficiencies of bank provide permanent differences in the results of productivity.

5.2.4 Conclusion

As the Malmquist productivity index methodology is applied in banking study, there is a well-established literature on banking productivity across different countries. These researches provide index number measurements of productivity. The results can be compared with continuous time. There are mixed results regarding the outcome of deregulation on banking productivity. Most literature finds that deregulation increases U.S. banking productivity through technological improvement (Devaney and Weber, 2000; Alam, 2001; Tirtiroglu et al., 2005). However, there is conflicting result in studies of European banking, where no significant improvement in banking productivity achievement during deregulation period (Grifell-Tatje and Lovell, 1996; Mendes and Rebelo, 1999). In Asian and Australian banking, financial liberation in different countries provides technological innovation of the banking industry, thus improving banking productivity (Park and Weber, 2006; Hadad et al., 2011) However, contrary outcomes are found in Indian banking. The restructure of Indian banks happened in the early 2000s, but there is no corresponding increase of productivity in Indian banking (Fujii et al., 2014). There are tables providing general information on banking productivity literature in appendices.

There is limited research on the productivity of regional banks, specifically in China. Only two papers mention urban commercial banks in their productivity research. Matthews and Zhang (2010) has 47 urban commercial banks in their research sample, but their research period stops at 2007. Chang et al. (2012) only have five urban commercial banks in their sample. These two papers do not attempt to measure the productivity of urban commercial banks by capturing spatial dependence and do not analyse the impact of market restructure on productivity.

As an essential part of the national economy and financial system, it is worthwhile to investigate the productivity of Chinese urban commercial banks. This chapter measures the productivity of Chinese urban commercial banks by a spatial total factor productivity index. By adding spatial components, the results provide more accuracy comparing to traditional productivity index. This chapter also analyses the effect of market restructure on banks' productivity.

5.3 Data and Methodology

5.3.1 Sample of Variables

The model estimation uses a balanced dataset that includes 64 Chinese urban commercial banks over the period 2013-2016. Due to data availability, the dataset covers most regions of mainland China (26 out of 31 regions). Data are collected from Orbis Bank Focus, and the model contains three inputs (deposit, labour and fixed assets) and one output (loans), with the number of employees as the labour variable. Those input and output variables are found by the intermediation approach (Sealey and Lindley, 1997). Regarding the issue of missing data—some banks only have staff expenses instead of number of employees—I fill the blanks by staff expenses dividing the average annual wage (data on the annual average financial industry wage of each region are collected from the National Bureau of Statistics of China). All of the sample data are geometric mean-adjusted for sample mean elasticities. Here is the table that shows the statistic detail of data:

Table 5.1 Summary Statistics of Sample Data

Variable	Model notation	Mean	Std. Dev.	Min	Max
Loans, in 100 million yuan	y	961.23	1222.32	97.20	8679.55
Deposits, in 100 million yuan	x1	2221.68	2786.16	257.16	18098.62
Labour, number of employees	x2	4765.50	4589.02	432.00	39811.00
Fixed assets, in 100 million yuan	x3	15.85	17.27	0.65	87.35

As Table 5.1 displays, loans (y) is the single output of the mode. The inputs are deposits (x1), labour (x2), and fixed assets (x3). The difference between the biggest and smallest bank are quite big. For example, maximum deposits of urban commercial banks are 1,809.9 billion RMB while minimum deposits are only 25.7 billion RMB. A large difference exists between loans and labour. The standard deviation of fixed assets is 17.27. It is smaller compared to other variables' standard deviation. However, there is a small amount of minimum fixed assets. The maximum fixed assets are more than 134 times larger than minimum fixed assets.

5.3.2 Spatial Total Factor Productivity

As mentioned in Section 5.2, most of the research on banking productivity uses the Malmquist TFP index methodology. However, economy development has spatially dependence. For regional banking, it provides financial services for local companies and individuals. Therefore, it carries a geographical characteristic. The traditional Malmquist TFP index methodology cannot capture spatial components and might provide bias on the measurement of regional blanking productivity.

As discussed in Chapter 4, Glass et al. (2013) employ a model that decomposes Total Factor Productivity (TFP) with partial spatial extension. Later, Glass and Kenjegalieva (2019) extend the model with a full spatial extension of TFP. This chapter follows Glass and Kenjegalieva (2019) to measure the spatial TFP index of Chinese urban commercial banks. This model estimates the spatial autoregressive production frontier by adding spatial lag of the dependent variable into the ordinary production frontier. The spatial autoregressive production function can be expressed as Equation 5.1:

$$\ln y_{\mathrm{it}} = \alpha + \beta \sum_{h=1}^{H} \sum_{i=1}^{N} \ln \mathrm{x}_{\mathrm{hit}} + \tfrac{1}{2} \rho \sum_{h=1}^{H} \sum_{i=1}^{N} (\ln x_{\mathrm{hit}})^2 + \lambda \sum_{h=1}^{H} \sum_{i=1}^{N} \ln x_{\mathrm{hit}} \ln x_{(\mathrm{h+1})\mathrm{it}} + \delta \sum_{\mathrm{k}=1}^{\mathrm{N}} \sum_{i=1}^{N} w_{ik} y_{kt} + \nu_{\mathrm{it}} + \kappa_{\mathrm{i}} - \mu_{\mathrm{it}} - \eta_i \qquad (5.1)$$

where y_{it} represents bank produced output from observed unit i, i = 1, …, I, at time period t, t = 1, …, T, x_{it} is vector of inputs which bank i used for processing during time t, vectors of α, β, ρ, and λ are regression parameters, $\delta\sum_{k=1}^{N}\sum_{i=1}^{N} w_{ik} y_{kt}$ indicates the spatial lag of the dependent variable, δ is the spatial parameter that needs to be estimated, and w_{ik} represents the spatial arrangement of each individual bank where $i \neq k$. v_{it}, κ_i, μ_{it}, η_i are four components of random errors. In addition, this model separates random errors into time-variant and time-invariant components which can be expressed as $\varepsilon_{it}^{*} = \varepsilon_{it} + \varepsilon_i = v_{it} + \kappa_i - \mu_{it} - \eta_i$. v_{it} is the standard idiosyncratic error based on unobserved heterogeneity of random effects, κ_i is time-invariant random error of unit specific effect, μ_{it} is net time-variant inefficiency, and η_i is net time-invariant inefficiency. The model assumes these two inefficiencies are half-normal distribution and lay between [0,1]. Then this chapter can observe gross inefficiency by combining these two inefficiencies and expressing them as $\text{GVI}=\text{NVI}*\text{NII}=\mu_{it} * \eta_i$. Therefore, gross inefficiency is time-variant inefficiency and lays between [0,1] (Glass and Kenjegalieva, 2019).

This chapter uses a spatial total factor productivity index to measure the productivity of Chinese urban commercial banks. Following Kumbhackar and Lovell (2003), the Total Factor Productivity (TFP) index can decompose into three components, which are technical efficiency change (EC), technical change (TC), and returns to scale efficiency change (RSC). Therefore, the TFP can be stated as:

$$\mathrm{TFP}=\mathrm{EC}+TC+RSC \tag{5.2}$$

In this chapter, the spatial TFP index adds spatial direct (feedback) and indirect (spatial spillovers) components of RSC into general TFP and the Equation 5.2 can be updated as:

$$\mathrm{TFP}_{\mathrm{it}}^{Tol}=\mathrm{GVEC}_{it}+TC_{it}^{Tol}+RSC_{it}^{Tol} \tag{5.3}$$

where GVEC_{it} is gross time-variant efficiency change, TC_{it}^{Tol} is the total technical change, and RSC_{it}^{Tol} is total returns to scale efficiency change. The combination of direct and indirect components is explained as a total component. Each total component can be calculated as:

$$\mathrm{GVEC}_{\mathrm{it}}=GVE_{it}-GVE_{it-1} \tag{5.4}$$

According to gross inefficiency from the spatial autoregressive production frontier, this analysis adopts gross time-variant efficiency change instead of traditional technical efficiency change in spatial TFP index measurement.

$$TC_{it}^{Tol} = \frac{1}{2}\left[\frac{d\ln y_{it}^{Tol}}{dt} + \frac{d\ln y_{it-1}^{Tol}}{dt}\right] = \frac{1}{2}\left[\frac{d\ln y_{it}^{Dir}}{dt} + \frac{d\ln y_{it-1}^{Dir}}{dt} + \frac{d\ln y_{it}^{Ind}}{dt} + \frac{d\ln y_{it-1}^{Ind}}{dt}\right] \quad (5.5)$$

Technical change is the movement of the frontier over each year. Because of data availability, this chapter has a short research period (four years). Therefore, this analysis assumes there is no technical change during the research period.

$$\begin{aligned} RSC_{it}^{Tol} &= \frac{1}{2}\sum_{h=1}^{h}\left[\left(\varphi_{it}^{Tol}-1\right)\frac{\varphi_{hit}^{Tol}}{\varphi_{it}^{Tol}} + \left(\varphi_{it-1}^{Tol}-1\right)\frac{\varphi_{hit-1}^{Tol}}{\varphi_{it-1}^{Tol}}\right]*\left[\sum_{h=1}^{h}x_{hit} - \sum_{h=1}^{h}x_{hit-1}\right] \\ &= \frac{1}{2}\sum_{h=1}^{h}\left[\left(\varphi_{it}^{Tol}-1\right)\frac{\varphi_{hit}^{Dir}}{\varphi_{it}^{Tol}} + \left(\varphi_{it-1}^{Tol}-1\right)\frac{\varphi_{hit-1}^{Dir}}{\varphi_{it-1}^{Tol}}\right]*\left[\sum_{h=1}^{h}x_{hit} - \sum_{h=1}^{h}x_{hit-1}\right] + \\ &\quad \frac{1}{2}\sum_{h=1}^{h}\left[\left(\varphi_{it}^{Tol}-1\right)\frac{\varphi_{hit}^{Ind}}{\varphi_{it}^{Tol}} + \left(\varphi_{it-1}^{Tol}-1\right)\frac{\varphi_{hit-1}^{Ind}}{\varphi_{it-1}^{Tol}}\right]*\left[\sum_{h=1}^{h}x_{hit} - \sum_{h=1}^{h}x_{hit-1}\right] \end{aligned} \quad (5.6)$$

where $\varphi_{it}^{\mathrm{Tol}}$ is total sum of all inputs elasticities, φ_{hit}^{Tol}, φ_{hit}^{Dir}, and φ_{hit}^{Ind} represents total, direct, and indirect elasticity of input h with respect to output for bank i, i = 1, …, I, at time t, t = 1, …, T. By decomposing total returns to scale into direct and indirect returns to scale, this model can measure the weight of direct and indirect output elasticities change. The direct elasticity contains effects of feedback from the spatial matrix, which is the same as non-spatial model elasticity. The indirect elasticity can be explained as: the average change of the dependent variable from the remaining units in the sample following a change of an independent variable from one observed unit, or; average change of the dependent variable from one observed unit following a change of an independent variable from remaining units in the sample. The sum of direct and indirect elasticities is total elasticity.

This chapter employs a spatial contiguity matrix across 26 regions. The matrix gives the same equal weight to each neighbouring region (with sum equal to one) and giving zero to the region itself and the non-neighbouring regions. This analysis uses a random effects model based on unobserved heterogeneity to deal with distributional assumption of four independent error components.

5.4 Results and Discussion

5.4.1 Residual Skewness Test

Starting with an Ordinary Least Squares residual skewness test (Schmidt and Lin, 1984), the result of -0.68 skewness with a 1 per cent significance level, meets the expectation of the production function (details in appendices). Therefore, this chapter can reject the null hypothesis of non-skewness of OLS residual and start running the random effect spatial autoregressive production model. For random effect spatial autoregressive production model estimation, Table 5.2 provides full details.

5.4.2 Estimation Results

Table 5.2 illustrates model estimated results with standard, direct, indirect, and total coefficients. All standard, direct, indirect, and total coefficients of deposits (β_1), labour (β_2), and fixed assets (β_3) to loans are positively significant. This confirms production function monotonicity condition (Kumbhackar and Lovell, 2003).

Table 5.2 Estimated Direct, Indirect and Total Elasticities

Variables	Parameter	Standard Coefficient	Direct	Indirect	Total
lx1	β_1	0.714***	0.716***	0.091***	0.807***
lx2	β_2	0.081**	0.079**	0.010**	0.089**
lx3	β_3	0.121***	0.124***	0.016**	0.139***
lx1x1	ρ_{11}	0.008	0.008	0.001	0.009
lx2x2	ρ_{22}	-0.041*	-0.040*	-0.005	-0.045*
lx3x3	ρ_{33}	0.030	0.032	0.004	0.036
lx1x2	λ_{12}	0.072	0.072	0.009	0.081
lx1x3	λ_{13}	-0.051	-0.053	-0.007	-0.059
lx2x3	λ_{23}	0.002	0.004	0.001	0.004
ωy	δ	0.116***			

Note: ***, **, and * represent statistically significance at 1%, 5%, and 10% level.

The standard coefficients of deposits, labour, and fixed assets are 0.714, 0.081, and 0.121 respectively. The deposits have the biggest impact on banking production, followed by fixed assets. Labour has less effect on banks' output. The coefficients of interaction variables are not significant, except square of labour (ρ_{22}). The standard coefficient of square of labour is -0.041 with one-star significance. As discussed in Chapter4, this indicates that Chinese urban economical banks experience labour inefficiency. This means more labour applied in urban commercial banks leadd to production decline. Furthermore, the coefficient of labour is two-star significant, while the coefficients of deposits and fixed assets are three-star significant.

The estimated spatial parameter δ is positively significant at the 1 per cent level. It suggests that the performance of Chinese urban commercial banks is involved with positive spatial dependence of their neighbouring regions' banks. By capturing this spatial dependence in this model, the productive results of this chapter are more accurate. The value and significance of direct parameters are in line with standard model estimation, which fits the monotonicity properties of the production frontier. The indirect parameters describe spillover of each variable to urban commercial banks. The indirect parameters of deposits, labour, and fixed assets are 0.091, 0.01, and 0.016 with significance. The value of these parameters is smaller than the standard model. It suggests that there is a small amount of spilliover of inputs in Chinese urban commercial banks. The indirect parameters of interaction variables are all non-significant. The total parameters are combined by direct and indirect parameters. So, the value and significance of total parameters are close to the standard model.

5.4.3 Productivity Results

Table 5.3 provides statistic details of the spatial TFP index, gross time-variant efficiency changing and returns to scale efficiency changing (total, direct, and indirect).

Table 5.3 Total Factor Productivity, Efficiency Change and Return to Scale Change Results

Variable	Mean	Std. Dev.	Min	Max
TFP total	1.426	0.254	0.785	2.157
GVEC	1.003	0.066	0.868	1.346
RSC total	1.431	0.292	0.695	2.267
-RSC direct	1.372	0.248	0.724	2.067
-RSC indirect	1.039	0.024	0.960	1.097

As Table 5.3 shows, the average spatial total factor productivity (TFP) of Chinese urban commercial banks is 1.426. This means, on average, Chinese urban commercial banks experience a productivity increase of around 42.6 per cent between 2013 and 2016. The maximum result of TFP is 2.157 and minimum result is 0.785; this suggests that the fastest growth bank increases productivity more than twice and the slowest growth bank suffers productivity decreases of around 21.5 per cent. For efficiency change (GVEC), the average, maximum, and minimum results are 1.003, 0.346, and 0.868. The average result states that efficiency changes almost remain the same, but the fastest growth bank improves 34.6 per cent efficiency and the lowest reduces 13.2 per cent. Similarly, with the productivity result, the average, maximum, and minimum of returns to scale are 1.431, 0.695, and 2.267. The average total returns to scale change increase 43.1 per cent, with the range of the fastest growth bank increasing more than twice and the lowest bank decreasing by 30.5 per cent. This high growth rate confirms the rapid expansion of Chinese urban commercial banks.

The values of direct returns to scale are close to the total returns to scale. Indirect returns to scale change show a more stable result; average performance increases 3.9 per cent. The fastest performance grows 9.7 per cent; the lowest performance reduces 4 per cent. Therefore, the spillover of returns to scale exists in Chinese urban commercial banks, but total returns to scale are achieved by direct returns to scale. Comparing efficiency and returns

Figure 5.1 Distribution of Total TFP, GVEC, and Total RSC

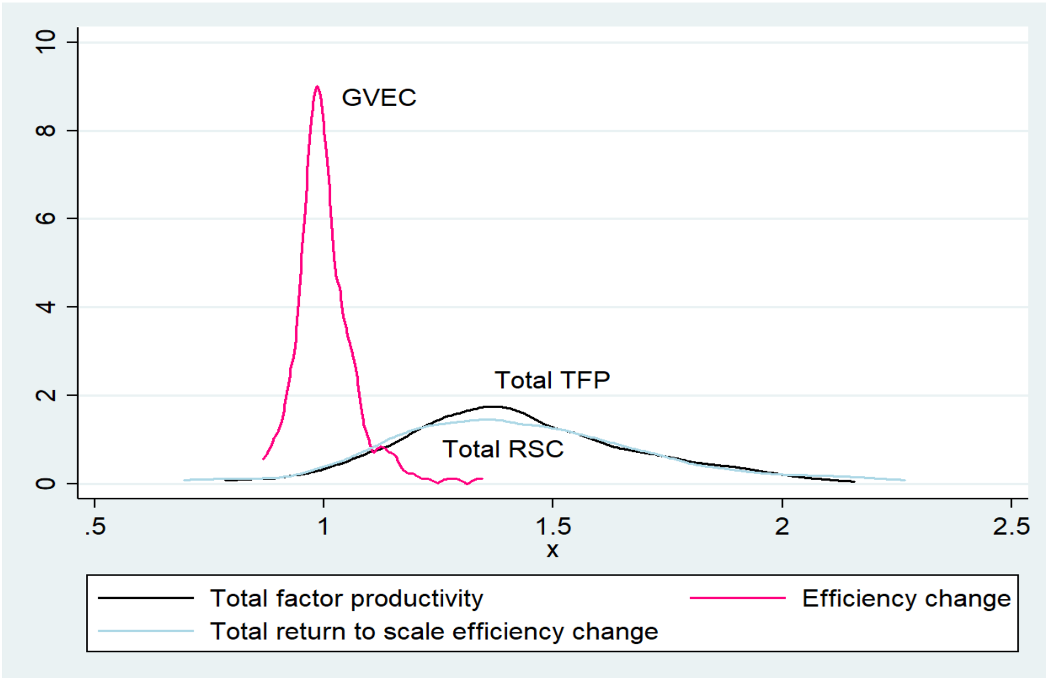
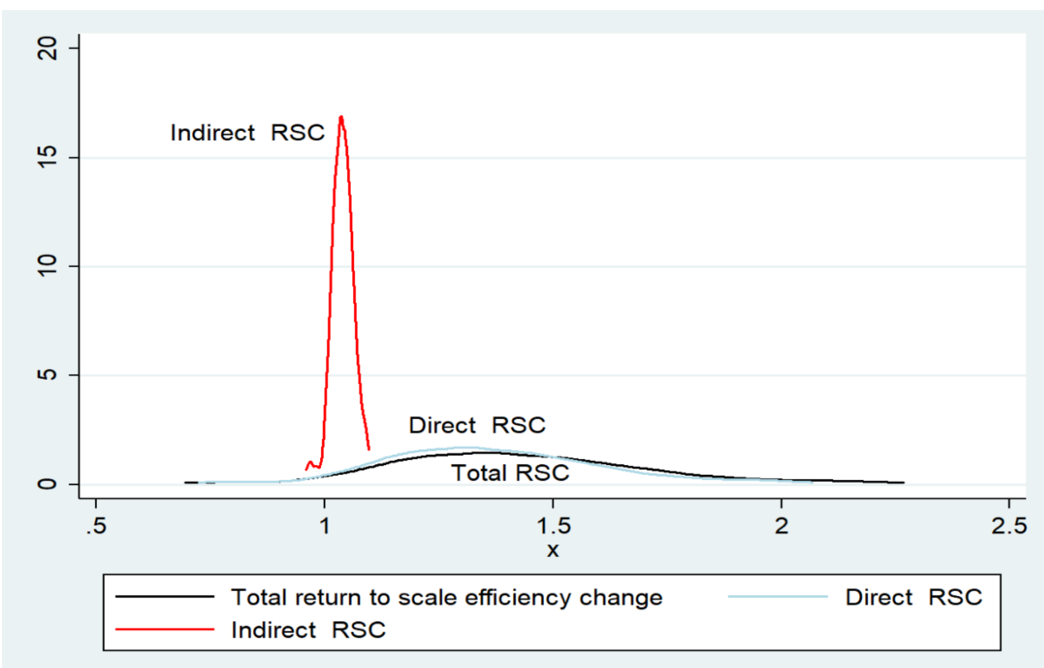


Figure 5.2 Distribution of Total, Direct, and Indirect Return to Scale Changing



to scale change, returns to scale change mainly contributes to the spatial TFP index (specific by the direct returns to scale change) and efficiency change only slightly contributes to the spatial TFP index. Figures 5.1 and 5.2 present diagrams depicting these situations.

As Figure 5.1 presents, the spatial TFP index and total returns to scale change have wider distribution and overlap in most areas. Efficiency change is narrowly distributed around 1. This figure visualises result of Table 5.3. The efficiency is nearly unchanged, while the productivity increases and is improved by returns to scale change. A similar situation is shown in Figure 5.2; total and direct returns to scale overlap in the main areas and have wider distribution. Indirect returns to scale have a tight distribution around 1, similar to efficiency change. Therefore, the improvement of returns to scale mainly comes from indirect returns to scale. The indirect returns to scale (spillover) slightly helps the total returns to scale. Looking at productivity in different regions, this chapter summarises the spatial TFP index, efficiency changing, and return to scale changing (total, direct, and indirect) into Tables 5.4 to 5.8. Each table presents average, minimum, and maximum results followed by ranking.

As Table 5.4 displays, all regions' average spatial TFP indexes are greater than 1. All regions' urban commercial banks experience productivity growth in the post market restructure period from 2013 to 2016. Because of data availability, some regions only display one bank in the results; they actually contain more than one but less than three urban commercial banks in their region, except Shanxi and Xinjiang. The rest of the regions have more than three urban commercial banks (except Heilongjiang, Hunan, Guangxi and Chongqing). There are 12 regions that have less than three banks and 14 that regions have more than three banks. Four of the top five ranking regions (Hebei, Jiangxi, Henan and Fujian) contain more than three urban commercial banks in their regions (except Hunan) and there are only four regions that have less than three urban commercial banks ranking in the top 10 (Hunan, Gansu, Chongqing and Anhui). In general, regions with more banks (more than three urban commercial banks) rank higher than regions with fewer banks (fewer than three urban commercial banks). Eight of the top ten ranking regions for average productivity are eastern regions. For maximum spatial TFP index, the top five regions are Fujian, Guangdong, Hebei, Jiangsu, and Liaoning. All of these regions are eastern regions and have more urban commercial banks. Practically, 12 regions ranking in the top 16 are regions with more banks. Furthermore, most banks with a high rate of productivity growth come from regions with more banks (14 regions achieve more than a 70 per cent productivity growth rate and 10 of them are regions with more banks). However, looking at minimum productivity results, six regions have results below 1 (Liaoning, Heilongjiang, Hubei, Guangdong, Guangxi, and Sichuan). There are some banks in these six regions that experience a productivity decline during

Table 5.4 Total TFP Results for Each Region

Region	No. of banks	Mean	Ranking	Min	Ranking	Max	Ranking
Beijing	<3	1.343	17	1.303	7	1.421	21
Tianjin	<3	1.368	15	1.296	9	1.474	19
Hebei	>3	1.717	1	1.467	1	2.021	3
Shanxi	>3	1.211	24	1.129	16	1.353	23
Inner Mongolia	>3	1.422	10	1.052	18	1.728	13
Liaoning	>3	1.334	18	0.825	25	1.953	5
Jilin	<3	1.303	19	1.171	14	1.417	22
Heilongjiang	<3	1.299	21	0.785	26	1.907	6
Shanghai	<3	1.299	20	1.251	11	1.329	24
Jiangsu	>3	1.534	7	1.274	10	1.963	4
Zhejiang	>3	1.383	13	1.052	19	1.903	7
Anhui	<3	1.444	9	1.329	4	1.526	18
Fujian	>3	1.574	5	1.307	5	2.157	1
Jiangxi	>3	1.595	2	1.244	13	1.865	9
Shandong	>3	1.380	14	1.089	17	1.864	10
Henan	>3	1.575	4	1.372	3	1.799	12
Hubei	<3	1.117	26	0.884	23	1.257	26
Hunan	<3	1.583	3	1.246	12	1.899	8
Guangdong	>3	1.345	16	0.964	22	2.126	2
Guangxi	=3	1.418	11	0.859	24	1.837	11
Chongqing	<3	1.508	8	1.305	6	1.687	15
Sichuan	>3	1.291	22	0.985	21	1.667	16
Yunnan	=3	1.405	12	1.297	8	1.620	17
Gansu	<3	1.568	6	1.416	2	1.701	14
Ningxia	<3	1.269	23	1.159	15	1.450	20
Xinjiang	>3	1.181	25	1.042	20	1.299	25

the research period; three of these regions (Liaoning, Guangdong, and Sichuan) have more banks.

As displayed in Table 5.5, half of the regions (13 of 26) have average results above 1 for efficiency change. However, efficiency improvement is within 5 per cent. Eight of these regions have more urban commercial banks. The rest of the 13 regions experience little efficiency reduction, within 5 percent. In general, the efficiency remains nearly unchanged during the research period. For the maximum result of efficiency change, banks that achieve a high rate of efficiency improvement come from economically advanced regions (eastern regions) that have more banks. For instance, the highest ranked maximum efficiency change is Guangdong province, which has five urban commercial banks. Zhejiang province ranks second and has 14 urban commercial banks. There are 10 regions that have higher efficiency changing banks (more than 10 per cent), and 6 of the regions are regions with more banks. These indicate that economic advancement encourages competition in urban commercial banks; it might improve bank efficiency. For the minimum results of efficiency change, all regions have banks that experience efficiency decline. Regions with more banks rank lower than regions with fewer banks. For example, Gansu and Ningxia province have fewer than three urban commercial banks. Minimum result ranking of Gansu is second and minimum result ranking of Ningxia is fourth. Shandong has 14 urban commercial banks and Liaoning has 15 urban commercial banks. Minimum result ranking of Shandong is twenty-sixth and

Table 5.5 Efficiency Change Results for Each Region

Region	No. of banks	Mean	Ranking	Min	Ranking	Max	Ranking
Beijing	<3	0.985	18	0.965	7	0.997	23
Tianjin	<3	0.966	23	0.916	16	1.000	22
Hebei	>3	1.006	10	0.899	22	1.136	9
Shanxi	>3	1.002	11	0.974	3	1.038	15
Inner Mongolia	>3	1.038	4	0.974	5	1.145	6
Liaoning	>3	0.995	14	0.869	25	1.058	14
Jilin	<3	0.980	19	0.951	9	1.021	16
Heilongjiang	<3	1.015	9	0.882	23	1.130	10
Shanghai	<3	0.952	26	0.902	21	0.984	25
Jiangsu	>3	1.000	13	0.947	10	1.064	13
Zhejiang	>3	0.991	16	0.871	24	1.279	2
Anhui	<3	0.959	24	0.926	15	0.982	26
Fujian	>3	1.028	8	0.970	6	1.181	3
Jiangxi	>3	1.039	3	0.941	12	1.173	4
Shandong	>3	0.971	22	0.868	26	1.008	21
Henan	>3	0.958	25	0.915	17	0.993	24
Hubei	<3	1.034	6	0.957	8	1.136	8
Hunan	<3	1.031	7	0.939	13	1.152	5
Guangdong	>3	1.046	1	0.909	19	1.346	1
Guangxi	=3	1.044	2	0.946	11	1.138	7
Chongqing	<3	0.979	20	0.913	18	1.020	17
Sichuan	>3	1.001	12	0.927	14	1.098	11
Yunnan	=3	0.975	21	0.907	20	1.018	18
Gansu	<3	0.995	15	0.979	2	1.008	20
Ningxia	<3	0.991	17	0.974	4	1.010	19
Xinjiang	>3	1.038	5	0.993	1	1.075	12

minimum result ranking of Liaoning is twenty-fifth. Therefore, Regions with more banks have both better as well as worse performing banks at the same time.

Tables 5.6, 5.7, and 5.8 provide information on total, direct, and indirect returns to scale change. Table 5.6 displays very similar results to Table 5.4. The average returns to scale change for all regions is above 1. This means all regions experience business expansion of urban commercial banks. In fact, Chinese urban commercial banks had rapid business expansion in the last 20 years (as detailed in Chapter 2). This can explain that the major contribution to productivity improvement is total returns to scale. in comparing results of total, direct, and indirect returns to scale change, the ranking of direct returns to scale is simliar to total returns to scale including average, maximum and minimum results. Thus, returns to scale change mainly come from direct returns to scale of urban commercial banks. Total returns to scale are a combination of direct returns to scale and indirect returns to scale (the spillover among neighbouring regions). The indirect return to scale measures the spillover of Chinese urban commercial banks. As Table 5.8 illuminates, all average, maximum, and minimum results of indirect returns to scale change are greater than 1 for all regions. It indicates that there is a spillover of returns to scale existing in urban commercial banks.

Table 5.6 Total Returns to Scale Change for Each Region

Region	No. of banks	Mean	Ranking	Min	Ranking	Max	Ranking
Beijing	<3	1.365	17	1.309	6	1.473	21
Tianjin	<3	1.421	12	1.296	7	1.609	19
Hebei	>3	1.718	1	1.411	3	2.198	4
Shanxi	>3	1.212	24	1.088	16	1.389	23
Inner Mongolia	>3	1.381	14	0.919	21	1.740	16
Liaoning	>3	1.368	15	0.780	23	2.248	2
Jilin	<3	1.332	19	1.148	12	1.463	22
Heilongjiang	<3	1.301	21	0.695	26	2.021	8
Shanghai	<3	1.366	16	1.339	5	1.387	24
Jiangsu	>3	1.534	8	1.262	10	1.923	10
Zhejiang	>3	1.405	13	1.013	18	2.061	6
Anhui	<3	1.508	9	1.373	4	1.647	18
Fujian	>3	1.539	7	1.143	14	2.209	3
Jiangxi	>3	1.548	5	1.184	11	1.951	9
Shandong	>3	1.426	11	1.115	15	2.105	5
Henan	>3	1.647	2	1.419	2	1.841	12
Hubei	<3	1.097	26	0.778	24	1.315	25
Hunan	<3	1.556	4	1.082	17	2.023	7
Guangdong	>3	1.303	20	0.716	25	2.267	1
Guangxi	=3	1.363	18	0.813	22	1.755	15
Chongqing	<3	1.547	6	1.288	8	1.848	11
Sichuan	>3	1.298	22	0.933	20	1.798	13
Yunnan	=3	1.452	10	1.274	9	1.785	14
Gansu	<3	1.574	3	1.447	1	1.687	17
Ningxia	<3	1.283	23	1.148	13	1.490	20
Xinjiang	>3	1.141	25	0.998	19	1.307	26

Table 5.7 Direct Returns to Scale Change for Each Region

Region	No. of banks	Mean	Ranking	Min	Ranking	Max	Ranking
Beijing	<3	1.317	16	1.269	6	1.410	21
Tianjin	<3	1.365	12	1.258	7	1.525	19
Hebei	>3	1.614	1	1.358	3	2.010	4
Shanxi	>3	1.185	24	1.078	16	1.338	23
Inner Mongolia	>3	1.329	14	0.928	21	1.634	16
Liaoning	>3	1.313	17	0.802	23	2.050	2
Jilin	<3	1.289	19	1.130	13	1.401	22
Heilongjiang	<3	1.256	22	0.724	26	1.866	8
Shanghai	<3	1.318	15	1.296	5	1.336	24
Jiangsu	>3	1.461	8	1.229	10	1.785	10
Zhejiang	>3	1.349	13	1.012	18	1.899	6
Anhui	<3	1.439	9	1.324	4	1.556	18
Fujian	>3	1.463	7	1.126	14	2.018	3
Jiangxi	>3	1.471	6	1.162	11	1.809	9
Shandong	>3	1.368	11	1.101	15	1.935	5
Henan	>3	1.556	2	1.364	2	1.718	12
Hubei	<3	1.083	26	0.800	24	1.274	25
Hunan	<3	1.477	4	1.072	17	1.867	7
Guangdong	>3	1.260	20	0.744	25	2.067	1
Guangxi	=3	1.313	18	0.833	22	1.646	15
Chongqing	<3	1.471	5	1.251	8	1.724	11
Sichuan	>3	1.258	21	0.940	20	1.682	13
Yunnan	=3	1.390	10	1.239	9	1.671	14
Gansu	<3	1.495	3	1.388	1	1.590	17
Ningxia	<3	1.246	23	1.130	12	1.424	20
Xinjiang	>3	1.123	25	0.998	19	1.268	26

Table 5.8 Indirect Returns to Scale Change for Each Region

Region	No. of banks	Mean	Ranking	Min	Ranking	Max	Ranking
Beijing	<3	1.036	15	1.031	6	1.045	21
Tianjin	<3	1.040	11	1.030	7	1.055	19
Hebei	>3	1.062	1	1.040	3	1.093	4
Shanxi	>3	1.021	24	1.009	16	1.038	23
Inner Mongolia	>3	1.035	16	0.990	21	1.065	16
Liaoning	>3	1.031	19	0.972	23	1.096	2
Jilin	<3	1.032	18	1.016	12	1.044	22
Heilongjiang	<3	1.025	23	0.960	26	1.083	8
Shanghai	<3	1.036	14	1.034	5	1.038	24
Jiangsu	>3	1.049	7	1.027	10	1.077	10
Zhejiang	>3	1.038	13	1.002	18	1.085	6
Anhui	<3	1.047	9	1.036	4	1.058	18
Fujian	>3	1.048	8	1.015	14	1.094	3
Jiangxi	>3	1.049	5	1.019	11	1.079	9
Shandong	>3	1.040	12	1.012	15	1.088	5
Henan	>3	1.058	2	1.040	2	1.072	12
Hubei	<3	1.008	26	0.972	24	1.031	25
Hunan	<3	1.049	6	1.009	17	1.083	7
Guangdong	>3	1.027	22	0.963	25	1.097	1
Guangxi	=3	1.033	17	0.977	22	1.066	15
Chongqing	<3	1.050	4	1.029	8	1.072	11
Sichuan	>3	1.028	20	0.992	20	1.069	13
Yunnan	=3	1.042	10	1.028	9	1.068	14
Gansu	<3	1.053	3	1.043	1	1.061	17
Ningxia	<3	1.028	21	1.016	13	1.046	20
Xinjiang	>3	1.014	25	1.000	19	1.031	26

In summary, regions with fewer banks rank in the middle of the results, whereas regions with more banks appear in the head and tail. This suggests that a competitive market environment encourages banking productivity growth. The historical problem of non-performing loans can explain the lower ranking banks in regions with more banks. Most of the regions with more banks are in eastern China, where they have an economic advantage compared to western regions (details in appendices). With this advantage, banks from eastern regions can expand faster than other regions' banks. This confirms the results that changes in returns to scale mainly contribute to bank productivity.

5.5 Conclusion

By establishing a spatial autoregressive production frontier to measure the spatial total factor productivity index, this chapter analyses the productivity of Chinese urban commercial banks from 2013 to 2016. This chapter decomposes a spatial TFP index into efficiency change and returns to scale change of 64 banks, which covers most Chinese regions. Therefore, the productivity results contain spatial direct (feedback) and indirect (spatial spillovers) components.

There is a positive spatial dependence of banks' production to their neighbouring regions banks. On average, productivity of Chinese urban commercial banks increases in the post market restructure period from 2013 to

2016. Returns to scale change mainly contribute to productivity improvement as efficiency is nearly unchanged. The result confirms the rapid expansion of urban commercial banks. Examining specific areas, regions with more urban commercial banks (more than three) experience an increase in productivity and returns to scale compared to regions with fewer urban commercial banks (less than three). This implies that a competitive market environment encourages increasing productivity in banks. This is also supported by the current situation of the Chinese economy, where regions with more banks (eastern regions) have an economical advantage compared to regions with fewer banks (western regions). In addition, there is a slight returns to scale spillover among Chinese urban commercial banks.

Chapter 6 - Conclusions

This thesis extends research on the efficiency and productivity of national and regional Chinese commercial banks. It starts with an efficiency analysis of general commercial banks and then moves to the analysis of regional banks. This thesis takes urban commercial banks as its research target. As Chapter 3 demonstrates the price of labour is the costliest input for Chinese commercial banks; different ownership of the commercial banks reveals a significant difference in their performance.

The overall efficiency of Chinese commercial banks increased from 2002 to 2006; but there was an efficiency drawback during the world financial crisis of 2006 to 2008. The Chinese central bank took several actions to face the crisis. As the results suggest, the overall efficiency of commercial banks was gradually increased from 2008 to 2014. For ownership comparison, joint-stock, urban, and rural commercial banks show similar and higher efficiency performance, followed by foreign banks and the state-owned commercial banks, which reported the lowest cost efficiency. Those results are in line with findings from other literature on Chinese banking except Chen et al. (2005a). The trends of efficiency performance for each type of bank all display an upward tendency.

This thesis identifies a research gap in regional banking performance. With boosted growth in last 20 years, urban commercial banks became the third largest group of commercial banks in China; Chapter 3 indicates that they also achieve higher efficiency performance than other commercial banks. Based on their geographical characteristics, this thesis applies a spatial production analysis on the performance of urban commercial banks. This methodology provides more accurate results for regional banking analysis.

Instead of traditional production function, this thesis adds spatial lag of independent variables and spatial lag of dependent variables to capture spatial dependence for urban commercial banks of adjacent regions (Glass et al., 2016a; 2016b). Among three inputs, deposits have the biggest effect on loans of banks. The model results display a significant positive spatial dependence of Chinese urban commercial banks. It indicates that the production (loans) of urban commercial bank has a positive relationship with production of their neighbouring regions' banks. Regions which have more than three urban commercial banks located in eastern China have an advantage of economic development compared to western regions. Most of the regions with fewer than three banks are located in western China. Our efficiency measurement results suggest that the average performance of banks in regions with fewer banks is higher.

Building on the efficiency analysis of Chinese regional banking, this thesis analyses the productivity of Chinese urban commercial banks in Chapter 5. This thesis introduces a spatial total factor productivity index by adding spatial direct and indirect components into the traditional Total Factor Productivity index (Glass and Kenjegalieva, 2019). The overall productivity of Chinese urban commercial banks increases and mainly due to the returns to scale component. Efficiency is almost unchanged during the research period. With a view of productivity for each region, the results are different compared to their efficiency performance. The regions that have more than three banks have better productivity results than regions with fewer than three banks. Furthermore, all highest productivity growth banks come from regions with multiple banks. Those differences between efficiency and productivity demonstrate that a boost in expansion has helped urban commercial banks to achieve high productivity, but their efficiency does not improve with productivity growth.

6.1 Policy Implications of the Findings

The findings from this thesis confirms the positive effect of financial reforms on efficiency performance in Chinese commercial banks. After China joined the World Trade Organization, the financial market gradually opens to foreign participants. This improves the competition and regulation of Chinese commercial banks. The cost efficiency increases after 2002. However, the 2008 global financial crisis drags down the efficiency of most Chinese commercial banks. Interest rate liberalisation (open loan interest rate to market adjustment) and ownership restructure (banks listed in the stock market) help Chinese commercial banks recover their cost efficiency. The lowest efficient banks—state-owned commercial banks—could learn the operation strategies of joint-stock and regional commercial banks in order to improve their performance.

There is a positive spatial relationship among Chinese urban commercial banks. It can be simply interpreted that if one urban commercial bank increases its output, the outputs of other banks from its neighbouring regions should increase to a certain level as well. The market restructure of urban commercial banks—the transformation of credit cooperative into urban commercial banks—improves the efficiency and productivity of urban commercial banks. This indicates that the lowest efficient urban commercial banks could improve their efficiency through mergers with other banks and financial institutions. More banks in the region imply that both the best and worst efficiency banks exist in the region. Therefore, a highly competitive market encourages banks to achieve higher efficiency; however, the economic advantage does not affect average efficiency for the whole region. This situation can be explained by the historical problem of urban commercial banks (the non-performing loans from urban credit cooperatives). However, a number of urban commercial banks from eastern regions still lag behind their peers from western regions.

Chinese urban commercial banks are experiencing a boost in expansion that contributes to their productivity growth. However, their efficiency is nearly unchanged. The business expansion of urban commercial banks gains positive returns to scale change. But for long-term productivity growth, urban commercial banks must improve their efficiency. The advantage of the eastern region is that their GDP and population help their urban commercial banks expand business. However, when these banks reach a bottleneck of returns to scale change, they need efficiency enhancement to gain productivity.

6.2 Limitations of the Studies

The limitation of this thesis is the data scale. For the cost efficiency review of Chinese commercial banks, many small bank—such as urban and rural commercial banks—do not have data available for analysis. Even for the available data, there is a negative value of other operating expenses and equity. This might lead to a bias conclusion. For urban commercial banks, there are only three years' data for efficiency analysis and four years; data for productivity analysis after the market restructure. The spatial model requires a balanced dataset, and merger and stock listing activities caused missing data. The dataset only covers half of Chinese urban commercial banks. If there were a long time period dataset, this thesis could add technology change into our analysis. The analysis would be more comprehensive and convinced.

6.3 Area for Further Research

There are many interesting areas that could be investigated for further research, including: the performance analysis of Chinese development banks; a comparison between urban and rural commercial banks; the spatial dependence of rural commercial banks; and risk measurement of Chinese commercial banks. By identifying spatial dependence that exists among Chinese urban commercial banks, future research could continue work on the second stage analysis of efficiency and productivity, competition of each region, impact of non-performing loans, and the impact of merger and acquisition on performance.

Appendix

Table A.0.1 Statistic Summary of OLS Residuals for Chapter 3

		Residuals		
	Percentiles	Smallest		
1%	-0.60	-0.67		
5%	-0.38	-0.66		
10%	-0.31	-0.65	Obs	899
25%	-0.19	-0.64	Sum of Wgt.	899
50%	-0.05		Mean	-2.91E-10
		Largest	Std. Dev.	0.30
75%	0.14	1.11		
90%	0.34	1.14	Variance	0.09
95%	0.65	1.16	Skewness	1.23
99%	1.05	1.23	Kurtosis	5.46

Table A.0.2 Skewness Test Result for Chapter 3

Skewness/Kurtosis tests for Normality					
				------- joint ------	
Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	chi2(2)	Prob>chi2
Residuals	899	0	0	203.89	0

Table A 0.3 General Information from Literature on Bank Efficiency Analysis

Study	Type of bank	Sample size	Method	Research period	Result
Altunbas et al., 2000	Japanese commercial banks	139 banks	SFA Cost function	1993 to 1996	Risk and quality factors have an effect on bank efficiency measurement, and capital has an impact on scale efficiency
Berger et al., 2009	Chinese banking	38 banks	SFA Cost and profit function	1994 to 2003	Foreign banks are more efficient than state-owned banks, and minority foreign ownership can improve efficiency
Chen et al., 2005a	Chinese Commercial and investment banks	43 banks	DEA Cost function	1993 to 2000	Large state-owned banks and smaller banks are more efficient than medium sized banks

Table A 0.4 General Information from Literature on Bank Efficiency Analysis (continued)

Study	Type of bank	Sample size	Method	Research period	Result
Drake et al., 2006	Hong Kong banking	Whole banking industry	Slacks-Based measure DEA	1995 to 2001	Environmental factors have differential impact on different size banks
Eskelinen and Kuosmanen, 2013	Finnish bank group	1 bank	Stochastic semi-nonparametric envelopment of data Cost function	2007 to 2010	The new approach can assess sale efficiency which can improve management and sale practice
Fu and Heffernan, 2007	Chinese commercial banks	14 banks	SFA Cost function	1985 to 2002	On average, the joint-stock banks are more X-efficient than the state-owned commercial banks

Table A 0.5 General Information from Literature on Bank Efficiency Analysis (continued)

Study	Type of bank	Sample size	Method	Research period	Result
Glass et al., 2014b	Kazakh banking	Whole banking industry	SFA Cos revenue, and profit functions	2007 to 2010	Ratio of bad loans to total loans shows the effect of cost, input-distance, and alternative profit frontiers due to the increasing of bad loans.
Jiang et al, 2009	Chinese commercial banks	All major commercial banks	SFA Output distance function	1995 to 2005	Joint-stock ownership is associated with better performance in terms of profitability than state ownership.
Kenjegalieva et al., 2009	Eight Eastern European countries banking	Whole banking industry	DEA X-efficiency	1999 to 2003	Overall X-efficiency is increasing but few environment factors have differential effect on efficiency

Table A 0.6 General Information from Literature on Bank Efficiency Analysis (continued)

Study	Type of bank	Sample size	Method	Research period	Result
Koutsomanoli-Filippaki et al., 2009	10 Central and Eastern European countries banking	186 banks	Direct distance function Luenberger productivity indicator	1998 to 2003	Initially productivity is decreasing but has improved in recent structural reforms.
Lensink et al., 2008	105 countries foreign banks	2,095 commercial banks	SFA Cost function	1998 to 2003	Foreign ownership has negative effect on efficiency, but good governance can reduce it
Portela and Thanassoulis, 2007	Portuguese bank	1 bank	DEA Transactional, operational, and profit efficiency	2001 to 2002	There is positive relationship between transactional and operational efficiency

Table A 0.7 General Information from Literature on Bank Efficiency Analysis (continued)

Study	Type of bank	Sample size	Method	Research period	Result
Tabak et al., 2013	US saving bank	198 banks	SFA Geographically weighted estimation process	2001 to 2009	It is important to consider of local environment factors for performance analysis
Tan and Floros, 2013	Chinese commercial banks	101 banks	Three stage least square estimation DEA	2003 to 2009	There is positive relationship between risk and efficiency, and negative relationship between risk and level of capitalisation.
Wang et al., 2014	Chinese commercial banks	16 banks	Network DEA	2003 to 2011	Overall efficiency is increasing due to the reform

Table A.0.8 Statistic Summary of OLS Residuals for Chapter 4

	Residuals			
	Percentiles	Smallest		
1%	-0.57	-0.69		
5%	-0.37	-0.57		
10%	-0.30	-0.53	Obs	195
25%	-0.10	-0.48	Sum of Wgt.	195
50%	0.04		Mean	0.00
		Largest	Std. Dev.	0.20
75%	0.13	0.33		
90%	0.22	0.34	Variance	0.04
95%	0.28	0.34	Skewness	-0.73
99%	0.34	0.49	Kurtosis	3.58

Table A.0.9 Skewness Test Result for Chapter 4

Skewness/Kurtosis Tests for Normality					
				-------joint ------	
Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	chi2(2)	Prob>chi2
epsilon	195	0.0001	0.1041	17.77	0.0001

Table A.0.10 General Information on Literature Discussing National and Regional Banking Efficiency

Study	Type of bank	Sample size	Method	Research period	Result
Ariff and Can, 2008	Chinese Commercial banks	28 banks	DEA Cost and profit function	1995 to 2004	Medium-sized banks are more efficient than small and large banks
Bonin et al., 2005a	Foreign, government, and private banks in 11 transition countries	225 banks	SFA Cost and profit function	1996 to 2000	Foreign banks are more efficient than other banks. Government and privatisation offer similar efficiency results
Bos and Kool, 2006	Local banks in Netherlands	401 banks	SFA Cost and profit function	1998 to 1999	Environment factors have to affect bank efficiency but within limited extents

Table A.0.11 General Information on Literature Discussing National and Regional Banking Efficiency (continued)

Study	Type of bank	Sample size	Method	Research period	Result
Boubakri et al., 2005	Privatised banks in 22 developing countries	81 banks	Univariate tests Panel data estimation	1986 to 1998	Newly privatised banks are exposed to more credit risk and lower efficiency but can improve in the long term
Berger and Deyoung, 2001	U.S. banking	Over 7,000 banks	Distribution-Free approach Cost and profit function	1993 to 1998	There is a relationship between geographic expansion and bank efficiency
Collender and Shaffer, 2003	U.S. local banking	2,539 banking market	Hereafter J&S model	1973 to 1996	Local banks behave differently from non-local banks; geographic liberalisation has an effect on local growth

Table A.0.12 General Information on Literature Discussing National and Regional Banking Efficiency (continued)

Study	Type of bank	Sample size	Method	Research period	Result
Fu and Heffernan, 2009	Chinese Commercial banks	14 banks	Efficient-Structure hypothese X-efficiency Scale efficiency	1985 to 2002	Joint-stock commercial banks are more efficient than state-owned commercial banks
Hasan et al., 2009	11 European countries banking	7,000 banks	Dynamic panel growth model SFA Cost and profit function	1996 to 2004	Improvement of bank efficiency encourages more regional growth
Lin and Zhang, 2009	Chinese banking	60 banks	Berger et al. (2005)	1997 to 2004	State-owned banks are less efficient than banks held by foreign shares and public listing

Table A.0.13 General Information on Literature Discuss National and Regional Banking Efficiency (continued)

Study	Type of bank	Sample size	Method	Research period	Result
Sun et al., 2013	Chinese city commercial banks	72 banks	SFA Profit function	2002 to 2009	Strategic investor has an effect on efficiency of city commercial banks, and there is negative relation between strategic investor and level of regional economic development
Vennet, 2002	17 European countries banking	2,375 banks	SFA Cost and profit function	1995 to 1996	De-specialisation may lead to more efficient banking system in Europe
Wu et al., 2006	Canada banking	808 banking branches	Fuzzy DEA		Fuzzy DEA provides a comparison of environment variable of different region

Table A.0.14 Statistic Summary of OLS Residuals for Chapter 5

		Residuals		
	Percentiles	Smallest		
1%	-0.53	-0.71		
5%	-0.37	-0.53		
10%	-0.29	-0.53	Obs	256
25%	-0.11	-0.52	Sum of Wgt.	256
50%	0.029		Mean	-2.0E-10
		Largest	Std. Dev.	0.19
75%	0.12	0.37		
90%	0.22	0.37	Variance	0.04
95%	0.28	0.43	Skewness	-0.68
99%	0.37	0.47	Kurtosis	3.66

Table A.0.15 Skewness Test Result for Chapter 5

Skewness/Kurtosis tests for Normality					
				------- joint ------	
Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	chi2(2)	Prob>chi2
Residuals	256	0	0.05	21.44	0

Table A.0.16 General Information on Banking Productivity Literature

Study	Type of bank	Sample size	Method	Research period	Result
Alam, 2001	Large US bank (total asset > $500 million)	166 banks	DEA Malmquist productivity Index	1980 to 1989	Large US commercial banks received productivity gain from different regulatory environment
Assaf et al., 2010	Japanese shinkin bank	291 banks	Output distance function Malmquist productivity Index	2000 to 2006	Both efficiency and productivity have no significant improvement during examined period
Assaf et al., 2013	Turkish commercial bank	45 banks	Inputs distance function Bayesian stochastic frontier approach	2002 to 2010	Positivity increase of Turkish banking productivity due to technology change

Table A.0.17 General Information on Banking Productivity Literature (continued)

Study	Type of bank	Sample size	Method	Research period	Result
Banker et al., 2010	Korean commercial bank	14 banks	DEA Non-parametric Smirnov test	1995 to 2005	Bank reform provides uneven impact on individual banks productivity within Korean bank industry
Bernad et al., 2010	Spanish savings bank	77 banks	Cobb-Douglas production function	1986 to 2004	Half of the merger improve banks' productivity and remaining activities have negative or non-effect productivity
Casu et al., 2004	Large European bank (total asset > Euro 450 million)	More than 2,000 banks	Parametric and non-parametric Malmquist total factor productivity (TFP) index	1994 to 2000	Positive productivity improvement during the research period and mainly contributed by technology

Table A.0.18 General Information on Banking Productivity Literature (continued)

Study	Type of bank	Sample size	Method	Research period	Result
Chang et al., 2012	Chinese commercial bank	19 banks	Input-oriented directional distance function Input slack-based productivity index	2002 to 2009	Banks experienced productivity growth of29.84% over research period due to technology change
Chen, 2012	Taiwanese banking	42 banks	Input-oriented generalised metafrontier Malmquist productivity index	1999 to 2007	Adding risk as input provides better bank frontier and public bank received more productivity than private bank
Devaney and Weber, 2000	U.S. rural banking	More than 4,000 banks	Output distance function Malmquist productivity index	1990 to 1993	Rural banks have average 11.4% productivity increase during the period by technology change

Table A.0.19General Information on Banking Productivity Literature (continued)

Study	Type of bank	Sample size	Method	Research period	Result
Feng and Zhang, 2012	US. commercial and community bank	5,896 banks	Output-distance-function-based Divisia productivity index	1997 to 2006	US large and community banks have downtrend productivity growth rate
Fiordelisi and Molyneux, 2010	European banking	France, Germany, Italy and UK industry	DEA TEP	1995 to 2002	Productivity increasing under technology change and productivity change describes the variation of shareholder value
Fujii et al., 2014	Indian banking	Whole industry	Luenberger Productivity Indicator	2004 to 2011	Indian banking productivity have non-significant improvement during research period

Table A.0.20 General Information on Banking Productivity Literature (continued)

Study	Type of bank	Sample size	Method	Research period	Result
Glass and Kenjegalieva, 2019	Larger U.S. banks (total asset > $3 billion)	192 banks	Spatial decomposition of TFP	1992 to 2015	Productivity of large US bank grows after financial crisis mainly depending on bank itself rather than spatial spillovers.
Kumbhakar and Wang, 2007	Chinese commercial bank	14 banks	Input distance functions TFP	1993 to 2002	Joint-stock commercial banks have a much higher growth rate than state-owned commercial bank productivity
Matthews and Zhang, 2010	Chinese commercial bank	61 banks	DEA Malmquist productivity Index	1997 to 2007	City commercial banks have more productivity growth than state-owned and joint-stock commercial banks

Table A.0.21 General Information on Banking Productivity Literature (continued)

Study	Type of bank	Sample size	Method	Research period	Result
Mukherjee et al., 2001	Large US commercial bank	201 banks	DEA Malmquist productivity Index	1984 to 1990	Overall productivity increase at average of 4.5% per year
Nakane and Weintraub, 2005	Brazil commercial bank	242 banks	Production function Levinsohn and Petrin (2003)	1990 to 2002	State-owned banks have less productivity than private bank; privatisation improves productivity
Park and Weber, 2006	Korean banking	Whole industry	Luenberger productivity indicator	1992 to 2002	Bank reform provides productivity growth by technology improvement offset of efficiency decline

Table A.0.22 Annual GDP of Each Region in 100 million RMB

Region	2015	2014	2013	2012
Beijing	23014.59	21330.83	19800.81	17879.40
Tianjin	16538.19	15726.93	14442.01	12893.88
Hebei	29806.11	29421.15	28442.95	26575.01
Shanxi	12766.49	12761.49	12665.25	12112.83
Inner Mongolia	17831.51	17770.19	16916.50	15880.58
Liaoning	28669.02	28626.58	27213.22	24846.43
Jilin	14063.13	13803.14	13046.40	11939.24
Heilongjiang	15083.67	15039.38	14454.91	13691.58
Shanghai	25123.45	23567.70	21818.15	20181.72
Jiangsu	70116.38	65088.32	59753.37	54058.22
Zhejiang	42886.49	40173.03	37756.58	34665.33
Anhui	22005.63	20848.75	19229.34	17212.05
Fujian	25979.82	24055.76	21868.49	19701.78
Jiangxi	16723.78	15714.63	14410.19	12948.88
Shandong	63002.33	59426.59	55230.32	50013.24

Source: National Bureau of Statistics of China

Table A.0.23 Annual GDP of Each Region in 100 million RMB (continued)

Region	2015	2014	2013	2012
Henan	37002.16	34938.24	32191.30	29599.31
Hubei	29550.19	27379.22	24791.83	22250.45
Hunan	28902.21	27037.32	24621.67	22154.23
Guangdong	72812.55	67809.85	62474.79	57067.92
Guangxi	16803.12	15672.89	14449.90	13035.10
Hainan	3702.76	3500.72	3177.56	2855.54
Chongqing	15717.27	14262.60	12783.26	11409.60
Sichuan	30053.10	28536.66	26392.07	23872.80
Guizhou	10502.56	9266.39	8086.86	6852.20
Yunnan	13619.17	12814.59	11832.31	10309.47
Tibet	1026.39	920.83	815.67	701.03
Shaanxi	18021.86	17689.94	16205.45	14453.68
Gansu	6790.32	6836.82	6330.69	5650.20
Qinghai	2417.05	2303.32	2122.06	1893.54
Ningxia	2911.77	2752.10	2577.57	2341.29
Xinjiang	9324.80	9273.46	8443.84	7505.31

Source: National Bureau of Statistics of China

Table A.0.24 Value-added of Financial Institutions to GDP of Each Region in 100 million RMB

Region	2015	2014	2013	2012
Beijing	3926.28	3357.71	2943.13	2536.91
Tianjin	1603.23	1422.28	1235.91	1001.59
Hebei	1480.92	1347.58	1137.72	913.66
Shanxi	1140.54	897.26	809.90	639.61
Inner Mongolia	829.20	724.16	625.14	502.01
Liaoning	1869.46	1482.17	1249.71	969.37
Jilin	565.27	464.96	399.54	244.63
Heilongjiang	847.66	707.47	606.22	485.11
Shanghai	4162.70	3400.41	2823.81	2450.36
Jiangsu	5302.93	4723.69	3958.79	3136.51
Zhejiang	2922.93	2767.44	2795.13	2762.24
Anhui	1241.87	1046.67	912.77	617.62
Fujian	1681.33	1449.82	1264.72	1015.37
Jiangxi	897.65	739.70	542.83	413.07
Shandong	2994.66	2709.65	2383.43	1936.11

Source: National Bureau of Statistics of China

Table A.0.25 Value-added of Financial Institutions to GDP of Each Region in 100 million RMB (continued)

Region	2015	2014	2013	2012
Henan	1991.11	1509.20	1280.92	1013.60
Hubei	1853.12	1372.61	1179.55	870.36
Hunan	1104.18	950.04	758.90	579.76
Guangdong	5757.08	4447.43	4122.81	3171.96
Guangxi	1018.01	876.47	777.60	573.05
Hainan	242.82	210.63	187.14	130.69
Chongqing	1410.18	1225.27	1080.14	915.65
Sichuan	2202.23	1828.09	1712.77	1303.56
Guizhou	607.11	491.65	444.53	365.87
Yunnan	981.85	860.98	725.90	541.18
Tibet	68.05	55.58	41.75	32.04
Shaanxi	1082.37	948.93	738.52	551.20
Gansu	443.12	364.84	294.18	184.43
Qinghai	220.87	175.21	145.23	83.73
Ningxia	256.38	230.16	206.34	167.48
Xinjiang	563.80	536.94	473.57	360.40

Source: National Bureau of Statistics of China

Table A.0.26 Resident Population for Each Region in 10000 Persons

Region	2015	2014	2013	2012
Beijing	2171	2152	2115	2069
Tianjin	1547	1517	1472	1413
Hebei	7425	7384	7333	7288
Shanxi	3664	3648	3630	3611
Inner Mongolia	2511	2505	2498	2490
Liaoning	4382	4391	4390	4389
Jilin	2753	2752	2751	2750
Heilongjiang	3812	3833	3835	3834
Shanghai	2415	2426	2415	2380
Jiangsu	7976	7960	7939	7920
Zhejiang	5539	5508	5498	5477
Anhui	6144	6083	6030	5988
Fujian	3839	3806	3774	3748
Jiangxi	4566	4542	4522	4504
Shandong	9847	9789	9733	9685

Source: National Bureau of Statistics of China

Table A.0.27 Resident Population for Each Region in 10000 Persons (continued)

Region	2015	2014	2013	2012
Henan	9480	9436	9413	9406
Hubei	5852	5816	5799	5779
Hunan	6783	6737	6691	6639
Guangdong	10849	10724	10644	10594
Guangxi	4796	4754	4719	4682
Hainan	911	903	895	887
Chongqing	3017	2991	2970	2945
Sichuan	8204	8140	8107	8076
Guizhou	3530	3508	3502	3484
Yunnan	4742	4714	4687	4659
Tibet	324	318	312	308
Shaanxi	3793	3775	3764	3753
Gansu	2600	2591	2582	2578
Qinghai	588	583	578	573
Ningxia	668	662	654	647
Xinjiang	2360	2298	2264	2233

Source: National Bureau of Statistics of China

Table A.0.28 Household Consumption Expenditure for Each Region

Region	2015	2014	2013	2012
Beijing	39200	36057	33337	30350
Tianjin	32595	28492	26261	22984
Hebei	12829	12171	11557	10749
Shanxi	14364	12622	12078	10829
Inner Mongolia	20835	19827	17168	15196
Liaoning	23693	22260	20156	17999
Jilin	14630	13663	13676	12276
Heilongjiang	16443	15215	12978	11601
Shanghai	45816	43007	39223	36893
Jiangsu	31682	28316	23585	19452
Zhejiang	28712	26885	24771	22845
Anhui	13941	12944	11618	10978
Fujian	20828	19099	17115	16144
Jiangxi	14489	12000	11910	10573
Shandong	20684	19184	16728	15095

Source: National Bureau of Statistics of China

Table A.0.29 Household Consumption Expenditure for Each Region (continued)

Region	2015	2014	2013	2012
Henan	14507	13078	11782	10380
Hubei	17429	15762	13912	12283
Hunan	16289	14384	12920	11740
Guangdong	26365	24582	23739	21823
Guangxi	13857	12944	11710	10519
Hainan	17019	12915	11712	10634
Chongqing	18860	17262	15423	13655
Sichuan	14774	13755	12485	11280
Guizhou	12876	11362	9541	8372
Yunnan	13401	12235	11224	9782
Tibet	8756	7205	6275	5340
Shaanxi	15363	14812	13206	11852
Gansu	11868	10678	9616	8542
Qinghai	15167	13534	12070	10289
Ningxia	17210	15193	13537	12120
Xinjiang	13684	12435	11401	10675

Source: National Bureau of Statistics of China

Table A.0.30 Local Governments Tax Revenue in 100 million RMB

Region	2015	2014	2013	2012
Beijing	4263.91	3861.29	3514.52	3124.75
Tianjin	1578.07	1486.88	1310.66	1105.56
Hebei	1934.29	1866.06	1724.87	1560.59
Shanxi	1056.60	1134.34	1136.89	1045.22
Inner Mongolia	1320.75	1251.07	1215.20	1119.87
Liaoning	1650.45	2330.57	2521.62	2317.19
Jilin	867.12	884.40	856.41	760.57
Heilongjiang	880.34	977.40	912.82	837.80
Shanghai	4858.16	4219.05	3797.16	3426.79
Jiangsu	6610.12	6006.05	5419.49	4782.59
Zhejiang	4168.22	3853.96	3545.66	3227.77
Anhui	1799.89	1692.52	1520.22	1305.09
Fujian	1938.71	1893.73	1723.28	1440.34
Jiangxi	1517.03	1381.13	1178.74	978.08
Shandong	4203.12	3965.76	3533.49	3050.20

Source: National Bureau of Statistics of China

Table A.0.31 Local Governments Tax Revenue in 100 million RMB (continued)

Region	2015	2014	2013	2012
Henan	2101.17	1951.46	1764.71	1469.57
Hubei	2086.50	1873.11	1604.85	1324.44
Hunan	1527.52	1438.52	1299.15	1110.74
Guangdong	7377.07	6510.47	5767.94	5073.88
Guangxi	1031.65	978.07	875.74	762.46
Hainan	514.31	480.55	411.63	350.80
Chongqing	1450.93	1281.83	1112.62	970.17
Sichuan	2353.51	2312.46	2103.51	1827.04
Guizhou	1126.03	1026.70	839.67	681.66
Yunnan	1210.54	1233.23	1215.66	1063.90
Tibet	92.00	85.86	71.54	70.07
Shaanxi	1290.33	1335.68	1256.24	1131.55
Gansu	529.79	490.26	417.73	347.78
Qinghai	205.81	199.39	175.05	146.69
Ningxia	256.31	250.33	237.49	207.02
Xinjiang	861.73	887.79	826.34	698.93

Source: National Bureau of Statistics of China

Table A.0.32 Local Governments Expenditure on Financial Regulation in100 million RMB

Region	2015	2014	2013	2012
Beijing	12.80	4.09	3.54	3.00
Tianjin	3.67	2.93	3.02	2.81
Hebei	3.19	1.98	7.84	4.89
Shanxi	5.61	2.91	9.35	5.15
Inner Mongolia	13.16	3.21	2.44	3.25
Liaoning	12.37	3.89	4.82	7.62
Jilin	5.54	18.62	10.47	4.62
Heilongjiang	0.80	1.15	1.67	2.61
Shanghai	17.87	15.20	15.09	17.05
Jiangsu	18.05	14.84	16.50	22.98
Zhejiang	30.51	10.13	12.14	9.87
Anhui	6.93	5.02	3.63	4.04
Fujian	4.86	2.98	2.78	2.98
Jiangxi	10.22	4.32	6.71	6.92
Shandong	48.74	11.89	12.93	17.35

Source: National Bureau of Statistics of China

Table A.0.33 Local Governments Expenditure on Financial Regulation in 100 million RMB (continued)

Region	2015	2014	2013	2012
Henan	40.92	27.71	28.72	25.06
Hubei	10.51	9.79	13.76	9.05
Hunan	8.83	5.76	2.35	3.22
Guangdong	141.17	45.56	16.43	27.67
Guangxi	33.79	2.65	7.04	5.12
Hainan	0.53	1.64	1.39	0.75
Chongqing	13.51	9.76	9.88	3.51
Sichuan	17.40	7.33	6.51	10.72
Guizhou	0.79	0.52	0.48	0.97
Yunnan	2.32	4.73	2.98	4.43
Tibet	2.84	2.62	1.10	0.34
Shaanxi	12.86	5.32	5.48	7.51
Gansu	2.16	1.89	0.16	8.10
Qinghai	6.00	12.93	1.82	6.26
Ningxia	7.11	16.12	1.07	4.95
Xinjiang	1.18	1.20	0.87	16.89

Source: National Bureau of Statistics of China

Table A.0.34 Local Governments General Budgetary Expenditure in 100 million RMB

Region	2015	2014	2013	2012
Beijing	5737.70	4524.67	4173.66	3685.31
Tianjin	3232.35	2884.70	2549.21	2143.21
Hebei	5632.19	4677.30	4409.58	4079.44
Shanxi	3422.97	3085.28	3030.13	2759.46
Inner Mongolia	4252.96	3879.98	3686.52	3425.99
Liaoning	4481.61	5080.49	5197.42	4558.59
Jilin	3217.10	2913.25	2744.81	2471.20
Heilongjiang	4020.66	3434.22	3369.18	3171.52
Shanghai	6191.56	4923.44	4528.61	4184.02
Jiangsu	9687.58	8472.45	7798.47	7027.67
Zhejiang	6645.98	5159.57	4730.47	4161.88
Anhui	5239.01	4664.10	4349.69	3961.01
Fujian	4001.58	3306.70	3068.80	2607.50
Jiangxi	4412.55	3882.70	3470.30	3019.22
Shandong	8250.01	7177.31	6688.80	5904.52

Source: National Bureau of Statistics of China

Table A.0.35 Local Governments General Budgetary Expenditure in 100 million RMB (continued)

Region	2015	2014	2013	2012
Henan	6799.35	6028.69	5582.31	5006.40
Hubei	6132.84	4934.15	4371.65	3759.79
Hunan	5728.72	5017.38	4690.89	4119.00
Guangdong	12827.80	9152.64	8411.00	7387.86
Guangxi	4065.51	3479.79	3208.67	2985.23
Hainan	1239.43	1099.74	1011.17	911.67
Chongqing	3792.00	3304.39	3062.28	3046.36
Sichuan	7497.51	6796.61	6220.91	5450.99
Guizhou	3939.50	3542.80	3082.66	2755.68
Yunnan	4712.83	4437.98	4096.51	3572.66
Tibet	1381.46	1185.51	1014.31	905.34
Shaanxi	4376.06	3962.50	3665.07	3323.80
Gansu	2958.31	2541.49	2309.62	2059.56
Qinghai	1515.16	1347.43	1228.05	1159.05
Ningxia	1138.49	1000.45	922.48	864.36
Xinjiang	3804.87	3317.79	3067.12	2720.07

Source: National Bureau of Statistics of China

Table A.0.36 Number of Employed Financial Institutions in 10000 Persons

Region	2015	2014	2013	2012
Beijing	47.16	43.16	39.14	37.56
Tianjin	12.13	8.91	8.09	7.82
Hebei	29.91	27.66	25.64	24.65
Shanxi	16.82	15.62	15.61	15.77
Inner Mongolia	11.57	11.33	11.08	10.79
Liaoning	26.01	24.44	23.21	22.52
Jilin	11.83	11.48	11.02	10.93
Heilongjiang	18.70	16.90	15.92	16.01
Shanghai	33.74	33.03	30.03	29.46
Jiangsu	35.05	33.32	30.79	29.36
Zhejiang	42.30	37.96	36.32	36.38
Anhui	19.12	17.66	17.24	16.83
Fujian	17.88	16.48	15.13	14.75
Jiangxi	12.58	12.18	11.27	10.63
Shandong	41.56	38.83	34.76	32.74

Source: National Bureau of Statistics of China

Table A.0.37 Number of Employed Financial Institutions in 10000 Persons (continued)

Region	2015	2014	2013	2012
Henan	24.35	23.98	24.13	23.32
Hubei	19.47	17.99	17.32	16.33
Hunan	24.04	22.38	21.20	20.74
Guangdong	46.07	43.15	43.33	47.59
Guangxi	13.27	11.76	11.59	11.66
Hainan	4.10	3.43	2.78	2.77
Chongqing	13.28	13.21	13.12	13.03
Sichuan	25.87	24.22	24.12	22.97
Guizhou	8.65	8.35	8.04	7.38
Yunnan	9.95	10.11	9.90	9.85
Tibet	0.90	0.94	0.97	0.83
Shaanxi	18.00	16.07	15.04	14.62
Gansu	7.47	7.23	7.21	7.19
Qinghai	2.25	2.24	2.16	2.19
Ningxia	3.77	3.41	3.06	2.96
Xinjiang	9.02	8.88	8.74	8.13

Source: National Bureau of Statistics of China

Table A.0.38 Total Wage of Employees in Financial Institutions for Each Region in 100 million RMB

Region	2015	2014	2013	2012
Beijing	1114.73	945.30	791.39	674.56
Tianjin	125.31	102.17	92.65	80.16
Hebei	216.14	196.66	167.21	146.86
Shanxi	123.96	115.65	104.82	96.47
Inner Mongolia	87.19	83.24	76.80	68.83
Liaoning	212.97	186.17	167.31	155.71
Jilin	89.04	82.62	72.74	64.74
Heilongjiang	116.44	96.96	89.37	87.82
Shanghai	709.31	651.15	550.22	517.85
Jiangsu	399.83	359.59	319.02	261.79
Zhejiang	520.13	483.92	444.91	411.63
Anhui	140.93	123.91	111.38	98.60
Fujian	186.64	173.89	150.47	136.61
Jiangxi	94.06	85.05	80.59	56.49
Shandong	365.39	337.34	276.99	233.84

Source: National Bureau of Statistics of China

Table A.0.39 Total Wage of Employees in Financial Institutions for Each Region in 100 million RMB (continued)

Region	2015	2014	2013	2012
Henan	176.63	164.08	149.23	132.73
Hubei	165.56	136.64	115.71	100.37
Hunan	213.24	185.70	160.21	134.39
Guangdong	611.02	537.58	491.38	478.21
Guangxi	115.95	99.10	93.30	80.06
Hainan	35.71	28.81	20.92	19.06
Chongqing	153.21	146.10	123.12	111.71
Sichuan	215.77	199.41	182.49	158.34
Guizhou	104.90	97.09	80.43	58.91
Yunnan	116.40	109.25	101.95	87.13
Tibet	15.01	12.66	12.91	9.55
Shaanxi	136.65	125.99	106.23	87.39
Gansu	43.94	37.41	34.72	31.56
Qinghai	18.20	16.84	14.23	12.67
Ningxia	28.79	27.30	22.50	20.16
Xinjiang	77.04	69.76	63.86	54.81

Source: National Bureau of Statistics of China

Table A.0.40 Average Wage of Employees in Financial Institutions for Each Region

Region	2015	2014	2013	2012
Beijing	248320	225482	206110	184612
Tianjin	112059	118263	118448	104335
Hebei	74795	73130	65547	60304
Shanxi	75620	74778	67729	62678
Inner Mongolia	76093	73866	69426	63880
Liaoning	83537	77949	73851	69453
Jilin	75102	71894	66938	59995
Heilongjiang	65140	58112	57390	55849
Shanghai	208658	195718	181909	174682
Jiangsu	119198	111934	105289	92156
Zhejiang	130734	130337	124711	117291
Anhui	77300	72215	65920	59416
Fujian	108537	107826	101550	94708
Jiangxi	76035	71160	70497	53798
Shandong	90869	89331	80835	72345

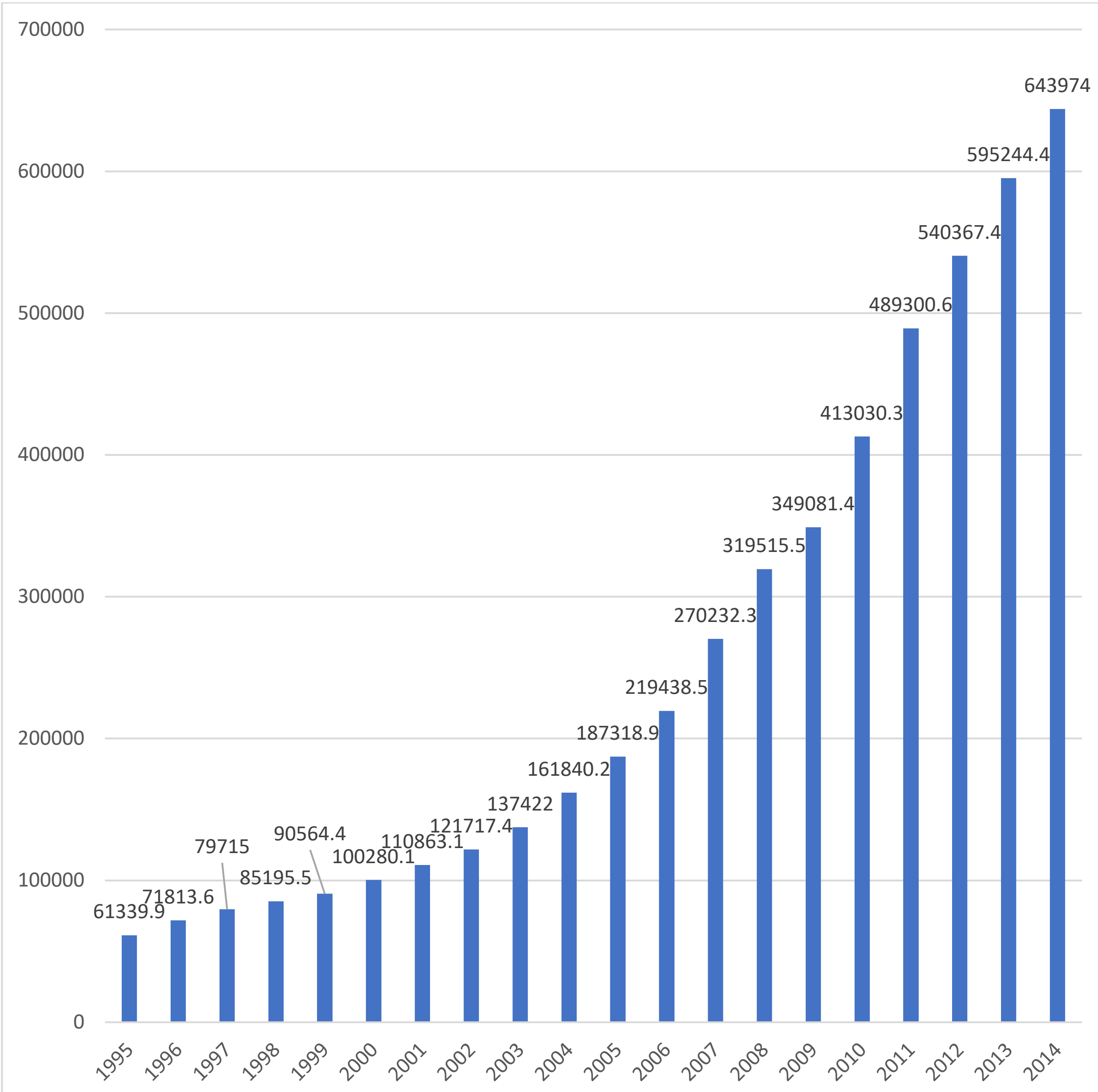
Source: National Bureau of Statistics of China

Table A.0.41 Average Wage of Employees in Financial Institutions for Each Region (continued)

Region	2015	2014	2013	2012
Henan	74441	69223	62835	57364
Hubei	87293	76995	68047	62301
Hunan	92826	84674	77457	65336
Guangdong	138069	127285	117219	101308
Guangxi	92062	86500	82062	69852
Hainan	93187	88362	75429	69316
Chongqing	120355	115065	100437	87720
Sichuan	86084	84601	76687	69846
Guizhou	123592	118477	102294	81630
Yunnan	118166	110235	104144	88699
Tibet	171441	137736	137033	119165
Shaanxi	76896	74340	71987	57997
Gansu	59923	52334	48791	44437
Qinghai	81359	77354	67182	59574
Ningxia	81019	82011	74026	68814
Xinjiang	88212	79653	74551	69445

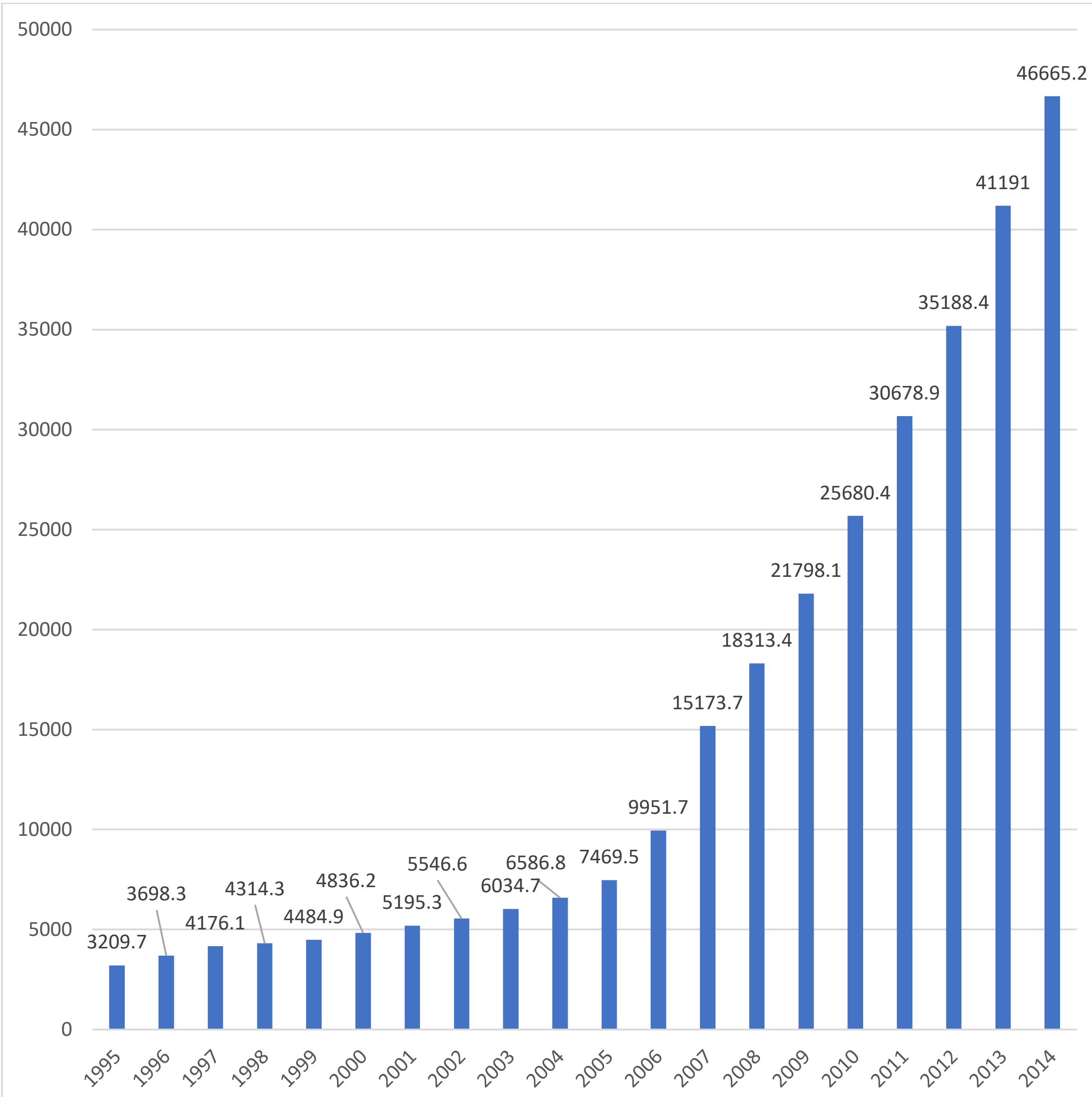
Source: National Bureau of Statistics of China

Figure A.0.1 Annual GDP of China from 1995-2014 (in 100 million RMB)



Source: National Bureau of Statistics of China

Figure A.0.2 Financial Institutions Value-added to GDP in China from 1995-2014 (in 100 million RMB)



Source: National Bureau of Statistics of China

Figure A.0.3 Tendency of Efficiency for State-owned Commercial Banks

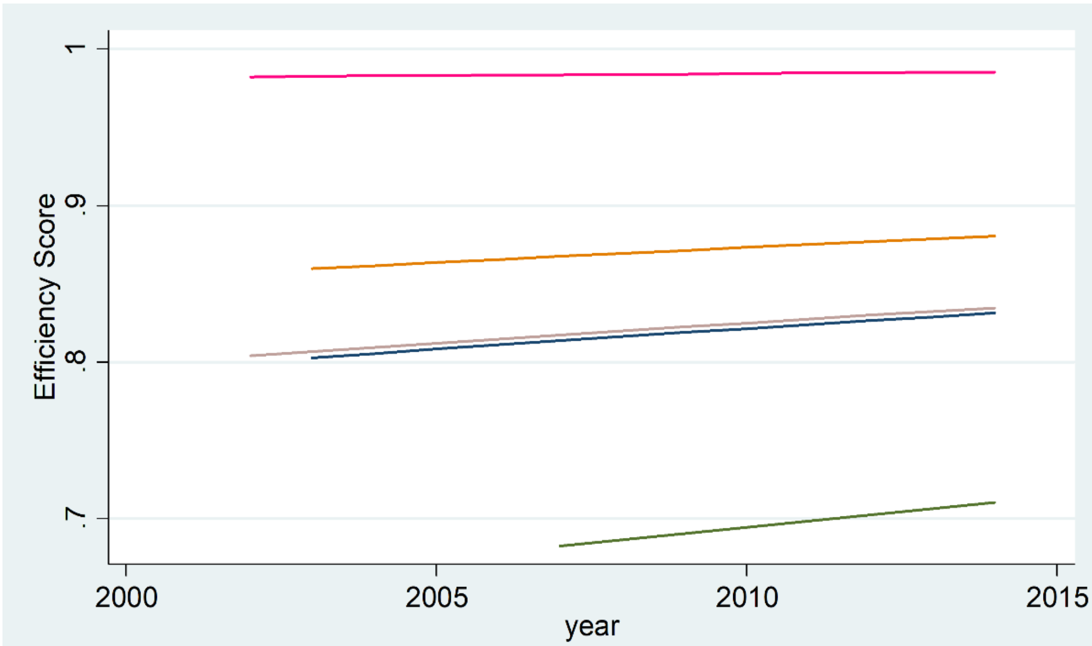


Figure A.0.4 Tendency of Efficiency for Joint-stock Commercial Banks

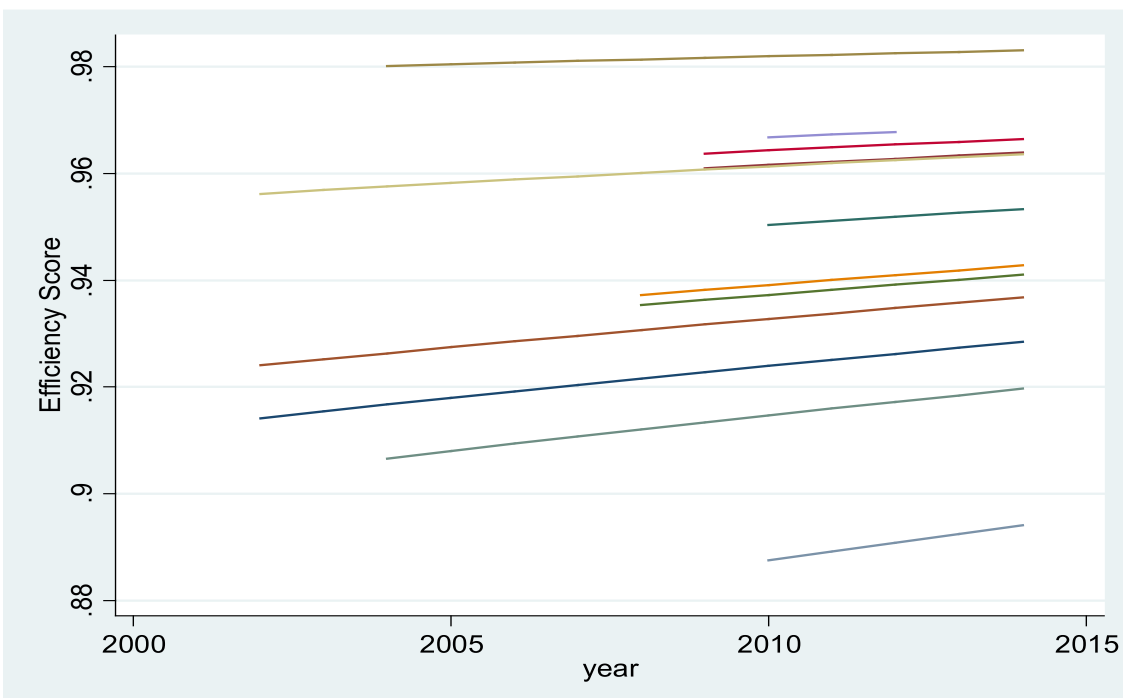


Figure A.0.5 Tendency of Efficiency for Urban Commercial Banks

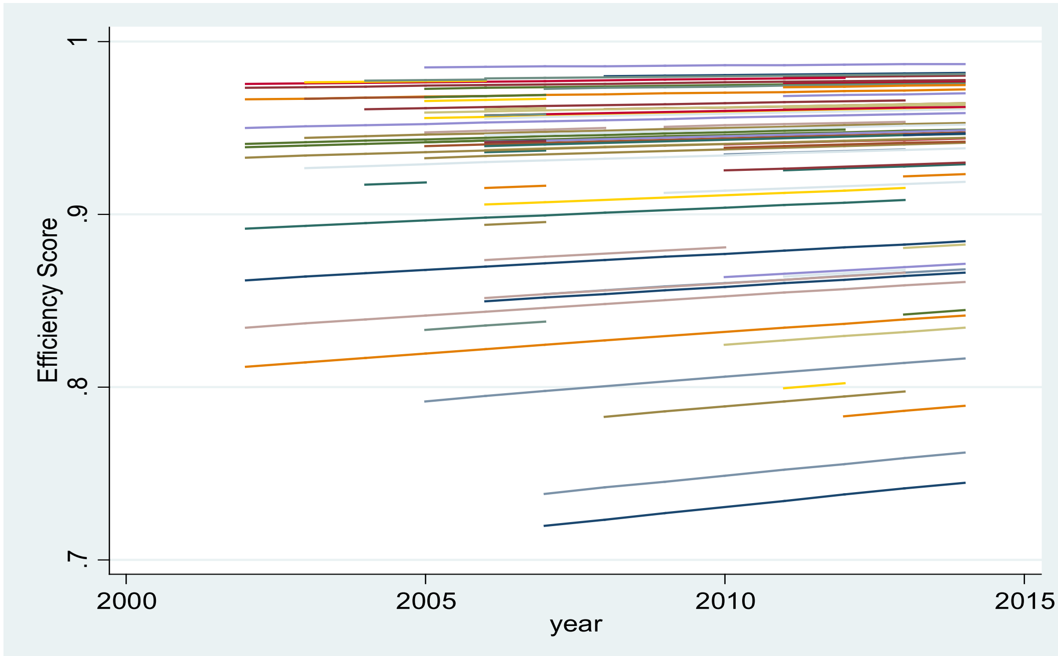


Figure A.0.6 Tendency of Efficiency for Rural Commercial Banks

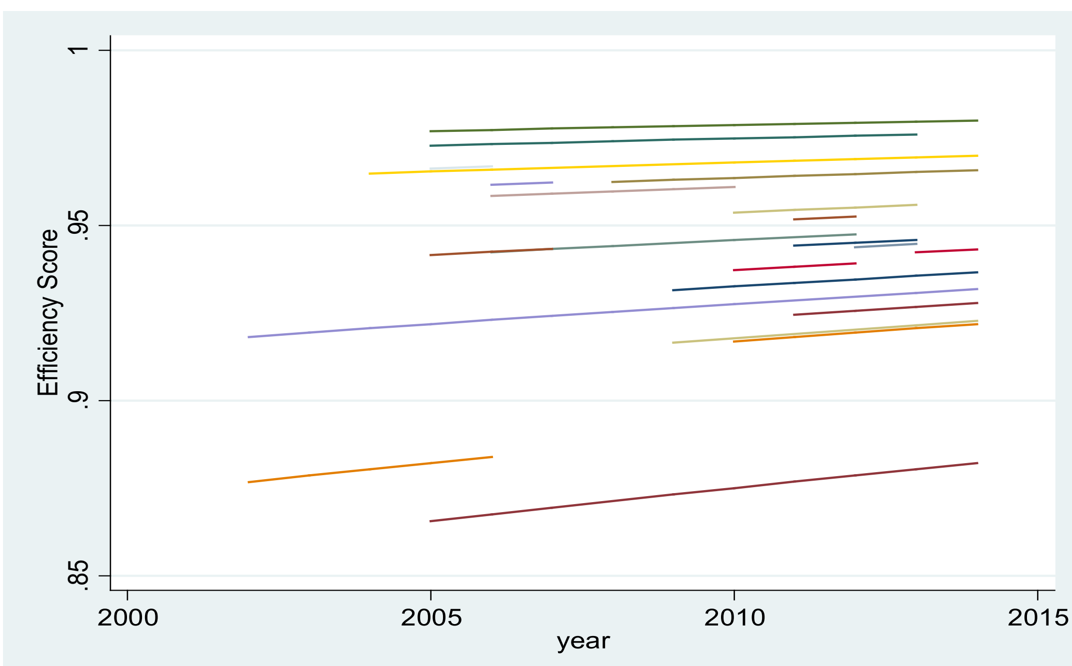
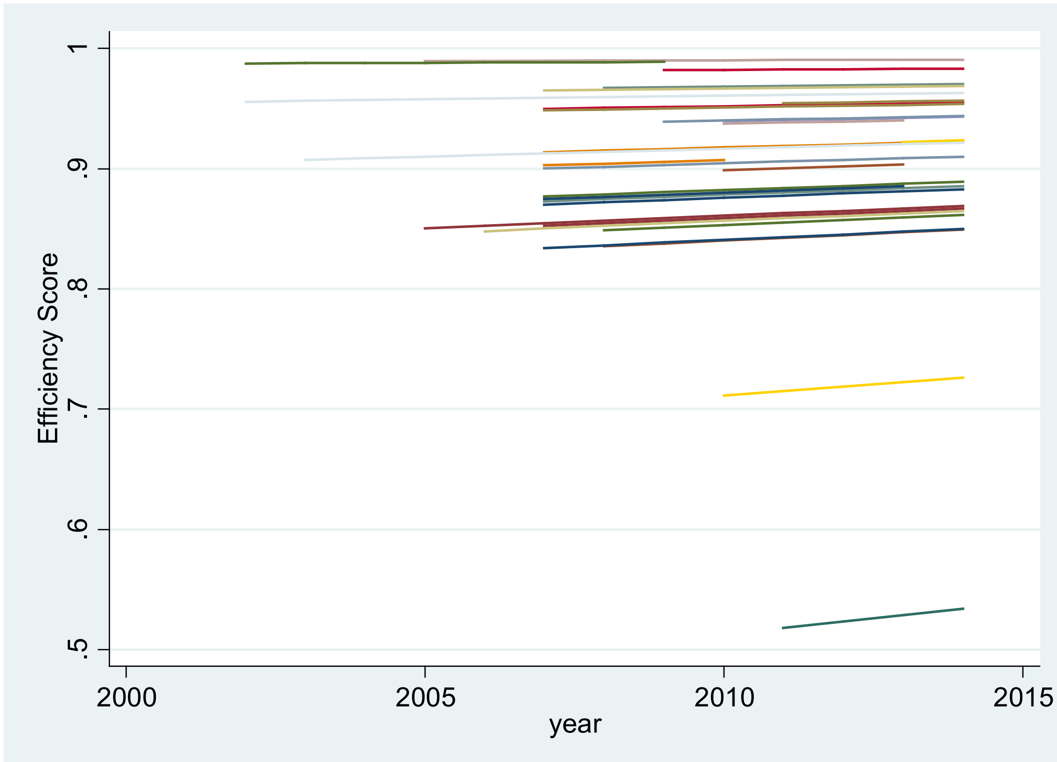


Figure A.0.7 Tendency of Efficiency for Foreign Commercial Banks



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