경제학석사 학위논문

- 한국과 러시아 상업은행들의 효율성 비교연구 -

The Comparative Study on Russian and Korean Commercial Banks Efficiency
- Based on the Measurement of Relative Efficiency Using the Data Envelopment Analysis -

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Abstract

Using data envelopment analysis (DEA), the present study aims to measure the relative efficiencies of ten largest (capital-wise) Russian and Korean commercial banks in 2010-2014 periods.

The empirical results reveal that in 2010-2014 largest Russian and Korean banks operated at almost the same relative efficiency level while Korean banks were slightly more effective. Korean banks have shown a decreasing overall technical efficiency trend in 2010-2014 periods, while their Russian counterparts have shown an increasing trend after a substantial decline in 2011.

Both Russian and Korean commercial banks from the sample tend to have a relatively effective management. The main reason for their relative overall technical inefficiency is inability to operate at most productive scale size. Decreasing returns-to-scale trend is a predominant form of scale inefficiency among the DMUs in the sample. Operational downscaling might be appropriate, in order to achieve cost reduction and relative efficiency.

KEY WORDS: Commercial banks, Technical efficiency, Pure technical efficiency, Scale efficiency, Data envelopment analysis.

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Abstract

Data Envelopment Analysis (자료 포락 분석, DEA)를 사용하여, 본 논문는 2010-2014 년에 가장 큰 10 러시아와 한국은행들의 상대적 효율성을 측정하는 것을 목표로 한다.

실증분석결과에 의하면 2010-2014 년에 가장 큰 러시아와 한국은행들은 거의 동일한 상대효율수준에서 작동하였다. 게다가 한국은행들은 약간 더 효과적이었다. 2010-2014 년에 한국은행들은 전체기술효율성 (OTE)에 감소하는 추세를 보였다. 하지만 러시아은행들은 2011 년에 상당히 감소한 후에 증가하는 경향을 보였다.

샘플에 있는 은행들은 모두 상대적으로 효율적인 관리를 하는 경향이 있다. 샘플 은행들 중에서 상대적으로 전반적인 기술의 비효율성 (OTIE)에 대한 주된 이유는 가장 생산적인 규모의 크기로 작동할 수 없다는 것이다. 샘플에서 Decrease Returns to Scale (DRS) 추세는 지배적 스케일 비효율성의 유형이다. 비용 절감 및 상대 효율을 달성하기 위해, 연산의 다운스케일링이 적절할 수 있다.

KEY WORDS: Commercial bank 상업 은행; Technical efficiency 기술 효율성; Pure technical efficiency 순수 기술 효율성; Scale efficiency 스케일의 효율성; Data envelopment analysis 자료 포락 분석.

1. Introduction

The significance of commercial banks cannot be underestimated. These institutions are both an indicator of country's economic potential and economic growth catalyst. In order to stimulate economic growth, banks must grow themselves, which is impossible without efficient management. However, in order to make correct management decisions we must understand what makes a bank efficient. This brings us to the importance of well-timed and reliable analysis of bank's economic values and indicators.

Commercial banks are also known known as "financial mediators". They attract people's financial resources and other monetary assets that become available during the process of economic activities and assign them for temporary use to other economic agents in need of additional capital.

All the participants of economic process are concerned about banks' efficiency. From the regulators' (central banks, ministries of finance) perspective, inefficient banks are riskier and have a higher likelihood of failure. Further, the efficiency of banks is directly related to the productivity of the economy. Without a reliable and efficient banking system, the economy cannot function smoothly and efficiently. When a banking system fails, the whole of a nations' payments system is in jeopardy.

From the point of view of customers, only efficient banks can offer better services at reasonable prices and guarantee deposit safety. The point of stakeholders is that only efficient banks ensure reasonable returns. The perspective of bank managers is that in a dynamic and competitive market environment, only efficient banks will survive and maintain their market share, and inefficient ones will eventually be eliminated. The efficient banks are more competitive because of their lower operational costs; they can even steal business away from less efficient banks. In sum, the relative efficiency of

banks is always a matter of serious interest to the regulators, customers, stakeholders, and managers.

The topic of the current dissertation was chosen considering author's professional past in commercial banking and particular interest in studying the elaboration of mathematical methods in economy.

The Data Envelopment Analysis, chosen for this research, has proven to be a versatile and well-developed analytical method for studying financial service institutions efficiency. Recently DEA has become very popular for analyzing economy branches, regions, major firms, banks, education institutions, hospitals etc. World's leading science magazines devote special issues to DEA, international scientific conferences are being held annually. However, this method is apparently uncommon for Russian economic efficiency studies; this fact adds an element of innovation to the current research.

This dissertation is organized as follows: Chapter II presents an overview of literature, used or studied for the purposes of the current research, Chapter III contains a historical and theoretical overview of Russian and Korean banking systems, Chapter IV presents a methodological basis of the current research, Chapter V contains obtained empirical results, and Chapter VI concludes and summarizes the dissertation.

2. Literature Review

Since the DEA method is relatively rare in Russian economic literature and Russian versus Korean commercial banks' efficiency comparison was probably never conducted by neither Russian nor Korean economists at all, the list of literature, used in this research, contains mostly theoretical DEA sources and empirical banking efficiency researches. For the basic understanding of the DEA method and efficiency studying, the following scientific papers were read.

Debreu (1951) addressed the question of resource utilization at the aggregate level. Subsequently, Farrell (1957) defined technical and allocative efficiency as two separate components of the economic efficiency of a firm and developed the formal linear programming model for measuring technical efficiency.

Farrell and Fieldhouse (1962) recognized the restrictive nature of the CRS assumption underlying the Farrell measure of technical efficiency and proposed an appropriate transformation of the data that would allow non-constant returns to scale within an activity analysis framework.

Introduced by Charnes, Cooper, and Rhodes (1978, 1981) the method of DEA generalized Farrell's measure of technical efficiency from the single output to the multiple output case, also the classic constant returns-to-scale CCR model was developed.

Forsund and Hjalmarsson (1979) proposed a generalization of the Farrell efficiency measure separating scale efficiency from the pure technical efficiency using a parametric production function.

Banker, Charnes, and Cooper (1984) introduced a slight modification of the CCR model (BCC model) that allows the estimation of pure technical efficiencies under variable returns-to-scale hypothesis. Also a new separate variable was introduced which made it

possible to determine whether operations were conducted in regions of increasing, constant or decreasing returns to scale (in multiple-input and multiple-output situations).

Banker and Thrall (1992) extended the returns-to-scale concept from single-output case to multiple-output cases using DEA and derived a number of important results relating to the most productive scale size.

Charnes, Cooper, Lewin, and Seiford (1994) offered a brief over view of the primal and dual specifications along with a number of extensions of the basic CCR model. They also trace the chronology of development the literature subsequent to the seminal CCR paper through an interesting flow chart.

In order to get familiar with the practical side of the banking efficiency analysis several empirical researches were read. Lee S.Y. and Ryu S.L. (2014) in their paper studied the efficiency of Korean commercial banks in 1991-2012 using DEA. They found that the efficiency of Korean commercial banks declined sharply during the financial crisis of 1997-1998, but improved in the subsequent bank restructuring period that occurred over 1998-2002, and continued to improve through 2007. In addition, they discovered that the efficiency of Korean banks has shown a downward trend since the world economic crisis in 2008.

Caner S. and Kontorovich V. (2004) studied the efficiency of Russian banks in comparison with European banks using a standard stochastic frontier model. The obtained results indicated that Russian banks in 1999-2003 were significantly less effective than European ones.

Karas A., Schoors, K. and Weill L. (2010) studied whether bank ownership is related to bank efficiency in Russia. They researched 747 banks before (2002) and 471 banks after (2006) the introduction of state deposit insurance system in 2004. They eventually

discovered that foreign banks are more efficient than domestic private banks, and that domestic private banks are not more efficient than domestic public banks.

In addition plenty of other related periodic articles, literature, annual statistics reports, and financial regulators' annual reports were studied to obtain more general information, about Russian and Korean banking sector and application of non-parametric mathematical methods in financial institutes' efficiency analysis.

3. Russian and Korean Banking History and Overview

3.1 Russian Banking System Overview

Since the Soviet Union had no retail banking tradition, banking reforms in modern Russia were complex and large-scale. The legislative basis for Russian banking system was established in 1990. Russia organized two-level banking system with a central bank (*Bank of Russia*) at the upper level and commercial banks and other non-bank financial institutions on lower level. The Bank of Russia was made completely independent from executive power (see Fig. 1).

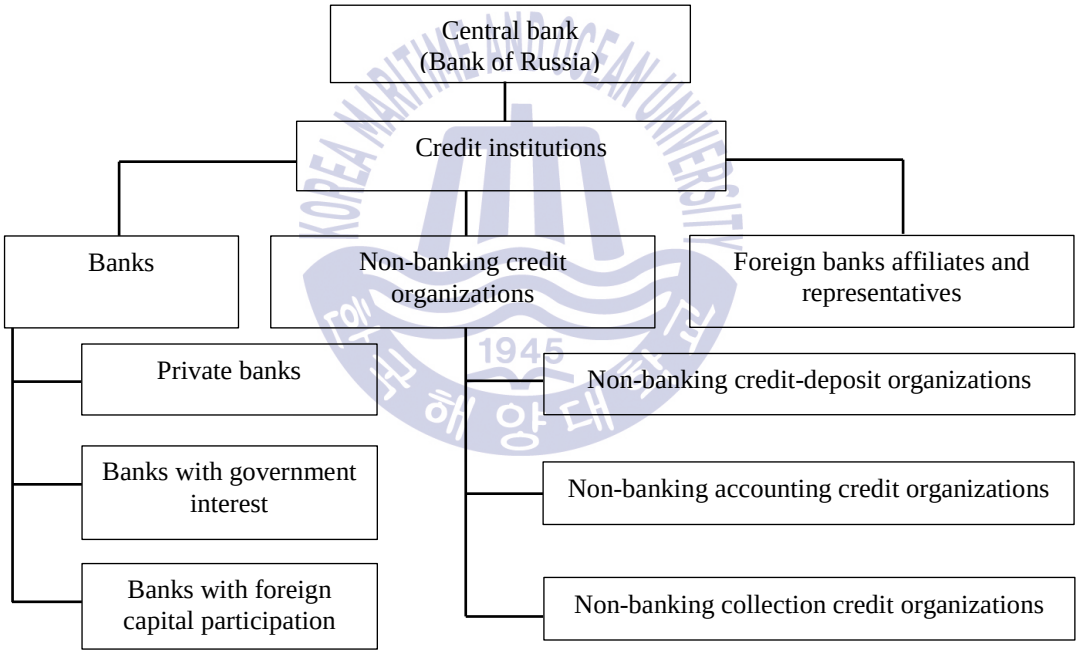

Fig. 1 Russian banking system structure

The Bank of Russia executes monetary regulation, banking supervision, and accounting system control. It can perform banking operations with credit organizations only; the Bank of Russia cannot directly enter the banking market, lend credits to companies and enterprises, and must not compete with commercial banks.

Commercial banks and other credit organizations form up the second, lower level of the system. They perform mediation in accounting, crediting, and investing, but do not take part in development and implementation of monetary policy. Instead of that, they follow the approved economic parameters and requirements and must obey the rules and regulations of Bank of Russia.

The specific feature of modern Russian banking system is the principle of universality of banks. It means that all banks that operate within Russian territory have universal functionality. In other words, all Russian banks have the right to perform all short-term commercial operations and long-term investment operations, provided by legislation and banking licenses.

According to Russian law, a credit organization is a legal entity that has a right, given by special permission (license) of the Bank of Russia, to perform legal banking operations, having acquiring of profit as its main goal.

A bank is a credit organization that has an exclusive right to perform the following operations: attraction of retail and wholesale client deposits, allocation of attracted deposits on legal conditions, banking accounting services for individuals and organizations.

The main functions of commercial banks in Russia are:

1. Accumulation of temporary free monetary resources and savings;
2. Lending credits to firms, enterprises, organizations, state, and population;
3. Organization and performing of accounting in the economy;
4. Bill of exchange accounting and operations;
5. Securities operations;
6. Safekeeping of financial and material valuables;
7. Trust transactions.

Non-banking credit organization is a credit organization that has the right to perform not all but some of legal banking operations. The Bank of Russia establishes the list of banking operations, allowed to be performed by non-banking organizations.

Foreign banks are the banks that were officially registered in a foreign state. In Russian territory foreign banks can participate in local banks' shareholders equity, including creation of subsidiaries and affiliates.[1]

During the early post-soviet era, new Russian banks grew up in numbers at unparalleled rate. For instance, it took 80 years to create 1000 banks in USA, but 2700 banks had appeared in Russia for only 6 years (1989-1995). Unfortunately, there were not enough qualified employees and managers able to operate in free market conditions and the Bank of Russia failed to control the banking system efficiently. (Lavrushin, 2014)

Year 1998 became the most dramatic for Russian banking system. The infamous Russian economic crisis of 1998 was an aftershock of Asian financial crisis of 1997. In the wake of economic turmoil in Asia, raw material prices and investment levels in the world market fell down significantly. These factors accompanied by riskful economic policy, conducted by the government, eventually led to the announcement of technical default that was a crippling blow for the economy. The Banking system suffered from liquidity drop, resource base decrease, external debt crisis, and equity losses. Even the largest banks went bankrupt; the total quantity of banks had decreased from 2502 to 1476 by the beginning of 1999. Many banks experienced equity decrease, sometimes even to negative values. Overall banking system capital decreased threefold.

Russian banks suffered from heavy ruble devaluation and government bonds' interest payment delays. These problems along with faulty management resulted in significant capital deficit. Crisis resulted in considerable decrease in scale of banking operations,

[1] All the legal definitions are presented according to the Federal Law of Russian Federation №395-1 of December the 2nd 1992.

banks' total assets had dropped by 16, 3% by the end of 1998. High rates of deposit withdrawal and clients' distrust led to further crisis aggravation – for 5 months of 1998 population deposits in national currency had dropped by 17%, deposits in foreign currencies had dropped by 55%. Banking system's total losses equaled 33 billion rubles.

The crisis of 1998 happened due to plenty of reasons. Faulty economic and monetary policy, led by the government and the Bank of Russia, was not oriented for growth and improvement of the real sector of the economy. It ranged from strict monetarism to artificially supported financial stabilization. Material production, a basic fundament of every economy, was not adequately supported and deteriorated with every year. A significant part of banking system capital was used for financing government budget deficit through government bonds market. (Lavrushin, 2014)

Most Russian banks concentrated their efforts on instantly profitable financial operations (foreign exchange, securities, and other financial instruments). These operations became the main source of banks' income and liquidity. In 1998 for every ruble of bank investments in the economy, 76 kopeks accounted for state securities (government bonds). Technical default on government obligations' payments, announced by the government, blocked almost 50% of major banks' assets that were considered as most reliable and liquid.

Crisis situation demanded institutional reforms and restoration measures in order to prevent the total collapse of country's banking and financial system. The Bank of Russia organized multilateral banking clearing to restore settlement system that helped to improve the banking system's liquidity. In addition, several new regulation rules were adopted along with stabilizing credits lending. Recapitalization of banks became the main priority of banking reforms, several measures were implemented in order to create favorable conditions for capital replenishment. Banks were encouraged to get self-sufficient, use their own resources with maximum effect, increase quantity of banking operations, attract

new clients, diversify service range, minimize operational costs and capital spending, and attract new deposits and investments. (Lavrushin, 2014)

Banks were obliged to correct their strategy and credit policy to exclude new losses, restore their solvency, obtain adequate capital reserves and keep liquidity at normal level. Any privileges or benefits for banks were considered unacceptable, because only free market competition could reinforce the banking system. The Bank of Russia also claimed that banks should switch their interest towards material production that was the key factor for creating strong economic environment. Unfortunately, anti-crisis measures and reforms were implemented slowly and ineffectively due to the lack of deep economic changes and adequate government control. Thus, the banking system institutional shortcomings remained uncured.

Nevertheless, in general, the period of 1999-2008 was positive for overall development of Russian economy. External trade was very profitable due to high oil and raw materials prices, industrial growth was significant, and retail credit demand was very high. Russian banks managed to increase their profits and capitalization values.

Unfortunately, Global financial crisis of 2007-2008 could not ignore Russian economy and banking sector. First signs of a new system crisis were observed in August 2007. For seven months of 2007 banks' refinancing volume had grown by 350 times. Further growth of refinancing volumes led to massive repurchase agreement failures. In 1998-2007 the Bank of Russia was issuing national currency while accumulating foreign currencies in its official reserves. Shortage of export income, caused by critical decrease of world oil prices, resulted in relative shrinking of money stock in the economy.[2]

A significant part of Russian financial market and many companies heavily depended on external financing .Thus, the increase of interest rates in the international financial market

[2] Central Bank of Russia Annual report 2008. www.cbr.ru

and implemented limitations for lending credits to developing economies led to collapse of Russian inter-bank credit market.

The external debt of Russian banks and companies accounted for almost 500 billion dollars. Liquidity crisis in banking sector forced many foreign investors to leave Russian market, in 2008 net withdrawals of private capital from Russia reached 130 billion dollars.[3]

Most experts continue to believe that modern Russian banking system institutional reforms are still far from complete. More than one thousand banks operate in the market but asset distribution between them is extremely irregular. Two hundred largest banks control 94% of total assets and about 90% of equity in the system, but at the same time top five largest banks control about 50% of total assets, loans, and deposits. However, the largest Russian bank (Savings bank of Russia) controls 25% of total assets, 20% of equity, 30% of total loans, and 50% of total retail deposits.

Banking service density is about 28 thousand subdivisions per 100 thousand of population at average - this can be compared to service density in Eastern Europe; however Eastern European bank subdivisions are distributed evenly, unlike Russian subdivisions that are mostly concentrated in "central" part of the country and in the capital.

Many small banks conduct risky, irresponsible and speculative policy undermining the whole system. Such small banks are usually badly managed and tend to go bankrupt very often. The central bank is obliged to compensate losses that clients suffer from such bankruptcies, thus decreasing its own funds. The situation is redoubled by Bank of Russia's recent activities in banking system cleansing, accompanied by large-scaled license withdrawals from ineffective banks that failed to comply with laws and regulations. About 200 banks had lost their licenses since 2014.

In 2014-2015 Russian banking sector featured low extensive growth, asset quality reduction, liquidity deficit, and regulation reinforcement. In 2014 total assets of Russian

[3] Central Bank of Russia Official Statistics. www.cbr.ru

banking sector increased by 13% (16% growth in 2013). The growth forecast for 2015 is only 10%. In modern economic circumstances, banking sector assets move from minor banks to large ones, while bank clients tend to move their deposits to most stable and reliable commercial banks.[4]

In order to overcome the institutional and functional ineffectiveness under negative macroeconomic conditions Russian commercial banks must improve their management and resource allocation while central bank and the government must continue to provide proper legislative and regulative support to sanitize the banking system.

3.2 South Korean Banking System Overview

Having remained among the world's poorest countries before the 1960s, the Republic of Korea subsequently achieved and sustained rapid economic growth over a long period of time that raised the nation's status to a much higher level.

The foundations of the modern financial system in Korea were laid during the early 1950s when the central (Bank of Korea) and commercial banking systems were realigned under the new institutional bases. Specialized banks were established during the 1960s, in order to increase capital mobilization and to strengthen financial support for underdeveloped or strategically important sectors. Most non-bank financial institutions were introduced during the 1970s in order to diversify financing sources, to promote the development of the money market, and to attract funds into the organized market. From the early 1980s, several commercial banks and non-bank financial institutions were added as part of a series of broad measures to spur financial liberalization and internationalization. This coincided with a shift from a government-orientated stance on economic policy towards a market-orientated stance. The modern structure of the Bank of Korea is presented in Fig. 2.

[4] Central Bank of Russia Annual Report 2014. www.cbr.ru

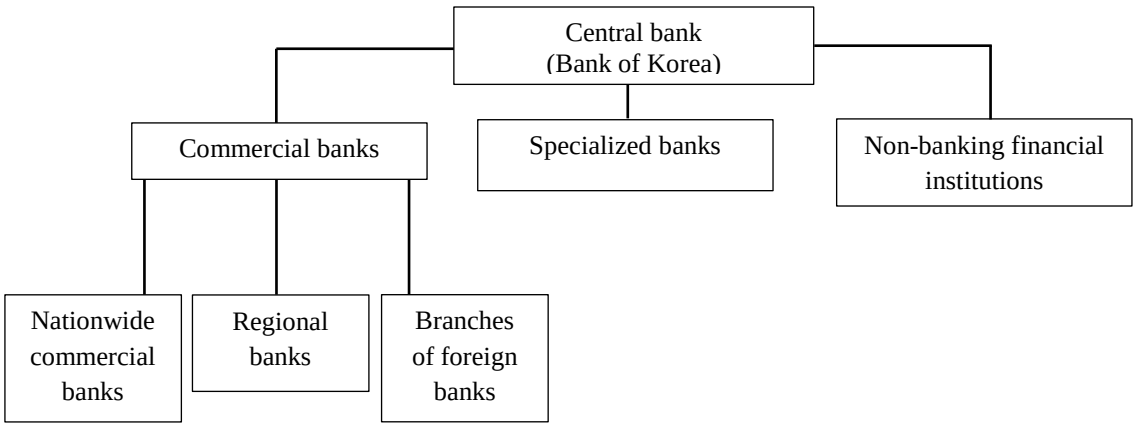

Fig. 2 South Korean banking system structure

The Bank of Korea currently performs the following functions: formulation and execution of monetary policy through open market operations and lending/depositing facilities, and setting of the Base Rate. It also comprehensively analyzes and evaluates the overall stability of the financial system while carrying out analyses on the management conditions of financial institutions and joint examinations of them in order to pick up in advance on risk factors that might give rise to financial instability and to draw up plans for dealing with them.[5]

The Bank holds the exclusive right to issue currency in the Republic of Korea, an important function conferred upon the central bank and its banknotes and coins are the sole legal tender and may be used for all transactions without limit. Through its operation of BOK-Wire+ payment system, the Bank provides interbank settlement services, and oversees and appraises the primary payment and settlement systems, thus promoting the security and efficiency. Other functions of the Bank include foreign exchange services, management of foreign exchange reserves, management of Treasury deposits, issuance and redemption of Treasury bonds, research, statistical compilation, and cooperation with international financial organizations.

[5] Bank of Korea Annual Report 2014. www.bok.kr

Korean banks are categorized into commercial and specialized banks. A commercial bank is established and operated in accordance with general banking legislation and specialized banks in accordance with particular specialized banking acts.

A commercial bank's inherent business includes deposits and loans, as well as payment and settlement. Commercial banks are categorized into nationwide banks, local banks and domestic branches of foreign banks. A nationwide bank operates all over the country. Local banks are established within certain region in order to distribute financial institutions geographically throughout the nation and promote balanced regional economic development.

Specialized banks are established with specific purpose of bolstering financing in problematic areas that lack financing, profitability and expertise, thus promoting balanced economic development. As a result, a specialized bank serves as a supplementary financial institution for reinforcing weak spots in commercial banking fund management, and as a specialized financial institution for certain fields. Because of the supporting role of their main functions, specialized banks depend heavily on government funding and bond issuance rather than deposits attraction. However, due to changes in the economic environment, specialized banks may switch their orientation towards more common traditional commercial banking practices. Accordingly, commercial banks may sometimes start operating in areas that previously were exclusively occupied by specialized banks. (Cho, 2010)

Until the end of the 1970s, the banking sector in Korea was subject to extensive state controls serving as policy instrument to finance "Big-Push" investments, the cornerstone of a government-planned industrialization. Under state ownership of most commercial banks and through direct intervention in banks management, the banking sector operated as non-profit public agency and its primary mission was to provide cheap credits to the private business sector, especially family-owned big business groups called chaebol.

Considering low saving rates, Korean economy heavily depended on foreign credits. The government controlled the allocation of foreign loans tightly to subsidize favoured industry

sectors. Foreign loans were channeled through government-owned policy banks and almost all of them were guaranteed by the government. While stimulating economic growth by directed lending and foreign borrowing, the government maintained a high inflation along with negative interest rate policy. In return for low interest rates, the government explicitly and implicitly guaranteed bank loans. (Cho, 2010)

Since there were virtually no market disciplines, all risks associated with politically directed lending were socialized through costly bailouts of failed private companies and banks. The state-controlled credit allocation resulted in a highly concentrated economy dominated by a small number of chaebol. The repressed banking sector was to bear financial burdens and risks incurred from the government-promoted industrialization.

In 1980 the new military regime, which came to power through a military coup, brought US-trained economists to key positions in economic policymaking. Committed to free market ideology, economic policymakers embarked on market-oriented reforms seeking to remedy structural deficiencies that resulted from decades-long state intervention in the economy. As part of an overall liberalization of the economic system, financial deregulation was initiated. One of the key reform objectives was to contain the growing share of chaebol in the economy by promoting market competition. The focus in credit policy switched from chaebol toward small- and medium-sized companies without abandoning the credit policy to meet overall growth targets and finance industrial upgrading. (Frankel, 1993)

Unfortunately, government's stance on financial liberalization was characterized by asymmetry and imbalance between the external and domestic sector, between banking and nonbanking sector, and between long-term and short-term markets. It lacked a deliberate and comprehensive strategy regarding pace, scope, and sequence of reforms. Reform implementations were ineffective and, despite formal progress, there was often a wide gap between de jure and de facto.

In the early 1980, the government took important steps for domestic financial deregulation. Several state-owned commercial banks were privatized and entry barriers were lowered. Credit ceilings for individual banks were abolished and directed lending to preferred industry sectors was reduced. (Cho, 2010)

Preferential interest rates on policy loans by commercial banks were removed. At the same time new regulation measures were imposed, including limits on loans to chaebol and ceilings on bank ownership by non-financial corporations. Another important element was to promote non-banking financial institutions and security markets as alternative corporate financing as well as a way out of the chronic non-performing loans problem in the banking sector. In the second half of the 1980s, however, the banking sector reforms were halted, largely thanks to US dollar depreciation resulting from the Plaza Accord in 1985, which put significant upward pressure on the won and inflation. In response, the government retreated from partial liberalization of capital inflows in the early 1980s and re-imposed controls on capital inflows.

In the early 1990s, when Korea's trade balances returned to deficit because of the won appreciation in the late-1980s and the global recession, the government resumed the reform process with a greater fervor and pushed ahead with external liberalization. A more market-oriented exchange rate system, which allowed interbank rates to float freely within a specified margin, was adopted by the government. In 1992, foreign investors were allowed for the first time to invest in the Korean stock market. Foreign direct investment in manufacturing sector was considerably liberalized. Along with external liberalization, a gradual, staged deregulation of interest rates was implemented. All remaining state-owned commercial banks were privatized by 1997. Entry barriers and restriction on the scope of activities in the banking and nonbanking sector were substantially relaxed.

However, since the government still considered banks as policy instrument, even though they were being privatized, the liberalization process moved slowly and inconsistently.

Furthermore, merchant banks took full advantage of the unbalanced liberalization. They emerged as a key financing vehicle for chaebol's aggressive investment drive in domestic and overseas markets in the 1990s. Thus, the government attempts to contain chaebol's expansion by enhancing free market competition completely failed. On the contrary, the financial liberalization greatly assisted chaebol's in becoming financially independent from the government and more powerful. With the government's withdrawal from active industrial policies and investment regulations in the early 1990s regulatory obstacles to chaebol's expansion disappeared, which has catalyzed chaebol's aggressive expansion.

Chaebol's unimpeded expansion, financed by non-banking financial institutions through short-term domestic and overseas borrowing, made the entire financial system vulnerable, in the end leading up to the financial crisis in 1997. The first signs of the ensuing crisis emerged in the early 1997, when Hanbo Steel, the fourteen largest chaebol, went bankrupt with a debt of more than five trillion won ($5.85 billion), but the government refused to bail out the company. A series of medium-sized chaebol's failure followed was evolving into a full-fledged corporate debt crisis. (Cho, 2010)

Korea's impressive economic miracle, politically adorned with its OECD entry in 1996, came to an abrupt end in the late 1997, when the devastating tsunami of financial crises, which begun in Thailand, reached Korea. The overseas borrowing spree by domestic entities became fatal, ending up to a twin crisis - currency and banking crisis. The panicked government asked the IMF for an emergency bailout package in November 1997 and signed a Letter of Intent to the IMF on December 3, 1997 accepting painful structure adjustment programs (SAP) in exchange for financial support worth of $57 billion. The swift actions for financial restructuring were followed as part of broader SAP imposed by the IMF.

The essential components of the government intervention in the early crisis years included closure of failed banks, recapitalization and clean-up of bad assets of viable

banks. Insolvent but systemically important nationwide banks were nationalized. Several non-viable banks were merged with stronger ones. Viable banks were required to file detailed restructuring plans entailing recapitalization, management improvement, and downsizing. In case of failure to meet their targeted performance, banks could face harsh punishment measures such as suspension of government support and even closure.

As institutional vehicles for taxpayer-financed restructuring, three government agencies were set up: the Korea Asset Management Corporation (KAMCO), the Korea Deposit Insurance Corporation (KDIC), and the Financial Supervisory Commission (FSC). The FSC in concert with the Ministry of Finance conducted the restructuring process by using the full range of options, forcing liquidation, mergers and nationalization. KDIC was responsible for bank recapitalization, compensation for losses, and deposit protection. KAMCO assumed the role of bad bank buying up and disposing banks' bad assets, which marked the first move ever to develop a market for distressed assets. (Cho, 2010)

The government initial effort to restore banking stability had only limited success. In 2000, banks originally deemed viable failed rehabilitation due largely to the continued big corporate failures. The corporate bond market also collapsed. In contrast with the previous approach, the government kept all insolvent banks alive to continue their lending operation. This policy change led to further bank nationalization during 2000. The number of commercial banks under government control increased to eight, and state ownership in the entire banking sector including specialized banks increased from 33 percent in 1996 to 54 percent in 2000. The decisive government rescue actions freed the Korean banking system from the shackles of bad loans and allowed it to get on a recovery track, reporting net profits in 2001.

However, the regained stability in the banking sector came at a high cost for the Korean taxpayer. By 2001, the total fiscal support for bank restructuring amounted to 157.7 trillion won. This is equivalent to 30 percent of Korea GDP in 2000 and would be

even higher if the welfare costs for laid off workers were included. This makes the Korean financial crisis one of the most expensive ones in recent history. (Kalinowsky & Cho, 2009)

Given the improved conditions since 2001 the government advanced to a second round of bank restructuring consisting of strategic mergers and the re-privatization of nationalized banks. The policy objective was shifted to enhance economies of scale and scope in the Korean banking industry. The financial authorities saw the Korean banking sector "over-banked", which was believed to hamper its competitiveness, and concluded that reflecting the global trend Korea needs "mega banks doing universal banking." (Cho, 2010)

The government took the lead in forming a new landscape in the Korean banking sector. Along with enacting a new Financial Holding Company Act in October 2000, the government merged four nationalized banks (Hanvit, Peace, Kwangju and Kyongnam) and several NBFIs to create Woori Finance Holding Company in April 2001, Korea's first financial holding company providing universal banking services. This was government's response to failed attempts to induce voluntary mergers among viable banks in the first phase of bank restructuring. By allowing banks to set up financial holding companies, it was expected to facilitate banking sector consolidation through mergers.

After the 1997 financial crisis, the Korean government took radical steps for further financial liberalization. In response to the previous unbalanced financial liberalization leading up to the crisis the government was committed to full-fledged financial liberalization and opening. The government strategy for financial development focused primarily on promoting capital markets to reduce the predominance of commercial banks in the Korean financial system. The long-term goal was to transform the bank-based financial system to a market-based one. Conventional commercial banking was regarded not only as anachronistic but also more crisis-prone. Financial supermarkets like Citigroup,

largest international financial conglomerate, were suggested as alternative business model that the Korean banking industry should pursue. For banks to become financial supermarkets, it was required to diversify their asset portfolios, reducing over-reliance on lending activities and expanding capital market-related ones. Diversified banks engaging in multiple business lines were expected to better withstand credit risks and a banking crash like the 1997 crisis. (Cho, 2010)

In pursuit of financial development, the priority was given to capital account and foreign exchange (FX) market liberalization. The experience with the 1997 crisis underscored the need for developing the shallow FX market in Korea, which had few market participants and dominated by a few big players. Furthermore, after the introduction of a free-floating FX system in December 1997 and substantial financial opening immediately after the crisis, it was feared that the financial opening would increase market volatility. Thus, the development of a larger FX market was seen as critical for better absorption of external shocks.

Given lack of capital market-related experience and expertise, foreign participation was regarded as necessary to catalyze capital market development. The ceiling on foreign investment in Korean stock markets was abolished and local bond market and money market were fully opened to foreign investors in May 1998. Full-scale FX market liberalization reforms were undertaken after that with introduction of the Foreign Exchange Transaction Act in April 1999. All current account transactions by corporations and banks were fully liberalized. Regulations on capital account transactions were converted into a negative list system, allowing all capital account transactions unless specifically prohibited. FX dealing was opened to all eligible financial institutions. In 2001, limits on external payments by residents and withdrawal of domestic assets by non-residents were eliminated. Non-residents were allowed to open deposits and trusts in local

currency with maturities of less than one year and to local real estate. Foreign currency purchase by non-residents from foreign exchange banks was liberalized.

In 2002, the Korean government under the newly elected President No Mu-hyeon announced a national agenda to promote Korea as a financial hub of Northeast Asia by 2010. The financial hub project was a deliberate industry policy designating the financial industry as the key strategic sector as future growth engine for the Korean economy.

In January 2006 capital account transaction permission system was abolished, replaced by an ex post reporting system. One reason why the government hastened FX market liberalization already underway was the free trade pact negotiations with the US set to begin in 2006. Through speeding up FX market liberalization the Korean government sought to gain leverage in bilateral free trade negotiations with the US and get more concessions from the US to open up US markets.

Concomitant with FX market liberalization, domestic capital market deregulation was reinforced, culminating in the promulgation of the Capital Market Consolidation Act (CMCA) in August 2007, which took effect in February 2009. The aim was to create domestic investment banks competing with big players in the global financial markets. Six capital-market related laws – securities, asset management, merchant banking, trust business, derivatives trading, and futures trading - were consolidated and the combined operation of the previously separated financial investment businesses was permitted. Regarding the scope of financial products, a negative list system was introduced which expanded the range of financial services.

Thanks to the government capital market promotion policies, the Korean stock market experienced a dramatic growth, which in turn considerably affected the banking sector business. Similar to the financial sector development prior to the 1997 crisis, the banking sector faced competition threat from NFBIs. Massive flows of private savings into the booming stock market led to decline in deposit growth. Facing difficulties in mobilizing

low-cost funding, the banking sector increasingly turned to capital market products such as certificates of deposit (CDs) and bonds as well as short-term foreign borrowing to fund its aggressive expansion driven by fierce competition for market share.

Like the 1997 crisis, both the financial authorities and the Korean banking industry were caught unprepared for external shocks when the global credit crisis struck in 2008. Rapid withdrawal of foreign loans and a surge in domestic and global market interest rates led to an acute liquidity crisis. In late 2008, banks' balance sheets deteriorated rapidly. This prompted the government to intervene introducing a wide-range of countermeasures. In early 2009, the government announced plans of additional foreign liquidity provision of $55 billion for interbank transactions, NPL Restructuring Fund of 10 trillion won, and Bank Recapitalization Fund (BRF) of 20 trillion won to prop up banks' balance sheets. Other financial stabilization measures were introduced including Bond Market Stabilization Fund of 10 trillion won, Stock Market Stabilization Fund of 500 billion won, and Corporate Restructuring Fund of 40 trillion won. These pre-emptive measures to restore overall financial stability combined with massive fiscal stimulus package of 23.3 trillion won and aggressive interest rate cuts by BOK helped the banking sector to weather shocks of the global financial crisis. (Cho, 2010)

Economists claim that ineffective oversight of financial institutions' operations and government's excessive intervention in largest industrial groups' credit activities has led to significant losses during the crises. A significant size of Korean banking sector means significant costs, needed for its clean-up. Decisive actions of government regulators, supported by world financial organizations and international partners, should assist the institutional reorganization of Korean banking system and lead to stabilization of financial markets.

4. Methodology

4.1 Data Envelopment Analysis

The approach to frontier estimation proposed by Michael J. Farrell (1957) was not given much detailed empirical attention for about two decades, until a paper by A. Charnes, William W. Cooper and E. Rhodes in 1978, in which the term Data Envelopment Analysis was first used. Since then there has been a large number of papers, which have applied and extended the methodology.[6]

Data envelopment analysis (DEA) is a nonparametric mathematical programming technique for measuring the relative efficiency of a set of similar units, usually referred to as Decision Making Units (DMUs) DMUs are usually defined as entities responsible for turning input(s) into output(s), such as firms and production units. In our current study, DMUs refer to the commercial banks. A DMU must, as the name indicates, have at least some degree of freedom in setting behavioral goals and choosing how to achieve them.

DEA is based on a concept of efficiency very similar to the microeconomic one; the main difference is that the DEA production frontier is not determined by some specific functional form, but it is generated from the actual data for the evaluated firms. In other words, the DEA frontier is formed as the piecewise linear combination that connects the set of 'best-practice observations' in the data set under analysis, yielding a convex Production Possibility Set (PPS). As a consequence, the DEA efficiency score for a specific DMU is not defined by an absolute standard, but it is defined relative to the other DMUs in the specific data set under consideration. This feature differentiates DEA from the

[6] For more information, see Charnes, A., Cooper, W.W. & Rhodes, E., 1978. Measuring the Efficiency of Decision Making Units. *European Journal of Operational Research* 2, pp.419-444.

parametric approaches, which require a specific pre-specified functional form of the modelled production or cost function.

When we focus on service organizations, such as commercial banks, we generally cannot determine what the engineered, optimum or absolute efficient output-to-input ratio is. Consequently, we cannot determine whether a bank is absolutely efficient. We can, however, compare several banks' output-to-input ratios and determine that one bank is more or less efficient than another - benchmarking. The difference in efficiency will be due to the technology or production process used, how well that process is managed, and/or the scale or size of the unit.

DEA was initially used to assess the relative efficiency of non-profit organizations such as schools and hospitals; however, gradually its application has been extended to cover for-profit organizations as well. Its first application in banking industry appeared with the work of Sherman and Gold (1985). Over the years, DEA has emerged as a very potent technique to measure the relative efficiency of banks (see Berger and Humphrey, 1997).

In the current study, the use of DEA has been preferred over other techniques of measuring relative efficiency for several reasons:

- It allows the estimation of overall technical efficiency (OTE) and decomposes it into two mutually exclusive and non-additive components, namely, pure technical efficiency (PTE) and scale efficiency (SE). It identifies the DMUs that are operating under decreasing or increasing returns-to-scale;
- In DEA, there is no need to select a priori functional form relating to inputs and outputs like Cobb-Douglas and Translog production/cost functions (Banker, 1984);
- DEA easily accommodates multiple-inputs and multiple-outputs of DMUs;
- It provides a scalar measure of relative efficiency, and the areas for potential addition in outputs and reduction in inputs;

- In DEA, it is not necessary to provide values for weights associated with input and output factors, although the user may exert influence in the selection of weight values;
- DEA works particularly well with small samples.

On the other hand, DEA's major shortcoming is that it assumes data to be free of measurement error, and could give unreliable results if the integrity of data is not assured.

4.2 DEA Model Input and Output Orientation

DEA models can be configured to measure efficiency in different ways. These configurations are usually being specified in either input-oriented or output-oriented models. With input-oriented DEA, the model is configured to determine how much the input of a firm could be reduced if used efficiently in order to achieve the same output level (i.e. minimize the use of inputs to produce a given level of output). For the measurement of capacity, the only variables used in the analysis are the fixed factors of production. Modifications to the traditional input-oriented DEA model, however, could be done such that it would be possible to determine the reduction in the levels of the variable inputs conditional on fixed outputs and a desired output level.

In contrast, for output-oriented DEA, the model is configured to determine a firm's potential output given its inputs if it operated efficiently as firms along the best practice frontier (i.e. maximize the level of output given levels of the inputs).

Therefore, for the purposes of current research and considering the specifics of our DMUs (commercial banks), the DEA model was specified as input-oriented.

4.3 Constant Returns to Scale model (CCR model)

In their original paper (1978), Charnes, Cooper and Rhodes proposed a model that had an input orientation and assumed constant returns to scale (CRS). This model is also called the CCR model, after its developers.

This model is an extension of the ratio technique used in traditional efficiency measurement approaches. The measure of efficiency of any DMU is obtained as the maximum of a ratio of weighted output to weighted input subject to the condition that similar ratios for every DMU be less than or equal to unity. This can be formulated as:

$$\max h_0 = \frac{\sum_{r=1}^{s} u_r\, y_{r0}}{\sum_{i=1}^{m} v_i\, x_{i0}}$$

Subject to:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1; \qquad j = 1, \ldots\ldots, n$$

$$u_r, v_i \geq 0; \qquad r = 1, \ldots\ldots, s; \qquad i = 1, \ldots\ldots, m \tag{1}$$

Where:

n - Number of DMUs;

s - Number or outputs;

m - Number of inputs.

y_{rj}, x_{ij} (all positive) - Known outputs and inputs of the *jth* DMU;

$u_r, v_i \geq 0$; - Variable weights to be determined by the solution of this problem.

The input-output values are obtained by collecting information on the resources used and outputs produced from past observations.

The efficiency of one of the DMUs from the set j = 1,...., n is to be evaluated relative to the others. It is therefore represented in the objective function (for optimization) as well as in the constraints. In the objective function, it is distinguished by assigning the subscript zero to its inputs and outputs.

Model (1) is a fractional programming problem. In its current form, it is computationally intractable when the number of DMUs (n) is large and the number of inputs (m) and outputs (s) is small. Therefore, Charnes, Cooper and Rhodes (1978) converted it into a linear programming form, which is as follows:

$$\min g_0 = \sum_{i=1}^{m} \eta_i x_{i0}$$

Subject to:

$$-\sum_{r=1}^{s} \mu_r y_{rj} + \sum_{i=1}^{m} \eta_i x_{ij} \geq 0$$

$$\sum_{r=1}^{s} \mu_r y_{r0} = 1 \qquad (2)$$

$$\eta_i \mu_r \geq 0$$

Where

$$\eta_i = tv_i; \qquad i = 1, \ldots, m,$$
$$\mu_r = tu_r; \qquad r = 1, \ldots, s,$$
$$t^{-1} = \sum u_r y_{r0},$$

The dual of (2) (as obtained by Charnes, Cooper and Rhodes (1978)) is:

$$\max z_0$$

subject to:

$$-\sum_{j=1}^{n} y_{rj}\lambda_j + y_{r0} z_0 \leq 0; \qquad r = 1, \ldots, s,$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j \leq x_{i0}; \qquad i = 1, \ldots, m. \qquad (3)$$

$$\lambda_j \geq 0; \qquad j = 1, \ldots, n.$$

The purpose of the dual (3) is to determine the amount of inefficiency of the inefficient DMUs by projecting them onto the efficient frontier.

The drawback with the CCR model is that it compares DMU's only based on overall efficiency assuming constant returns to scale. It ignores the fact that different DMU's could be operating at different scales.

4.4 Variable Returns to Scale model (BCC model)

The CCR model is designed with the assumption of constant returns to scale. This means that there is no assumption that any positive or negative economies of scale exist. Under constant returns to scale it is assumed is that even a small commercial bank should be able to operate as efficiently as a large one. To overcome this drawback, Banker, Charnes and Cooper (1984) developed the BCC model, which assumes variable returns to scale and compares DMUs purely on the basis of technical efficiency[7]. The BCC primal linear programming problem is depicted as:

$$\max \; h_o = \sum_{r=1}^{s} u_r y_{ro} + c_o$$

$$\text{subject to}$$

$$\sum_{i=1}^{m} v_i x_{io} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - c_o \le 0 \qquad (4)$$

$$u_r, v_i \ge \varepsilon$$

The BCC model is closely related to the standard CCR model as is evident in the dual of the BCC model:

$$\min(\theta,\lambda) = \theta$$

$$\text{subject to} \quad \begin{aligned} &\theta x_0 - X\lambda = s^- \\ &Y\lambda = y_0 + s^+ \\ &e\lambda = 1 \\ &\lambda \ge 0, s^+ \ge 0, s^- \ge 0 \end{aligned} \qquad (5)$$

[7] For more detailed information, see Banker, R.D., Charnes, A. & Cooper, W.W., 1984. Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Management Science* 30(9), pp.1078-1092.

The difference compared to the CCR model is the introduction of the convexity condition $e\lambda = 1$ - this additional constraint gives the frontiers piecewise linear and concave characteristics.

4.5 Technical and Scale Efficiencies

The CRS assumption is only appropriate when all DMUs are operating at an optimal scale. However, factors like imperfect competition and constraints on finance may cause a DMU not to be operating at optimal scale. As a result, the use of the CRS specification when some DMUs are not operating at optimal scale will result in measures of technical efficiency (TE) which are confounded by scale efficiencies (SE).

Technical efficiency (TE) relates to the productivity of inputs. The technical efficiency of a firm is a comparative measure of how well it actually processes inputs to achieve its outputs, as compared to its maximum potential for doing so, as represented by its production possibility frontier. Thus, technical efficiency of the commercial bank is its ability to transform multiple resources into multiple financial services. A bank is said to be technically inefficient if it operates below the frontier.

A measure of technical efficiency under the assumption of constant returns-to-scale (CRS) is known as a measure of overall technical efficiency (OTE). The OTE measure helps to determine inefficiency due to the input/output configuration as well as the size of operations. For the purposes of current research, terms overall technical efficiency (OTE) and constant returns-to-scale technical efficiency (CRSTE) are interchangeable.

In DEA, OTE measure has been decomposed into two mutually exclusive and non-additive components: pure technical efficiency (PTE) and scale efficiency (SE). This decomposition allows an insight into the source of inefficiencies.

The PTE measure is obtained by estimating the efficient frontier under the assumption of variable returns-to-scale (VRS). It is a measure of technical efficiency without scale

efficiency and purely reflects the managerial performance to organize the inputs in the production process. Thus, PTE measure has been used as an index to capture managerial performance. For the purposes of current research, terms pure technical efficiency (PTE) and variable returns-to-scale technical efficiency (VRSTE) are interchangeable.

The ratio of OTE to PTE provides SE measure (SE = OTE/PTE or CRSTE/VRSTE). The measure of SE provides the ability of the management to choose the optimal size of resources, i.e., to decide on the bank's size or in other words, to choose the scale of production that will attain the expected production level.[8]

Microeconomic theory of the firms guide that one of the basic objective of the firms is to operate at most productive scale size i.e., with constant returns-to-scale in order to minimize costs and maximize revenue. Inappropriate size of a bank (too large or too small) may sometimes be a cause of technical inefficiency. This is referred as scale inefficiency and takes two forms: decreasing returns-to-scale (DRS) and increasing returns-to-scale (IRS). Decreasing returns-to-scale (also known as diseconomies of scale) implies that a bank is too large to take full advantage of scale and has supra-optimal scale size. In contrast, a bank experiencing increasing returns-to-scale (also known as economies of scale) is too small for its scale of operations and, thus, operates at sub-optimal scale size. Naturally, a bank is considered scale efficient if it operates at constant returns-to-scale (CRS).

In the short run, firms may operate in the zone of IRS or DRS, but, in the long run, they will move towards CRS by becoming larger or smaller to survive in the competitive market. The process might involve changes of a firms' operating strategy in terms of

[8] For more information on scale efficiency, see Forsund, F. & Hjalmarsson, L., 1979. Generalized Farell Measures of Efficiency: An application to milk processing in Swedish Dairy Plants. *Economic Journal* 89, pp.294-315.

scaling up or scaling down of size. The regulators may use DEA to determine whether the size of representative firm in the particular industry is appropriate or not.

4.6 Choosing Inputs and Outputs

There are two main approaches to the choice of how to measure the flow of services provided by financial institutions. Both these approaches apply the traditional microeconomic theory of the firm to banking and differ only in the specification of banking activities. Under the "production approach", also called the service provision or value added approach that was pioneered by G.J. Benston (1965), financial institutions are considered as the producers of services for account holders – they perform transactions and process documents for customers. Under this approach, output is best measured by the number and type of transactions or documents processed over a given time period. Unfortunately, such detailed transaction flow data is typically proprietary and not generally available.[9]

Under the alternative 'intermediation" approach, as proposed by Sealey and Lindley (1977), financial institutions are mainly considered as fund mediators between savers and investors. With this approach, since service flow data are not usually available, the flows are typically assumed proportional to the stock of financial value in the accounts, such as the numbers of dollars of loans, deposits, or insurance in force. Since the intermediation approach is more appropriate for evaluating entire financial institutions, for our model we have chosen inputs and outputs accordingly. [10]

[9] For more information, see Benston, G. J., 1965. Branch Banking and Economies of Scale. *Journal of Finance* 20(2), pp.312-331.

[10] For more information, see Sealey Jr., C.W., & Lindley J.T., 1977. Inputs, Outputs, and a Theory of Production and Cost at Depository Financial Institutions. The Journal of Finance (32)4, pp.1251-1266.

Since DEA results are influenced by the size of the sample, various empirical rules are available in DEA literature for choosing an adequate sample size. For example, Cooper et al. (2007) provides two such rules that can be generally expressed as:

$$n \geq \max\{m * s; 3(m + s)\}$$

Where n – number of DMUs, m – number of inputs and s – number of outputs. The first empirical rule states that sample size should be greater than or equal to product of inputs and outputs. While the second rule states that number of observation in the data set should be at least three times the sum of number of input and output variables. It should be mentioned that there are plenty of other empirical rules proposed in other DEA studies.

Given m=3 and s=2, the sample size (n=10), used in the current research, complies only with the first rule. Extension of the DMU sample size for current study would demand for additional data, which could be problematic, considering realities of Russian and Korean banking services markets. Inconsistency and implicitness of some commercial banks' financial information, especially the smaller ones, obstructs effective gathering of data.

5. Data and Empirical Analysis

5.1 Data

For this research we chose five largest (by overall amount of total assets) commercial banks in Russia and Korea respectively. These banks are Savings Bank of Russia (Sberbank), VTB, VTB 24, Gazprombank, Rosselkhozbank (Agricultural Bank of Russia), Industrial Bank of Korea, Woori Bank, Kookmin Bank, Shinhan Bank, and Hana Bank.

For DEA model, three inputs and two outputs were assumed. Inputs are x1 – Number of employees, x2 – Fixed assets, and x3 – Total equity. Outputs are y1 – Total loans and y2 – Operating Revenue. All money values were converted into USD through the respective average annual exchange rates (Table 1).

Table 1 Model Inputs and Outputs

Variable	Description	Units	Average	Min	Max	Standard Deviation
Y1	Total Loans	million $	147939	24334	467648	93467
Y2	Operating Revenue	million $	8110	219	43768	10498
X1	Number of Employees	people	50143	9000	275723	70326
X2	Fixed Assets	million $	3257	329	14710	3513
X3	Total Equity	million $	18491	2910	59126	12788

The period of 2010-2014 was chosen for the research purposes because of the relative availability of financial data for these years. In addition, this period lacks any critical global economic events, except for the negative post-effects of the Great recession. All the data were collected from respective banks' annual reports and financial statements. For the current research, we used the DEAP Version 2.1 computer software by Tim Coelli. This program is used to construct DEA frontiers for the calculation of technical and cost efficiencies and for the calculation of Malmquist TFP Indices.[11]

[11] http://www.uq.edu.au/economics/cepa/deap.php

5.2 Results and Interpretations

Since our research DEA model was specified as input-oriented, it is necessary to mention that input-oriented efficiency measures address the question: "By how much can input quantities be proportionally reduced without altering the output quantities produced?" Table 2 presents average efficiency scores of 10 DMUs in 2010-2014 period.

Table 2 Russian and Korean Banks Average Efficiency in 2010-2014

Year	Country	CRSTE	VRSTE	SE
2010	RUS	0.905	0.988	0.916
	KOR	0.970	0.982	0.987
2011	RUS	0.856	0.958	0.898
	KOR	0.956	0.999	0.958
2012	RUS	0.897	0.969	0.927
	KOR	0.945	0.958	0.985
2013	RUS	0.936	1.000	0.936
	KOR	0.929	1.000	0.929
2014	RUS	0.940	1.000	0.940
	KOR	0.928	0.995	0.933
Average for 5 years	RUS	0.907	0.983	0.923
	KOR	0.946	0.987	0.958

CRSTE –Constant Returns to Scale Technical Efficiency; VRSTE – Variable Returns to Scale Technical Efficiency; SE – Scale Efficiency; SE = CRSTE/VRSTE.

The average results (Table 2) indicate that largest Russian and Korean banks operate at almost the same efficiency level with Korean banks being slightly more effective. The average CRSTE of 10 DMUs, in percentage terms, ranges between 85.6% and 97% percent. The average CRSTE score for Russian banks in the research period is 0.907, for Korean banks – 0.946. This suggests that, upon average, Russian/Korean banks, if producing their outputs on the efficient frontier instead of their current (virtual) location, would need only 90.7/ 94.6 percent of the inputs that are currently being used.

To visualize the "distance" from DMU's current (virtual) location to the efficient frontier, some researchers use the technical inefficiency value (TIE), that can be obtained from TIE

= 1 – TE. Thus, the average CRSTIE of Russian banks in the researched period is 1 – 0.907 = 0.093 or 9.3%; for Korean banks: 1 – 0.946 = 0.054 or 5.4%. This means that, by adopting best practice technology, DMUs can, on an average, reduce their inputs of number of employees, fixed assets and total equity by at least 9.3/5.4% and still produce the same level of outputs. Of course, the potential reduction in inputs from adopting best practices may vary from DMU to DMU.

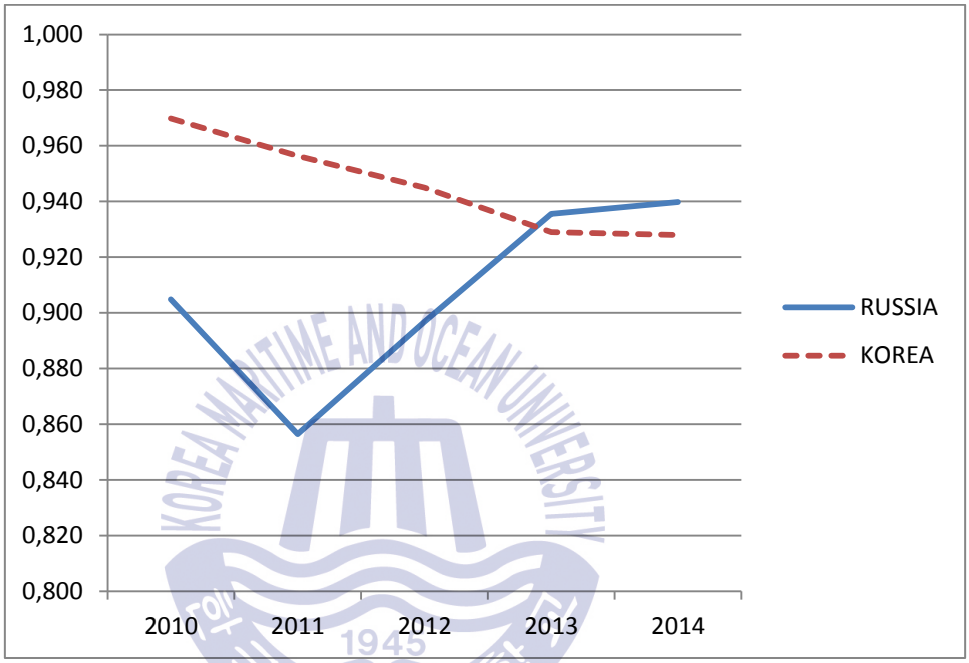

Fig. 3 Overall Technical Efficiency Trends of Russian and Korean Banks in 2010-2014

If we construct a graphical plot of the average OTE results (Fig. 3), we can see that Korean banks have shown a decreasing CRSTE trend in 2010-2014 periods, while their Russian counterparts have shown an increasing CRSTE trend after substantial decline in 2011. The decreasing Korean banks' OTE trend, discovered here, fits the results of another research by Lee and Ryu (2014), which discovered that Korean banks' efficiency showed a downward trend since the beginning of the World economic crisis of 2008 and afterwards[12].

[12] See Lee, S.Y. & Ryu, S.L., 2014. Efficiency of Korean Commercial Banks: An Exploratory Study. *Advanced Science and Technology Letters* 47, pp.97-100.

It is necessary to say that a bank with CRSTE score equal to 1 is considered the most efficient amongst the banks included in the analysis. A bank with CRSTE score less than 1 is considered relatively inefficient. Table 3 shows the efficiency scores, obtained through our DEA model (DMU-wise).

Table 3 Efficiency scores of Russian and Korean banks in 2010-2014

DMU		2010	2011	2012	2013	2014	AVERAGE
DMU 1 (SBB)	CRS	0.732	0.626	0.723	0.780	0.839	**0.740**
	VRS	1.000	1.000	1.000	1.000	1.000	**1.000**
	SE	0.732	0.626	0.723	0.780	0.839	**0.740**
DMU 2 (VTB)	CRS	0.908	0.866	0.921	0.898	0.860	**0.891**
	VRS	1.000	1.000	1.000	1.000	1.000	**1.000**
	SE	0.908	0.866	0.921	0.898	0.860	**0.891**
DMU 3 (V24)	CRS	1.000	1.000	1.000	1.000	1.000	**1.000**
	VRS	1.000	1.000	1.000	1.000	1.000	**1.000**
	SE	1.000	1.000	1.000	1.000	1.000	**1.000**
DMU 4 (GPB)	CRS	1.000	1.000	1.000	1.000	1.000	**1.000**
	VRS	1.000	1.000	1.000	1.000	1.000	**1.000**
	SE	1.000	1.000	1.000	1.000	1.000	**1.000**
DMU 5 (RSB)	CRS	0.884	0.790	0.840	1.000	1.000	**0.903**
	VRS	0.941	0.791	0.847	1.000	1.000	**0.916**
	SE	0.939	0.999	0.991	1.000	1.000	**0.986**
DMU 6 (IBK)	CRS	1.000	1.000	1.000	1.000	1.000	**1.000**
	VRS	1.000	1.000	1.000	1.000	1.000	**1.000**
	SE	1.000	1.000	1.000	1.000	1.000	**1.000**
DMU 7 (WB)	CRS	1.000	1.000	1.000	0.900	1.000	**0.980**
	VRS	1.000	1.000	1.000	1.000	1.000	**1.000**
	SE	1.000	1.000	1.000	0.900	1.000	**0.980**
DMU 8 (KB)	CRS	0.849	0.993	0.939	0.949	0.897	**0.925**
	VRS	0.910	0.994	0.943	1.000	0.974	**0.964**
	SE	0.933	0.999	0.996	0.949	0.921	**0.960**
DMU 9 (SHB)	CRS	1.000	0.789	0.786	0.796	0.743	**0.823**
	VRS	1.000	1.000	0.847	1.000	1.000	**0.969**
	SE	1.000	0.789	0.928	0.796	0.743	**0.851**
DMU 10 (HNB)	CRS	1.000	1.000	1.000	1.000	1.000	**1.000**
	VRS	1.000	1.000	1.000	1.000	1.000	**1.000**
	SE	1.000	1.000	1.000	1.000	1.000	**1.000**

Of the ten DMUs, four banks (VTB 24, Gazprombank, Industrial Bank of Korea, and Hana Bank) were found to be technically efficient, in the researched period, since they have CRSTE score of 1. These banks together define the best practice or efficient frontier and, thus, form the reference set for inefficient banks. The resource utilization process in these banks is functioning well. It means that the production process of these banks is fulfilled without any waste of inputs. In DEA terminology, these banks are called peers and set an example of good operating practices for inefficient banks to emulate.

The remaining six banks have CRSTE score less than 1, which means that they are technically inefficient. The results, thus, indicate a presence of marked deviations of the banks from the best practice frontier. Among the researched banks, the Sberbank was found to be the least technically efficient DMU in the 2010-2014 periods. Overall technical efficiency can be improved by reducing inputs. CRSTE scores among the inefficient banks range from 0.626 for Sberbank in 2011 to 0.993 for Kookmin Bank in 2011. This implies that Sberbank and Kookmin Bank in 2011 could potentially reduce their input levels by 37.4% and 0.7% respectively while leaving their output levels unchanged. This interpretation of OTE scores can be extended for other inefficient banks in the sample.

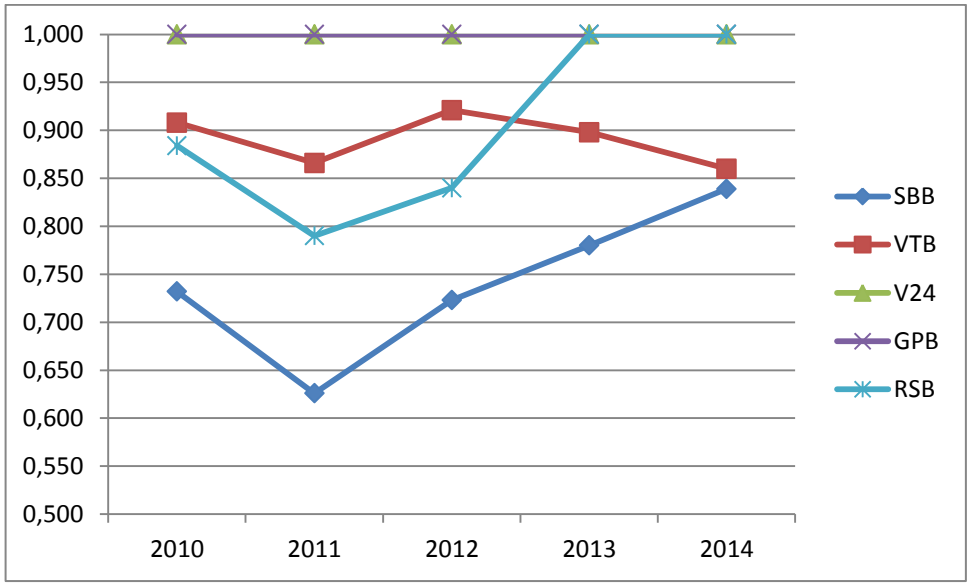

Fig. 4 Overall Technical Efficiency Trends of Russian Banks in 2010-2014

The DMU-wise presentation of Russian commercial banks' CRSTE trends on the plot (Fig. 4) shows us that only two out of five Russian banks in the sample may be considered relatively technically effective in the researched period. These effective banks are Gazprombank (GPB) and VTB 24 (V24). These banks have shown a stable CRSTE score of 1 in the research period. This implies that these banks were relatively effective in utilizing their inputs.

The VTB bank shows rather unstable effectiveness trend with a definite decrease in the 2012-2014 periods. Rosselkhozbank (RSB), on the other hand, has managed to overcome its ineffective input utilization and has become technically efficient by 2014. Sberbank (SBB) turned out to be the least technically effective DMU among all the commercial banks in the sample.

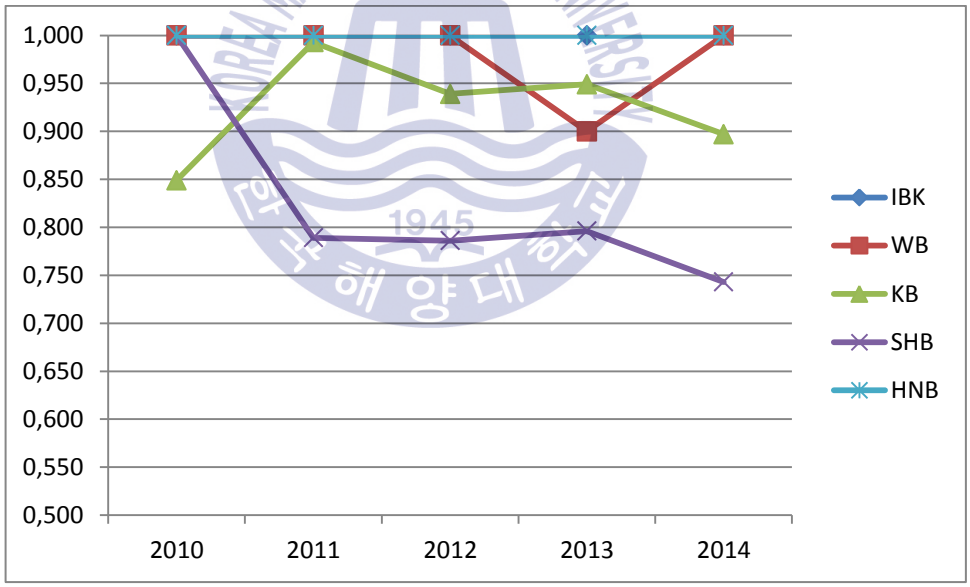

Fig. 5 Overall Technical Efficiency Trends of Korean Banks in 2010-2014

As for Korean commercial banks, the situation is pretty much the same (Fig. 5). Industrial Bank of Korea (IBK) and Hana Bank (HNB) have proven themselves relatively technically effective in the reviewed period. Woori Bank (WB) showed an interesting trend – while it was relatively efficient in 2010-2012, in showed a substantial decrease in effectiveness in 2013 and had managed to become effective again by 2014. Kookmin Bank

(KB) showed an unstable technical efficiency trend during 2010-2014. After becoming effective in 2011, its efficiency began to decrease. Shinhan Bank (SHB) showed a negative efficiency trend after a critical drop in 2010 – 2011.

Once again, it should be noted that OTE measure helps to measure combined inefficiency that is due to both pure technical inefficiency (PTIE), i.e., inefficiency, caused by poor management performance and scale inefficiency (SIE), i.e., inefficiency, caused by inappropriate size of resources.

However, the PTE measure derived from BCC model, under assumption of VRS, neglects the scale effects. Thus, the PTE scores provide that all the inefficiencies directly result from managerial underperformance (i.e., managerial inefficiency) in organizing the banks' inputs.

Table 2 and Table 3 show us the PTE and SE scores obtained. It has been observed that seven banks (Sberbank, VTB, VTB 24, Gazprombank, IBK, Woori Bank, and Hana Bank) received the PTE score equal to 1 for the duration of the research period. This implies that these banks' management is relatively efficient. On the other hand, three banks (Rosselkhozbank, Kookmin Bank, and Shinhan Bank) showed PTE scores of less than 1 for the duration of the research period. This implies that these banks have pure technical inefficiency, probably caused by relative managerial underperformance.

It is important to say that three out of seven banks that showed PTE score of 1 during the research period (Sberbank, VTB, and Woori Bank) at the same time showed OTE scores of less than 1. This implies that OTIE shown by these banks is not caused by poor input utilization (i.e., managerial inefficiency) but rather by the inappropriate scale size of bank operations.

Some DMUs (Rosselkhozbank, Kookmin Bank, Shinhan Bank) showed both OTE and PTE scores of less than 1 during the researched period. Additionally, in some periods,

Rosselkhozbank and Kookmin Bank have PTE score less than SE score. This indicates that the inefficiency in resource utilization (i.e., OTIE) in these two banks is primarily attributed to the managerial inefficiency rather than to the scale inefficiency.

Considering the results of the DEA model, we can state that both Russian and Korean DMUs tend to have a relatively effective management, while failure to operate at most productive scale size serves as the main reason of their overall technical inefficiency.

The DEA results show that in 2010-2014 Russian banks showed an average OTE score of 0.907, PTE score of 0.983 core of 0.923. This may be interpreted as that only 1.7% (1 - 0.983) of 9.3% of OTIE (1 - 0.907) is caused by bank managers who are not following appropriate management practices and operate with incorrect input combinations. The rest of OTIE is caused by inappropriate scale of banking operations. These calculations may be also applied to Korean banks. In 2010-2014, they showed an average OTE score of 0.946 and PTE score of 0.987. This means that only 1.3% of 5.4% of OTIE is caused by poor management, the rest goes to inadequate scale of operations.

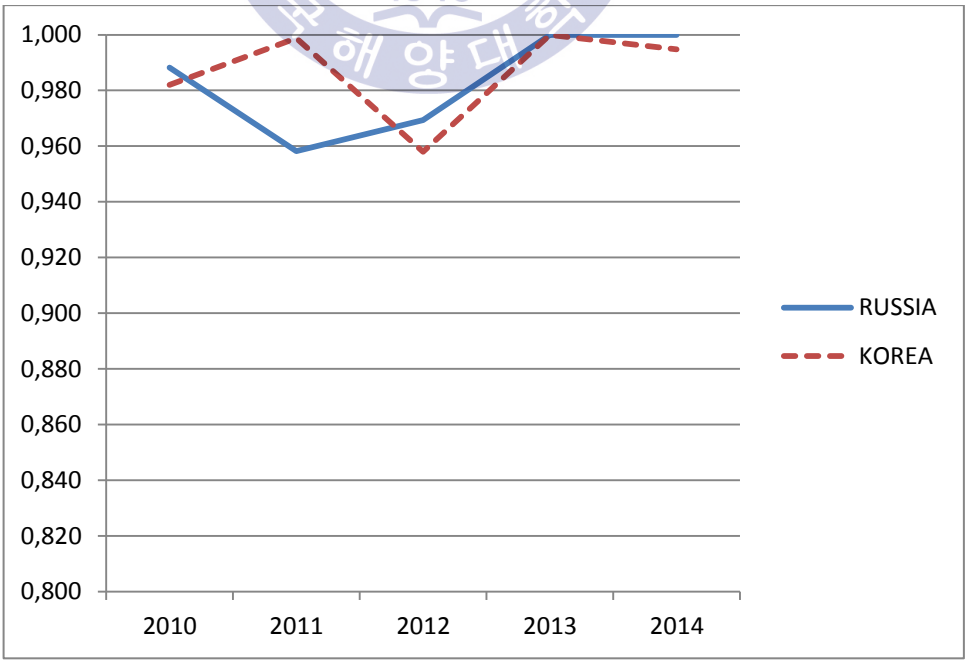

Fig. 6 Pure Technical Efficiency Trends of Russian and Korean Banks in 2010-2014

On Fig. 6 we can see the average PTE trends of Russian and Korean banks in the duration of the research period. It may be noted that in the researched period Russian banks have managed to increase their relative PTE after a substantial drop in 2011. Korean banks' trend, on the other hand, looks unstable throughout the research period with an improvement in 2013; however, in 2013-2014 there was a slight decrease. In 2012 the average PTE of Korean banks showed minimal value in the researched period, which may be probably caused by overall slowdown in domestic economy and financial sector in that period, along with stabilization efforts of Bank of Korea that may have caused a decline in managerial performance.

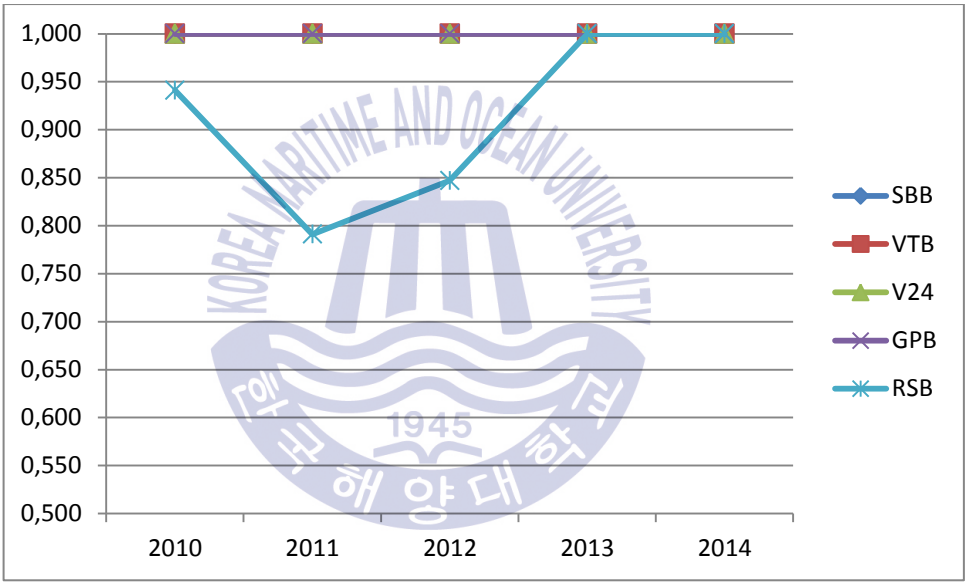

Fig. 7 Pure Technical Efficiency Trends of Russian Banks in 2010-2014

On Fig. 7 we can observe PTE trends for Russian Banks in the researched period. All banks showed effective managerial process in the researched period (i.e. earned PTE score of 1; their trend lines look fused on the graph), except for Rosselkhozbank (RSB) that had managed to reach relative effectiveness only by 2013-2014.

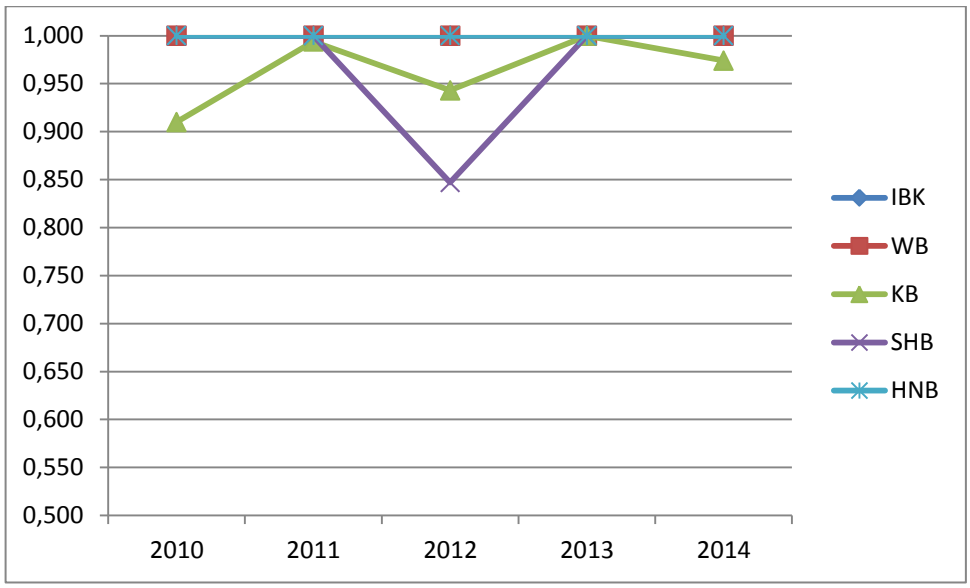

Fig. 8 Pure Technical Efficiency Trends of Korean Banks in 2010-2014

On Fig. 8 we can observe PTE trends for Korean Banks in the researched period. Three banks showed effective management for the duration of the research period (IBK, WB, and HNB – their trend lines look fused). Kookmin Bank's (KB) trend is unstable and multidirectional while Shinhan Bank (SHB) had only one serious effectiveness drop in 2012.

Table 4 shows the returns-to-scale measurements of our DMUs. The results indicate that four banks (VTB 24, Gazprombank, Industrial Bank of Korea, Hana Bank) were operating at the most productive scale size and experienced constant returns-to-scale (CRS) for the duration of the research period.

Table 4 Model Returns-to-Scale Measurements

DMU	2010	2011	2012	2013	2014
Sberbank	DRS	DRS	DRS	DRS	DRS
VTB	DRS	DRS	DRS	DRS	DRS
VTB 24	CRS	CRS	CRS	CRS	CRS
Gazprombank	CRS	CRS	CRS	CRS	CRS
Rosselkhozbank	DRS	IRS	IRS	CRS	CRS
Industrial Bank of Korea	CRS	CRS	CRS	CRS	CRS
Woori Bank	CRS	CRS	CRS	DRS	CRS
Kookmin Bank	DRS	IRS	IRS	DRS	DRS
Shinhan Bank	CRS	DRS	DRS	DRS	DRS
Hana Bank	CRS	CRS	CRS	CRS	CRS

Three banks (Sberbank, VTB, Shinhan Bank) were operating in the decrease returns-to-scale (DRS), i.e. on supra-optimal scale size and, thus downscaling would be a suitable course of action, in order to achieve cost reduction.

None of the DMUs in our research has shown a clear and constant increased returns-to-scale (IRS) for the duration of the research period. For instance, Rosselkhozbank had an IRS period in 2011-2012 that indicated that the bank was operating on sub-optimal scale size and a size increase was advisable. That fact was apparently taken into consideration, because after 2012 Rosselkhozbank demonstrated a steady CRS. On the other hand, Kookmin bank showed IRS in 2011-2012, but in 2013-2014 scale of operations shifted to DRS, that was probably due to excessive expansion.

In general, decreasing returns-to-scale is observed to be the predominant form of scale inefficiency among the DMUs in the sample.

6. Summary and Conclusions

This paper endeavors to conduct a comparative study of 10 largest Russian and Korean commercial banks efficiency in 2010-2014. In order to achieve the research objectives, an input-oriented DEA model has been applied in which the estimates of overall technical, pure technical, and scale efficiencies for individual DMUs have been obtained by CCR and BCC models.

The results indicate that in 2010-2014 largest Russian and Korean banks operated at almost the same relative efficiency level while Korean banks were slightly more effective. Furthermore, Korean banks have shown a decreasing overall technical efficiency trend in 2010-2014 periods, while their Russian counterparts have shown an increasing trend after a substantial decline in 2011.

VTB 24, Gazprombank, Industrial Bank of Korea, and Hana Bank were found to be technically efficient in the researched period, since they have an OTE score of 1. These banks together defined the best practice or efficient frontier for the model DMUs.

Russian Sberbank turned out to be the least technically effective DMU among all the commercial banks in the sample. Sberbank is Russia's largest commercial bank and its combined inputs and outputs surpass other four largest Russian banks' inputs and outputs combined. It seems that the "large assets mean large efficiency" proposition is not valid for our research sample.

Sberbank, VTB, VTB 24, Gazprombank, IBK, Woori Bank, and Hana Bank received the PTE score equal to 1 for the duration of the research period. This means that these banks' management is relatively efficient. Sberbank, VTB, and Woori Bank's overall technical inefficiency, revealed by DEA, is not caused by poor input utilization (i.e., managerial inefficiency) but by the inappropriate scale size of bank operations. In such

case adjusting the scale of banking operations would be an appropriate course of action for these banks to increase their relative efficiency.

Generally, the study showed that both Russian and Korean commercial banks from the sample tend to have a relatively effective management. The main reason for their relative overall technical inefficiency is inability to operate at most productive scale size.

In 2010-2014, Russian banks have managed to increase their relative PTE after a substantial drop in 2011. Korean banks' trend, on the other hand, looks unstable throughout the research period with an improvement by 2013 and a slight decrease in 2013-2014.

In 2010-2014 VTB 24, Gazprombank, Industrial Bank of Korea, and Hana Bank were operating at the most productive scale size and experienced constant returns-to-scale for the duration of the research period. Decreasing returns-to-scale trend is a predominant form of scale inefficiency among the DMUs in the sample. Operational downscaling might be a suitable course of action, in order to achieve cost reduction and relative efficiency.

There is a possibility of current DEA model's improvement if more DMUs and/or inputs-outputs are included. Research period increase might be effective as well; however, involving earlier years in the research would make cross-sectional data gathering problematic. In addition, more complicated research techniques can be employed for determination of environmental factors (market share, asset quality, exposure to off-balance sheet activities, profitability, and size) impact on commercial banks' relative efficiency.

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