INDIA'S EFFICIENT BANKS, TODAY AND TOMORROW: A COMPARATIVE PERFORMANCE ANALYSIS DURING POST REFORM PERIOD

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Preface

Banks are the backbone of financial systems and play an important role in economic development of the countries. Banks are the highest financial intermediaries in our economy and therefore they always deserve careful study. Major changes took place in the functioning of Banks in India due to the economic reforms in India which was started in early nineties. It is a fact that reforms have changed the depth and width of financial system in India. The nature of the Indian banks are quickly changing due to financial deregulation, financial innovations, financial inclusion, advancement in technology, customers' demands etc. The high valuation in the capital markets and high growth rates in retail financing and product distribution have attracted a number of new players both global and domestic. The new entrants/players with redefined business model based on advanced technology are likely to shape the future of the financial services and banking. Foreign banks and private sector banks in India have progressed well in the areas of technology upgradation in operations, extending the business hours, introduction of new products and various services. PSBs with their vast client base and unparallel treasury of trust are also evolving their own way to retain and attract new costumers. Indian banks are now facing competition from inside and outside the country from foreign entities and non-banking institution as well. In this highly competitive market, a question which strikes in the mind of regulators, managers, stakeholders, customers, and researchers like me is which banks and what types of banks will survive and dominate the Indian banking sector. Customers expect quality services with reasonable price, stakeholders expect assurance of reasonable returns, and managers want to know whether their banks can maintain market share and regulators desire smooth and efficient functioning of the banks for the development of the economy of the country. Only the efficient banks are able to

fulfill their expectation i.e. the success of banks for meeting these expectations largely depends on how efficiently they utilize their resources in delivering services. Efficiency, therefore, has become pivotal for banks' survival and growth. It has been empirically found that banks having high efficiency scores are much more likely to survive than banks which have relatively low scores. Against this backdrop, the present study intends to measure and examine the relative technical efficiency of the Indian banks using non-parametric frontier methodology- Data Envelopment Analysis (DEA). Though in our country some works have already been done in this area but there exists a lot of scope to undertake research work in this area which still remains under explored.

There is a vast literature on bank efficiency using DEA technique particularly in United States and other developed countries. But, the studies analyzing the efficiency of banks using this approach in India are fewer. As a result there has been a serious gap in this respect in India. Moreover, the attempts on the efficiency analysis of banks in Indian context are not in a comprehensive manner. Many of them use data for a single time period. While some studies concentrate on the efficiency of only public sector banks. Main focus of other studies is to show the impact of reform measures on the efficiency only. Therefore, the present study will be able to throw further light on the existing banking literature in Indian by analyzing the relative technical efficiency of different measures in a very comprehensive manner during the recent period covering from 2004-05 to 2007-08.

In dealing with the benefits of the Indian banking sector, we try to categorise the banks from various angles. These categorizations help regulators to take various measures for improvement of efficiency of the Indian banking sector.

In dealing with the perception of the common people, stakeholders, managers, the study has developed a humble approach to provide strict rankings to the selected banks under study so that we can prepare a brief ranking of India's efficient banks: today and tomorrow.

The main dilemma we face is the selection of appropriate input output variables for efficiency measurement that enables to capture multi dimensional functions of the banks and all sort of differences among the banks under study. However, the present study is expected to provide a brief overview of the efficiency level and efficiency positions of the individual Indian banks. The findings and suggestions of this study will be helpful for the policy makers, bank managers, customers, researchers, academicians along with the general readers who are interested about our vibrant banking sector.

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The responsibility for errors remains to me alone.

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List of Abbreviations

ABs – All Banks
AQY- Asset Quality
ATM- Automated Teller Machine
BCC – Banker, Charnes and Cooper
BFS- Board of Financial Supervision
BSR- Banking Sector Reforms
CCR –Charnes, Cooper and Rhodes
CFS- Committee on Financial System
CIBIL- Credit Information Bureau of India Ltd
CRR - Cash Reserve Ratio
CRS – Constant Returns to Scale
DEA – Data Envelopment Analysis
DMU – Decision Making Unit
DMUs – Decision Making Units
DRS – Decreasing Returns to Scale
FE- Financial Efficiency
GDP- Gross Domestic Product
GF- Grand Frontier
GOI- Government of India
IA- Intermediation Approach
IBA – Indian Banks Association
IMF- International Monetary Fund
IRS- Increasing Returns to Scale
IT- Information Technology
LDY- Liquidity
MPSS- Most Productive Scale Size
MQY- Management Quality
MXIE- Mix Inefficiency
NBs – Nationalized Banks
NPA - Non-performing Assets
NPBs – New Private Banks
OPBs – Old Private Banks
OTE – Overall Technical Efficiency
OTIE – Overall Technical Inefficiency
PA- Production Approach
PE- Profit Efficiency
PPS – Production Possibility Test
PSBs – Public Sector Banks
PTE – Pure Technical Efficiency
PTIE – Pure Technical Inefficiency
PVBs – Private Sector banks
PYTIE -Purely Technical Inefficiency
RBI – Reserve Bank of India
RBS- Risk Based Supervision
RE- Risk Efficiency

RI- Risk Index
ROA- Return on Asset
ROE- Return on Equity
SARFAESI- Securitization, Reconstruction of Financial Assets and Enforcement of Security Interest Act, 2002
SBs – State Banks
SCBs – Scheduled Commercial Banks
SE – Scale Efficiency
SEM- Super-efficiency Model
SIE – Scale Inefficiency
SLR - Statutory Liquidity Ratio
SPE –Super-efficiency
TE- Technical Efficiency
TFT- Total Factor Productivity
VRS- Variable Returns to Scale

Chapter - I

Introduction

1.1: Role of Banks

The importance of financial systems for economic development of a country is well recognized world wide [e.g., Levine and Zervos[1] (1998), Levine[2] (1997), Rajan and Zingales[3] (1998), King and Levine[4] (1993)] as well as in India [RBI[5] (2000); Bhattacharya and Sivasubramanian[6] (2003)]. A well-functioning financial sector facilitates efficient intermediation of financial resources. The more efficient a financial system is in resource generation and in its allocation, the greater is its contribution to economic growth[7]. Banks are the backbone of financial systems and play an important role in economic development of the countries including India. Banks are financial institutions that accept deposit and provide loans. They act as intermediaries in channelising funds from surplus units to deficit units. They also play a role in payment and settlement system and conduct of monetary policy. These financial activities are important in ensuring that the financial system and economy run smoothly and efficiently. An efficient system of financial intermediation also contributes to the risk mitigation process in the economy. Banks are the highest financial intermediaries in our economy and therefore they deserve careful study.

1.2: Competition and Indian Banking Drives

Over the years, the banking systems all over the world have witnessed a significant transformation underpinned by various factors – deregulation, globalization, technology innovation[8]. The Indian banking industry has witnessed radial changes and has experienced different degrees of repressive policies in the transformational regulatory requirements regime after the introduction of financial sector reform in 1991. With these initiations laid through the first and second generation reforms, there has been substantial improvement in efficiency and performances of the Indian scheduled commercial banks of our country (R Mohan[9] 2006, Reddy[10] 2002). This development has resulted in increased competitive pressure among the banks in India. Indian banks are now facing competition from inside and outside the country from foreign entities and non-banking institution also. Banks now compete on price of their input (deposit) and output (loan). Banks, therefore, have been introducing innovative products, seeking new source of

income, diversifying into non-traditional activities and economizing on capital[11]. Banks are constantly seeking new ways to add value to their services. In this very completive market, the question "What drives performance?" is at the top of the minds of managers and policy makers alike.

1.3: Public Banks vs. Private Banks

As per Phase II of roadmap started from April 2009, foreign banks may be permitted to have overall investment of 74 per cent (maximum) in the equity of private banks of India. So we have now gradually moved into a market driven competitive system. Three trends are found in this regard – consolidation through merger and acquisitions, globalization of operations, and universalisation of banking. The expected deregulation in the financial service landscape after April,2009, the high valuation in the capital markets and high growth rates in retail financing and product distribution have attracted a number of new players both global and domestic. The new entrants/players with redefined business model based on advanced technology are likely to shape the future of the financial services and banking. Foreign Banks and old and new Private Sector Banks in India, have progressed well in the areas of technology up-gradation in operations, extending the business hours, introduction of new products and services like "Any Where Banking", "Any Time Money", "Electronic Fund Transfer", "Electronic Clearing", "Tele-Banking" etc. These new tools enabled them to improve the quality of service and introduce Value Added Products[12]. Foreign banks have proved that they are more profitable than their counterpart domestic banks. PSBs are least active in FDI and FII areas and foreign banks are attracting huge foreign investment coming to India. In retail, Private Banks have developed leadership. The market share of PSBs in terms of total assets was 75.6 per cent in 2003, which reduced to 70.5 per cent in 2007. However, private banks, which had a share of 17.5 per cent in terms of total assets, stood at 21.5 per cent in 2007 and foreign banks which was 6.9 per cent in 2003 which increased to 8 percent in 2007. Public sector banks in the country are losing around one per cent market share per annum on an average for over 15 years to the private sector, as per credit rating agency, Moody's[13]. On the other side public banks have extended the banking services to the people of rural areas. Yet reach to the rural India still remain a challenge for private

and foreign banks, though public banks has addressed the issue through financial inclusion. PSBs with their vast client base and unparallel treasury of trust are also evolving their own way to retain and attract new costumers. 94.6% of the branches public banks have already been fully computerized. Out of 94.6 %, 67.7% branches are under CBS (as on 31.03.08, RBI). The recent developments in public sector such as advancement of technology and its use in almost all the sector of banks, reduction of employees through VRS scheme, securitization bill and professional attitude towards banking has greatly reduced costs, and NPA level, thereby increasing efficiency among public banks. The RBI noted that "Development after 1996 indicate that the majority of the public banks have been able to progress considerably towards the direction of passing the acid test of achieving competitive efficiency"[14] They are not far ahead so far as modern banking approaches such as net banking, mobile banking etc. Public Sector Banks are aiming to divide customers into different segments on the basis of the type of service they would like to render and also trying to segregate their servicing counters in their respective branches to enable customer to have easy access to a particular transaction[15].

Over time Indian banking has attained to a fair amount of maturity in terms of services provided, products offered. Today's banking structure is transformed with the help of securitization and derivatives trading. Securitization has decreased the risk involved in the banking sector.

1.4: Future Challenges

Indian banking has to face some challenges also. A few major challenges facing the Indian banks now are: threats of risks from globalization, implementation of Basel II; improvement of risk management systems; implementation of new accounting standards; enhancement of transparency and disclosures; enhancement of customer service; and application of technology. Besides the market is observing discontinuous growth driven by new products and services that include opportunities in credit cards, consumer finance and wealth management on the retail side, and in fee-based income and investment banking on the wholesale banking side requiring new skills in sales & marketing, credit

and operations. The cost of intermediation remains high and bank penetration is limited to only a few customer segments and geographies. While bank lending has been a significant driver of GDP growth and employment, periodic instances of the "failure" of some weak banks have often threatened the stability of the system. Structural weaknesses such as a fragmented industry structure, lack of institutional support infrastructure, restrictive labour laws, weak corporate governance and ineffective regulations beyond Scheduled Commercial Banks (SCBs), unless addressed, could seriously weaken the health of the sector and also affect future banking performance[16].

1.5: Banking Efficiency Issue

The resultant competitive forces, coupled with future challenges faced and more stringent regulatory framework, have created pressure on the Indian banks to perform efficiently. Efficiency, therefore, has become critical for banks' survival and growth. It has been empirically found that banks receiving high efficiency scores are much more likely to survive than banks which have relatively low scores[17]. Another study has validated a negative and significant relation between cost efficiency and the risk of a bank failure[18]. The assessment of efficiency and productivity of banking, thus, assumes high importance. Enhanced efficiency in banking can result in greater and more appropriate innovations, improved profitability as well as greater safety and soundness when the improvement in productivity is channeled towards strengthening capital buffers that absorb risk[19]. Moreover, banking efficiency or productivity measures could act as leading indicators for evolving strengths or weaknesses of the banking system and could enable pre-emptive steps by the regulator when necessary. Therefore, investigation and measurement of efficiency in the banking sector have always been the areas of interest of researchers, academicians, policy-makers and banks managers and customers.

1.6: Objectives

In Indian context, there are a lot of studies regarding banking performance and efficiency analysis especially from 1970s. But most of the studies have used accounting measures for estimating efficiency levels of the banks [e.g. Ram Mohan[20] (2002), Rakesh Mohan[21] (2006), Reddy[22] (2002), C Rangarajan[23] (1998) Mohan and Ray[24] (2004),

Shanmugam and Das[25] (2004), Ataullah et al.[26] (2004), Reddy[27] (2004), Das et al.[28] (2005), Kumbhakar and Sarkar[29] (2003), Sensarma[30] (2005), Das and Ghosh[31] (2006)]. Number of studies on banking efficiency in India using Data Envelopment Analysis (DEA) technique is not so high. Some notable studies using this approach have been made by the researchers to analyze the efficiency of the Indian banking sector [e.g. Bhattacharya et al.[32] (1997), Das (1997[33], 1999[34], 2000[35]), Sathye (2001[36], 2003[37]), Das et al.[38] (2004), Omprakash et al.[39] (2008), Debasish[40] (2006), Kumar and Gulati[41] (2008), Mohan and Ray[42] (2003), Noulas and Ketkar[43] (1996), Saha and Ravishankar[44] (2000), Ray[45] (2007), Mukherjee et al.[46] (2002)]. Most of them have used data for a single time period which makes it difficult to compare the efficiency over the time. While some studies concentrate on the efficiency of only public sector banks, others look at the relationship between ownership group and efficiency. Main focus of their studies is to show the impact of reform measures on the efficiency at aggregate level i.e. comparing the efficiency level among the different ownership groups. Few studies have taken into consideration the bank size, income diversification as factors of efficiency variation. Majority studies have considered maximum 2 or 3 common inputs and outputs. Thus multidimensional nature of the recent banking operations have not been reflected in their studies. The impact of technology use, capitalization from owned fund, bank size, profitability, cost-revenue management ability, capital adequacy, non-performing assets(NPA) on bank performance has not been the main focus of their research. So, there is hardly any comprehensive study on measuring and examining the efficiency of Indian banks.

Therefore, some issues have to be addressed over the time as the reform process is entrenched further. With this background, present study adopts multiple measures of DEA efficiencies: overall technical efficiency, pure technical efficiency, scale efficiency and super-efficiency of the selected individual Indian banks for in-depth efficiency analysis in the more recent period spanning 2004-05 to 2007-08. This study differs from other studies in at least three ways: (i) the time period (2005-08) taken in the analysis and (ii) the DEA models used to

measure the efficiency scores, (iii) the input-output variables specification in the DEA model.

Therefore, the present study will be able to throw further light on the existing banking literature in Indian in the following way -

First, the fact that despite the substantial structural changes and importance of the Indian banking sector, the sector has remained under research using DEA methodology compared to studies in other countries. The present study tries to fill this gap in the existing banking literature in India.

Second, this study critically measures and examines the technical efficiency of a sample of 36 major Indian domestic commercial banks during the period 2005-2008 using CCR and BCC model of data envelopment analysis. Present study provides the efficiency scores -- overall technical efficiency and pure technical efficiency on individual bank wise of each year and for the study period as a whole. This is contrary to the results of existing studies that reported the results at highly aggregated levels such as public versus private banks and with other groups.

Third, the study categorizes the banks under evaluation into two groups- efficient and inefficient.

Fourth, the study provides bank wise main source of technical inefficiency

Fifth, the study also provides bank wise nature of returns to scale.

Sixth, the study categorizes the efficient banks and inefficient banks separately from various angels to trace out the important features of the efficiency of Indian banks.

Seventh, the study also indicates inefficient bank wise input output improvement plan in order to convert inputs into outputs in an efficient way.

Eighth, present study investigates efficiency in terms of ownership group and bank size separately.

Ninth, the study also explores a new set of bank specific factors in addition to ownership pattern and bank size affecting efficiency variation among the banks.

Lastly, the study also ranks the Indian banks based on the super efficiency score using Andersen and Petersens'[47] (1993) super-efficiency DEA model. Various financial performances parameters are also taken into consideration for overall rankings. No attempt has yet been made so far in this way for such a comprehensive ranking of the Indian banks.

In short, the broad objective of this study:

1. To estimate and examine the relative technical efficiency of Indian scheduled commercial domestic banks for a period from 2004-05 to 2007-08.

2. To provide strict ranking to the selected banks under study.

3. To categorize banks of different efficiency status.

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Chapter - II

Indian Banking:

An Overview since Independence

2.1: A Brief History of Indian Banking Industry

Banking in India has a long history and it has evolved over the years passing through various phases. The history of modern banking in India started in the first half of 18th Century with the establishment of three presidency banks under Presidency Bank's act 1876 i.e. Bank of Calcutta latter renamed as Bank of Bengal (1806) Bank of Bombay (1840) and Bank of Madras (1843). In 1921, all presidency banks were amalgamated to form the Imperial Bank of India. Imperial bank carried out limited central banking functions also prior to establishment of RBI. The Hilton Young Commission in 1926 recommended the establishment of a separate bank in the country known as Reserve Bank of India[1]. So a bill was introduced in the Legislative Assembly in 1933 which led to the establishment of Reserve Bank on 1 April 1935 in accordance with the provisions of the Reserve Bank of India Act, 1934. After the establishment of Reserve Bank of India, the Imperial Bank was authorized to function as a sole agent of the Reserve Bank of India (RBI) at all places in India where the RBI had no branches. After the 1860 introduction of the concept limited liability, private banks began to appear, and foreign banks entered the market. From 1860 till the beginning of the 20thCentury, several joint stock banks were established (e.g. Oudh Commercial Bank in 1881 followed by the Punjab National Bank in 1895 and People's Bank in 1901).

A brief evaluation of Indian Banking Industry since independence can be summarized as follows.

Pre-nationalization Period (1947 – 1967)

The entire banking was under the ownership and control of big industry houses. The banking scenario in the early independence phase raised three main issues[2]: (i) bank failures had raised concern regarding the soundness and stability of the banking sector; (ii) there was large concentration of resources in a few business families; and (iii) the share of agriculture in total bank credit was very small though the development of rural areas was accorded the highest priority in the first five year plan 1951-56. Before independence an important occasion in Indian banking history was the establishment of the Reserve bank of India in 1934. In 1955, the RBI acquired control of the Imperial

Bank of India which was formed in 1921 by amalgamating three banks set up under the Presidency's act of 1876, which was re-christened the State Bank of India. Later, the State Banks of India (Subsidiary Banks) Act was passed in 1959 enabling SBI to take over eight former state associated banks as its subsidiaries.

Post-nationalization Period (1967-1991)

1969 the year was a landmark in the history of commercial banking India. Fourteen major banks were nationalised in 1969 and six in 1980. With this, the major segment of the banking sector came under the control of the Government. With the nationalization of commercial banks the country witnessed massive expansion of branch network especially in rural areas. This helped in mobilising deposits and stepping up the overall savings rate of the economy. Some other social controls were also implemented such as increasing priority sector lending targets. There was a shift of emphasis from industry to agriculture.

Ketkar and Ketkar[3] (1992), and Ketkar[4] (1993) observed that bank nationalization has been a mixed blessing. Aggressive bank branch expansion program, especially in rural areas, has increased financial savings and investment but credit controls had a negative effect on the deposit mobilization, efficiency and profitability of PSBs. Notwithstanding, Indian banks, especially PSBs, have made remarkable progress in achieving social goals and bringing financial deepening along with catering to the needs of planned development in a mixed economy framework.

From the mid-1960s to the early 1990s, the Government of India (GOI) increasingly used the banking system as an instrument to finance its own deficit (Hanson and Kathuria[5] 1999, Agarwal[6] 2003). This was done by high Cash Reserve Ratio (CRR) and Statutory Liquidity Ratio (SLR)[7]. Along with high CRR and SLR (as high as 40% of the total lending in 1989-90), the operational freedom of the banks was curtailed. Bhattacharyya and Patel[8] 2003 and Reddy[9] (1998) observed that in the pre-reforms years, for every rupee of deposit in banks, only about one-third to one-half was available for lending to the commercial sector. Further, rates of return were low by international standards, the capital base had eroded, NPAs were on the rise, and

customer service was below expectation [10]. More important, the lack of proper disclosure norms led to many problems being kept under cover. Poor internal controls raised serious doubts about the integrity of the system itself [11]. The Non Performing Assets (NPA) increased from 14% in 1969 to 35.4% in 1990. Further, in 1992/1993, NPAs of 27 PSBs amounted to 24% of total credit, only 15 PSBs achieved a net profit, and half of the PSBs faced negative net worth[11]. Jagirdar[13] (1996) observed that the average return on assets (ROA) in the second half of the 1980s was only about 0.15% which was abnormally low by all standards. Return on equity was higher about 9.5% but this was simply a reflection of low capitalization of Indian banking. In the language of Joshi and Little et al.[14] by 1996 the country had erected an unprofitable, inefficient and financially unsound banking sector. In this period the surprising thing is that the profitability of the Indian banks was extremely low inspite of the rapid growth of deposit through dramatic expansion of banks and bank branches throughout the country.

The major factors that contributed a lot for deteriorating bank performance included (a) too stringent regulatory requirements (i.e., high cash reserve ratio (CRR) & statutory liquidity ratio (SLR) (b) low interest rates usually charged on government bonds (as compared with those on commercial advances); (c) directed and concessional lending; (d) administered interest rates; and (e) lack of competition etc. In addition, due to the expansionary policy pursued by RBI, the number of loss making bank branches increased, especially in rural areas, which depleted resources of the banking industry. However, bank nitionalisation creates its own problems like excessive bureaucratization, red-tapism and problem of trade unions of bank employees.

Banking Sector Reforms Period (1991-Till now)

In 1991, Indian economy faced a major balance of payment crisis. The foreign exchange resources had almost disappeared. Fiscal deficit was high and the inflation rate reached double digits. This crisis led to Indian policy makers recognizing that a robust financial sector reform was necessary to support economic reforms taken by the Indian economy in the year 1991 with an objective of brining about sustainable growth and development rapidly. In this backdrop a wide range of banking sector reforms were

introduced in India in 1992 as an integral part of the economic reforms (1991) in two district phases. The financial sector reforms in India began as early as 1985 itself with the implementation of the recommendations of Chakrabarti committee[15] report. But the real momentum was given to it in 1992 with the implementation of recommendations of the Committee on Financial System (CFS) (Narasimham Committee[16] I) which focused on (a) deregulation (b) competition and (c) reliability. Almost all of the recommendations of the CFS have been implemented in a phased manner. In 1998 another committee, the committee on Banking Sector Reforms (BSR) (Narasimham Committee[17] II) was constituted with a greater emphasis on structural measures, improvement in disclosure and transparency standards in order to align with the international best practice. The recommendations of the BSR committee have also been implemented in a phased manner. Following are the important financial sector reforms introduced after 1992

Entry deregulation, branch de-licensing, phased deregulation of interest rates, and permission to public sector banks to raise a maximum of 49% of equity in the capital market were among key measures aimed at improving bank efficiency. The reforms also aimed to improve bank profitability through the gradual reduction of the Cash Reserve Ratio (CRR) and the Statutory Liquidity Ratio (SLR). Further, in 1992, the Reserve Bank of India issued guidelines for income recognition, asset classification and provisioning, and also adopted the Basle Accord capital adequacy standards. The government also established the Board of Financial Supervision (BFS) in the Reserve Bank of India and recapitalized public-sector banks in order to give banks sufficient financial strength and to enable them to gain access to capital markets. In 1993, the Reserve Bank of India permitted private entry into the banking sector, provided that new banks were well capitalized and technologically advanced, and at the same time prohibited cross-holding practices with industrial groups. The RBI also aimed at reducing the banking sector's fragility by implementing Bank of International Settlements' (BIS) norms. The objective of these changes was to create a competitive environment in the medium and long run, and would lead to substantial gains in efficiency, profitability, and productivity. One of the major objectives of banking sector reforms in India was to promote flexibility, operational autonomy and competition in the system and to raise the banking standards in India to the international best practices

(Reddy[18], 2002).

During the last 16 years, an extensive program of banking reforms has been followed to strengthen market institutions and allow greater autonomy to the banks. The details on various reform measures and their impact on the structure of the Indian banking industry have been documented. Some notable references may be made to the works of Sen and Vaidya[19] (1997), Hanson and Kathuria [20](1999), Arun and Turner[21] (2002), Shirai[22] (2002), Bhide et al[23] (2002), Yoo[24] (2005).

2.2: Important Initiatives of Reform Process of Commercial Banks in India

Some important initiatives as a part of reform process of commercial banks are listed below[25].

- The GOI has injected about 0.1% of GDP annually into weak public sector banks (Hanson [26] 2005; Rangarajan[27]2007). During the period 1992/1993 to 2001/2002, GOI contributed some Rs. 177 billion, about 1.9% of the 1995/1996 GDP, to nationalized banks (Mohan and Prasad [28]2005).
- In 1993, the State Bank of India (SBI) Act, 1955 was amended to promote partial private shareholding. The SBI became the first PSB to raise equity in the capital markets. The amendment of the Banking Regulation Act in 1994 allowed the PSBs to raise private equity up to 49% of paid up capital. Since then 20 PSBs have diversified their ownership, although the government has remained as the largest shareholder.
- India adopted the Basel Accord Capital Standards in April 1992. An 8% capital adequacy ratio was introduced in phases between 1993–1996, according to banks ownership and scope of their operations. Now it is 9%.
- The time for classification of assets as non-performing has been tightened over the years, with a view to move towards the international best practice norm of 90 days by end 2004.
- From 2000–2001, the PSBs are required to attach the balance sheet of their subsidiaries to their balance sheets.
- In 1993, the RBI issued guidelines concerning the establishment of new private

sector banks. Nine new private banks have entered the market since then. In addition, over 20 foreign banks have started their operations since 1994.

- A high powered Board of Financial Supervision (BFS) has been constituted in 1994. BFS exercised the power of supervision in relation to the banking companies, financial institutions, and non-banking companies, creating an arms–length relationship between regulation and supervision. On-site supervision was introduced in 1995, and annual supervision of capital adequacy, asset quality, management quality, earnings, liquidity, and systems (CAMELS) was introduced in 1997.
- Strengthening of prudential framework by developing sound risk management system and encouraging transparency and accountability.
- Implementation of Risk based supervision (RBS)

  Merger and amalgamation of banks (The mergers between non-banking financial companies and banks as also between private sector banks are now permitted, subject to the RBI guidelines issued on May 11, 2005.)[29]
- Managerial autonomy of public sector banks.
- Implementation of the new capital adequacy framework (Basel II norms) - As regards the timeframe for implementation of Basel II framework, the foreign banks operating in India and the Indian banks with foreign branches are required to adopt the Standadrised Approach for credit risk and the Basic Indicator Approach for the operational risk, with effect from March 31, 2008. All other commercial banks are required to adopt these approaches not later than March 31, 2009.
- The enactment of Securitization, Reconstruction of Financial Assets and Enforcement of Security Interest (SARFAESI) Act, 2002 addressing the problem of NPAs.
- Improvement of customer services through Customer Services Committee of the Board, banking Ombudsman etc.
- Credit Information Bureau of India Ltd. (CIBIL) for compilation and dissemination of credit information covering data on defaults to the financial system.

- Technology use in banking operations – RBI has played a proactive role in the implementation of IT in the banking sector. IT based initiatives – ATM, Internet banking, mobile banking, telephone banking i.e. any where any time banking has improved the customer services and overall systematic efficiency of this sector.

However the Policy makers, which comprise the Reserve Bank of India (RBI), Ministry of Finance and related government and financial sector regulatory entities, have made several notable efforts time to time to improve regulation and supervision in the sector. Various reform measures along with constant regulation and supervision resulted in an improvement in profitability, financial health, soundness and overall efficiency of the banking sector. The sector now compares favorably with banking sectors in the region on metrics like growth, profitability and non-performing assets (NPAs) level. A few banks have established an outstanding track record of innovation, growth and value creation. This is reflected in their market valuation. Now India is on the global map as one of the fastest growing economies. At present Indian economy continues on a sustainable high economic growth. The GDP growth has averaged 7.6 percent during the 10th five year plan (2002-03 – 2006-07), highest during any plan period.

Despite substantial improvements in the banking sector reforms some issues or major challenges that are likely to be faced by Indian Banking Industry in coming few years (as per Report on Currency and Finance 2007-08 , RBI) :-

- Managing Resource Mobilisation
- Managing Capital and Risk
- Financial Inclusion
- Competition and Consolidation
- Regulatory and Supervisory Challenges in Banking

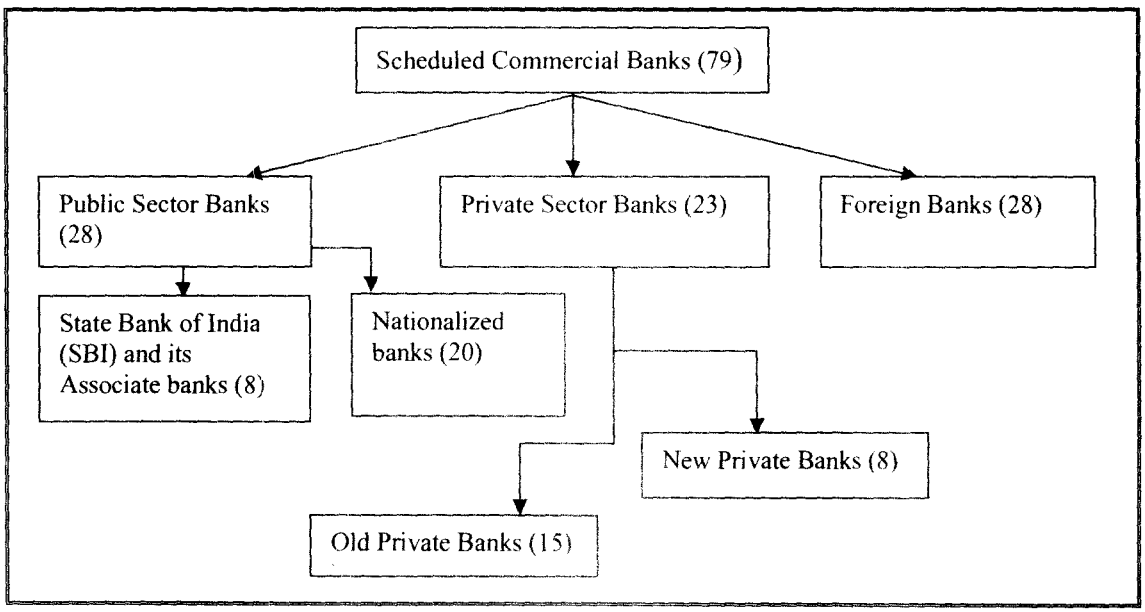
2. 3: The Structure of Indian Banking Sector

The Reserve Bank of India (RBI) is the central bank of the country that regulates the operations of other banks, manages money supply, and discharges other myriad responsibilities that are usually associated with a central bank. The banking system in

India comprises commercial and co-operative banks, of which the former accounts for more than 90 percent of the assets of the banking system and banks within the category of commercial banks, there are two types: i) schedule commercial banks (i.e., which are listed in Schedule II of the Reserve Bank of India Act, 1934); and ii) non-scheduled commercial banks. This study is concerned with measurement and analysis of technical efficiency of the selected listed scheduled commercial Indian banks. A commercial bank is a financial intermediary of accepting deposits from public and lends them with a view of making profit. The roles of commercial banks are important for economic development of any country.

Box: 2.1

Structure of Scheduled Commercial Banks in India



Note- Scheduled commercial banks excluding RRBs. Number of banks of each ownership group is mentioned as per Statistical Table Relating t Banks, 2007- 08, RBI.

Despite the large number of private and foreign banks operating in the country, banking market is still very much dominated by the public sector banks controlling about 69% of the total assets (2007-08) of the scheduled commercial banks. PSBs have a countrywide network of branches. The contribution of PSBs in India's economic and social development is enormous and well documented. They have strong presence at rural and semi-urban areas, and employ a large number of staff. On the other side, Foreign Banks

and old and new Private Sector Banks in India, have progressed well in the areas of technology up-gradation in operations, extending the business hours, introduction of new products and services. They have limited number of branches confined in major urban and metropolitan centers and they are less labor intensive and more profitable.

Table: 2.1

Summery Statistics of the Scheduled Commercial Banks

Statistics	1969	2001	2003	2005	2006	2007	2008
Number of Scheduled Commercial Banks	73	293	286	285	218	179	170
of which: Regional Rural Banks -	-	196	196	196	133	96	91
Number of Bank Offices in India	8262	68195	69170	7.373	71685	74346	77773
Population per Office (in thousands)	68	15	16	16	16	15	15
Per capita Deposit of Scheduled Commercial Banks (Rs.)	88	9770	12253	16281	19130	23382	28610
Per capita Credit of Scheduled Commercial Banks (Rs.)	68	5228	7275	10752	13869	17541	21218

Source: RBI

2.4: Performance of scheduled Commercial Banks

The total banking sector asset constitutes more than 91.8 percent of the GDP [30] at the end of March 2008 and the commercial banking asset constitutes more than 95 percent of the total banking asset. The strong macroeconomic environment in 2003-04, supported by monetary and financial policies, helped to restore the growth momentum and improve financial performance of the Indian banks.

Table: 2.2

Performance indicators of Scheduled Commercial Banks#

Indicators	1996-97	2004-05	2005-06	2006-07	2007-08
Growth in Major aggregates –					
1. DEPOSIT	19.7	16.6	17.8	24.6	23.1
2. CREDIT	17.7	33.2	31.8	30.6	25.0
Financial Indication (as a % of Total Assets)					
1.Operating Profit	1.9	2.2	2.0	1.9	1.9
2.Net Profit	.7	.90	.97	.96	1.0
Non-Performing Assets (NPA) (as a % of Advances)					
1.Gross NPA	15.7	5.2	3.3	2.5	2.3
2.Net NPA	8.1	2.0	1.2	1.0	1.0

Source: Report on Trend and Progress of Banking in India, RBI (various issues), and # excluding RRBs

Table: 2.3:

Some Select Performance Indicators of Banks grouped by Ownership Pattern

Indicators	Year	SB	NB	OPB	NPB	ASCBs
Operating Cost to Assets	1991-92	2.48	2.67	2.97	-	2.59
	1998-99	2.70	2.63	2.22	1.74	2.65
	2006-07	1.98	1.67	1.88	2.11	1.91
Net Interest Margin (spread)	1991-92	3.8	2.86	4.01	-	3.3
	1998-99	2.85	2.78	2.17	2.01	2.79
	2006-07	2.79	2.58	2.74	2.36	2.69
Business per Branch(Rs in Core))	1991-92	10.53	8.27	4.87	-	9.12
	1998-99	24.92	19.23	19.04	66.34	22.75
	2006-07	77.14	62.78	52.31	293.96	79.39
Return on Assets	1991-92	.21	.33	.57	-	.39
	1998-99	.51	.37	.46	1.05	.50
	2006-07	.82	.83	.69	.92	.90
Return on Equity	1991-92	12.72	10.45	26.77	-	14.77
	1998-99	11.10	6.26	8.41	16.66	8.59
	2006-07	15.30	14.65	10.32	13.57	14.24

Note: SB-State Banks Group, NB-Nationalized Banks group, OPB-Old Private Banks group, NPBs –New Private Banks Group and ASCMBs-All commercial banks
Source: Report on Currency and Finance- 2007-08, RBI

From the above Tables: 2.3, it is clear that Indian banking sector has been improving towards a sound and efficient banking system during the study period 2005-08. Banks are able to maintain reasonable profitability in spite of declining trend of spread indicating substantial enhancement of efficiency level in banking operations. The trend of improvement in asset quality of banks continued during the years.

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Chapter - III

Survey of Existing Literature on Banking Efficiency

3.1: Introduction

The measurement of financial institutions' efficiency using parametric and non-parametric frontier models has received considerable attention over the past two decades. Among the various approaches used, the use of Data Envelopment Analysis (DEA) approach has been frequent. There exists a great amount of literature on bank efficiency across the globe. But there has been little research effort in measuring and analyzing efficiency of banks in India using the approach - DEA during the post reform period. Rapid changes in the financial service industry make it important to determine the efficiency of financial institutions. Banks play an important role in financial market in developing countries like India and it is important to evaluate whether banks are operating efficiently or not. Therefore, investigation and measurement of efficiency and productivity in the banking sector have always been areas of interest for economic research. Numerous attempts have been made to study the efficiency of banks in developed countries. There is a vast literature on bank efficiency particularly in United States (see surveys in Berger et al.[1], 1993; Berger and Humphrey[2], 1997). In recent times examining the efficiency of financial institutions with frontier techniques has expanded rapidly in several other countries including India[3]. But, the studies analyzing the efficiency of banks using modern approach in India are far fewer. As a result there has been a serious gap in this respect in India and the effort of the present study is to fill this gap.

Thus, review of banking efficiency literature is framed in this study in two phases- literature on banking efficiency of the countries other than India and banking efficiency literature in Indian context.

3.2: Literature Review in Global Context

Several studies have analyzed the performance of the banking industry in developed and other countries. Berger and Humphrey[4] (1997) reviewed the empirical studies of efficiency of banking industry in the world. Of the 130 studies of financial institutions efficiency, 116 were published between 1992 and 1997. They find that, overall depositor financial institutions/banks operate at an annual average technical efficiency level of around 77% (median 82%). The non-parametric technique has been

extensively used to evaluate the efficiency of the US banking. Some notable studies on US banking efficiency are:

Rangan et al.[5] (1988) examined the technical efficiency of 215 bank in1986. Using three inputs (viz. labour, capital, purchased fund) and five outputs (viz. commercial and industrial, consumer, real estate loans, demand and time & savings deposit) they found an average efficiency of 70%. Decomposing total efficiency produces pure technical efficiency 72% and scale efficiency 97% implying that efficiency problem is caused by pure technical not scale inefficiency.

Grabowski et al.[6] (1994) estimated the efficiency of a group of banks of 670 using same three inputs and five outputs like Rangan et al. (1988) only exception with securities in place of time and savings deposit. They concluded that pure technical inefficiency is the main source of total technical inefficiency.

Aly et al[7]. (1990) explored various measures of efficiency for 322 banks in 1986. They find technical, scale and pure technical efficiencies are .75, .97 and .77. They agreed that bank size is positively related with efficiency. But, product diversity has negative relation with efficiency. They also reported that there is a positive link between urbanization and efficiency.

Ferrier and Lovell[8] (1990) and Elyasiani and Mehdian[9] (1990) estimated productive performance of the US banks they considered for their studies. They suggested that efficiency of US banking industry ranges from 65% to 90%.

Miller et al[10]. (1996) investigated technical efficiency – pure and scale of 201 large-sized banks from 1984 to 1990 considering four inputs (total transactions deposit, total non-transaction deposit, total interest and total non-interest expenses) and six outputs (commercial and industrial, consumer, real estate loans, investment, total interest income and total non-interest income). They suggested that average technical inefficiency was just over 5%. Large and profitable banks have higher levels of technical efficiency. They also reported that larger banks are more likely to operate at decreasing returns to scale.

Barr et al.[11] (1999) used a constrained multiplier, input-oriented, data envelopment analysis (DEA) model to evaluate the productive efficiency and performance of U.S. commercial banks from 1984 to 1998. They found strong and

consistent relationships between efficiency and the inputs and outputs, as well as independent measures of bank performance. Further, their results suggested that the impact of varying economic conditions was mediated to some extent by the relative efficiencies of the banks that operate in these conditions. Finally, they found that a close relationship exists between efficiency and soundness as determined by bank examiner ratings.

Efficiency studies on banking firms operating in countries other than US have also been rapidly increasing over the last a few years. Some notable studies are

Jackson and Fethis'[12] (2000) study on Turkish banks found that the profitable banks are more likely to operate at higher levels of technical efficiency and the capital adequacy ratio has a statistically significant adverse impact on the performance of banks.

Rezvanian et al.[13] (2002) examined production performance and cost structure of the Singaporean banks using both parametric and non-parametric technique. Non-parametric approach indicated that Singapore banks could have reduced cost by 43% had they all been overall efficient.

Isik et al.[14] (2002) estimated the efficiency of Turkish banks over the 1988-1996 periods. Result of their study indicated that dominance of source of inefficiency in Turkish banks is due to technical inefficiency rather than allocative inefficiency, which is mainly attributed to diseconomies of scale. Bank management is responsible for scale inefficient operations.

Ali et al.[15] (2002) examined the performance of banks in Kuwait during the period of financial renaissance, 1994–1997. They computed several measures and productivity changes on the basis of the Data Envelopment Analysis and the Malmquist Index. The result indicated that cost efficiency of Kuwait banks averaged 68% only. The empirical results also suggested that Kuwaiti banks fail to optimally utilize a significant proportion of their resources. The sources of bank inefficiency appear to be both allocative (regulatory) and technical (managerial) in nature. The results also indicated that smaller banks in Kuwait are more efficient than larger ones, although all banks have improved their efficiency-levels and experienced some gains in productivity

Casu and Molyneuxs'[16](2003) study on European banking concluded that debt equity ratio had no effect on efficiency; more profitable banks were more efficient, listed

banks were more efficient than non-listed banks and commercial banks were more efficient than cooperative banks. Efficiency differences across European banking markets appear to be mainly determined by country-specific factors.

Fries et al.[17] (2005) examined the relative cost efficiency of a sample of 289 banks in 15 east European countries for the years 1994–2001. They found that privatized banks with majority foreign ownership are the most efficient and those with domestic ownership are the least. They also suggested that early stages of reform are associated with cost reductions, while costs tend to rise at more advanced stages.

Al-Faraj et al.[18] (2006) investigated the performance of the Saudi commercial banking industry using DEA to evaluate the technical efficiency of Saudi banks for the year 2002 and compared with world mean efficiency scores. Their study revealed that the mean efficiency score of Saudi commercial banks compares very well with the world mean efficiency scores. They recommended that Saudi banks should continue their efforts of adapting new technologies and providing more services in order to sustain competitive advantages as Saudi Arabia continues to deregulate the banking industry.

Lili Cao[19] (2007) selected 4 major state-run commercial banks and 10 shareholding system commercial banks to evaluate the management efficiency from 2001 to 2003 using a C2R model and super-efficiency models. The result indicated that super-efficiency models can really carry on full appraisal and sort. Chinese commercial banks' management efficiency is generally improved. but not high yet. Shareholding system commercial banks' efficiency is generally higher than state-run commercial banks.

DENG Chen-guo et al[20]. (2007) estimated efficiency of fourteen Chinese commercial banks in 1999 using BCC model of DEA technique. They also used super-efficiency model to rank all the banks completely.

Tahir and Haron[21] (2008) examined the technical efficiency of the Malaysian commercial banks over the period of 2000-2006, using the stochastic frontier approach (SFA). The findings revealed that Malaysian commercial banks have exhibited an average overall efficiency of 81 percent implying an input waste of 19 percent. The results also found that the level of efficiency has increased during the period of study.

Malak REDA[22] (2008) in his current study measured the efficiency and productivity change of Egyptian commercial banks from 1995 to 2003, using a non-

parametric technique -Data Envelopment Analysis (DEA) and Malmquist Productivity Index. Results indicated that Egyptian commercial banks' technical inefficiency was 22 percent. In general, smaller banks were found to be least efficient. Malmquist results for a panel of 24 banks indicated that the productivity of commercial banks deteriorated by four percent per year on average during the study period. Moreover, most Egyptian banks operate at incorrect scale.

Supachet Chansarn[23] (2008) examined the relative efficiency of Thai commercial banks. He revealed that the efficiency of 13 Thai commercial banks during 2003 – 2006 via operation approach is very high and stable with the average efficiencies over 90% in every year while via intermediation approach moderately high but somewhat volatile with the average efficiencies about 86% in 2003 and 2005 and about 72% in 2004 and 2006.This result reflected that size of commercial banks does not have any influence on the performance of Thai commercial banks in costs /revenues management. Moreover, small banks, in average, are the most efficient banks via intermediation approach.

Ahmed & Ahmad[24] (2008) estimated technical efficiency of profit of 33 commercial banks operating in Pakistan in the year 2004. They investigated the technical efficiency using input oriented DEA technique under two different specifications. This study provided an insight to commercial banks about their technical efficiency level of profit with respect to other banks operating in the market. At the same time, it ranked the commercial banks on the basis of input used to produce profit and intermediate output produced to generate profit.

Roberto et al.[25](2009) estimated cost, technical and allocative efficiencies for the Brazilian banking system in the recent period (2000-2007) suggesting that Brazilian banking inefficiency is high if compared to other countries. The average allocative and technical efficiencies (inefficiencies) are about 66.9% (51.40%) and 63.3% (57.98%), respectively. They also found that non-performing loans is an important indicator of efficiency level, as well as market share. Size is not an important factor for economic efficiency although descriptive statistics suggests that small banks are more efficient within the time period under analysis. Banks with foreign participation and the foreign banks are the least economic efficient compared to other ownership types, which suggests that global advantage hypothesis is not prevailing in Brazil.

Nigmonov[26] (2010) measured the efficiency of Uzbek banks during 2004-2006 applying two basic DEA models. The study found that the main source of inefficiency is due to the pure technical efficiency. It, then, compared the relative performance between the private, joint-stock and foreign banks for which no significant divergence were found. The investigation of differences between the small, medium and large banks lead to the observation of significant difference between the small and medium sized banks.

Khalid Al Khathlan et al.[27] (2010) used basic DEA models i.e. CCR and BCR to evaluate the relative efficiency of Saudi Banks using annual data from 2003 through 2008. The average index of technical efficiency during the study period varied in between 81.91% to 86.78%, of pure technical efficiency varying at 87.88% to 95.34%, and of scale efficiency varying at 89.16% to 93.55%. So, the results shown that, on a relative scale, Saudi banks are efficient in the management of their financial resources.

Md. Usman et al.[28](2010) employed data envelopment analysis to a panel of commercial banks operating in Pakistan for a period 2001 – 2008 in order to measure the technical efficiency of banks. They found foreign owned banks to be the most efficient, followed by state owned banks and domestic private banks are found to be the least efficient. Further, the scale inefficiency is found to be the main source of overall technical inefficiency.

There are many studies which have attempted to analyse efficiency issues by using non-parametric techniques viz. Sherman and Gold[29] (1985), Parkan[30] (1987), Oral and Yolalan[31] (1990), Berg et al.[32] (1993), Fukuyama[33] (1993), Yeh[34] (1996), Grifell-Tatje' and Lovell[35] (1996), Humphrey and Pulley[36] (1997), Jackson et al.[37] (1998), Avkiran[38] (2000), Patti and Hardy[39] (2005) and Kumbhakar and Wang[40] (2007). These studies have examined efficiency and associated effects on the performance of banks from several different perspectives such as ownership, bank size, differences in the regulatory framework, deregulation policy and merger & acquisitions. Kumar and Gulati[41] (2008a) have provided an extensive review on the impact of deregulation on the efficiency of banking.

3.3: Literature Review in Indian Context

From the beginning, the Reserve Bank of India (RBI) and Government of India has been constituted various committees for study, in order to make the banking sector

more viable and efficient[42]. In 1977, the Reserve Bank of India set up a committee to study the efficiency, productivity and profitability of the nationalized banks. This is popularly known as Luther Committee[43] which studied the performance of the nationalized banks for the period 1969-1975. This study measured operational efficiency using defined efficiency indicators. PEP Committee[44] (1977) proposed a system of assessment of relative performance banks on four major aspects, viz. productivity, social objectives,(spatial), social objectives (sectoral) and profitability. Sukhmoy Chakrabarty Committee [45](1985) observed the concept of operational efficiency associated with cost effectiveness, profitability, customers' service, priority sector lending, and mobilization of deposit, deployment of credit in rural and backward regions and so on. There are other studies which reported time to time for adoption of various measures to improve the performance of the Indian banks. The other studies are: Pendekhar Working Groups[46] (1982-83), Padmanabhan Working Group[47] (1991), Narasimham Committee (1991[48], 1997[49]) and Verma Committee[50] (1999).

In Indian context the whole literature of efficiency of the banking sector which has been a major concern especially since 1970s can be divided into two parts based on the methodologies used (i) Studies based on comparison of financial and operational performance using traditional measures (ii) more recent studies that use parametric or non-parametric techniques i.e. frontier approaches

3.3.1: Studies based on Traditional Measures

The major works under traditional measures are:

Divatia and Venkatachalam[51] (1978) used factor analysis to construct a composite index of efficiency and productivity for fifteen major public sector banks. Later Angadi[52] (1983) used data on operating costs and output (measured in terms of total deposits and deposit accounts and total credit and credit accounts) to construct and determine operational efficiency. Angadi[53] (1987) ranked twenty-eight public sector banks by accounting and economic profits. Swami and Subrahmanyam[54] (1994) combined certain items of income and expenditure to construct an index of performance of banks. Hansda and Venkatachalam[55] (1995) used principal component analysis to construct a composite index of performance of twenty eight public sector banks. Using principal component analysis, Sarkar and Das[56] (1997) also developed a composite index of bank efficiency.

This study examined the interbank difference in the productivity and profitability for 73 major banks (public, private and foreign) for the year 1994-95.

Sathye[57] (2005) utilized financial ratios to study the effect of privatization on the performance and efficiency of banks. Efficiency was defined in terms of net profit per employee and deposit and loans per employee. This study concluded that the financial performance of partially privatized banks were significantly better than that of the fully public sector banks. There was no significant difference in performance of partially privatized banks and fully private banks. Ram Mohan[58] (2002) found a trend towards convergence in performance among the three categories of banks – public, private and foreign using financial measures of performance. The latter study by Ram Mohan[59] (2003) used risk adjusted return performance to compare bank across ownership groups and concluded that there is no statistical difference between the performance of public and private sector banks.

An important study on banking sector reform analysis by Rakesh Mohan[60] (2005) gave a quantitative review of the performance of the Indian baking sector. He pointed out that there were very significant improvements over the decade of reforms by analyzing reform measures based on variables of financial statement of the commercial banks only. A few contemporary works have discussed the post liberalization banking business in India.

There are some recent works on performance analysis of the Indian commercial banks which include C Rangarajan[61] (1998), Y. V. Reddy[62] (2002), Rakesh Mohan[63] (2006) and. All the studies have shown the pre and post reform Indian baking scenario from the perspective of banking regulations, guidelines and reform measures. They examine whether various reform measures have accelerate the profitability, efficiency and stability of the Indian banking sector as a whole. An important works regarding performance analysis of the baking sector in India has been done by Bhide et al.[64] (2002). This study assess the performance of the commercial banks on the basis banking groups i.e. ownership pattern taking into account the factors like risk management, corporate governance, universal banking, deposit insurance etc.

3.3.2: Studies based on Modern Measures

There are basically two approaches: parametric and non-parametric approach. Probably the first published study on efficiency of Indian banks using parametric approach was Keshari and Paul[65] (1994). They applied frontier approach to one year cross sectional data to determine the technical efficiency of foreign and domestic banks. Sum total of advances plus deposits was taken as a measure of output, and labor, capital and materials as inputs. Their conclusion was that the efficiency of foreign banks is slightly lower than that of domestic banks.

De [66](2004) used an econometric approach to determine the technical efficiency of the Indian banks, relationship between ownership and efficiency and impact of reforms on efficiency. Panel data for the years 1985 to 1995-96 were used in a stochastic frontier production function. Two alternative measures of output (gross income and total earning assets) and four inputs (sum of deposits and borrowings, fixed capital, number of officers and number of other employees) were used for a Cobb-Douglas technology. The study concluded that the efficiency did not improve after liberalization, and the foreign banks, as a group, had the highest efficiency.

Kumbhakar and Sarkar (2003[67], 2004[68]) used the parametric method to evaluate the efficiency of the Indian banking system using panel data for the period 1986-2000. Postulating a cost function and using stochastic cost frontier, they determined the changes in efficiency over time. Using dummy variables, they also found contribution of reforms and role of ownership to the change in efficiency. They found the Indian banking system to be cost inefficient but the tendency for inefficiency to decline over time. They found the private sector banks to be more cost efficient than public sector banks. The deregulation resulted in increase in inefficiency and there was no significant difference in impact of deregulation on private sector and public sector banks.

One of the first published studies using non-parametric production frontier approach was Noulas and Ketkar[69] (1996). Using intermediation approach with three inputs and two outputs, they determined the technical and scale efficiency of public sector banks for 1993. They found average technical inefficiency of 3.75 percent, of which two thirds was due to scale inefficiency. Hence, they concluded that efficiency of banks in India could increase by increasing the scale.

Bhattacharya et al.[70] (1997) examined the efficiency of Indian banks using a two step procedure, DEA technique to determine the technical efficiency and then applying stochastic frontier approach to explain variation in calculated efficiency. They applied intermediation approach using two inputs (interest expense and operating expense) and three outputs (deposits, advances and investments) on five-year data of 70 banks, for the period 1986-1991. They constructed one grand frontier on the entire data set for DEA analysis and found that the public sector banks were more efficient than foreign banks, which in turn were marginally more efficient than private sector banks. The average efficiency of the sector as a whole was found to be 80.35 percent, ranging from an average of 75.37 percent for private sector banks and 87.40 percent for public sector banks. They also found that 78 percent of banks operated with decreasing returns to scale while 16 percent showed increasing returns to scale. For the second stage, regression analysis, they used a set of variable to account for time, ownership and regulatory policy. They concluded that public sector bank efficiency declined over time whereas that of foreign sector banks improved over time. The performance of private sector banks remained almost unchanged.

Das[71](1997) studied technical, allocative and scale efficiency of different public sector banks for the period 1990-96 using non-parametric DEA approach. He used the intermediation approach with two inputs-labour and loanable funds – and one output measures. The efficiencies were calculated for each year for all the banks. The study found decline in overall efficiency over time, decline in technical efficiency with slight improvement in allocative efficiency. Thus, change in inefficiency was due to technical inefficiency rather allocative inefficiency. The State bank was found to be more efficient than other public sector banks.

Das [72](1999) compared performance among public sector banks for three years 1992, 1995, 1998. He found a certain convergence in performance. He noted that there was a welcome increase in non-interest income, bank tended to show risk –adverse behavior by opting for risk- free investments.

Das[73] (2000) determined the efficiency of 27 public banks using cross-sectional data for the year 1998. SBI group was more efficient than nationalized bank group. Inefficiency in PSBs was both technical and allocative in nature.

Saha and Ravishankar[74] (2000) analyzed the performance of Indian banks using DEA approach. They examined performance of 25 public sector banks over a period 1992-1995. Their findings indicated that efficiency of public sector banks improved over the time period.

Mukherjee et al.[75] (2002) shown that Indian banks of different ownership pattern outperformed in the rapidly evolving and liberalizing sector during 1996-99.

Sathya[76] (2001) compared productive efficiency of publicly owned, privately owned and foreign owned banks operational in India in the year 1997/1998 and found that private sector commercial banks as a group is paradoxically lower than that of public sector and foreign banks.

Sathye[77](2003) measured the productive efficiency of 94 banks in India, including public sector and private sector banks and foreign banks, assuming VRS technology, applying DEA. The efficiency was calculated for 1996-97. In one model, he used interest expense and non-interest expense as inputs and interest income and non-interest income as outputs. A second DEA analysis was also run using deposits and staff members as inputs and loans and non-interest income as outputs. The study found that the average efficiency score of 0.83, and that the public sector banks were on average more efficient than foreign banks, which in turn were more efficient than private banks.

Ram Mohan and Ray[78] (2003) studied productivity and efficiency of public and private sector banks in India, using non-parametric DEA, for the period 1992-2000. They examined 27 public sector banks, 21 old private sector banks and 14 foreign banks. They employed three measures: Tornquist total factor productivity growth, Malmquist efficiency index and revenue maximization efficiency. They assumed CRS technology and used intermediation approach with interest cost and operating cost as inputs and loan income, investment income and non-interest income as outputs. They found public sector banks to be more efficient and productive compared to their private sector competitors.

Shanmugam and Das[79] (2004) analyzed the efficiency of Indian commercial banks during the reform period, 1992-1999 using a parametric methodology. The results

indicated that the efficiency of raising interest margin was time invariant while the efficiencies of raising other outputs-non-interest income, investments and credits were time varying. They found that the foreign banks are more efficient than their counterparts namely, public sector and privately owned domestic banks.

Das et al.[80] (2004) measured various DEA efficiencies of scheduled commercial Indian banks during 1997-2003. They found that there were no much differences in terms of input or output oriented technical efficiency and cost efficiency but having difference sharply in respect of revenue and profit efficiencies among the Indian banks. They also observed the bigger banks in particular have improved during post reform period.

Chakrabarti and Chawla[81] (2005) estimated the efficiency of 70 Indian banks during 1990-2002 and found that the foreign banks as a group, have been considerably more efficient that all other bank groups followed by private banks and then public banks.

Debasish[82] (2006) examined the relative efficiency of the Indian banks using output oriented CRR DEA model over the period 1997-2004. The study shown the increasing trend of efficiency across all the bank groups ranging mean efficiency score of 44.5% (1998) to 77.9% (2004)

Ray[83] (2007) used data covering the period 1997 through 2003 to measure size levels of efficiency of individual Indian banks. The findings do suggest wide spread size inefficiency across banks and years.

Omprakash et al.[84] (2008) measured relative efficiencies of 57 Indian domestic banks using DEA for the period 1999-2003. The study raveled that SBI and its group have the highest efficiency followed by private banks, and the other nationalized banks. The results were consistent over the period, but efficiency differences diminish over period of time. The capital adequacy ratio was found to have a significantly positive impact on the productive efficiency.

Kumar and Gulati[85] (2008a) examined the efficiency levels among Indian public sector banks (PSBs) during the post-reforms period spanning from 1992/1993 to 2005/2006. The empirical results indicated that the majority of PSBs have observed an ascent in technical efficiency during the post-reforms years. They also found that the banks with low level of efficiency at the beginning of the period were growing more

rapidly than the highly efficient banks. In sum, the study confirmed a presence of convergence phenomenon in the Indian public sector banking industry. In another study, Kumar and Gulati[86] (2008b) measured the extent of technical, pure technical, and scale efficiencies in 27 public sector banks (PSBs) operating in India in the year 2004/05. The empirical finding revealed that PSBs operate at 88.5 percent level of overall technical efficiency. They also observed that pure technical inefficiency contributed more towards overall technical inefficiency. Further they found that majority of the public banks are operating in the region where decreasing returns-to-scale prevails. The results of logistic regression analysis provided that the exposure of the banks to off-balance sheet activities (i.e., non-traditional activities) has a strong and positive impact on the overall technical efficiency of banks. Very recent efficiency study by Kumar and Gulati[87] (2009) using cross-sectional data for 51 domestic Indian banks operating in the financial year 2006-2007 estimated the average technical efficiency score of .79 with a dominance of de novo private sector banks on the efficient frontier. Managerial inefficiency was the main source of Overall Technical Inefficiency in the Indian domestic banking industry. The efficiency differences between public and private sector banks are not statistically significant and there is a significant difference between large and medium banks with regard to Scale Efficiency.

Kaur and Kaur[88] (2010) empirically examined the impact of mergers that have been going over the post liberalization period of 1990-91 to 2007-08 on the cost efficiency of Indian commercial banks by using a non-parametric Data Envelopment Analysis. The findings of this study were that over the entire study period average cost efficiency of public sector banks was found to be 73.4 and for private sector banks 76.3 percent. The findings of this paper suggested that to some extent merger programme has been successful in Indian banking sector. The Government and Policy makers should not promote merger between strong and distressed banks as a way to promote the interest of the depositors of distressed banks, as it will have adverse effect upon the asset quality of the stronger banks.

There are many other studies since the 1990s in India, which have been confined to analyse the effect of deregulation on efficiency and productivity of banks. The basic hypothesis underlying deregulation is that it promotes competition and, thus, can induce

efficiency improvements[89]. It is expected a priori that deregulation would unleash competitive forces in the operating environment. Such competition would, in turn, enable banks to alter their input and output mix which when combined with technological developments facilitates increase in output that raises overall bank productivity and efficiency[90]. However, some important studies which have shown a positive impact of deregulation and liberalization policies on the efficiency and productivity of Indian banks are Bhattacharyya et al.[91] (1997), Ram Mohan and Ray[92] (2004), Shanmugam and Das[93] (2004), Ataullah et al.[94] (2004), Reddy[95] (2004), Das et al.[96] (2005), Chatterjee[97] (2006), Mahesh and Rajeev[98] (2006), Sensarma[99] (2006), Rezvanian et al.[100] (2008). A few studies which have shown an adverse or insignificant impact of the deregulation policy on the performance of Indian banks include Kumbhakar and Sarkar[101] (2003), Sensarma[102] (2005), Das and Ghosh[103] (2006). Kumbhakar found that public sector banks have not responded well to deregulatory measures and TFP has not been observed significant. Profit efficiency has shown a declining trend during deregulation period up to 2003 (Sensarma). DAS and Ghosh did not witness any significant increase in number of efficient banks and some banks have high degree of inefficiency during the liberalization period of 1992-2002.

So, an inspection of literature highlights that there are many empirical studies which rely on non-parametric technique - DEA for measuring banking efficiency. The most studies examining the empirical efficiency analysis focus mainly on developed economies. Banking efficiency studies using these techniques are expanding rapidly in other emerging economics also. Empirical results appear to vary depending on the country; bank ownership, and size[104].

However, the general conclusions that emerge from the above extensive review of literature on banking efficiency in Indian context are: First, there is still room for improvement in resource utilization of the Indian banks with the range of 5% to 30%. Second, there is an improvement in profit efficiency accelerated by the non-interest income source. Third, average cost efficiency has increased due to reduction of intermediation cost with the help technology used in banking operations. Fourth, there is an improvement in profit efficiency accelerated by the non-interest income source. On the whole most of the studies agree that deregulation has had a positive and favorable

impact on efficiency improvement of Indian banking industry. But, most of the studies which use non-parametric DEA technique to compute the efficiency scores for Indian banks are not in a comprehensive manner. Many of them use data for a single time period. While some studies concentrate on the efficiency of only public sector banks. Main focus of many other studies is to show the impact of reform measures on the efficiency only. Very few adopts of multiple measures of DEA efficiencies. There are hardly any studies which use super-efficiency scores for ranking of the Indian banks. Therefore, the present study will be able to throw further light on the existing banking literature in Indian by examining the relative technical efficiency of different measures and providing ranks to the Indian banks in a very comprehensive manner during the recent period covering from 2004-05 to 2007-08.

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Chapter - IV

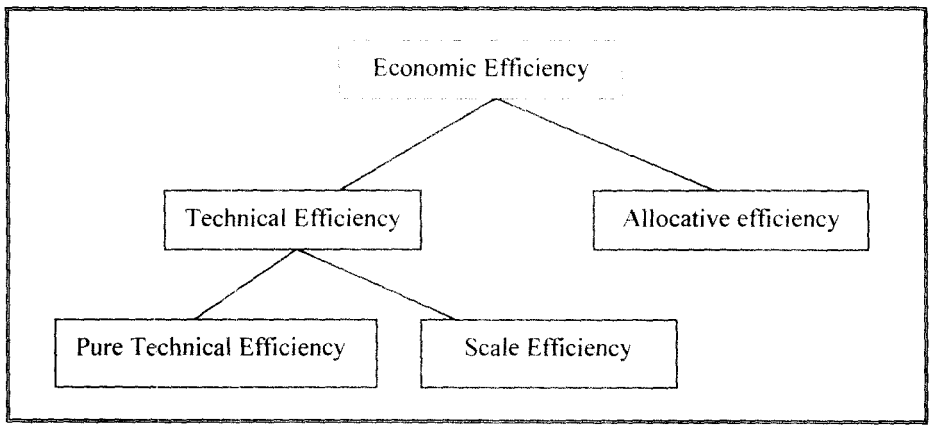
Research Methodology

4.1: Introduction

The main focus of this research is to measure and examine the efficiency of Indian domestic banks. The concept of efficiency is primarily an engineering concept, commonly used to describe the level of performance of a production unit in terms of its utilization of resources in generating outputs. Modern approach towards efficiency measurement is starting from the concept of efficiency of Farrell's[1] (1957). Michael J. Farrell, greatly influenced by Koopman's[2] (1951) formal definition and Debreu's[3] (1951) measure of technical efficiency has introduced a method to decompose the overall efficiency of a production unit into its technical and allocative components. However the different efficiency concepts are:

Box No: 4.1

Different Concepts of Efficiency



Economic efficiency or Overall efficiency means producing the "right" (Allocative efficiency) amount in the "right" way (Technical efficiency). Technical efficiency and allocative efficiency together form economic efficiency also called as X-efficiency. Overall efficiency i.e., economic efficiency refers to situation in which (with the given state of technology) it is impossible to generate a larger welfare total from the available resources . It means when more output cannot be obtained without increasing the amount of inputs. Production proceeds at the lowest possible per-unit cost. Profit maximization requires a firm to produce the maximum output by using given level of the inputs employed (i.e. be technically efficient), use the right mix of inputs in light of the relative price of each input (i.e. be input allocative efficient) and produce the right mix of outputs given the set of prices (i.e. be output allocative efficient) [4]. However, an

organization will only be economic efficient if it is both technically and allocatively efficient.

Allocative efficiency refers to whether inputs, for a given level of output and set of input prices, are chosen to minimize the cost of production. It refers to ability to combine inputs and outputs in the optimal proportion in the light of prevailing prices[5]. It refers to allocation of resource that allows maximum possible benefit or utility from the available resource.

Technical Efficiency - The most common efficiency concept is technical efficiency: the conversion of inputs into outputs. Technical efficiency considers technological aspect of production. It is therefore, a measure of how well the transformation process (from input to output) is performing. In other words, it refers to ability to avoid waste by producing as much output as input usage allows or by using as little input as output allows.

Koopmans defined technical efficiency as a feasible input/output vector where it is technologically impossible to increase any output without simultaneously reducing another output. This analogy holds for a reduction in any input or both a reduction in any input and an increase in any output. Farrell measured technical inefficiency as the maximum equi-proportional reduction in all inputs consistent with equivalent production of observed output.

Thus, technical efficiency measurement can have output orientation and input orientation. Input oriented efficiency means minimization of inputs with producing al least the given level of outputs. Output oriented efficiency means maximization of outputs with using given level of inputs. Managerial practices and the scale or size of operations affect technical efficiency, which is based on engineering relationships but not on prices and costs. Technical efficiency therefore consists of pure technical efficiency and scale efficiency. Present study deals with technical efficiency which is based on input-output configuration.

4.2: Efficiency Measurement Techniques

There are basically two efficiency measurement techniques: Accounting Measures and Economic Measures.

4.2.1: Accounting Measures of Efficiency

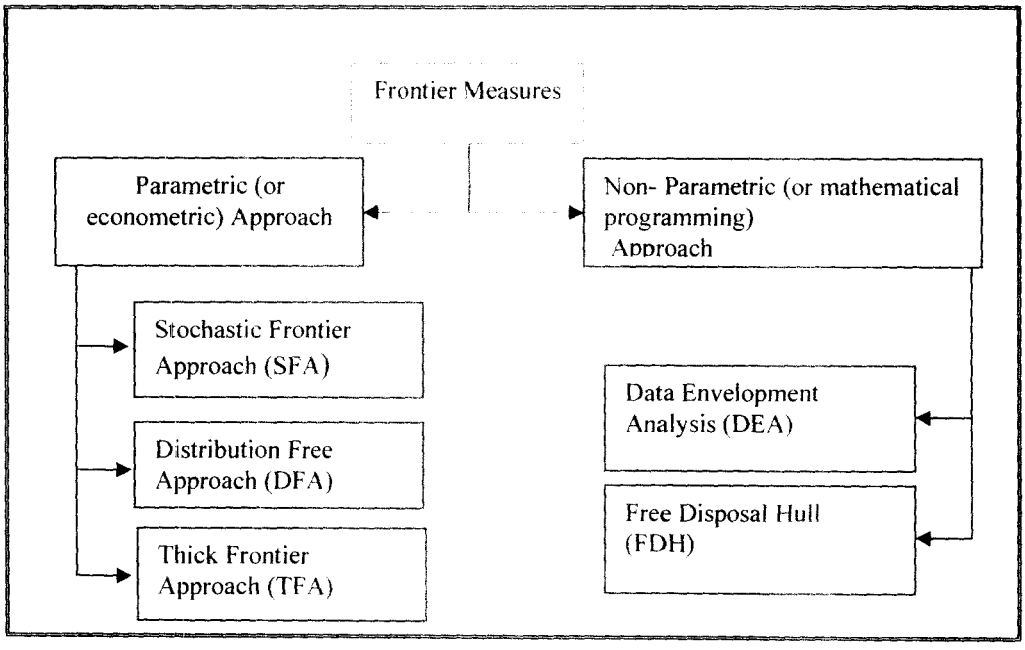
The earliest technique to assess the performances of business units is ratio analysis which examines the financial statements of individual firms and comparing them with a benchmark. These ratios are popular in financial analysis and even in economic literature only because of easy understanding. But analysis based on ratios is suffering from accounting biases. That is, accounting practices and norms in different environment differ significantly and hence ratios computed from two business units operating in differing economic environment may not be suitable for drawing economic conclusions. Besides, this technique fails to take into account the fact that banks produce multiple outputs from multiple inputs and consistent aggregation is not possible (See, for example, Barnes[6], 1987; Smith[7], 1990). The short comings of such a descriptive and static analysis of the data are overcome by later researchers with the use of parametric and non-parametric techniques.

4.2.2: Economic Measures of Efficiency

Economic measures estimate various efficiencies with broadly two types of approaches- parametric and non-parametric. Parametric and non-parametric technique is actually frontier technique which is highly accepted and widely used in the field of efficiency studies. The frontier techniques have the advantage to convey the information of many operational ratios in a single index, thus permitting ranking of decision-making units (DMUs) and summarizing of multiple possibly qualitative characteristics in a quantitative way. Various types of these modern efficiency measurement techniques are presented in Box No: 4.2.

Box No: 4.2

Frontier Approaches for Measuring of Efficiency



The parametric and non-parametric techniques differ mainly in how they handle random error and their assumptions regarding the shape of the efficient frontier. The parametric Stochastic Frontier Approach (SFA) and the non-parametric Data Envelopment Analysis (DEA) are the most used tools to measure efficiency, taking into account that the literature considers both techniques as equally satisfactory. As stated by Berger and Humphrey[8] (1997), there is no consensus on the preferred method for determining the best-practice frontier against which relative efficiencies are measured. Berger and Mester[9] (1997) find that in general the choice of measurement technique and functional form does not make a substantial difference in determining the average efficiency for the banking sector or raking of individual banks. We prefer to the DEA approach as we consider it to be a more appropriate tool in our analysis since it does not require an assumption of a functional form for the frontier relating to given specification of inputs and outputs of the sample composed of banks of different sizes, types and ages. Thus, DEA is an appropriate technique for this study as it fulfils the objectives of estimating and examining technical efficiency of the Indian banks and ranking them. It also enables to give an insight into efficiency of the banks.

4.3: Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a non-parametric performance assessment methodology originally designed by Charnes, Cooper and Rhodes[10] (1978) to measure the relative efficiencies of organizational units or decision making units (DMUs). This technique aims to measure how efficiently a DMU uses the resources available to generate a set of outputs. The DEA approach applies linear programming techniques to observe inputs consumed and outputs produced by decision-making units and constructs an efficient production frontier based on best practices. Each DMU's efficiency is then measured relative to this frontier.

DEA is defined by Giokas[11] (1997) as follows:

"DEA measures relative efficiency [of DMUs] by estimating an empirical production function which represents the highest values of outputs/benefits that could be generated by inputs/resources as given by a range of observed input/output measures during a common time period."

DEA is a non-parametric linear programming based data analytic technique for measuring and evaluating relative efficiency of a homogeneous set of units termed as decision making units (DMUs) which use variety of identical inputs to produce variety of identical outputs. DEA is a relatively new "data oriented" approach for evaluating the performance of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs[12]. DEA is an optimization method of mathematical programming to generalize the Farrell's (1957) single-output single-input technical-efficiency measure to multiple-output and multiple-input case by constructing a frontier of the best practice DMUs established mathematically by the ratio of weighted sum of outputs to weighted sum of inputs from the identical input output data set available from the DMUs under evaluation and to estimate efficiency of a DMU relative to the constructed frontier. Thus, DEA is a mathematical linear programming approach to frontier analysis. The estimated frontier of the best practice DMUs is also referred to as efficient frontier or envelopment surface. In DEA literature, DMUs lie on the frontier are

technically efficient having efficiency score equal to 1 and the DMUs lie off the frontier are technically inefficient having efficiency score between 1 and 0.

Box No. 4.3

DEA in summery

- DEA constructs an efficient frontier by yielding a piecewise linear production surface i.e., identifying best practice DMU(s) from the identical inputs and outputs data set available from the DMUs under evaluation.
- Frontier defines multiple inputs and multiple outputs productivity
- Frontier defines the (observed) efficient trade-off among inputs and outputs within a set of DMUs.
- Relative distance to the frontier defines efficiency.
- DMUs on the frontier are efficient and DMUs off the frontier are inefficient.
- Nearest point on frontier defines an efficient hypothetical DMU of the inefficient DMUs.
- Differences in inputs and outputs between DMU and hypothetical DMU define efficiency "gaps" (improvement potential)

Source: Author's compilation

4.3.1: Importance of DEA in Banking Efficiency Measurement

DEA with 30 years of journey since 1978 is now a very popular and well accepted methodology in the field of efficiency measurement and improvement of the units using multiple inputs to produce multiple outputs. DEA was firstly applied by Sherman and Gold[13] (1985) for assessing the efficiency of bank branches and, thereafter, it proved a very promising tool for monitoring the efficiency in banking industry. Of the 122 studies reviewed in the extensive survey carried out by Berger and Humphrey[14] (1997) on efficiency of depository financial institutions in 21 countries, 62 studies (i.e., just over 50%) employed DEA to examine the efficiency of the banking sector. The connotation of this reference is that over the years, DEA has emerged as a well accepted and popular technique for evaluating the efficiency of the banking system. Its popularity as an accepted method of efficiency analysis can also be realized from huge DEA bibliography database also[15].

Box No. 4.4

Strength and Weakness of DEA

Strengths

⇒ DEA produces a single score for each unit rather than population average, which makes the comparison easy. DMUs are directly compared against a peer or combination of peers.

⇒ Its main strength lies in its ability to handle multiple inputs and outputs situation effectively i.e. to capture the multidimensional nature (of inputs/outputs) in the production process which is the prevalent characteristics of many units under evaluation.

⇒ It places no restrictions on the functional form of the production relationship. That is it doesn't require an assumption of a functional form relating inputs to outputs.

⇒ DEA modeling allows the analyst to select inputs and outputs in accordance with a managerial focus.

⇒ Furthermore, the technique works with variables of different units (unit's invariance) without the need for standardization. There is as such no limit to the number of inputs and outputs. This is not possible through traditional ratio analysis.

⇒ There is no requirement for any *a priori* views or information regarding the assessment of the efficiency of DMUs. The weights for outputs and inputs are obtained by calculating the DEA models, rather than being given artificially

⇒ Another advantage of DEA that attracts analysts and management is its ability to identify the potential improvement for inefficient units by providing both the sources and the amount of inefficiency such as pure technical and mix inefficiencies. Moreover, the reference set used to benchmark these inefficiencies are also indentified. A deficiency of the econometric approaches is their inability to identify sources and estimates the inefficiency amounts associated with these sources. Hence, no clue as to corrective action is provided even when the inefficiencies are present.

Limitations

- The lack of allowance for statistical noise is widely regarded as the most serious limitation of DEA because this puts a great deal of pressure on users of this technique to collect data on all relevant variables and to measure them accurately.
- DEA is good at estimating "relative" efficiency of a DMU but not "absolute" efficiency. In other words, it can tell you how well you are doing compared to your peers but not compared to a "theoretical maximum."
- Since DEA is a nonparametric technique, statistical hypothesis tests are difficult.
- Results are sensitive to the selection of inputs and outputs

Source: Author's compilation

4.3.2: DEA Models

There is variety types of DEA models developed in the DEA literature since1978. There are two approaches in DEA models: radial and non radial. Differences exist in the characterization of input or output items. In DEA literature, two models namely CCR model (named after Charnes, Cooper and Rhodes[16], 1978) and BCC model (named after Banker, Charnes and Cooper[17], 1984) are called basic DEA models. These models which are radial measure of efficiency are of two types- input oriented and output oriented.

Input oriented technical efficiency aims at reducing input amounts as much as possible while keeping at least the present output levels and output oriented technical maximizes the output level while using at least the present input levels.

4.3.2.1: CCR and BCC Models

The study has utilized two most popular and widely used basic DEA models- input oriented CCR model and input oriented BCC models to estimate the bank wise level of relative technical efficiency. CCR model measures the efficiency called overall technical efficiency (OTE) and BCC model measures efficiency called pure technical efficiency (PTE). OTE and PTE allow to measure scale efficiency (SE). SE = OTE/ PTE. So, using these CCR and BCC models the study has estimated three types of efficiencies: OTE, PTE and SE for individual banks.

Figure: 4.1

CCR and BCC Frontier

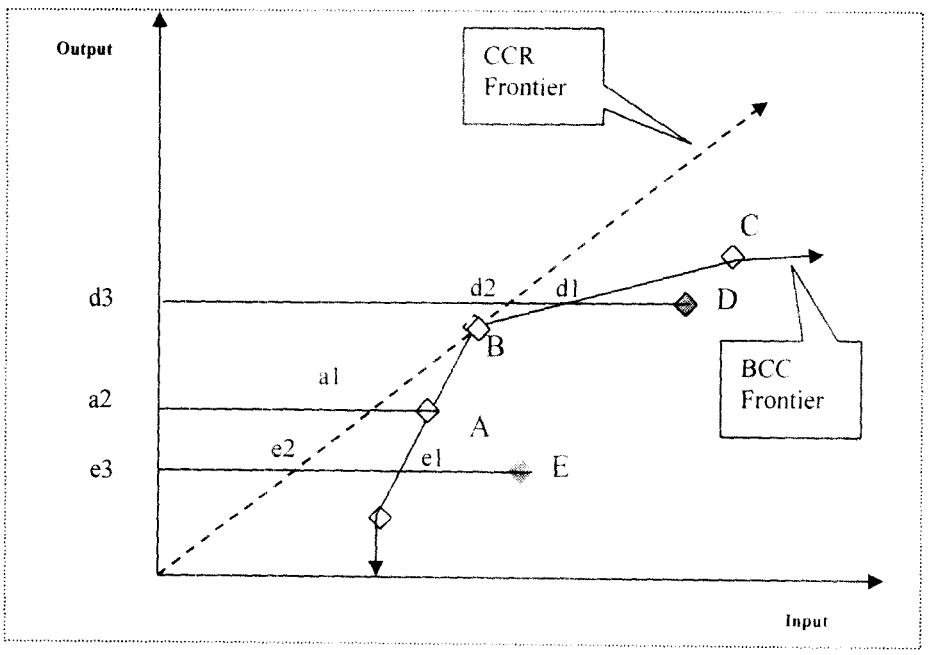


Figure 4.1 illustrates the CCR and BCC models in a simple single-input and singe-output along with the derivation of concept of OTE, PTE and SE. The CCR model assumes constant returns to scale so that all observed production combinations can be scaled up or down proportionally. This constant returns-to-scale DEA frontier is derived simply by the ray through the origin passing through point B. The DEA-BCC model, on the other hand,

allows for variable returns to scale and is graphically represented by the piecewise linear convex frontier. The areas to the right of the two frontiers represent production possibility set (PPS).CCR and BCC models define different production possibility sets and efficiency results. As an example, the input-oriented efficiency of unit 'E' in Figure 4.2 is given by e_3e_2/e_3e as yielded by the CCR model and e_3e_1/e_3e by the BCC model. The shape of the VRS frontier is piecewise boundary and closer to observed inefficient points which results in BCC efficiency score higher or equal to corresponding CCR score. The rational for this is that CCR efficiency incorporates scale efficiency while BCC do not.

DMUs 'A', 'B' and 'C' are BCC efficient, only 'B' is CCR efficient. DMUs 'D' and 'E' are both CCR and BCC inefficient and their input oriented projection individualizes reference points 'd_1' and 'e_1' on VRS frontier , 'd_2' and 'e_2' on CRS frontier. The difference between 'D1' and 'D2", 'E1' and 'E2' are due to control for scale. The ratio of e_3e_2/ e_3e_1 and d_3d_2/ d_3d_1 represents the scale efficiency of DMUs 'E' and 'D'. Here it is to be pointed out that the DMUs 'D' and 'E' are characterized by opposite scale properties. DMU 'E' is radially projected on a increasing return to scale facet of the VRS frontier while DMU 'D' is radially projected on a VRS surface where variable return to scale hold. It is important to note that if a DMU is fully efficient under both CCR and BCC score the DMU is said to be operating in the most productive scale size i.e. scale efficiency is 100% i.e. region where constant returns-to-scale (CRS) prevails.

However three types of DEA efficiency measures of DMUs E, A and B are presented below-

Table: 4.1

Different Efficiency Measures

Efficiency Type	DMU-'E' (CCR and BCC inefficient)	DMU-'A' (CCR inefficient but BCC efficient)	DMU-'B' (CCR and BCC efficient)
OTE	$e_3e_2/ e_3e <1$	$a_2 a_1/a_2 a <1$	$b_1b/b_1b= 1$
PTE	$e_3e_1/e_3e<1$	$a_2a/a_2a = 1$	$b_1b/b_1b= 1$
SE	$e_3e_2/e_3e_1<1$	$a_2 a_1/a_2 a <1$	$b_1b/b_1b= 1$

So, the important aspects of DEA methodology based on CCR & BCC models are

⇒ Reference set and improvement in efficiency i.e. projection of inefficient DMUs,

⇒ Returns-to-Scale and

⇒ Decomposition of technical efficiency

These important economic factors are again discussed at the time of analyzing them in the next chapter 'Empirical findings and analysis'.

4.3.2.2: Mathematical Formulation CCR and BCC Models

Graphical presentation cannot be used for frontier analysis in case of multiple inputs and multiple outputs. Hence a general mathematical formulation is needed to handle the multiple inputs outputs situation. The first mathematical linear programming based formulation of the frontier analysis was developed by Charnes et al. (1978) after 20 years of frontier analysis technique described by Farrel in 1957.The authors also coined the name Data Envelopment Analysis.

CCR Model

Assuming that there are n DMUs to be evaluated [DMUj (j = 1, 2... n)]. Each DMU consumes m different inputs of identical nature for all DMUs [x_{ij} (i = 1,2, ...,m)] to produces 's' different outputs of identical nature for all DMUS [y_{rj} (r = 1,2, ...,s)]. x_{ij} and y_{rj} are assumed to be positive ie $x_{ij} \geq 0$ and $y_{rj} \geq 0$ and further assumption is is that each DMU has at least one positive input and one positive output value. Given the data, the efficiency of DMU_k can be measured by the following programming

$$\underset{(\theta,\, \lambda_j\, s_i^-,\, s_r^+)}{\text{Min}}\ \theta_k - \varepsilon \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right) \qquad (1)$$

Subject to

$$\sum_{j=1}^{n} x_{ij} \lambda_j + s_i^- = \theta_k x_{ik} \qquad i = 1,2,\ldots\ldots,m.$$

$$\sum_{j=1}^{n} y_{rj} \lambda_j - s_r^+ = y_{rk} \qquad r = 1,2,\ldots\ldots,s$$

$$\lambda_j \geq 0 \qquad j = 1,2,\ldots\ldots,n$$

$s_i^-,\ s_r^+ \geq 0$ for all i and r.

x_{ij} = Amount of input of i utilized by the jth DMU

y_{rj} = Amount of output of r produced by the jth DMU

x_{ik} = Amount of input of i utilized by DMU_k

y_{rk} = Amount of output of r produced by DMU_k

θ_k= efficiency score of DMU 'k' being evaluated

λs represent the dual variables which identify benchmarks for inefficient units.

Slack variables - s_i^- (input slacks), s_r^+ (output slacks)

Here $\varepsilon > 0$ is non-Archimedean element defined to be smaller than any real number and to be accommodated without having to specify the value of ε.

Above mathematical formulation is the input oriented CCR model (envelopment form) used in this study to estimate OTE. Note that the above mathematical program yields an efficiency score (θ) of a particular DMU_k only. To get the efficiency score of other DMUs it is required to repeat this process for each DMU i.e., 'n' optimization one for each DMUj. DMUs for which $\theta < 1$ are inefficient, while DMUs for which $\theta = 1$ are on frontier line and efficient. Some frontier points or boundary points may be 'weekly efficient' because of presence of non zero slacks in inputs and/or outputs.

CCR efficient – a DMU is CCR efficient if the optimal solution of the above two-phase procedure satisfies both (i) $\theta = 1$ and (ii) all slacks are zero. So, DMUs which satisfy both the conditions are also called CCR efficient or strongly efficient or Pareto-Koopmans efficient.

CCR inefficient - a DMU is said to be CCR inefficient -

Case I: if and only if both (i) $\theta < 1$ and (ii) $s_i^- \neq 0$, $s_r^+ \neq 0$ for some i and r. or all slacks are non zero.

Case II: if and only if both (i) $\theta = 1$ and (ii) $s_i^- \neq 0$, $s_r^+ \neq 0$ for some i and r. This case is also termed as weakly efficient in DEA.

So there are two sources of inefficiencies: purely technical inefficiency represented by the radial measure (1- efficiency score obtained) and mix inefficiency represented by the input and output slack values.

BCC Model

The BCC (ratio) model is one of the most important extensions of CCR model. It measures technical efficiency rather pure technical efficiency. BCC model differs slightly yet remarkable from CCR model with an additional constraint

$$\sum_{j=1}^{n} \lambda_j = 1 \qquad (2)$$

in the above CCR envelopment model. This constraint is called convexity constraint in mathematics literature. It imposes of assessing the efficiency under VRS.

A DMU is BCC efficient if the optimal solution of the above two-phase procedure satisfies both (i) $\theta = 1$ and (ii) all slacks are zero. Otherwise, DMU is BCC inefficient.

Box No. 4.5

Summary of Models (CCR & BCC) Characteristics

- ⇒ CCR model considers the production possibility set based on constant return to scale assumption. Where BCC model based on variable return to scale assumption.
- ⇒ Optimal values of θ / Ø are independent of units in which inputs and outputs are measured provided these units are same for all DMUs under evaluation.
- ⇒ Note that the above mathematical program yields an efficiency score (θ) of a particular DMU_k only. To get the efficiency score of other DMUs it is required to repeat this process for each DMU i.e. 'n' optimization one for each DMUj.
- ⇒ DEA computes a unique set of input and output weights for each DMU using linear programming technique subject two condition i) no weights can be negative ii) weights must be universal i.e. resulting ratio must be ≤ 1 under the same input weights and output weights of the evaluated DMU i.e. DMUk.
- ⇒ All inputs and outputs data are assumed to be positive or semi positive and they can be varied at the discretion of management or other users i.e. 'discretionary variables'.
- ⇒ Both the BCC and CCR models are called ratio models because they define efficiency as the ratio of weighted outputs divided by weighted inputs.
- ⇒ Both the BCC and CCR ratio models use a radial or proportional measure to determine a unit's efficiency score. A unit's efficiency is defined by the ratio of the distance from the origin to the inefficient unit, divided by the distance from the origin to the composite unit on the efficient frontier.
- ⇒ The CCR models are *not* translation invariant but BCC are translation invariant.
- ⇒ CCR measure incorporates technical as well as scale inefficiency whereas BCC considers only technical inefficiency. That is why CCR efficiency score is called as overall technical efficiency or global technical efficiency and BCC score as pure technical efficiency or local technical efficiency.

Source: Author's compilation

4.3.2.3: Super-efficiency Model (SEM)

The study has also utilized input oriented super efficiency model under CRS assumption for ranking purpose as proposed by Andersen and Petersen[18] (1993). The basic DEA models- CCR & BCC mainly distinguish the DMUs into two groups – efficient DMUs (having score equal to one) and inefficient ones (having score less than

one). But it is not possible by these conventional models for ranking efficient DMUs since efficiency score of all the efficient DMUs are equal to one. To overcome this limitation, Andersen and Petersen (1993) have introduced super-efficiency DEA model. This model was originally introduced with the objective of providing tie breaking procedure for ranking DMUs rated as efficient in conventional DEA model. This model allows effective ranking of efficient DMUs based on super-efficiency scores which are more than one or equal to one i.e. not same for efficient DMUs.

The super-efficiency model is almost identical to the basic DEA models with the exception that the efficient DMU being evaluated is excluded from the production possibility set (PPS). This exclusion or removal from the PPS is the main philosophy of this model. This exclusion modifies the efficient frontier developed by the basic DEA models and forms a new frontier above such frontier and thereby allowing the efficiency score of the efficient DMUs grater than or at least equal to the value of 1(one). An important consideration of SEM is that this exclusion does not influence the efficiency score of inefficient DMUs. This is the specialty of this model. Like CCR and BCC models SEM are of two approaches – input oriented and output oriented both under CRS and VRS assumption. In this study input oriented SEM under CRS assumption is followed for effective ranking of efficient DMUs as determined by input oriented CCR model.

Figure 4.2

Super-efficiency Model (Input Oriented)

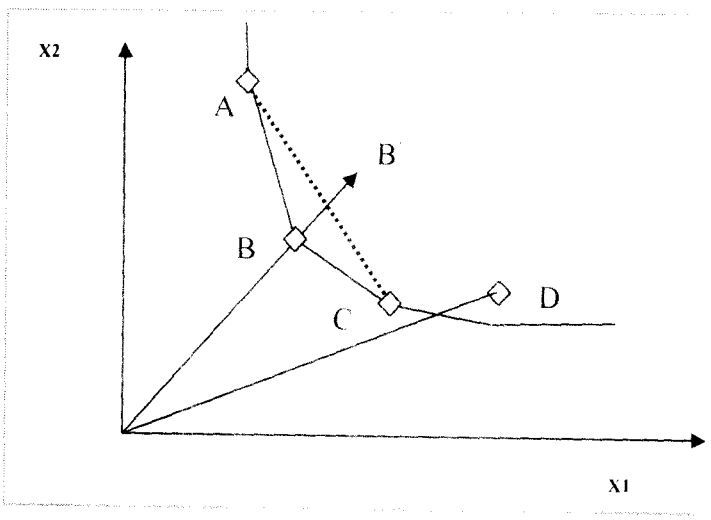


Figure: 4.2 provides input oriented radial supper efficiency model. The efficient frontier consisting line segment connecting efficient DMUs- A, B and C is developed by the standard DEA models. If DMU B is excluded from the reference set effect is to construct a new frontier consisting dotted line segment connecting DMUs A and C. Super-efficiency score of DMU B becomes OB' / OB ≥100% . This reflects that the maximum proportional increase in inputs by B preserving efficiency (100%) is 20% if super efficiency score of B is 120%. Efficiency score of inefficient DMU like 'D' remains unchanged.

Input oriented SEM provides a means of evaluating the extent to which an efficient DMU is able to increase its inputs level without violating its status as an efficient DMU. Super-efficiency score therefore provides a measure of stability of the 'efficient' status of the efficient DMUs. The study follows the following input oriented formulation of SEM under CRS assumption as described by Anderson and Petersen (1993).

$$\underset{(\theta\lambda)}{\text{Min}}\ \theta_k - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right) \qquad (3)$$

Subject to

$$\sum_{\substack{j=1 \\ j \neq k}}^{n} x_{ij}\lambda_j + s_i^- = \theta_k x_{ik} \quad i = 1,2,\ldots\ldots m.$$

$$\sum_{\substack{j=1 \\ j \neq k}}^{n} y_{rj}\lambda_j - s_r^+ = y_{rk} \quad r = 1,2,\ldots\ldots,s$$

$$\lambda_j \geq 0 \qquad j = 1,2,\ldots\ldots,n$$

$$\lambda_k = 0$$

$s_i^-, s_r^+ \geq 0$ for all i and r.

Where θ represents efficiency score of DMU 'k' , an efficient one is excluded from the reference set by equating input and output weights to zero i.e. ($\lambda_k = 0$)

4.4: DEA Software: Estimation of Efficiency Scores

We solve input oriented CCR, BCC and Super-efficiency model by using DEA software '**DEA-Solver Learning Version 3**' designed on the basis of the textbook - "Data Envelopment Analysis : A Comprehensive Text with Models, Applications, References and DEA-Solver Software".[19]

4.5: Selection of Input and Output Variables

The most challenging task to the researchers for estimating efficiency of banks through DEA methodology is to select appropriate and relevant inputs and outputs. The choice of inputs and outputs largely affects the derived efficiency level. There is no consensus on what constitutes inputs and outputs of banks. Banks mostly provide services to customers and play an important role of intermediaries in directing fund between depositors and creditors and also perform non-monetary activities. So, these wide ranges of bank activities which are mainly non-tangible in nature make difficult to define its input and output. There is a theoretical gap in the literature on multi-input and multi-output production structure of banking. In spite of increasing trend of interest on banking efficiency measurement, there is no universally accepted approach in the literature of banking efficiency for selecting input and output variables. However, in the context of banking efficiency measurement, there are mainly two approaches to deal with this problem: **Production Approach** and **Intermediation Approach**. Both the approaches apply the traditional microeconomic theory of the firm to banking and differ only in the specification of the banking activities.

Production Approach (PA) – This approach as pioneered by Benston[20] (1965) treats banks as providers of services to customers by administering customers' financial transactions, keeping deposits, issuing loans and managing other financial assets. Outputs under this approach are the services provided to the customers and best measured by the numbers and type of transactions and inputs include physical variables like labor and capital or their associated cost. This approach focuses on only non interest expenses and ignores completely interest expenses since it considers deposit as an output. This approach is also known as service provision or value added approach.

Intermediation Approach (IA) - This approach as proposed by Sealey and Lindley[21] (1977) treats bank as financial intermediaries for channeling fund from savers to borrowers. According to this approach only bank assets are thought as outputs. It is distinguished from PA by adding deposits as an input and therefore considers both operating cost and interest cost in the input side. Banks performing two major role of mobilizing resources (saving) in order to make investment activities (lending) in the economy are taken into consideration in this approach.

IA vs. PA

The main difference between these two approaches is the use of deposit as input or output. Berger and Humphrey[22] (1997) pointed out that neither of these two approaches is perfect because they can not fully capture the dual roles of banks as intermediaries of financial services as well as service providers. Therefore none is universally accepted approach. Berger and Humphrey (1997) suggested that IA is best suited for analyzing bank level efficiency where PA for branch level efficiency. This is because at the bank level, management will aim to reduce total cost not just non-interest expenses while minimization of total cost is not the headache of the branch. Branches are basically concerned with providing large customers' based services. Grifell Tatje and Lovel[23] (1999) argued that when interest is in the analysis on bank productivity, then PA prefers to IA as PA essentially focuses on the bank productivity. On other side, IA may be superior for evaluating banking performance since it considers all expenses including interest expenses as input. As a result, it enables for better reflection of bank profitability. In the banking literature, it is found that the IA has the larger appeal than the PA. One reason for this could be the non availability of published data on the number of accounts and type of transactions serviced for different financial instruments[24]. Though, in a customers' oriented market economy particularly (after 1996), Indian banks play both the role as intermediaries as well as providers of services but still now Indian commercial banks primarily mediate funds between depositors and creditors i.e., they play intermediating role much more than the service providing role. Therefore, given this and as a majority of the empirical literature present study adopts IA for selecting input and output variables for estimating bank level efficiency of Indian commercial banks.

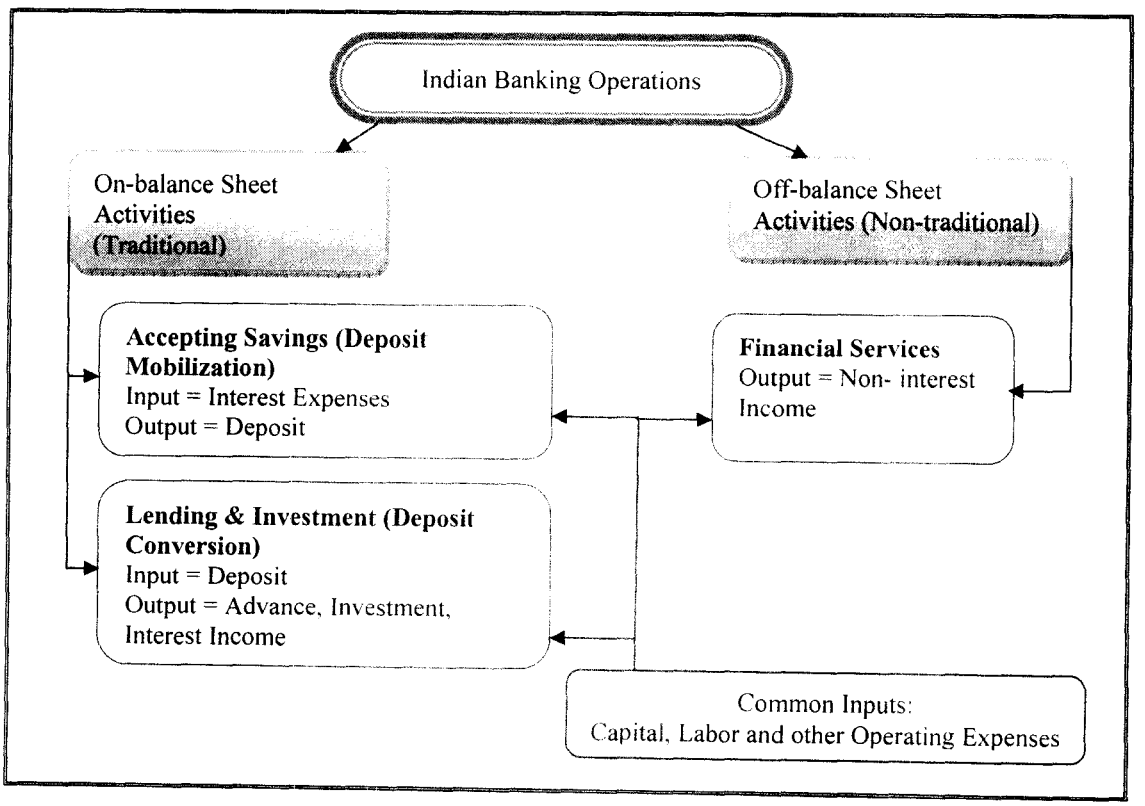
Summary of literature survey on inputs and outputs of some important and relevant studies on banking efficiency based on DEA methodology are listed in Annexure: 4 (A).

Literature on inputs and outputs specification for measuring bank efficiency summarizes that most of the studies rely on three inputs a) Fixed assets as a proxy of physical capital b) labor (No. of Employees) and c) Deposit and two outputs namely a) Interest Income b) Non-interest Income. In place of interest income some studies choose advance and investment in the output vectors.

With these existing theoretical strands, extant literature, the study selects finally four input and four output variables following the three stage procedures illustrated below. The choice of input and output variables is mainly guided by operational pattern, objectives of the Indian banking system in the post reform period and the availability of data.

Figure: 4.3

Banking Operation Patterns & Related Inputs and outputs



In the above diagram. banking operations pattern of the Indian commercial banks along with inputs and outputs in that specific area of operation are presented.

From the above diagram combining the traditional and non traditional activities of Indian banking, following input and output variables are specified based on the intermediation approach.

Stage-I: selection of Inputs and Outputs –

Input Variables	Output Variables
➢ Interest Expenses ➢ Deposit ➢ Operating expenses ➢ Fixed assets ➢ No. of Branches ➢ No. of employees	➢ Advance ➢ Investment ➢ Interest income ➢ Non-interest income

Number of Input & Output Variables

Selection of input and output items is the most important task for estimating efficiency level under DEA technique and the number of such items is also crucial for successful application of DEA. Inclusion of many variables is not a viable option in DEA as the number of inputs and outputs (m + s) increases in the model. more and more DMUs become efficient and efficiency discrimination among DMUs is questionable due to an inadequate number of degree of freedoms. A rough rule of thumb in the envelopment model is to choose n (number of DMUs) equal to or greater than max $\{m \times s, 3 \times (m + s)\}$ [25]

Therefore, some variables are excluded from the above mentioned inputs and outputs of stage-I to make the DEA models viable. This exclusion is based on the theoretical concepts and existing inputs and outputs in the literature. First 'interest expenses' and 'interest income' two variables are converted to single variable known as 'net interest income' or spread which is placed in output variables set. Now, three output variables-'advance', 'investment' and 'net interest income' are related to traditional banking activities. Therefore, as majority studies, we chose only 'net interest income' to represent the on-balance sheet activities of banking.

Fixed assets is then excluded from the inputs set of Stage-I. Most of the prior research used fixed assets as a proxy of physical capital. But they ignored the fact that in many cases, items of physical capital will be leased rather than owned. Even if they were owned, there might be problems with their valuation. In the sample banks, some are too old and some new. Some are rural and semi urban oriented and some are metropolitan based. Some are highly technology based and some are not. Therefore, there is a major difference among the banks so far as valuation of fixed assets are concerned. Besides fixed assets are partially represented through 'operating expenses (an input variable) since depreciation charge on fixed assets is included in operating expenses. Instead of fixed asset, the study considers 'No. of Branches' and 'No. of Employees' as proxy of physical capital. Actually both the variables provide the infrastructure to banks. Use of No. of Branches and No. of Employees as proxy of physical capital in the inputs vector is not universal in the prior literature, but it can be justified. Correlation between these two variables with Fixed Assets and Net worth are highly significant (at .01 level) over all the years. Therefore, this is reasonable justification to use 'No. of Branches' and 'No. of Employees' as proxy of physical capital as well as financial capital. They are highly positively correlated with the size (Total Assets) of banks also.

Table: 4.2

Correlation Results for Inputs Consideration

	2005		2006		2007		2008	
	No of Branches	No of Employees	No of Branches	No of Employees	No of Branches	No of Employees	No of Branches	No of Employees
Fixed Assets	0.481	0.564	0.524	0.647	0.483	0.575	0.561	0.605
Net Worth	0.799	0.886	0.736	0.839	0.753	0.847	0.701	0.784
Total Assets	0.874	0.952	0.864	0.943	0.839	0.917	0.876	0.928

Note: *All are significant at .01 levels*

In the prior research 'No. of employees' were used as a proxy of labour but they ignored non labour operating expenses which have been heavily incurring by the banks for technology upgradation. So the study uses 'operating expenses' as one of the inputs, which includes both labour and non-labour expenses. So, input-output variables of Stage-I are modified as follows -

Stage-II: Inputs and Outputs

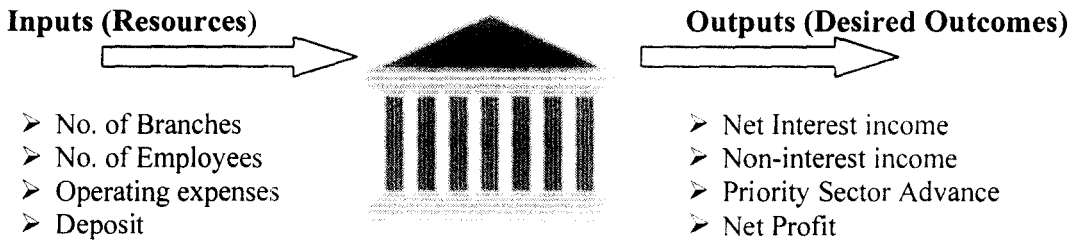
Input Variables	Output Variables
➢ No. of Branches ➢ No. of Employees ➢ Operating expenses ➢ Deposit	➢ Net Interest income ➢ Non-interest income

Inputs and output variables of stage-II except 'No of Branches' and 'No of Employees' are basically based on the monetary flows taken from both the Profit and Loss account and the Balance Sheet of the each banks considering three basic banking functions. Now, variables of Stage-II are again modified in order to accommodate the objectives of the Indian banking system in the post reform era into the input output vector.

In 1992, the RBI launched banking sector reform to create a more profitable, efficient and sound banking system. The reform opened the banking sector for private players. The emergence of new private banks exposed the inefficiency of public banks which are lager in size, large number of employees and branches with socio-economic obligation. But there is a debate among the authors and researchers that the profitability should not be the criteria for comparison of performance evaluation between public and private banks. They argue that PSBs are more social than economic. But profits are required to fulfill this socio-economic objective. That is why policy makers rightly laid emphasis on profitability as a criterion for performance evaluation of PSBs. Some public banks already are gone to partial privatization and most of the banks are listed in stock market. They are easily approachable to capital market to mobilize additional fund. In this back ground, after 18 years of reform process going on, profitability aspect should be considered for estimating and analyzing efficiency of the banks. Further, Indian banks have to invest in the priority sector. So, priority sector advance is also taken into consideration as an output variable for social objectives of the banks.

Therefore, two output variables namely 'Priority Sector Advance' and 'Net profit' are taken into consideration as output variables in order to have an effect on the socio economic objectives of the Indian commercial banks.

Stage 3: Final Input Variables and Output Variables



Finally, the study specifies four inputs and four outputs. All the inputs and outputs are measured by monetary terms of rupees in lakhs except 'No. of branches' and 'No. of employees' which are in terms of physical numbers.

'Number of Branches' and 'Number of Employees' are considered as inputs by Saha & Ravisankar[26] (2000), Ketkar, et al.[27] (2005). Many studies considers 'No of employees' as a proxy of labour [e.g. Das et al.[28] (2004), Kumar and Gulati[29] (2008)]. But, present study includes them into the input vector as proxy of physical and financial capital.

'Operating Expenses include all labor and non-labor cost which includes rent, printing charges, depreciation on banks properties, insurance and so on. [Sathye[30] (2003), Mohan & Ray[31] (2004), Chakrabarty & Chwala[32] (2005)]

'Deposit' includes all types of deposit: demand, savings and time deposit and it is used as a loanable fund. Most of the studies in India use it as an input.

'Net Interest Income' is also called spread computed by subtracting interest expenses from interest income. This variable represents the performance of the traditional activities of banking. [Das[33] (1997), Kumar[34] (2008)]

The output variable *'Non-interest Income'* accounts for income from off-balance sheet activities such as commission, brokerage and so on. The inclusion of this variable enables the capturing of recent changes in banking services. Most of the studies in India use it as an output.

'Priority Sector Advance' variable as output is considered to accommodate the social aspect of the Indian banking. Present study uses this variable as output probably for the first time for measuring efficiency of the Indian banking.

'Net Profit' computed by subtracting total expenditure including provision and contingencies from total income is considered for economic objective of the banking operation, which is very important for existence in the competitive market. [Debasish [35] (2006)]

However, the study tries to select input and output variables that minimize the problem of differences among the banks and bank groups under study.

4.6: Sampling and Data

Sample Banks

Oral and Yololan[36] (1990) suggests to use DEA models for firms employing similar resources and providing the same services. Quey-Jen Yeh [37] (1996) states that it is important to take into account the homogeneity condition during the choice of DMUs to make the DEA result more realistic. Regional Rural Banks are local banks with their domain of operations restricted to one or two contiguous districts and mostly provide credit to farmers and small enterprises whereas foreign banks with limited branches in the metropolitan cities only are operating mainly to serve their clients of their parent banks abroad. Based on the criteria of homogeneity condition, the study relies on selection of 36 Indian scheduled commercial domestic banks which have already been listed in the stock exchanges. Stock behavior pattern of the banks have not been taken into consideration in this study. The main objective of the study is to estimate and examine the technical efficiency (DEA) of the selected banks. Sample banks consist of both public and private banks. The banks which have been operating continuously in all the years of the study period are only included in the sample. Industrial Development Bank of India (IDBI) has been included in the list of public sector banks. Yes Bank has been excluded from the list due to unavailability of some important data and very recent entrance into the industry in 2004-05. UTI bank has been renamed as AXIS bank in 2007. Sample banks with their codes have been listed in the Annexure: 4 (B).

Data sources

All the data are annual and secondary in nature. Annual bank level data are obtained from the published annual accounts (Balance Sheet and P&L Account) in Annual Reports of the individual banks, collected mainly from the 'Statistical Tables relating to Banks in India' and 'Report on Trend and Progress of banks in India' for the various years under study, available on the official website of RBI[38]. Other sources of the data are annual reports of the respective banks, websites of the respective banks, Report on currency on finance, RBI; Handbook of statistics on Indian Economy, RBI.

Study period

The study covers a period of four years; beginning 2004-05 and ending in 2007-08. The period taken under analysis was one of great changes in the Indian banking system. During this period, most of the Indian banks have already been listed in stock market. They can easily approach capital market to mobilize additional fund. During this period, Indian economy has gathered more strength as indicated by the various economic factors.

Table: 4.3

Macroeconomic indicators in India

Indicator	*1996-2003*	*2003-08*
GDP growth	5.6	8.8
Inflation	4.6	5.3
Fiscal Deficit-GDP Ratio	5.7	3.8
Forex Reserves-GDP Ratio	9.5	20.7

Source - Samantaraya and Verrie3[39] (2009)

Banking performance is heavily depended on economic performance of the country as well as global. So, from the above factors it is clear that Indian economy during the period of evaluation was very stable and strong. During this period also, Indian capital market has witnessed a tremendous growth as indicated by the upward movement of BSE-Sensex from 5839 (as 31/12/03) to 21078 (08/01/08)[40]. Capital expenditure by the government and private industry, demographic profile, regulatory and technological advancement and investment opportunity across all segments are expected to enable Indian

banks leading to higher growth. Healthy growth of the assets of commercial banks driven primarily by credit growth and sharp rise in credit-GDP, deposit-GDP and M3-GDP ratios are reflective of significant financial deepening in India. So the period, we choose for efficiency evaluation, is favorable for better performance of the Indian banks.

However, with this sample and data, the study estimates the relative technical efficiency of a sample of 36 Indian banks during the period from 2004/05 to 2007/08 using DEA methodology.

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Chapter - V

Empirical Analysis and Findings

5.1: Introduction

The study aims to examine the relative efficiency of Indian commercial banks during 2005-08 by utilizing Data Envelopment Analysis (DEA). Four inputs (m = 4) and four outputs (s = 4) with a sample size of 36 (n = 36) are chosen. Therefore, the sample size in this study exceeds the desirable size as per the rule of thumb (36>24) i.e. n (number of DMUs) equal to or greater than max {m × s, 3 x (m + s)} [1]. So, this study utilizes the greatest advantage of DEA methodology properly by selecting multiple inputs and multiple outputs with an accepted number of degree of freedom i.e. efficiency discriminatory powers. Majority of the previous studies considered a small number of inputs and outputs and consequently failed to capture the multidimensional nature of the Indian banking and the various aspects of performances in the present competitive market. Thus, their studies could not take advantage of the specialty of the DEA methodology i.e., the ability to handle multiple inputs and outputs situation effectively.

Table: 5.1

Summary Statistics on Input/output Data for Measuring Grand Frontier Scores

	Inputs				Outputs			
	Input -1	Input -2	Input -3	Input -4	Output-1	Output-2	Output-3	Output-4
	(No of Branches)	(No of Employees)	(Operating Expenses)	(Deposit)	(Net Interest Income)	Non-interest Income	Priority Sector Advance)	(Net Profit)
Max	9408	190420	1155785	43000466	1565230	725482	7639094	1838548
Min	105	1367	8291	289198	8942	2562	54052	11905
Average	1289	20079	135738	5689137	183174	87539	1111396	260022
SD	1651	31775	204612	7564792	268441	143213	1402197	333671

Note: Year wise summary statistics on input/ output data are presented in Annexure: 5 (A)

From summary statistics for the inputs and outputs reported in Table 5.1, it is observed that the variations among the banks in terms of selected input output data are quite big. It is noticeable that output variable (Net profit) of two banks (DLB and INV) have negative values only in the year 2005. No further action is taken since our software can deal with non-positive values.

The degree of correlation between inputs and outputs is an important issue that has great impact on the robustness of the DEA model. A correlation analysis is

imperative to establish appropriate inputs and outputs. So, in order to obtain more robust and reliable results, the sensitivity of our efficiency indices are put into test of correlation between selected input and output variables. It is found that there is a high correlation between selected input and output variables as shown in Table: 5.2.

Table: 5.2

Correlation between Input/output Variables used for Grand Frontier Scores

Input -1	1	0.971	0.865	0.914	**0.923**	**0.732**	**0.895**	**0.936**
Input -2		1	0.939	0.962	**0.975**	**0.836**	**0.941**	**0.96**
Input -3			1	0.986	**0.986**	**0.969**	**0.981**	**0.962**
Input -4				1	**0.989**	**0.938**	**0.993**	**0.984**
					1	0.918	0.977	0.977
						1	0.944	0.897
							1	0.99
								1

Note: Year wise correlations are presented in Annexure. 5 (B).

This correlation is also high in all the years under study (Annexure: 5. (B)). This is a reasonable validation of the DEA models applied in this study.

So, with this appropriate number of inputs and outputs and reasonable validation by high degree of correlation between them, the study estimates relative technical efficiency by constructing separate four annual efficient frontiers to measure year to year efficiency level of the individual banks. The study also constructs a grand frontier to estimate efficiency level over the study period (2005-08) as a whole for all the banks. Grant frontier is framed basing on the average inputs and outputs value over the study period.

As mentioned earlier, the study estimates first two types of DEA efficiencies – Overall Technical Efficiency (OTE) Pure Technical Efficiency (PTE) using input oriented CCR and BCC model respectively. Use of these two models together allows estimation of scale efficiency (SE).

Overall Technical Efficiency (OTE) or CCR efficiency under constant return to scale (CRS) assumption represents the efficiency which measures inefficiency due to wrong mix of input output configuration i.e.. operational inefficiency as well as scale

inefficiency. That is why, this efficiency is also called overall technical efficiency (OTE) or (global) technical efficiency or technical and scale efficiency.

Pure Technical Efficiency (PTE) or BCC efficiency measures efficiency without considering scale of operation. This efficiency is also rightly named as pure technical efficiency (PTE) or (local technical efficiency which provides inefficiency resulting from managerial underperformance. It is significant to note that PTE is greater than or equal to OTE since VRS frontier is piecewise boundary and closer to observed inefficient points. If a bank is BCC efficient but not CCR efficient then it is locally efficient but not globally efficient due to scale inefficiency. It is important to note that if a DMU is fully efficient under both CCR and BCC score the DMU is said to be operating in the most productive scale size i.e., scale efficiency is 100%.

Scale Efficiency (SE) - Another type of efficiency which measures whether a banking firm has the right size is known as scale efficiency (SE). This is the relationship between a firm's per unit production cost and production volume. Thus, scale efficiency (SE) based on CCR and BCC score is defined by SE = CCR score / BCC score, SE is not greater than one.

Here it is also significant to explain again that input oriented technical efficiency score obtained from CCR and BCC model indicates minimization of input use while producing at least given level of outputs i.e., how much inputs can be reduced without altering the given level of outputs produced compares with the best practice utilization of inputs.

Year wise DEA scores help to observe the trend of efficiency movement over the years under evaluation. DEA scores should not be used as a basis for comparison across the years since it measures relative efficiency not absolute efficiency. Thus, the study has analyzed the efficiency of the banks based on the grand frontier scores unless otherwise mentioned. Out of CCR and BCC efficiency, the study considers CCR efficiency scores for analysis purpose since CCR efficiency measures both technical and scale aspect of efficiency. BCC efficiency scores are mainly used to identify the source of inefficiency of the banks. Financial year 2004-05 starting from 1st April, 2004 and ending on 31st March, 2005 is written as 2005, 2005-06 as 2006 and so on.

Yearly frontier and grand frontier based various efficiency scores (OTE, PTE and SE) of the individual banks are presented in Annexure: 5. (C).

5.2: Insights of DEA Efficiency

DEA not only measures efficiency level but also indicates and helps to explain the various insights into efficiency. That is why in the first section of the analysis; this study aims to look at six issues (various insights of DEA efficiency) explained one by one –

⇒ Examination of relative efficiency of the banks in a generalized way.

⇒ Efficient and Inefficient Banks

⇒ Decomposition of Technical Efficiency

⇒ Returns-to-Scale

⇒ Reference Sets

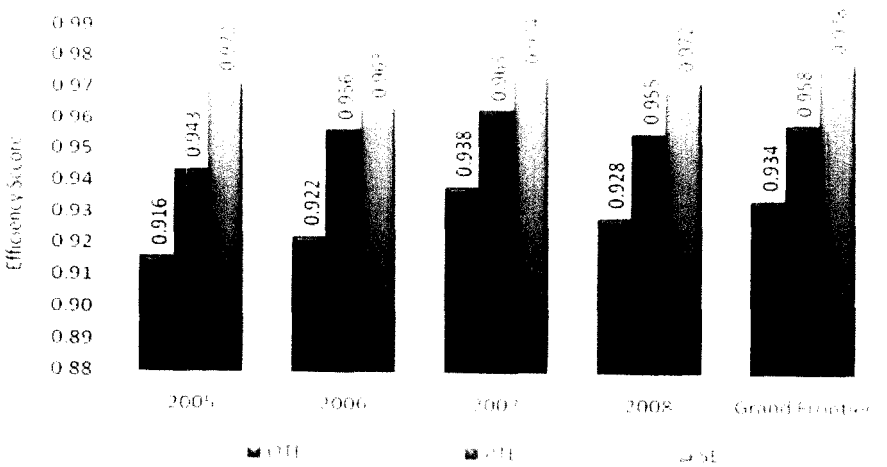
⇒ Improvement in Efficiency

5.2.1: Examination of Relative Efficiency

Average efficiency of different DEA measures are displayed in Figure: 5.1.

Figure: 5.1

Mean Scores of Different Efficiency



The average overall technical efficiency (OTE), pure technical efficiency (PTE) and scale efficiency (SE) based on grand frontier scores are 93.4 percent, 95.8 percent, and 97.8 percent respectively. The above results suggest that average inefficiencies of these three efficiency measures (average dispersions of banks from the best-practice banks) are 6.6%, 4.6% and 2.2% respectively. Now, we are discussing these three types of efficiencies one by one.

The summary statistics of three types DEA efficiencies are given in Table: 5.3.

Table: 5.3

Descriptive Statistics of OTE, PTE and SE scores

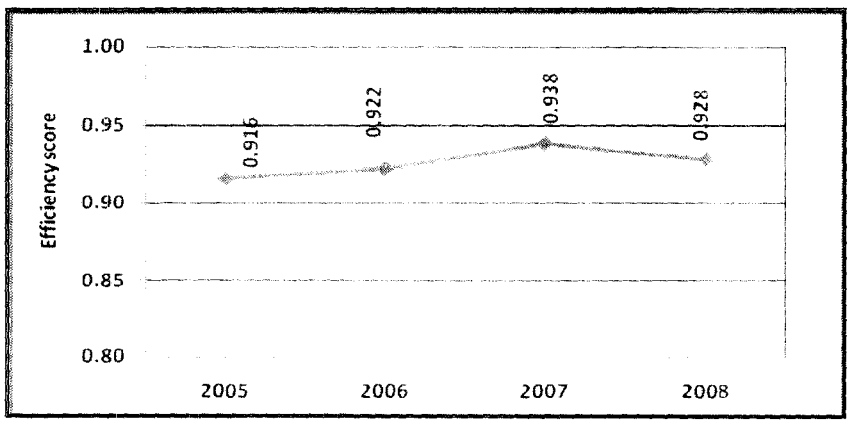
	Year Wise Frontier				Grand Frontier
	2005	2006	2007	2008	
Overall Technical Efficiency (OTE)					
No. of Banks	36	36	36	36	36
Average Efficiency (AVE)	0.916	0.922	0.938	0.928	0.934
Average Inefficiency (1 - AVE)	0.084	0.078	0.062	0.072	0.066
SD	0.104	0.100	0.080	0.084	0.086
Minimum	0.632	0.562	0.733	0.651	0.646
Maximum	1	1	1	1	1
No. of Efficient Banks (%)	15(42%)	15(42%)	17(47%)	14(39%)	16(44%)
Pure Technical Efficiency (PTE)					
No. of Banks	36	36	36	36	36
Average Efficiency (AVE)	0.943	0.956	0.963	0.955	0.958
Average Inefficiency (1 - AVE)	0.057	0.044	0.037	0.043	0.042
SD	0.095	0.075	0.060	0.067	0.073
Minimum	0.641	0.643	0.755	0.709	0.647
Maximum	1	1	1	1	1
No. of Efficient Banks (%)	23(64%)	22(61%)	22(61%)	22(61%)	21(58%)
Scale Efficiency (SE)					
No. of Banks	36	36	36	36	36
Average Efficiency (AVE)	0.972	0.963	0.974	0.972	0.978
Average Inefficiency (1 - AVE)	0.028	0.037	0.026	0.030	0.022
SD	0.057	0.058	0.054	0.050	0.049
Minimum	0.702	0.736	0.733	0.783	0.735
Maximum	1	1	1	1	1
No. of Efficient Banks (%)	15(42%)	15(42%)	17(47%)	14(39%)	16(44%)

Overall Technical Efficiency (OTE) -

Average OTE during study period is 93.4 % showing that the Indian banks are quite technically efficient. Therefore, the study reveals that the mean efficiency score of Indian domestic commercial banks compares very well with the world mean efficiency scores of 86% as per Berger and Humphrey[2] (1997). Though they also pointed out that cross-country efficiency estimates need to be interpreted with caution because of the differences in regulatory framework, economic environment etc. This high OTE scores support the hypothesis of high competition in the Indian banking industry. The mean OTE (93.4%) suggests that inefficiency in resource utilization of the Indian banks is 6.6% implying that Indian banks (based on sample) could have saved 6.6% of present level of inputs used to produce present level of outputs i.e., if utilizing inputs on the efficient frontier instead of its current location, would decrease on an average 6.6% of inputs currently being used. Alternatively Indian banks have the scope of producing 7 % (1/.934) more outputs than the present outputs produced from the same level of inputs currently utilized.

Figure: 5.2

Trend of Overall Technical Efficiency



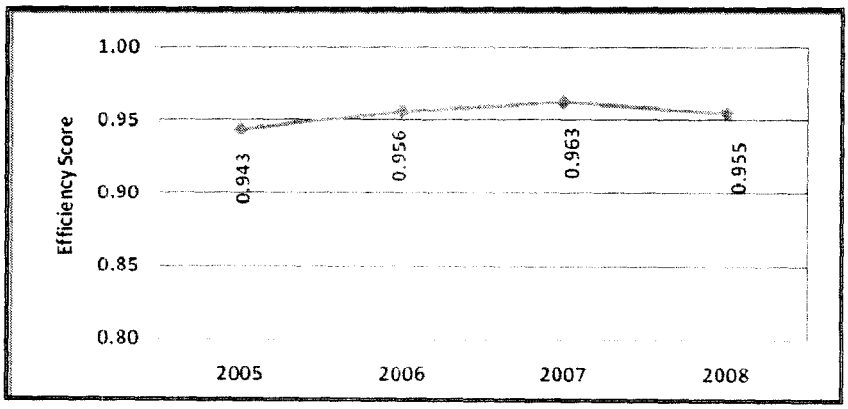
From the Figure: 5.2, it is observed that OTE is increasing in trend during the study period. The results also indicate that there is still asymmetry between Indian banks as regards their OTE that ranges between 56.15% (lowest in 2006) and 100%. But it is to be pointed out that this asymmetry is decreasing in trend, which is also evidenced from the SD of OTE score reducing from .104 to .084. It is also observed that 44% of the sample banks are 100% globally technical efficient during study time.

Pure Technical Efficiency (PTE)

Theoretically OTE ≤ PTE, this is not exceptional in my study but the pure technical efficiency (PTE)) of the Indian banks are much more than OTE both in terms of average (95.8%) and number of fully efficient banks (21banks i.e. 58% of the sample banks) during study period. Asymmetry with regard to PTE as expected but to a great extent is low in comparison to OTE (PTE ranging between 64.1% (lowest in 2006) and 100% with SD ranging between 9.5% and 6%). Increasing trend of managerial performance of the Indian banks is also found over the study period.

Figure: 5.3

Trend of Pure Technical Efficiency

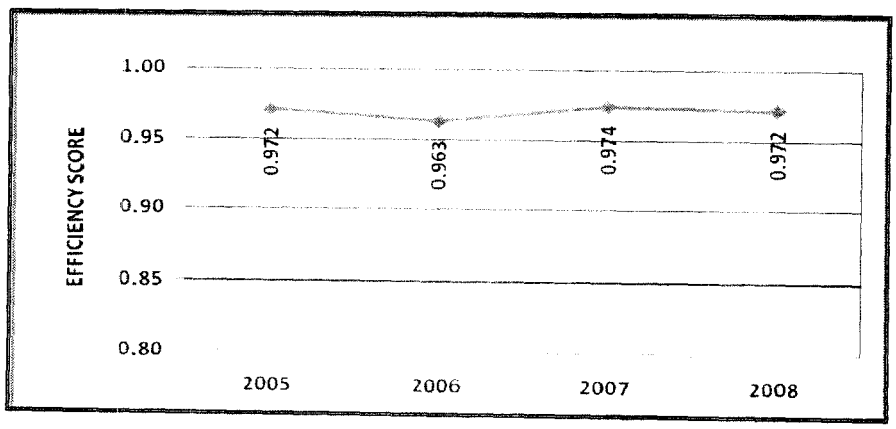


Scale Efficiency –

Most of the Indian banks as represented by the sample banks have been experiencing higher scale efficiency (97.8%) than PTE (95.8%).

Figure: 5.4

Trend of Scale Efficiency



Mean Scale efficiency over the study period is stable with lowest asymmetry ranging between .702 (lowest in 2005) and 1 and SD ranging between .058 and .050 compare to that of OTE and PTE.

From the above generalized analysis of DEA efficiencies, two important findings /observations are made.

The first observation is that average OTE **(93.4%)** of the Indian banks is not as high as it should be from the higher average PTE **(95.8%)** as well as SE **(97.8%).** The possible reason is that the some banks under study have higher pure technical efficiency but their scale efficiency is poor, on the other side some other banks which have higher scale efficiency are having lower pure technically efficiency. So majority of the inefficient banks (by CCR efficiency) are facing a large difference between pure technical efficiency and scale efficiency which may not increase OTE level more than 93.4%.

Secondly, this study supports the hypothesis that the performance of the banking relates to the economy strength and banks are getting the advantage of economies of scale during strong economy. In 2006-07 when Indian economy touched the highest GDP growth rates of about 9.6%, most of the Indian banks have reached to the highest score of all these three types of efficiency during the study period. It is also noticeable that in 2007-08 when GDP growth rate has gone down from 9.6% to 9 %[3]. movement of all these efficiencies of most of the banks has also gone down from those of 2006-07. This is reflected in the lower average score of all efficiency types in 2007-08 in comparisons to 2006-07 which again prove that the performance of the banking depends to the economy strength.

5.2.2: Efficient and Inefficient Banks

Specialty of the DEA methodology is to discriminate the DMUs (banks) into efficient (efficiency score = 1 or 100%) and inefficient (efficiency score < 1) status. Thus, in this section, we segregate the 36 selected banks into efficient and inefficient banks based on CCR and BCC efficiency scores. Banks are categorized into three groups

CCR and BCC efficient (OTE = PTE =1)

BCC efficient but not CCR efficient (PTE = 1 but OTE <1)

CCR and BCC inefficient (OTE & PTE < 1)

Table 5.4 provides the list of efficient and inefficient banks in terms of above mentioned three categories.

Table: 5.4

List of Efficient and Inefficient Banks

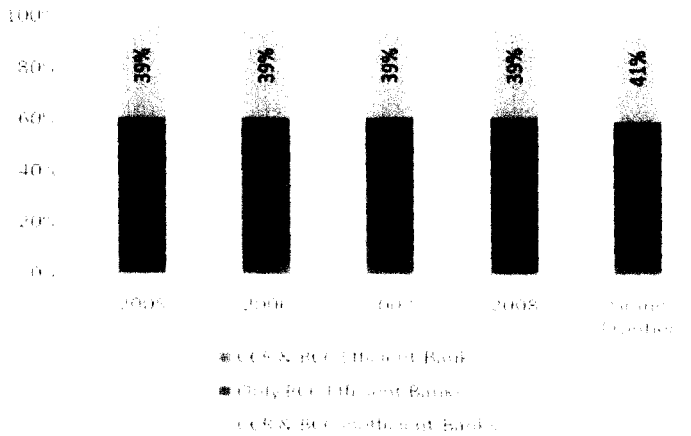
C-I	C-II	C-III	C-I	C-II	C-III	C-I	C-II	C-III	C-I	C-II	C-III	C-I	C-II	C-III
2005			2006			2007			2008			Grand Frontier		
ANB	CAB	ALB	CAB	ALB	ANB	ALB	CAB	ANB	ALB	BOI	ANB	COB	PNB	ALB
COB	IOB	BOI	COB	IOB	BOB	COB	PNB	BOB	COB	CAB	BOB	IDL	SBI	ANB
IDL	PNB	***BOB***	IDL	PNB	BOI	IDL	SBI	BOI	IDL	IOB	BOM	IOB	SBJ	BOB
OBC	SBI	BOM	OBC	SBI	BOM	IOB	DLB	BOM	OBC	PNB	DEB	OBC	CAB	BOI
UBI	DLB	DEB	UBI	SBM	***DEB***	OBC	IIB	DEB	SBT	UBI	SYB	UBI	DLB	BOM
VJB	JKB	SYB	SBJ	DLB	SYB	UBI		SYB	CUB	SBI	UCB	SBT		DEB
SBJ	AXB	UCB	SBT	IIB	UCB	SBT		UCB	FDB	DLB	VJB	CUB		SYB
SBT	CBP	SBM	CUB		VJB	CUB		VJB	JKB	LVB	SBJ	FDB		UCB
CUB		BOR	JKB		BOR	FDB		SBJ	KVB		SBM	JKB		VJB
KTB		FDB	KTB		FDB	JKB		SBM	AXB		BOR	KTB		SBM
KVB		IVB	KVB		IVB	KTB		BOR	HDB		IVB	KVB		BOR
HDB		***LVB***	AXB		***LVB***	KVB		IVB	ICB		KTB	AXB		CBP
ICB		SIB	HDB		SIB	AXB		***LVB***	IIB		SIB	HDB		IVB
IIB			ICB		CBP	CBP		SIB	KMB		***CBP***	ICB		LVB
KMB			KMB			HDB						IIB		SIB
						ICB						KMB		
						KMB								

Note: C-I = CCR and BCC efficient; C-II = BCC efficient but not CCR efficient C-III = CCR and BCC inefficient. Banks are arranged as per order of ownership group.

From the Table: 5.4 we calculate the number of banks belonging to these categories. Year wise numbers of banks under the three categories are found to be more or less same in all the years under study (Figure: 5.5).

Figure: 5.5

Number of Efficient & Inefficient Banks (%)



Over the study period (grand frontier), about 45% banks are found to be both CCR and BCC efficient. They are also called as globally efficient banks in DEA literature. They are actually technically and scale efficient (PTE = SE = 1) banks. Thus 55% banks are globally inefficient or CCR inefficient having OTE< 1. Out of these 55%, 14% are BCC efficient but not CCR efficient i.e. only locally efficient banks and remaining 41% banks are CCR and BCC inefficient i.e. locally inefficient banks (OTE & PTE< 1). All the globally efficient banks are also locally efficient or BCC efficient ones. Thus, there are 58 % (44%+14%) banks locally or BCC efficient banks. Similar explanation is for yearly results.

From the above list of efficient and inefficient banks, the study also reveals that out of 36 banks, there are 9 top performing banks and 9 least performing banks which are efficient and inefficient in all the years under study both in terms of OTE and PTE respectively.

Table: 5.5

List of Top and Least Performing Banks during the Study Period

Top Performing Banks (OTE=PTE = 1)	COB, IDL, OBC,SBT,CUB, KVB, HDB, ICB, KMB
Least Performing Banks (OTE & PTE < 1)	BOB, BOM, DEB, SYB, UCB, BOR, DLB*, IVB, SIB

**DLB is included in the least performing banks group since its pure technical efficiency score of 100% is caused by its use of smallest amount of inputs. It is actually a least performing bank throughout the study time. Its OTE is also very poor relative to other least performing banks listed above.*

5.2.3: Decomposition of Technical Efficiency

There is a relation among these three types of DEA efficiencies – OTE, PTE and SE. This relationship is popularly known as decomposition of efficiency in DEA literature. Following relationship demonstrates a decomposition of efficiency.

OTE = PTE × SE

[OTE – Overall Technical Efficiency measured by CCR Model, PTE – Pure Technical Efficiency by BCC model and SE – Scale Efficiency measured by OTE/ PTE.]

From this efficiency equation OTE is always less than or equal to PTE. The equality holds when the scale efficiency is one or 100%. BCC technique gives maximum efficiency score while CCR technique minimum efficiency scores. This decomposition depicts the sources of inefficiency i.e., whether inefficiency of a DMU is caused by inefficient operation (PTE) of the DMU itself or by the disadvantageous conditions under which the DMU is operating. Technical inefficiency of the Indian banks is found to be caused by both pure technical inefficiency (PTIE) and scale inefficiency (SIE). But it is observed that the main source of inefficiency of Indian banking is pure technical inefficiency (PTIE) since SE is more than PTE throughout the study period as evidenced from lower mean and higher standard deviation of PTE (95.8%, 7.3%) compared to that of SE (97.8%, 4.9 %). So, pure technical inefficiency contributes more towards overall technical inefficiency. But this contribution of pure technical inefficiency over scale inefficiency is not high as because the mean score difference between PTE and SE is only 2%. In other words Scale efficiency contributes more towards overall technical efficiency. Therefore possible OTE improvement can be achieved more by improving PTE rather improving SE since mean scale inefficiency (SIE) of 2.2% is lower compared to the mean pure technical inefficiency 4.2%. This finding was reported in several studies for other countries as well as in India. Such studies include Aly[4] *et al.* (1990) for US banking, Fukuyama[5] (1993) for Japanese banks, and Zaim[6] (1995) for Turkish banking, Noulas and Ketkar[7] (1996), Kumar and Gulati[8] (2009) for Indian banking.

Based on the concept of decomposition of technical efficiency, banks are divided into three categories as under in order to find further insights.

Category I -Banks with PTIE=SIE=0, i.e., PTE = SE=1

Category II-Banks with PTIE < SIE i.e., PTE> SE and

Category III- Banks with PTIE > SIE i.e., PTE< SE

By this category, this section helps to identify bank wise main source of inefficiency in resource utilization whether caused by inefficient management or disadvantageous condition under which they are operating. Banks of category I is nothing but the globally efficient banks (OTE = 1) and banks of category II & III are globally inefficient banks or CCR inefficient banks (OTE<1).

Table: 5.6

Bank-wise Main Source of Inefficiency as per Grand Frontier result

Category-I (PTIE=SIE=0)				Category-II (PTIE< SIE)				Category-III (PTIE> SIE)			
Banks	OTIE	PTIE	SIE	Banks	OTIE	PTIE	SIE	Banks	OTIE	PTIE	SIE
COB	0	0	0	ANB	0.087	0.032	0.057	ALB	0.07	0.049	0.022
IDL	0	0	0	BOB	0.162	0.082	0.088	BOM	0.142	0.128	0.016
IOB	0	0	0	BOI	0.15	0.07	0.086	DEB	0.126	0.114	0.014
OBC	0	0	0	CAB	0.038	0	0.038	SBM	0.054	0.028	0.026
UBI	0	0	0	PNB	0.001	0	0.001	SYB	0.178	0.147	0.037
SBT	0	0	0	SBI	0.097	0	0.097	UCB	0.162	0.141	0.025
CUB	0	0	0	SBJ	0.017	0	0.017	VJB	0.056	0.055	0.001
FDB	0	0	0	DLB	0.265	0	0.265	BOR	0.354	0.353	0.002
JKB	0	0	0	LVB	0.106	0.044	0.065	IVB	0.14	0.134	0.006
KTB	0	0	0	CBP	0.057	0.026	0.032	SIB	0.117	0.117	0
KVB	0	0	0								
AXB	0	0	0								
HDB	0	0	0								
ICB	0	0	0								
IIB	0	0	0								
KMB	0	0	0								
Average	**0**	**0**	**0**	**Average**	**0.098**	**0.025**	**0.074**	**Average**	**0.139**	**0.126**	**0.014**

Table: 5.6 shows that banks of category-I which are nothing but 100% CCR efficient have no inefficiency (PTIE = SIE = 0). Banks of category II & III are CCR inefficient. Inefficiency of category II is primarily caused by disadvantageous condition under which they are operating while category III by inefficient management. Table 5.5 shows that 4 banks viz. CAB, PNB, SBI and SBJ of Category II are 100% efficient in management (PTE =1). Therefore, their overall technical inefficiencies are only attributed to disadvantageous conditions under which they are operating. SBI has the highest SIE (9.7%) among the banks of category II (not considering DLB) followed by BOB (8.8%), BOI (8.7%). Other banks of Category II have very marginal SIE. PNB is very close to 100% SE. whereas, BOM, SYB, UCB, BOR and IVB in category III have PTIE more than 12% i.e. suffering from managerial underperformance.

With this analysis, over the study period, this study finds that 16 banks out of 36 banks under study of category I i.e., 44% of the sample banks are 100% technical and scale efficient (i.e. PTE = SE = 1 and OTE = 1). Inefficiencies of 10 banks of category II (28% of the sample banks) are caused mainly by their operations with inappropriate size rather than managerial inefficiency as evidenced from the mean SIE which is more than PTIE by 4.9% (7.4% - 2.5%). Inefficiencies of other 10 banks with category III (28% of the sample banks) are caused primarily by their inefficient operations or management rather than scale inefficiency since PTIE is more than SIE by 11.2% (12.6% - 1.4%). So, it is find out that 50% of the CCR inefficient banks are suffering from scale inefficiency and 50% from managerial inefficiency.

From table 5.6 it is also find out that OTIE of category II (9.8%) is much lower than that of category III (13.9%). Thus, the banks which are suffering mainly from scale inefficiency have higher OTE than those of the banks suffering mainly from managerial inefficiency. So the earlier observation of higher contribution of pure technical inefficiency towards overall technical inefficiency is primarily responsible for the banks under category III (PTIE > SIE). And this contribution is not to a great extent because 50% of the CCR inefficient banks are with PTIE < SIE and remaining 50% are with PTIE > SIE.

Again from the decomposition of efficiency point of view, it is clearly viewed that the Indian inefficient banks are facing the problem of mismatch between PTE and SE. 50% of the inefficient banks have higher PTE than SE by about 4.9%, while remaining 50% have higher SE than PTE by about 11.2%. This highly mismatch between PTE and SE of the inefficient banks can not increase mean OTE of all banks under study beyond 93.4%. This finding proves the previous observation that average OTE **(93.4%)** of the Indian banks is not as high as it should be from the higher average PTE **(95.8%)** as well as SE **(97.8%).**

5.2.4 Efficiencies and Returns to Scale

Scale inefficiency appears to affect the overall inefficiency of Indian banks. It is worthwhile to examine their returns to scale. Therefore, the issue of scale inefficiencies is explored with greater detail by considering returns-to-scale (RTS) properties of the individual banks. This section shows that whether Indian banks are enjoying economics of scale or facing the problem of diseconomies of scale. This section also identifies that which banks should go for scaling up or scaling down their activities to improve overall technical efficiency. In production theory, the change in output levels due to changes in input levels is termed as returns to scale (RTS).

Obviously, there are three possible cases:

- Increasing returns to scale (IRS) occur when one percent increase in inputs produces more than one percent increase in outputs.
- Constant returns to scale (CRS) occur when one percent increase in inputs results in exactly one percent increase in outputs.
- Decreasing returns to scale (DRS) happen when one percent increase in inputs leads to less than one percent increase in outputs.

BCC and CCR model identify the returns to scale characteristic of the individual DMUs. The study has followed the CCR model to determine the nature of returns to scale of the banks following the theorem of Banker and Thrall[9] (1992). Employing the CCR

envelopment model to obtain an optimum solution (λ_j), returns to scale can be determined from the following conditions

$\sum_{j=1}^{n} \lambda_j = 1$ in any alternate optimum then constant return to scale prevails.

$\sum_{j=1}^{n} \lambda_j > 1$ in all alternate optimum then decreasing return to scale prevails.

$\sum_{j=1}^{n} \lambda_j < 1$ in all alternate optimum then increasing return to scale prevails.

Banker and Thrall (1992) proved this theorem on the assumption that DMU is on the efficient frontier. However, numerous studies in DEA literature attended to the identification of scale economics. [Bankers et al.[10] (1984), Ray[11] (2005) and Tone[12] (1996).]

This study mentions bank wise nature of returns to scale (RTS) properties (i.e., whether banks are operating under DRS, IRS or CRS) as identified by the theorem of Bankers and Thrall based on CCR projected activities. Nature of returns to scale of the individual banks is provided in Annexure: 5. (D).

It is observed that there are some banks which are operating at same scale throughout the study period. COB, IDL, OBC, SBT, CUB, KVB, HDB, ICB and KMB are found to be operating at region where constant returns to scale prevails whereas, BOB, BOI, BOM, PNB, SYB, SBI at decreasing returns to scale and BOR, DLB, IVB, LVB at increasing returns to scale. All other 18 banks are changing their nature of scale of operation during the study period. ALB, one of them is operating at DRS in 2005 and 2006 but at CRS in 2007 and 2008. But this bank is operating at DRS over the study period as a whole (based on the grand frontier). This finding indicates that ALB is gradually moving at the right scale of operation. Like ALB banks other banks e.g. DEB,

IOB, VJB, SBJ, FDB are tending to fluctuate their nature of scale over the study period and hence operate at high scale efficiency.

Returns to scale analysis suggest that globally efficient banks are 100% scale efficient and globally inefficient banks are operating in the region where IRS or DRS prevails. Banks with IRS have the possibility to improve their efficiency by scaling up their activities, whereas banks with DRS scaling down the operation to gain efficiency (OTE).

Table: 5.7

Number of Banks in % under various Returns-to- Scale

	CRS	DRS	IRS
2005	42%	36%	22%
2006	42%	39%	19%
2007	47%	31%	22%
2008	39%	31%	30%
Grand Frontier	45%	44%	11%

Note % is calculated on total number of banks in the sample i.e. 36

As per Table: 5.7, over the study period 45 percent banks show CRS, 44 percent DRS and only 11 percent IRS in their production technologies. It is pointed out here that as per the theorem of Ahn et. al.[13] (1989), a DMU is operating at most productive scale size (MPSS) if the DMU is found to be efficient with CCR model and with corresponding BCC model and constant returns-to scale prevails at that DMU. Accordingly, 45% of the Indian banks (based on sample) are operating at MPSS.

44% of the sample banks are facing the problem of scale inefficiency due to DRS or diseconomies of scale implying that they are above their optimal scale i.e. in general they are large. The DRS may arise due to inefficient managerial or labor policies or because of it is costly to manage a very large firm. Therefore, scaling down of their activities seems to be the appropriate strategic option of these banks to improve OTE. BOI, BOB and SBI belonging to DRS are suffering from scale inefficiency largely. Their scale efficiencies are .914, .912 and .902 respectively (from the lowest side). The case of SBI is more serious among them. Therefore, these three banks can also achieve larger increase in OTE by decreasing their size. Here it is to mention that banks with DRS are

operating at disadvantageous condition. Over the study period on an average more than 55% branches of banks with DRS group are located in rural and semi urban areas. But this is only 41% for banks with CRS group and 48% for banks with IRS group. More than 60% (BOB), 64% (BOI) and 69% (SBI) branches are located in rural and semi urban areas. Thus, dominance of banking operation in rural areas may be the major reason for lower scale efficiency of these banks.

11% of the sample banks are scale inefficient as a result of IRS or economics of scale implying that they are operating below the optimal scale i.e. they are small. This means that unit cost of these banks decline when they increase their production volume. This may be due to fixed nature of inputs cost. Significance of this finding is that these banks can enhance OTE by increasing their size.

With this analysis the study has found that majority banks have been experiencing constant returns to scale (CRS) in their operations during all the years under study. Over the study period, 45% banks are operating at most productive scale size where CRS prevails. Besides, about 14% banks (viz. DEB, VJB, BOR, OVB, SIB) which are operating at DRS or IRS are very close to 100% scale efficiency. These findings indicate that most of the Indian banks are operating at correct scale. Therefore, there is a little scope of improvement of OTE by eliminating scale inefficiency of the Indian banks. This observation supports the earlier findings that pure technical inefficiency is the main source of inefficiency.

During the four years study period (2004-05 to 2007-08) India has witnessed a strong and stable economy with average GDP growth rate 9%. During this period most of the banks are scale efficient. In the earlier section it has been found also that most of the inefficient banks have lower SIE than PTIE during all the years under study. The year 2006-07, when Indian economy has touched highest GDP growth rate (9.6%), has witnessed the highest scale efficiency by the Indian banks with maximum number of banks belonging to CRS (47% of the sample banks) and out of 31% at DRS, 13 % banks are very close to 100% scale efficiency. These findings support the hypothesis that banks are getting the advantage of economies of scale i.e. higher scale efficiency during strong economy.

Another observation is that number of banks with DRS is more than that of IRS throughout the study period. Thus, DRS is observed to be the predominant form of scale inefficiency in India.

5.2.5: Strength of Efficiency Analysis: Efficient Banks

The banks which provide the best practice of input utilization or efficient frontier form a reference set of the inefficient banks. In DEA literature these banks are called peer banks and inefficient banks should follow their good operating practice to improve their efficiency. The reference set i.e., peer group is a set of efficient units to which an inefficient unit has been most directly compared when calculating its efficiency rating. It contains the efficient units which have the most similar input/output orientation to the inefficient unit and should therefore provide examples of good operating practice for the inefficient unit to emulate.

Reference set for inefficient DMUs may differ from DMU to DMU.

DMU(s) which have $\lambda_j > 0$ form the reference set (R) of an inefficient DMU in CCR & BCC models.

$R_k = \{j / \lambda_j > 0\}$ $(j \in \{1 \ldots\ldots\ldots n\})$[14]

Higher the lambda value of an efficient DMU in a reference set greater is the similarity of such efficient DMU to the inefficient DMU compared to the other efficient DMUs in that reference set.

Magnitude of frequency in reference sets measures the extent of robustness of efficient banks relative to other efficient banks. In other words, higher the frequency the more robust is. The banks which appear frequently in the reference set of inefficient banks are the banks which are likely to remain efficient unless there are major shift in their fortunes. These banks may be termed as 'well round performer' or 'global leader'[15]. Efficient banks that appear seldom in the reference sets of inefficient banks are like to possess a very uncommon input and output mix and thus they are not good examples of operating practice to emulate for inefficient banks. Thus they are 'marginally efficient banks'. Efficient banks with zero frequency are termed as 'efficient by default' in DEA

terminology because they are somewhat odd or peculiar institution with characteristics. So, inefficient banks should not follow them to improve their efficiency.

Table: 5.8

Frequency in Reference Sets of Efficient Banks as per CCR model

SN	Banks	2005	2006	2007	2008	Grand frontier
1	**COB**	**13**	**5**	**0**	**1**	**4**
2	**IDL**	**5**	**5**	**8**	**8**	**6**
3	**OBC**	**4**	**6**	**1**	**1**	**3**
4	**SBT**	**3**	**0**	**11**	**15**	**10**
5	**CUB**	**4**	**14**	**2**	**3**	**13**
6	**KVB**	**1**	**14**	**12**	**3**	**10**
7	**HDB**	**9**	**14**	**8**	**5**	**5**
8	**ICB**	**1**	**3**	**3**	**10**	**4**
9	**KMB**	**8**	**6**	**8**	**9**	**10**
10	ALB	IE	IE	0	0	IE
11	CAB	IE	0	IE	IE	IE
12	IOB	IE	IE	3	IE	0
13	UBI	8	1	6	IE	1
14	VJB	3	IE	IE	IE	IE
15	SBJ	12	6	IE	IE	IE
16	FDB	IE	IE	5	17	1
17	JKB	IE	0	3	4	0
18	KTB	0	3	0	IE	0
19	AXB	IE	1	3	0	0
20	CBP	IE	IE	0	IE	IE
21	IIB	3	IE	IE	1	0
Average Frequency		4.9 ≈ 5	5.2 ≈ 5	4.2 ≈ 4	5.5 ≈ 5	4.2 ≈ 4

Note- IE- Inefficient (OTE < 1) in that year. 2005-08 based on grand frontier result

Table 5.8 shows the year wise frequency count of the individual efficient banks. Banks which are efficient in all the years of study (serial no 1 to 9) are placed in the upper side of this table. This table clearly indicates bank wise strength of the efficiency as measured by the frequency count. A closer examination of Table 5.8 reveals that the IDL and KMB are mostly stable so far as robustness of efficiency is concerned and their trend of efficiency strength is increasing over the years. HDB is stable but it is slightly decreasing in trend during study period. SBT is stable with increasing trend except 2006. COB, OBC, UBI, SBJ and CUB are inconsistent in their robustness of efficiencies and

their strength of efficiency is in decreasing trend during study period. ICB which have very low frequency in reference set in 2005 to 2007 has reached to the third position of the robustness of efficiency in 2008 as per frequency count after SBT and FDB.

If we look into the banks with serial No. 10 to 21, we can see that most of the banks have low frequency even with zero frequency and they are efficient in only one or two years out of four years of study. This finding indicates that the efficient banks with low frequency in reference set have lower stability in 100% efficiency status. ALB, CAB, VJB, AXB, CBP and IIB are the banks with low frequency in reference set during the study period. They are actually weak efficient banks i.e. strength of their efficiency is low. They would likely to drop from the efficient frontier if there is even a small increase (decrease) in the value of any input (output) variables. It is also further observed that the banks with a very higher frequency in reference sets in a particular year do not drop out from the efficient frontier in the next year. They are in the efficient banks group with at least a low frequency in the next year. It is clearly visible in case of COB and SBJ from 2005 to 2006, CUB from 2006 to 2007 and KVB from 2007 to 2008. Therefore, the chance of losing 100% efficiency status of banks with low or zero frequency in reference sets is very high compared to banks with higher frequency in reference sets.

Frequency in reference sets discriminates efficient banks as proposed by Chen[16], (1997) and Chen and Yeh[17] (1998) and helps to rank them. Average frequency (Table: 5.8) over the study period is 4 to5. On the basis of frequency level in reference sets, efficient banks may be categorized as follows -

I) Highly Efficient Banks (more than equal to average frequency i.e. $f \geq 5$)

II) Efficient banks (less than average frequency i.e. $f < 5$)

III) Efficient by default (frequency = 0)

Table: 5.9

Categories of Efficient Banks by Frequency count in Reference Set

Year	2005		2006		2007		2008		Grand Frontier	
Category	N	Banks	N	Banks	N	Banks	N	Banks	N	Banks
Highly Efficient Banks (f ≥ 5)	6	COB,IDL, UBI,SBJ,HDB ,KMB	6	IDL, SBJ, CUB,KVB, HDB, KMB	7	IDL,UBI, SBT,KVB, FDB,HDB, KMB	6	IDL,SBT,,FDB,ICB,HDB,KMB	6	IDL,SBT, CUB, KVB,HDB,KMB
Efficient Banks (f <5)	8	ANB,OBC,VJB,SBT,CUB ,KVB, ICB,IIB	6	COB,,OBC, UBI, KTB,AXB,ICB,	6	IOB,,OBC, CUB,JKB, AXB,ICB,	6	COB,OBC, CUB,JKB, KVB,IIB	5	COB,OBC,UBI, FDB, ICB
Efficient by default (f =0)	1	KTB	3	CAB,SBT,JKB	4	ALB,COB, KTB,CBP	2	ALB,AXB,	5	IOB,JKB, KTB,AXB, IIB

Note: N – number of banks within a group, banks are listed in each group according to ownership pattern -NB, SB, OPB and then NPB.

From the table 5.9, only three banks – IDL, HDB and KMB are in the highly robust banks group in all the years. ALB, CAB, CBP are in the 'efficient by default' group while AXB which is very renowned new private bank is weakly efficient and is placed in 'efficient' and 'efficient by default' banks group during the study time. However, during the study period, out of 16 CCR efficient banks (by grand frontier), six banks are highly efficient banks, 5 banks are efficient and 5 banks are efficient by default.

So from analysis of the frequency in reference sets, it can be easily predicted that IDL, SBT, CUB, KVB, HDB and KMB can be able to maintain their 100% efficiency position in future unless there are major shift in their fortunes. At the same time IOB, JKB, KTB, AXB, IIB may strike out from the efficient frontier in the coming years as indicated by their zero frequency in reference set unless there is a substantial improvement in their operations.

5.2.6: Improvement of Efficiency Analysis: Inefficient Banks

Earlier section deals with only fully CCR efficient banks and discriminates them into three groups based on the frequency of reference sets. This section of analysis deals with only CCR inefficient banks.

5.2.6.1: Categories of Inefficient Banks

Before discussing improvement of efficiency plan of inefficient banks to become fully efficient, an attempt is made to segregate the inefficient banks (OTE<1) into three groups based on the OTE scores distribution. This segregation helps to find better insights into improvement of efficiency plans.

Table: 5.10

Categories of Inefficient Banks by CCR scores

Year		2005	2006	2007	2008	Grand Frontier
Category		Banks	Banks	Banks	Banks	Banks
Marginally Inefficient (.90 - <1)	Banks	CTB,JKB,SBM,IOB,LVB,,PNB,AXB	IOB,FDB,PNB,SBM,VJB,SBI,IIB,IVB,DEB,ALB	IIB,CAB,PNB,SBJ,VJB,DEB,SBM,LVB,IVB	UBI,IOB,PNB,VJB,BOI,CAB,SBJ,SIB,KTB,BOM	PNB,SBJ,CAB,SBM,VJB,CBP,ALB,SBI
	N	7	10	9	10	9
	MS	0.95	0.94	0.95	0.95	0.95
Inefficient (.80 - <.9)	Banks	CAB,FDB,SBI,BOB,ALB,SYB,IVB	ANB,BOM,SYB,SIB,CBP,BOB	SIB,ANB,BOM,UCB,SBI,BOB,SYB,BOI	ANB,LVB,SBI,SYB,SBM,CBP,IVB,DEB,UCB,BOB	LVB,SIB,DEB,IVB,BOM,BOI,BOB,UCB,SYB
	N	7	6	8	8	9
	MS	0.87	0.87	0.85	0.85	0.86
Distinctively Inefficient (<.80)	Banks	SIB,UCB,DEB,BOI,BOM,DLB,BOR	UCB,LVB,BOI,DLB,BOR	BOR,DLB	DLB,BOR	DLB,BOR
	N	7	5	2	2	2
	MS	0.74	0.73	0.74	0.73	0.69

Note: N = No of Banks belonging to the group, MS = Mean Score (OTE) of the respective groups, Banks are listed in each group according to descending order of OTE scores

The marginally inefficient banks will have an efficiency rating in excess of 0.9 but less than 1 and could raise their score towards 1.0 with a relatively small amount of improvement in their operating results. Banks of this category can reach the efficient frontier by making radial reduction on an average 5% (1-.95) of the inputs they currently use. Medium inefficient banks that have efficiency score between 0.8 and 0.9 can lie on the efficient frontier through radial reduction on an average 14% of their current inputs level. Distinctively inefficient banks that have efficiency score of less than 0.8 would have significant difficulties making them efficient in the short term. Banks of this group are required to reduce current input usage by 31% which is much higher than that of other two groups.

With this analysis it is observed that marginally inefficient banks can attain the 100% efficient status by a little improvement in resource utilization. Banks of category II and then III are the worst performers in the sample and may be considered as 'target banks' in the recapitalization and the consolidation scheme that have been taken place in Indian banking sector. Therefore, the regulators must pay attention to enhance their efficiency level which ultimately will increase the overall efficiency position of the Indian banks. We further observe that the number of banks belonging to distinctively inefficient category is decreasing steadily while it is increasing in case of marginally inefficient banks during study time. On the whole, distribution of efficiency score is skewed towards the higher efficiency score.

5.2.6.2: Input-output Improvement Plan

As already discussed in the methodology chapter, there are two sources of inefficiencies: *purely technical inefficiency*[18] *(PYTIE)* represented by radial measure (1-efficiency score obtained) and *mix inefficiency (MXIE)* represented by the input and output non-zero slacks.

Linear programming based DEA technique provides zero and non zero input and output slacks corresponding to input output constraints. In DEA, zero input and output slacks exist for both efficient and inefficient DMUs. But non zero input and output slacks

exist only for the inefficient DMUs. An inefficient DMU becomes efficient by improving its input and output. This can be calculated from both the CCR & BCC models as follows

Input reduction i.e. Input improvement = Actual Input values x (1 – efficiency score obtained) + Input Excess/ Input Slack if any.

Output augmentation / output improvement = Output shortfall (slack) if any.

Hence, an inefficient DMU can be efficient by achieving input and output target which is calculated as follows-

Input Target = Actual Input - Input improvement = Actual Input * Efficiency score - Input Excess (Slack)

Output Target = Actual Output + Output improvement = Actual Output + Output shortfall (slack).

This input and output target i.e. improvement plan is called in DEA literature as projection. This projection shows how an inefficient bank becomes fully efficient by indicating the level of inputs to be utilized and level of outputs to be produced. Table 5.10 shows the CCR projection i.e., input output improvement plan which would make inefficient banks efficient ones.

Input projection (%) = Input Improvement/ Actual Input used × 100.

Output Projection (%) = Output Improvement / Actual Output produced × 100.

Input projection is presented with a negative sign and output projection with positive sign as because of inputs to be reduced and output to be enhanced for efficiency improvement philosophy.

Table: 5.11

Inefficient Bank wise Input-output Improvement Plan

SN	DMU	ES	Inputs								
			RAP (1-MS)	I (No of Branches)		II (No of Employees)		II (Operating Expenses)		IV (Deposit)	
				SAP	T P	SAP	T P	SAP	T P	SAP	T P
1	ALB	93.0%	7.0%	-28.6%	-35.6%	0.0%	-7.0%	0.0%	-7.0%	0.0%	-7.0%
2	ANB	91.3%	8.7%	-17.5%	-26.2%	-3.5%	-12.2%	0.0%	-8.7%	0.0%	-8.7%
3	BOB	83.8%	16.2%	0.0%	-16.2%	-5.8%	-22.0%	0.0%	-16.2%	0.0%	-16.2%
4	BOI	85.0%	15.0%	0.0%	-15.0%	-13.2%	-28.2%	0.0%	-15.0%	0.0%	-15.0%
5	BOM	85.8%	14.2%	-21.8%	-36.1%	-4.0%	-18.3%	0.0%	-14.3%	0.0%	-14.3%
6	CAB	96.2%	3.8%	0.0%	-3.9%	-8.8%	-12.7%	0.0%	-3.9%	-6.9%	-10.8%
7	DEB	87.4%	12.6%	-32.7%	-45.3%	-13.2%	-25.8%	0.0%	-12.6%	0.0%	-12.6%
8	PNB	99.9%	0.1%	-13.0%	-13.2%	-16.9%	-17.0%	-3.0%	-3.2%	0.0%	-0.1%
9	SYB	82.2%	17.8%	-0.3%	-18.2%	0.0%	-17.8%	0.0%	-17.8%	0.0%	-17.8%
10	**UCB**	**83.8%**	**16.2%**	**-17.9%**	**-34.1%**	**-6.8%**	**-23.0%**	**0.0%**	**-16.3%**	**-7.1%**	**-23.3%**
11	VJB	94.4%	5.6%	-45.3%	-50.9%	0.0%	-5.6%	0.0%	-5.6%	-0.5%	-6.1%
12	SBI	90.3%	9.7%	-16.5%	-26.3%	-27.9%	-37.6%	0.0%	-9.7%	0.0%	-9.7%
13	SBJ	98.3%	1.7%	-23.6%	-25.3%	-16.3%	-18.0%	0.0%	-1.7%	0.0%	-1.7%
14	SBM	94.6%	5.4%	-31.6%	-36.9%	-27.9%	-33.3%	0.0%	-5.4%	0.0%	-5.4%
15	BOR	64.6%	35.4%	-19.9%	-55.3%	-2.7%	-38.2%	0.0%	-35.5%	0.0%	-35.5%
16	DLB	73.5%	26.5%	-41.8%	-68.3%	-8.4%	-35.0%	0.0%	-26.5%	0.0%	-26.5%
17	IVB	86.0%	14.0%	-10.0%	-24.0%	0.0%	-14.0%	-18.7%	-32.7%	0.0%	-14.0%
18	LVB	89.4%	10.6%	-41.7%	-52.4%	-10.1%	-20.7%	0.0%	-10.6%	0.0%	-10.6%
19	SIB	88.3%	11.7%	-31.5%	-43.2%	0.0%	-11.7%	0.0%	-11.7%	0.0%	-11.7%
20	CBP	94.3%	5.7%	-65.8%	-71.5%	-68.0%	-73.7%	-18.2%	-23.9%	0.0%	-5.7%

SN	DMU	ES	Outputs								
			RAP	I (Net Interest Income)		II (Non-interest Income)		III (Priority Sector Advance)		IV (Net Profit)	
				SAP	T P	SAP	T P	SAP	T P	SAP	T P
1	ALB	93.0%	0.0%	2.5%	2.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2	ANB	91.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.8%	0.0%	0.0%
3	BOB	83.8%	0.0%	0.0%	0.0%	0.0%	0.0%	7.8%	7.8%	13.2%	13.2%
4	BOI	85.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.9%	1.9%	0.0%	0.0%
5	BOM	85.8%	0.0%	0.0%	0.0%	52.8%	52.8%	0.0%	0.0%	7.7%	7.7%
6	CAB	96.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%
7	DEB	87.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.5%	5.5%
8	PNB	99.9%	0.0%	0.0%	0.0%	35.1%	35.1%	6.4%	6.4%	0.0%	0.0%
9	SYB	82.2%	0.0%	0.0%	0.0%	15.2%	15.2%	0.0%	0.0%	17.9%	17.9%
10	UCB	83.8%	0.0%	5.3%	5.3%	10.3%	10.3%	0.0%	0.0%	0.0%	0.0%
11	VJB	94.4%	0.0%	0.0%	0.0%	3.9%	3.9%	0.0%	0.0%	1.9%	1.9%
12	SBI	90.3%	0.0%	0.0%	0.0%	0.0%	0.0%	2.8%	2.8%	0.0%	0.0%
13	SBJ	98.3%	0.0%	5.6%	5.6%	7.0%	7.0%	0.0%	0.0%	0.0%	0.0%
14	SBM	94.6%	0.0%	2.3%	2.3%	0.0%	0.0%	1.3%	1.3%	0.0%	0.0%
15	BOR	64.6%	0.0%	0.0%	0.0%	8.2%	8.2%	22.2%	22.2%	32.7%	32.7%
16	DLB	73.5%	0.0%	0.0%	0.0%	33.4%	33.4%	0.0%	0.0%	1.8%	1.8%
17	IVB	86.0%	0.0%	0.0%	0.0%	12.8%	12.8%	0.2%	0.2%	0.0%	0.0%
18	LVB	89.4%	0.0%	25.5%	25.5%	14.4%	14.4%	0.0%	0.0%	0.0%	0.0%
19	SIB	88.3%	0.0%	0.0%	0.0%	29.8%	29.8%	0.0%	0.0%	7.3%	7.3%
20	CBP	94.3%	0.0%	0.0%	0.0%	0.0%	0.0%	9.7%	9.7%	117.9%	117.9%

Note: ES – CCR efficiency score obtained from grand frontier. RAP = Radial Adjustment Projection, SAP = Slack Adjustment Projection, T P = Total Projection, TP = RAP+SAP for inputs and TP = SAP for outputs.

Table 5.11 determines the way in which each inefficient bank can become DEA efficient. Each inefficient bank can be CCR fully efficient by reducing inputs of the present level by the % mentioned in 'TP' column in input side and enhancing outputs of present level by the % mentioned in 'TP' column in the output side in Table 5.11. Out of total projection in inputs there are two adjustments - one for ***radial adjustment*** (under RAP column which is common for each input of the respective banks) and other for ***slack adjustment*** (under SAP column). Since we follow input oriented model, radial adjustment is not required for outputs produced. Only slack adjustment requires for outputs. Radial adjustment removes purely technical inefficiency (PYTIE) whereas slack adjustment removes mix inefficiency measured by the non-zero slack values of the inputs and outputs if any.

For interpreting the content of Table 5.11, let us consider the case of UCB (UCO Bank).UCB can be 100% CCR efficient through the three phase of input output improvements plan. OTE of this bank is 83.8%

Phase I- It has to reduce its all inputs level by 16.2%.

Phase II – It has to reduce in addition to 16.2% input-I (No of Branches) by 17.9%, input-II (number of employee) by 6.8% and input –IV (deposit) by 7.1%

Phase III- It has to enhance Output I (Net interest Income) by 5.3% and output-II (Non-interest income) by 10.3 %.

Explanation of three phases of input-output improvement:

Phase I- Proportional reduction of each input by 16.2% (100% - 83.8%) removes the purely technical inefficiency of UCB. This is also known as radial adjustment in DEA. By the removal of purely technical inefficiency by reducing 16.2% of each input presently used, the DMU- UCB becomes weakly efficient (fulfill the 'Farrell' or 'week' efficiency, Cooper[18] et al. (2007)).

Phase II – Reduction of another 17.9%, 6.8% and 7.1% of the of the present level input I, II and IV respectively removes the mix inefficiency in respect of presence of non zero slacks of these three inputs .Out of total 34.1 % reduction in the Input –I (number of

branches), 16.2 is required for removing purely technical inefficiency and balance 17.9% for mix inefficiency. Similar explanation is for other two inputs II and IV. No further reduction is required for input III (operating expenses) used by UCB since there is no mix inefficiency for this input i.e. slack values corresponding to this input is nil. Thus the input 'operating expenses' only has the positive impact; whereas present level of 'number of branches', 'number of employees' and 'deposit' have no effect on efficiency evaluation of UCB during the study period.

Phase-III – Enhancement of the level of output-I by 5.3% and output-II by 10.3 % are required to remove mix inefficiency associated with these outputs by the presence of non zero slack values and no enhancement is required for other two output variables as because of zero slacks. Thus, current level of 'net interest income' and 'non-interest income' of UCB has no effect while other outputs play a positive role on the efficiency estimation procedure.

Phase-II & III are known as slack adjustments in DEA (Avkiran[19] (1999); Ozcan[20] (2008). However these slack adjustments in Phase-II & III after radial adjustment in Phase-I makes UCB strongly efficient (fulfill the 'Pareto- Koopmans' or 'strong' efficiency, Cooper[21] et al. (2007)). The similar explanation can also be extended for other inefficient banks. Now we turn to analyze the overall trend of input-output improvement plan or projection of the inefficient banks as a whole based on the mean result of the above CCR projection.

Table: 5.12 show the average input and output improvement of the CCR inefficient banks grouped by public, private and all banks. In order to be 100% efficient, Indian inefficient banks, on an average, need to reduce the use of the each input by 11.9% for radial adjustment and further reduction for input I by 23%, Input-II by 11.7%, input-II by 2 % and input-IV by 0.7% for input slacks adjustments and enhance the outputs – output I by 2.1%, output II by 111%, output III by 2.7% and output IV by 10.3% for output slacks adjustments in comparison to best practices of sample banks.

Table: 5.12

Mean Results of Input-output Improvement Plan grouped by Public and Private and All Banks

Bank group	Average Efficiency	Inputs									
		RAP (1- ES)	I (No of Branches)		II (No of Employees)		II (Operating Expenses)		IV (Deposit)	
			SAP	T P	SAP	T P	SAP	T P	SAP	T P
PUB	90.40%	9.60%	-17.80%	-27.40%	-10.30%	-19.90%	-0.20%	-9.80%	-1.00%	-10.60%
PVT	82.70%	17.30%	-35.10%	-52.40%	-14.90%	-32.20%	-6.20%	-23.50%	-0.00%	-17.30%
ALL	88.10%	11.90%	-23.00%	-34.90%	-11.70%	-23.60%	-2.00%	-13.90%	-0.70%	-12.60%

Bank group	Average Efficiency	Outputs									
		RAP	I (Net Interest Income)		II (Non-interest Income)		III (Priority Sector Advance)		IV (Net Profit)	
			SAP	T P	SAP	T P	SAP	T P	SAP	T P
PUB	90.40%	0.00%	1.10%	1.10%	8.90%	8.90%	1.50%	1.50%	3.30%	3.30%
PVT	82.70%	0.00%	4.20%	4.20%	16.40%	16.40%	5.30%	5.30%	26.60 %	26.60%
ALL	88.10%	0.00%	2.10%	2.10%	11.10%	11.10%	2.70%	2.70%	10.30 %	10.30%

Note: - ES = CCR efficiency score obtained from grand frontier. RAP = Radial Adjustment Projection measured by (1-MS). SAP = Slack Adjustment Projection. T P = Total Projection. TP = RAP + SAP for inputs and TP = SAP for outputs

By the magnitude of amount of inputs reduction and output augmentation by the slack value adjustments, we can easily rank the input wise utilization efficiency and output wise production efficiency of the Indian banks. Input-IV being the lowest reduction required, ranks first, then Input-III, II and I. Output-I being lowest augmentation required ranks first followed by output III, output IV and output II as per the mean inputs reduction and output augmentation over the study period respectively. So, the Indian banks are more efficient in using 'deposit' and 'operating expenses' rather than 'branches' and 'employees' as inputs and more efficient in producing 'net interest income' and 'priority sector advance' rather the 'non-interest income' and 'net profit'. This suggests that most of the inefficient banks need to utilize properly their branches and employees and to enhance the level of non-interest income and profitability for projecting themselves onto the efficient frontier. It is also observed that public banks require lower amount of input-output improvement in all the years for each input and output than that of private banks in order to be efficient.

5.2.6.3: Reference Banks for Inefficient Banks

One of the important advantages of DEA methodology is to identify the reference banks or peer banks for each inefficient bank based on the positive lambda values of the efficient banks for an inefficient bank under consideration. Now we mention inefficient bank-wise reference banks or peer banks i.e. a set of efficient banks. Inefficient banks should follow their good operating practices to improve their efficiency.

Table: 5.13

Inefficient Bank wise Peer Banks

		Efficient banks with Lambda values											
		SN	1	2	3	4	5	6	7	8	9	10	11
Inefficient banks	SN	Banks	COB	IDL	OBC	UBI	SBT	CUB	FDB	KVB	HDB	ICB	KMB
	1	ALB		0.022	0.099	0.142	0.926	1.343					
	2	ANB								3.361	0.026	0.007	0.141
	3	BOB		0.029				4.074	2.923		0.253		
	4	BOI	0.781	0.268				6.735		1.447	0.149		
	5	BOM					0.290	3.960					0.228
	6	CAB	0.497	0.297			2.824	0.050					
	7	DEB						1.368		1.323		0.026	0.031
	8	PNB								13.369			1.182
	9	SYB	0.083				0.059	2.485		4.449			
	10	**UCB**					**1.454**	**1.206**					
	11	VJB			0.291		0.426	0.623					
	12	SBI		0.910				9.400		13.874	2.837		
	13	SBJ					0.136			1.853			0.492
	14	SBM		0.088						1.329			0.348
	15	BOR						1.070			0.030		
	16	DLB					0.017	0.249					0.054
	17	IVB								1.053		0.016	0.085
	18	LVB					0.043			0.303			0.014
	19	SIB	0.119		0.015		0.061	0.604					
	20	CBP										0.045	0.350

Note – based on grand frontier result (CCR model)

Peer banks for say UCB (UCO Bank) are SBT and CUB since their lambda values are positive corresponding the efficiency score of the bank UCB. To improve efficiency, UCB bank should follow SBT and CUB since their input output configuration of similar with UCB, an inefficient bank. Lambda values of SBT and CUB approximately 1.454

and 1.206 respectively show the proportion contributed to the point used to evaluate UCB.

That is projected inputs value of UCB =
(Input value of SBT) × *1.454* + *(Input value of CUB)* × *1.206*
Similarly projected output value =
(Output value of SBT) × *1.454* + *(Output value of CUB)* × *1.206*
UCB has more similarity to SBT than CUB from magnitude of lambda values. This explanation for reference set of other inefficient banks is similar.

5.3: Efficiency: Ownership and Size

There is no consensus about the factors that explain the underlying differences in efficiency. Two specific factors explaining efficiency differences are widely used in almost all previous studies in Indian context. Conclusion of their study is mixed. These are ownership and size. These two aspects have assumed added significance in view of the consolidation process that is underway in India.

In this section we are trying to examine the relationship between 'efficiency and ownership pattern' and 'efficiency and bank size'. These relationship analysis is simply based on the comparison of mean OTE scores and number of 100% efficient banks (CCR) grouped by ownership pattern and bank size.

5.3.1: Efficiency and Ownership

Public sector banks (PSBs) which are mainstay of the Indian banking industry and account for more than 70% of the commercial banking assets (as on 31.03.08) are severely facing competition with the emergence of private players. Listings of PSBs on stock exchanges and increased private shareholding have also enhanced the severity of competition. The new private banks which accounted for 2.6 per cent of the commercial banking sector in March 1997 have developed rapidly and accounted for nearly 17 per cent of the commercial banking assets by end March 2008. In this market condition a question comes to our mind- 'Are public banks pushed to the back side?'

In this background, it is very important to show the relationship between efficiency and ownership pattern i.e. whether ownership type plays as an important role for efficiency gain or not.

Banking literature provides mixed evidence regarding the effect of ownership on bank efficiency. In Indian context, most of the studies in the post-reforms period have recommended that there is no serious effect of the ownership on the efficiency variance. [e.g. Mohan and Ray[22] (2004); Mahesh et al.[23](2006)]. Even the most recent study by Reserve Bank of India[24] (2008) also concludes that in the Indian banking sector, ownership has no definite relationship with efficiency. Sathye[25] (2003) has shown that public banks are more efficient than private domestic banks. Bhattacharya et al.[26] (1997) has concluded that the public sector banks have been the most efficient followed by the foreign then the private banks. Some other studies in India have shown that banks' overall efficiency is found to be higher for public sector banks than for foreign and domestic private banks [e.g. Ataullah & Le[27] (2006); Sensarma[28] (2006); Shanmugan & Das[29] (2004)]. Ketkar et al.[30] (2008) has concluded that the foreign banks are found to be most efficient followed by the private and then the public banks during 1997-2004 under production approach. Debasish[31] (2006) supports the conclusion that foreign owned banks are on average most efficient and new banks are more efficient that old ones which are often burdened with old debts. Kumar and Gulati[32] (2009) agree that there is no significant relationship between ownership and efficiency.

In global context, a study by Berger et al.[33] (2004), using 28 developing nations from various regions finds foreign banks to have the highest profit efficiency, followed by private domestic banks, and then state-owned banks. Tahir and Haron[34] 2008 observed that domestic banks are more efficient compared to foreign banks in Malaysia during 2000-2006. Berger[35] et al. (2009) suggest that state owned banks (four big banks) are by far the least efficient; foreign banks are most efficient; and minority foreign ownership is associated with significantly improved efficiency in china during 1994-2003. Md. Usman[36] et al. (2010) found that foreign owned banks to be the most efficient followed by state owned banks and domestic private banks are found to be the least efficient in Pakistan during 2001-08. However, the results of Bonaccorsi di Patti et al.[37] (2005) for Pakistan show that efficiency gains are high for all banks during the early years of privatization but subsequently, the level of efficiency for privatized banks decreased. New private domestic banks are the shining example of better performance while foreign

banks lagged behind. So, literature provides mixed effect of ownership on efficiency level.

For this analysis first sample banks are categorized according to ownership type as follows

Box No: 5.1

Bank Groups by Ownership Pattern

Banks Group	Numbers of Banks
Nationalized Banks (NBs)	16
State Banks (SBs)	4
Old Private Banks (OPBs)	10
New Private Banks (NPBs)	6
Public Banks (PUBs)	20 (16+4)
Private Banks (PVBs)	16 (10+6)
All banks (ABs)	36

Note -Ownership groups as mentioned are based on the sample banks comprising major banks of each group. Therefore, selected banks in the sample represent their respective ownership groups

Table: 5.14

Mean Efficiency and F value of Banks Grouped by Ownership

Efficiency	Ownership	2005	2006	2007	2008	Grand Frontier
OTE	NB	0.902	0.919	0.929	0.932	0.926
	SB	0.967	0.973	0.931	0.912	0.958
	OPV	0.877	0.884	0.919	0.9	0.902
	NPB	0.985	0.96	0.998	0.975	0.991
	AB	0.916	0.922	0.938	0.928	0.934
	F-Value (sig)	1.91 (.147)	1.12 (.356)	1.44 (.249)	1.06 (.380)	1.54 (.223)
PTE	NB	0.928	0.95	0.948	0.955	0.949
	SB	0.994	1	0.976	0.948	0.993
	OPV	0.914	0.938	0.957	0.938	0.935
	NPB	1	0.974	1	0.988	0.995
	AB	0.943	0.956	0.963	0.955	0.975
	F-Value (sig)	1.58 (.212)	.76 (.522)	1.16 (.338)	.576 (.635)	1.294 (.29)
SE	NB	0.972	0.967	0.979	0.976	0.976
	SB	0.973	0.973	0.955	0.964	0.965
	OPB	0.962	0.94	0.961	0.961	0.966
	NPB	0.985	0.986	0.998	0.986	0.995
	AB	0.972	0.963	0.974	0.972	0.975
	F-Value (sig)	.192 (.901)	.91 (.447)	.776 (.516)	.394 (.758)	.450 (.718)

Note: Efficiency scores are based on overall technical efficiency. NB- nationalized banks group, SB- State Banks group, OPB- Old Private Banks, NPB - New private Banks and AB- All Banks (in the sample). All these groups are based on the sample banks. Mean scores are calculated on the basis of number of banks of the respective bank group.

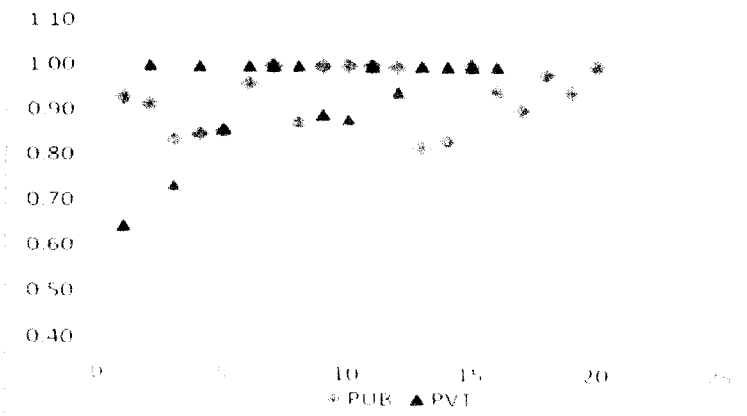
From the Table 5.14, it is observed that there is no significant difference in terms of mean score of all type of efficiency in all the years among the four ownership groups. Lower F value in one-way ANNOVA suggests the variation of efficiency due to difference among groups by ownership type is insignificant. This variation trend is decreasing over the study period. The larger the F-ratio, the greater is the difference between groups as compared to within group differences. F-value also suggests this efficiency variance by ownership is lowest in case SE. This would suggest that in the Indian context, the relationship between ownership and efficiency is not significant.

But Table 5.14 clearly shows that NPBs are the most efficient followed by the SBs, the NBs and the OPBs in terms of OTE based on the score (grand frontier) over the study period. In case of PTE, NPBs and SBs are equally efficient and then NBs and OPBs. In case of SE, this ranking is slightly changed - first NPBs followed by NBs then SBs and OPBs.

Insignificant relation between efficiency and ownership can also be justified by comparing the PUBs and PVBs in the top and least performing banks over the study period (see Table: 5.5). DEA efficiency and ownership analysis suggests that most efficient banks and least efficient banks are found both in the public and private sectors (Figure: 5.6).

Figure: 5.6

Efficiency and Ownership



Note: DEA efficiency (OTE) is based on grand frontier.

Inter groups (by ownership) efficiency comparison is different when it is based on number of 100% efficient banks.

Table: 5.15

Bank Group (ownership) wise Number of Fully Efficient Banks (in %)

Efficiency Type	Ownership Group	2005	2006	2007	2008	Grand Frontier
OTE /SE	NB	38%	31%	38%	25%	31%
	SB	50%	50%	25%	25%	25%
	OPV	30%	40%	50%	40%	50%
	NPB	67%	67%	83%	83%	83%
	AB	42%	42%	47%	39%	44%
	F-value	.74	0.76	1.55	2.41	1.94
PTE	NB	56%	50%	50%	56%	44%
	SB	75%	100%	50%	50%	75%
	OPV	50%	50%	60%	60%	60%
	NPB	100%	83%	100%	83%	83%
	AB	64%	61%	61%	61%	58%
	F-value	1.65	1.77	1.66	.50	1.18

Note: % is computed based on the number of banks of the respective bank groups.

First as per F value, there is no significant difference among the ownership groups in terms of number of 100% efficient during the study period as whole. But, F values clearly indicate this difference in terms of 100% efficiency of OTE is increasing over the study period and becomes significant in 2008 at 10% level of significance. Difference in terms of 100% efficiency of PTE is lower than that of OTE and it is more or less decreasing.

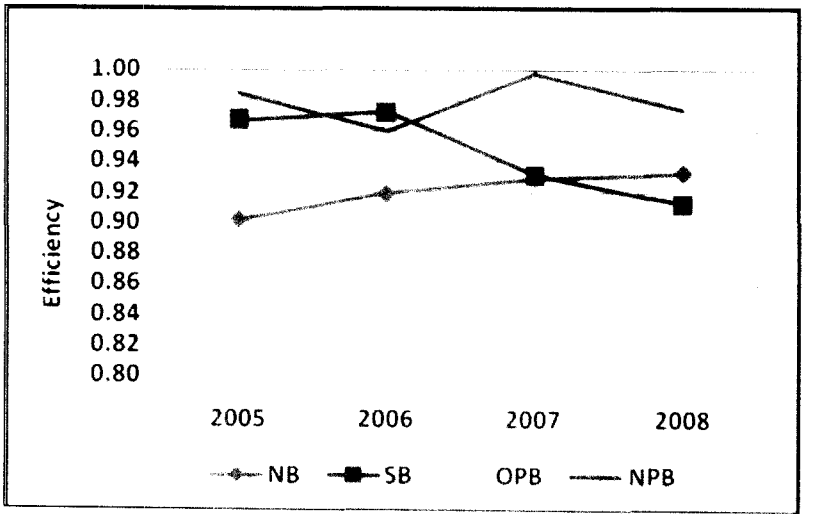
Table: 5.15 shows that NPBs group is the highest during all the years of the study and all other bank groups are inconsistent in their ranking position in terms of number of 100% efficient banks. However, about 83% of NPBs are CCR and BCC efficient banks based on grand frontier results. Interestingly OPBs which are least efficient in terms of mean score is the second highest in terms of number of 100% efficient banks. 75% of SBs are fully efficient in PTE which turns out them to second position among the four ownership groups in PTE. NBs are third in terms of OTE but the least in PTE. So the variance among the ownership in terms of fully efficient banks is higher than that of in terms of mean score. This variation is also present when it is compared between PUBs and PVBs also.

So with this efficiency analysis by ownership based on mean efficiency score suggests that ownership type has no definite relationship with efficiency. But it is to be noted that private banks are ahead of public banks when it is compared in terms of number of fully efficient banks.

'Efficiency and ownership' relationship analysis also helps to the various insights of efficiency among these four ownership groups.

Figure: 5.7

Average Efficiency (OTE) of Banks grouped by Ownership



Above Figure: 5.7 show the trend of efficiency (OTE) of the four ownership groups. Efficiency score of the entire bank groups except NBs are fluctuating over the study period. NBs only have been experiencing a steady increasing trend in OTE during the study time even in 2007-08 when efficiency score of all other groups decline. This steady growth of NBs is mainly because of achieving higher efficiency gain in scale efficiency caused by interconnection among the branches through core banking solution system (CBS) after 2005.

NPBs are most efficient in all the years except in 2005-06 because of two banks CBP (.840) which is suffering tremendously from inefficient management and IIB for profitability problem. Inefficient management and also scale inefficiency of CBP was also again responsible for highest fall of 2.32% in OTE of NPBs in 2007-08 in comparison to 2006-07.

Scale inefficiency of SB (16.8% in 2007, 13.6% in 2008) and managerial inefficiency of SBM (14.3% in 2008) are held responsible for slightly decreasing trend of efficiency of SBs after 2006. It is pointed out that scale efficiency of SBs group excluding SBI is on an average .986 which is the second highest among the groups.

OPBs are least efficient mainly because of worst performance of four banks – BOR and DLB, IVB and SIB.

Managerial inefficiency is the main source of overall technical inefficiency for NBs and OPBs where it is scale inefficiency in case of SBs. So the earlier observation of technical inefficiency largely due to pure technical inefficiency is mainly because of the banks belonging to OPBs and then NBs.

5.3.2: Efficiency and Bank Size

For the last two decades, the pace of financial market liberalization has increased in developing countries like India and creates greater competitive pressure which will affect local banks. In order to survive, banks are now going for merger and acquisitions scheme that is underway all over the world. One of the reasons for the consolidation process is the desire to achieve economies of scale. Moreover, mergers and acquisitions in the banking industry have resulted in large universal banks in terms of total assets, products, and geographical diversification. Large banks are in a better position to introduce technology and reduce cost than small banks. Large banks have normally large capital and easily utilize economies of scope. For all these reasons, size of banks is considered to be normally associated with higher efficiency. Bank size thus is now an important factor in today's banking efficiency analysis study. Information on optimal bank size is important, as this will enable policy-makers to formulate appropriate and sound policies to direct their banking industry. The optimal size of a bank depends on several factors like level of economic development, the number and diversity of financial institutions/instruments, the competitive situation in the market etc.

However banking literature does not suggest a consistent relationship between size and efficiency. In the Indian context, Ray and Sanyal[38] (1994) observed large economies of scale in the cost structure of banks, which decreases with increasing size.

Chartterjee[39] (1997), using bank deposits as outputs, indicated that small banks also feature inherent economies of scale. Moreover, Das[40] (2003), utilizing regression analysis, found a negative correlation between bank size and efficiency estimates in India. Large size banks are more efficient than small size banks as per the recent study RBI[41] (2008). Debasish[42] (2006) finds the smaller banks are globally efficient, but large banks are locally efficient. Kumar and Gulati[43] (2009) in their recent study has shown that there is a significant difference between large and medium banks with regard to Scale Efficiency (SE).

In global context, economics of scale of commercial banking operating in the US have been extensively studied (e.g. Humphrey 1990[44]; Berger and Humphrey[45] 1991; Noulas[46] 1990). They suggest economies of scale exist only for small banks. Analysis of cost structure of European banks (e.g. Zardkoohi[47] (1994) for Finland; Lang and Welzel[48] (1994) for Germany) indicate the presence of scale economics only for financial institutions of small and medium size. Rezvanian[49] et al. (2002) also finds that there are economics of scale for small and medium size banks in Singapore during 1991-1997. In a study by Asror NIGMONOV[50] (2010) the investigation of differences between the small, medium and large banks lead to the observation of significant difference between the small and medium sized banks in Uzbekistan during 2004-06. However, some studies have found significant positive relation between size and efficiency [Halkos and Salamouris[51], 2004; Drake et al.[52] (2003) Rangan et al.[53] (1988); Miller and Noulas[54] (1996)] some other negative relation (Hermelin and Wallace[55], 1994; Ali et al.[56] (1993)) and some others find insignificant relation (Mester[57], 1993; Girardone et al.[58], 2004; Isik and Hassan[59], 2002).

For analysis of relationship between efficiency and size, sample banks are classified into three groups – large, medium and small, based on the value of total assets.[60] Out of 36 sample banks, first 12 banks with highest value of total assets are considered as large sized banks next 12 banks as medium sized and the remaining 12 banks with lowest assets value as small sized banks. Large size banks contribute on an average 74% of the total assets of the sample banks while medium and small size banks contribute 20% and 6% respectively.

Table: 5.16

Mean Efficiency of the Banks grouped by Size

		2005	2006	2007	2008	Grand Frontier
Mean Score						
OTE	Large	0.915	0.928	0.924	0.947	0.934
	Medium	0.928	0.957	0.959	0.933	**0.954**
	Small	0.905	0.881	0.931	0.904	0.913
	Total	0.916	0.922	0.938	0.928	0.934
PTE	Large	0.954	0.956	0.958	0.981	0.963
	Medium	0.941	0.976	0.966	0.941	0.966
	Small	0.935	0.937	0.964	0.942	0.944
	Total	0.943	0.956	0.963	0.955	0.958
SE	Large	0.959	0.969	0.964	0.965	0.970
	Medium	0.986	0.980	0.993	0.991	**0.987**
	Small	0.969	0.940	0.966	0.960	0.969
	Total	0.972	0.963	0.974	0.972	0.975
Number of 100% Efficient Banks						
OTE &SE	Large	5	5	5	4	5
	Medium	5	6	6	5	5
	Small	5	4	6	5	6
	Total	**15**	**15**	**17**	**14**	**16**
PTE	Large	8	8	8	10	**8**
	Medium	8	7	6	5	6
	Small	7	7	8	7	**7**
	Total	**23**	**22**	**22**	**22**	**21**

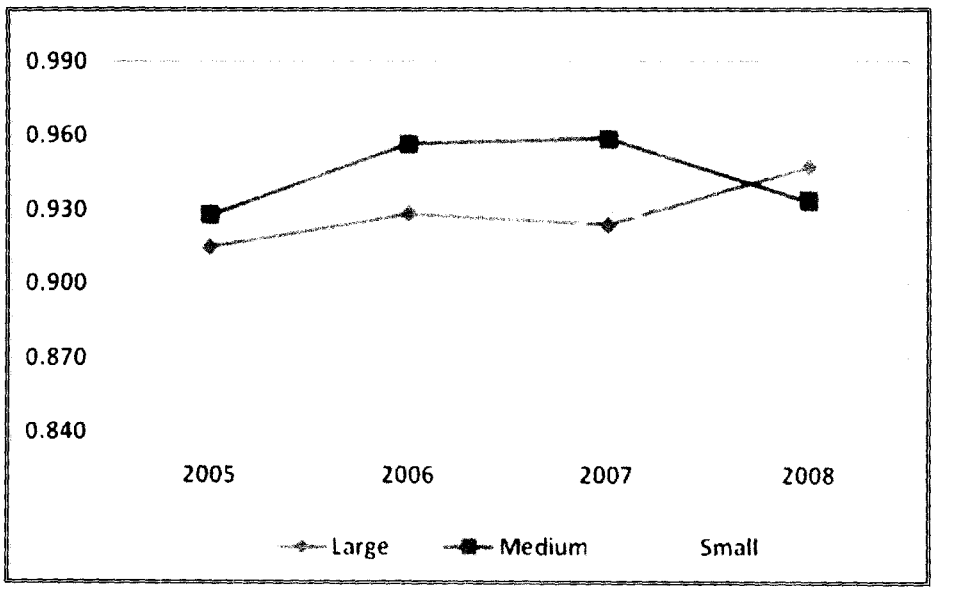
First it is clear from the Table: 5.16 that there is no significant difference between the three groups of banks by size in terms of mean efficiency score and number of 100% efficiency banks during all the years under study. Given these empirical results, the issue of the relationship between size and efficiency remains unresolved.

However, mean score of the OTE of the medium sized banks are highest in all the years except in 2008 when large size banks are the top most while small banks are the least in all the years except in 2007. So far as PTE is concerned large banks are highest in 2005 and 2008 and medium banks in 2006 and while medium and small size banks are almost equally efficient in 2007. In case of SE, medium size of banks are the most efficient in all the years while large and small banks are all most equal with a slight variation from year to year.

On the whole, an analysis of efficiency by size reveals that the medium sized banks appear to be the most efficient in terms of OTE (more than 2% of large size and 4% of small size) and SE (more than 3% of both large and small size) over the entire study period (based on GF). Large size and medium size banks are the most managerial efficient (PTE). Small size banks are least efficient in all the score.

Figure: 5.8

Average Efficiency (OTE) of Banks grouped by Size



Large size banks are in a more favorable position as indicated by the slow but steady positive efficiency growth of OTE in spite of the fact that three least performing banks- UCB, SYB and BOB (see, Table: 5.5) are within this group. In this growth journey, large size banks reach to the highest score in 2008. The reason for steady growth of large size banks may possibly be the improvement of management efficiency (PTE), well capitalization, strong internal and risk management system, technology use, vast customer base, proper accounting and disclosure and so forth of four top performing banks- IDL, ICB, HDB and UBI both in OTE & PTE and two banks - SBI and PNB in PTE. In all, medium and large sized banks are more efficient than the small sized banks. This suggests that larger banks in India tend to achieve higher efficiency gain. This observation of steady growth of efficiency score of large sized banks and higher efficiency gain by larger banks during study period validates the recent trend of merger and acquisition which is underway in the Indian banking sector.

Decomposing technical efficiency to its components – pure technical efficiency and scale efficiency – taking size into consideration, reveals that medium and small sized banks' inefficiency is mainly due to pure technical inefficiency i.e. PTIE> SE, whereas these are almost equal in case of large sized banks. This finding modifies again the earlier findings that the pure technical inefficiency contributing more than scale inefficiency towards overall technical inefficiency is mainly because of smaller size banks and most of them are in the nationalized and old private ownership group. This finding also reflects that efficiency gain could be achieved if small and medium size banks improve management efficiency and large size banks adjust their size of operation.

5.4: Ranking of Indian Banks

In this section, we are trying to develop a humble approach for ranking of the Indian banks. Ranking is a well established approach in social science and thus it is a pertinent issue in the banking efficiency study. In DEA context, ranking of organizational units has become also a well established approach in the last decade. There are several ranking methods in DEA literature (Adler et al.[61], Sexton[62] (1986) was the first to introduce full rank scaling of organizational units in DEA context by utilizing the Cross-Efficiency Matrix. Super-efficiency approach developed by Andersen and Petersen[63] (1993) is the most widespread ranking method in DEA literature.

In this study, input-oriented super-efficiency model under constant return to scale assumption as proposed by Andersen and Petersen (1993) is followed for ranking the banks under study. (Super-efficiency model is discussed in Methodology section). Besides, ranking by super-efficiency scores, the study has made overall rankings or composite rankings of the banks based on three parameters namely super-efficiency, profit efficiency and risk efficiency.

5.4.1: Rankings: Super-efficiency

Basic DEA models cannot provide rankings to the efficient banks as because of efficiency scores of all efficient DMUs are equal to 1 (one). Super-efficiency model solves this problem by allowing efficiency score of efficient banks as indentified by the basic models greater than or at least equal to the value of 1(one). Efficiency scores of

inefficient banks remain unchanged. The super-efficiency model is almost identical to the basic DEA models with the exception that the efficient DMUs being evaluated are allowing efficiency score greater than or at least equal to the value of 1(one). An important consideration of this model is that efficiency scores of inefficient DMUs remain unchanged. Table 5.17 clearly shows that efficiency scores of fully efficient banks indentified by CCR model exceed or at least equal to efficiency score of 1 (one) where as they are remain unchanged for inefficient ones.

Table: 5.17

Year wise Super-efficiency Scores and Ranking of Banks

	2005		2006		2007		2008		Grand Frontier	
Banks	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
ALB	0.848	27	0.901	25	1.019	14	1.022	14	0.93	23
ANB	1.056	11	0.879	26	0.887	28	0.892	25	0.913	24
BOB	0.878	26	0.817	31	0.827	32	0.809	34	0.838	32
BOI	0.762	33	0.78	34	0.814	34	0.95	19	0.85	31
BOM	0.746	34	0.873	27	0.852	29	0.904	24	0.858	30
CAB	0.897	23	1.014	13	0.984	19	0.937	20	0.962	19
COB	1.081	9	1.009	14	1.011	15	1.041	12	**1.045**	12
DEB	0.772	32	0.904	24	0.936	23	0.832	32	0.874	28
IDL	1.413	3	1.888	2	1.545	2	1.684	2	1.555	3
IOB	0.975	19	0.99	16	1.02	13	0.983	16	1.006	16
OBC	1.185	6	1.083	10	1.008	16	1.026	13	1.067	11
PNB	0.928	21	0.963	18	0.961	20	0.963	17	0.999	17
SYB	0.848	28	0.863	28	0.825	33	0.862	28	0.822	34
UCB	0.775	31	0.796	32	0.84	30	0.826	33	0.838	33
UBI	1.132	8	1.056	11	1.098	7	0.998	15	1.132	6
VJB	1.033	14	0.939	20	0.94	22	0.962	18	0.944	21
SBI	0.891	25	0.931	21	0.832	31	0.865	27	0.903	25
SBJ	1.046	12	1.014	12	0.96	21	0.933	21	0.983	18
SBM	0.977	18	0.959	19	0.932	24	0.852	29	0.946	20
SBT	1.04	13	1.004	15	1.096	8	1.176	5	1.125	7
BOR	0.632	36	0.562	36	0.746	35	0.651	36	0.646	36
CUB	1.062	10	1.176	5	1.023	12	1.048	11	1.068	10
DLB	0.702	35	0.736	35	0.733	36	0.783	35	0.735	35
FDB	0.894	24	0.986	17	1.048	11	1.125	8	1.017	15
IVB	0.818	29	0.912	23	0.904	26	0.839	31	0.86	29
JKB	0.981	17	1.091	9	1.127	5	1.116	10	1.136	5
KTB	1.135	7	1.113	6	1.008	17	0.914	23	1.026	13
KVB	1.021	15	1.109	7	1.12	6	1.134	7	1.087	8
LVB	0.94	20	0.793	33	0.909	25	0.878	26	0.894	26
SIB	0.799	30	0.851	29	0.896	27	0.932	22	0.883	27
AXB	0.92	22	1.093	8	1.076	9	1.151	6	1.085	9
CBP	0.988	16	0.84	30	1.059	10	0.849	30	0.943	22
HDB	1.303	4	1.322	4	1.331	4	1.191	4	1.267	4
ICB	1.907	1	2.274	1	3.277	1	2.192	1	2.238	1
IIB	1.247	5	0.919	22	0.988	18	1.124	9	1.022	14
KMB	1.606	2	1.487	3	1.365	3	1.657	3	1.561	2

Note-- Grant Frontier score i.e. efficiency score using average inputs and outputs over the study period (2005-08).

Table: 5.17 depict the rankings of the sample banks based on super-efficiency model. Efficiency score of efficient bank like COB 1.045 (based on grand frontier scores) indicates that COB can maintain it's fully (100%) efficiency status even after maximum proportional increase in inputs presently used by about 4.5%. Efficiency score of inefficient DMU like 'UCB' remains unchanged. Thus, input oriented SEM provides a means of evaluating the extent to which an efficient DMU is able to increase its input level without losing its status as a 100% efficient DMU. Super-efficiency score therefore provides a measure of stability of the 'efficient' status of the efficient DMUs.

Table: 5.18

Rank wise Super-efficient Banks over the study period

Rank	Banks	Rank	Banks	Rank	Banks	Rank	Banks
1	ICB	10	CUB	19	CAB	28	DEB
2	KMB	11	OBC	20	SBM	29	IVB
3	IDL	12	COB	21	VJB	30	BOM
4	HDB	13	KTB	22	CBP	31	BOI
5	JKB	14	IIB	23	ALB	32	BOB
6	UBI	15	FDB	24	ANB	33	UCB
7	SBT	16	IOB	25	SBI	34	SYB
8	KVB	17	PNB	26	LVB	35	DLB
9	AXB	18	SBJ	27	SIB	36	BOR

Note: Based on grand frontier super-efficiency

The Table 5.18 also classifies the banks into extreme and not extreme groups for over the study period. The first four super efficient banks in all the years ICB, IDL, KMB and HDB. ICB is the most super efficient banks in all years under study.

5.4.1.1: Projection of Efficient banks

Super-efficiency model provides the inputs outputs projection for both efficient and inefficient banks for improving efficiency. Projections for inefficient banks are same as basic model CCR (Presented in Table 5.11). Projection for efficient banks as per input oriented super efficiency model indicates how much inputs to be increased so that they can maintain 100% efficiency position. Table 5.19 provides input-output projection of the efficient banks as per grand frontier results. Each efficient bank can maintain its 100%

strongly efficient status even after changes in the inputs and outputs by the percentage mentioned for each bank in Table 5.19.

Table: 5.19

Input-output Projection for Efficient Banks

		Change(%) in Inputs				Change(%) in Outputs			
DMU	Score	No of Branches	No of Employees	Operating Expenses	Deposit	Net Interest Income	Non-Interest Income	Priority Sector Advance	Net Profit
ICB	2.238	123.8%	72.8%	3.9%	4.4%	0.0%	0.0%	14.5%	13.7%
KMB	1.561	56.2%	-10.3%	-18.3%	56.2%	0.0%	17.7%	0.0%	19.0%
IDL	1.555	-40.3%	-6.7%	55.5%	-2.5%	136.8%	0.0%	4.1%	0.0%
HDB	1.267	26.7%	21.2%	26.7%	26.7%	0.0%	28.1%	57.7%	38.1%
JKB	1.136	13.6%	-1.0%	13.6%	-16.1%	0.0%	47.6%	51.4%	45.0%
UBI	1.132	13.2%	9.0%	13.2%	-0.9%	8.9%	41.8%	9.8%	0.0%
SBT	1.125	12.5%	-10.8%	12.5%	12.5%	2.2%	59.0%	0.0%	15.8%
KVB	1.087	0.8%	8.7%	8.7%	8.7%	0.0%	0.0%	2.5%	0.0%
AXB	1.085	0.5%	8.5%	8.5%	-14.2%	0.0%	10.2%	0.0%	16.1%
CUB	1.068	-19.1%	-11.1%	6.8%	6.8%	0.0%	0.0%	0.0%	5.1%
OBC	1.067	-8.4%	6.7%	6.7%	-13.1%	0.0%	35.7%	0.0%	0.0%
COB	1.045	4.6%	4.0%	4.6%	4.6%	0.0%	0.0%	0.0%	0.0%
KTB	1.026	-6.7%	2.2%	2.6%	-6.7%	0.0%	0.0%	13.6%	4.4%
IIB	1.022	-19.1%	2.2%	2.2%	-16.0%	0.0%	45.1%	0.0%	0.0%
FDB	1.017	-7.7%	1.7%	1.7%	1.7%	0.0%	0.0%	0.0%	12.0%
IOB	1.006	0.6%	-4.9%	0.6%	0.6%	0.0%	27.3%	0.0%	0.0%

Note: As per grand frontier results of super efficiency model.

In a input-oriented DEA model, an input projection less than maximum proportional increase over 100% (e.g. in case of ICB 223.8% -100% =123.8%) allowed by the production possibility set, indicates the presence of non-zero slack in case of inputs and outputs which are to be increased, indicate the presence of non-zero slacks. In case of ICB, out of four inputs, three inputs except 'Number of Branches' and two outputs 'Priority Sector advance' and 'Net Profit' has non-zero slacks and thus, they have no impact on its super-efficiency score. Same explanation is for other banks.

This projection also indentifies input wise efficiency level of the individual banks (as per row wise % of changes in inputs of the respective banks of Table: 5.19). Higher the % of increase in inputs better is the utilization level of inputs. Thus the order of efficient use of four inputs in case of ICB is first No. of Branch (123.75%) followed by

No. of Employees (72.38%), Deposit (4.4%) and then operating expenses (3.9%). In case of outputs having zero slacks indicate better production.

Table 5.19 also identifies input wise efficient level of utilization among all the sample banks (as per column wise % changes in inputs of Table: 5.19). ICB is the most efficient in use of two inputs – 'No of Branches' and 'No of employees' while IDL for 'Operating Expenses' and KMB for 'Deposit' out of the sample banks. COB and HDB are the banks which is almost equally efficient in use of four selected inputs indicating almost same percentage of increase in all the inputs.

5.4.1.2 Reference Sets for Efficient Banks

DEA efficiency model of Andersen and Petersen also provides reference sets or peer banks for both efficient and inefficient banks. Reference sets for inefficient banks are same as basic CCR model presented in Table 5.13. Reference sets for efficient banks are presented in the following Table 5.20.

Table: 5.20

Efficient Bank Wise Reference Sets

DMU	Score	Rank	Reference set (lambda)				
ICB	2.24	1	IDL (3.44)	KMB (6.04)			
KMB	1.56	2	SBT(.110)	HDB(.12)	ICB (.02)		
IDL	1.56	3	KTB (.08)	ICB (.02)			
HDB	1.27	4	JKB (.03)	AXB (.99)	KMB (2.93)		
JKB	1.14	5	UBI (.22)	HDB (.04)			
UBI	1.13	6	CUB (6.15)	KVB (5.9)			
SBT	1.13	7	IDL (.16)	KVB (2.86)	KMB (.06)		
KVB	1.09	8	IDL(.02)	UBI (.08)	CUB (.12)	KMB (.02)	
AXB	1.09	9	OBC (.21)	HDB (.11)	ICB (.15)		
CUB	1.07	10	UBI (.03)	FDB (.06)	KVB (.07)		
OBC	1.07	11	COB (.89)	IDL (.1)	UBI (.07)	SBT(.24)	
COB	1.05	12	IDL (.11)	OBC (.11)	UBI (.17)	FDB (.63)	HDB (.06)
KTB	1.03	13	IDL (.06)	CUB (2.33)			
IIB	1.02	14	IDL (.08)	OBC(.04)	UBI (.01)	ICB (.04)	
FDB	1.02	15	COB (.39)	CUB (.68)	JKB (.07)	HDB(.003)	
IOB	1.01	16	SBT (.47)	CUB (7.19)	JKB (.27)	HDB (.16)	

Note: As per grand frontier results of super efficiency model.

Reference banks for ICB are IDL and KMB since their lambda values are positive under evaluation of ICB. Lambda values of IDL and KMB approximately 3.44 and 6.04 respectively show the proportion contributed to the point used to evaluate ICB. That is, projected inputs value of ICB =

(Inputs value of IDL) × *3.44* + *(Inputs value of KMB)* × *6.04.*

ICB has more similarity to KMB than IDL from magnitude of lambda values. ICB should follow the operating practices of KMB and IDL particularly for improving the use of two inputs- 'Deposit' and 'Operating Expenses' respectively. This explanation for reference set of other efficient banks is similar. From the Table 5.20 it is also found out that the IDL has the highest frequency (7 times) in the reference set than HDB and UBI both having 6 times. ICB which is the most super-efficient is referred for 4 times only for other efficient banks. Higher frequency in reference set in DEA indicates higher efficiency strength.

5.4.2: Rankings: Technical Efficiency and Financial Efficiency

The study has selected inputs and outputs specification after extensive verification of various input output combinations taking into consideration the major banking literature. But it is to be remembered that DEA results are very sensitive to the selection of input output variables[64] Number of inputs outputs, sample size, inclusion/exclusion of variables even model specification can affect the results. Another caveat of DEA is that those DMUs indicated as efficient are only efficient in relation to others DMUs selected in the sample. They may be inefficient outside the sample. In this study it may seem that ICB is the most super-efficient because of selecting 'No. of Branches' as one of the input variables. (ICB is the most efficient in using this input relative to other banks in the sample as per super-efficiency model). KMB which is the most efficient in using the input of 'Deposit' may be inefficient if it is considered as output under production approach. Therefore, ranking based only on Andersen and Petersens' ranking method i.e. super-efficiency scores should not be valid and justifiable. Cooper and Tone[65] rightly criticized Andersen and Petersens' ranking method. They do not rank efficient units as they claim that they all are on the efficient frontier. Moreover they do not accept DEA score as a ranking score for inefficient units since their weights vary from unit to unit.

Therefore it is necessary to rely on other efficiency parameters in addition to DEA efficiency to make ranking of the banks more reliable and justifiable. The study considers two financial parameters, profit efficiency and risk efficiency, in addition to DEA super efficiency for overall rankings of the sample banks for each year and for the study period as a whole.

Thus for overall rankings, we have considered three parameters to capture three important efficiency aspects – technical efficiency, profitability and risk which are essential for existence and sustainable growth of the banks in today's banking scenario. For measurement of profitability and riskiness, we basically rely on most frequently used financial ratios with some modifications. A common approach to efficiency and productivity analysis in the banking sector is ratio analysis, whereby a banking unit is judged in terms of certain ratios computed mainly from the financial statement. But ratio analysis is not a viable technique for drawing any economic conclusion because of differences in accounting practices and norms in different economic environments[66]. Inspite of this limitation, these ratios are still highly popular in financial analysis. Chandra[67] (2004) suggests that it works well if one is aware of accounting bases and makes adjustment for them. The popularity of ratios also emanates from the fact that most of the supervisory systems across the globe rely on these ratios such as CAMELS rating. So, overall rankings, we consider DEA efficiency as well as financial efficiency consisting of profit and risk efficiency.

Accordingly, DEA efficiency has been selected as the first criterion for overall rakings of the Indian banks with highest weight of 50% as because DEA technique is superior to ratio technique for efficiency evaluation. . Two other criteria – profitability and riskiness are assigned with equal weights of 25% each considering that they are equally important in current banking scenario. However, the study has developed four step procedures as under for overall rankings –

Step-1: Ranking banks based on each of the three parameters separately.

Step-2: Multiplying ranks by the weights assigned to the respective parameters.

Step-3: Aggregating weighted ranks resulting into composite index that determines overall rankings.

Step-4: Overall ranking is assigned by giving the best rank with least composite index i.e. lower composite index indicates better performance.

Above mentioned procedures are followed for year wise overall rankings as well as study period overall rankings of the sample banks.

5.4.2.1: Profit and Risk Efficiency Measurement

It is widely perceived that the competition among the banks operating in India has increased since the inception of financial sector reform in 1992. The competition level is increasing day by day. Banks are now in the race of becoming the best in the country by offering a host of products and services for better customer satisfaction. Indian banking is now in a position of "the survival of the fittest". In order to survive banks must be profitable. Profitability is therefore an important issue in this customer oriented market economy. In the race of making more profit, banks are forced to take risk in various respects. Thus, risk management is also an important and recent consideration of bank performance.

We have chosen two micro indicators and five micro indicators to measure and represent profit efficiency and risk efficiency respectively.

Composite scores of the selected ratios of each efficiency parameter (Box No: 5.2) measure the respective efficiency.

Box No.: 5.2

Indicators and Measuring Variables of Profitability and Riskiness

Profitability Indicators	*Measuring Variables*	*Indication of profitability*
1.Return to Assets (ROA)	Net Profit/ Average Total Assets	Higher ratio indicates better profitability
2.Return on Equity (ROE)	Net Profit/ Equity	Higher ratio indicates better profitability
Risk Indicators	***Measuring variables***	***Indication of riskiness***
1.Capital Adequacy (CAR)	Capital / Risk-weighted Assets	Higher ratio indicates lower risk
2.Asset Quality (AQY)	Net NPA / Net Advance	Lower ratio indicates lower risk
3.Management Quality (MQY)	Operating Expenses / Operating Income	Lower ratio indicates lower risk
4.Liquidity (LDY)	Liquid Asset / Total Assets	Higher ratio indicates lower risk
5.Riskiness (RI)	Risk Index (RI*) = [E(ROA) + CAP] / SD_{ROA}	Higher ratio indicates lower risk i.e. safer

Note: Risk indicators or parameters are chosen mainly from the point of view of CAMEL analysis Technique. (CAMEL stands for Capital Adequacy, Asset Quality, Management Quality, Earning Quality and Liquidity) and risk index proposed by Hannan and Hanweck (1988). Earning quality as per CAMEL rating is considered as the profit efficiency separately. All the ratios except RI are taken from the Statistical Table Relating to Banks, RBI (various years).*

Following two steps method are developed for computing composite score in a very meaningful and easy to understand way.

Step I- Converting each ratio of absolute measure to relative measure pattern following either output-oriented or input-oriented DEA concept of efficiency.

[Output-oriented technique is followed for the ratios indicating higher the ratio better the performance. And input oriented technique is used for the ratios indicating lower the ratio better the performance.

Output-oriented DEA efficiency =Actual performance / Best possible Performance.

Input-oriented DEA efficiency = Best possible Performance /Actual performance

Where Actual Performance (AP) is nothing but the actual ratio value of a bank and best possible performance (BPP) is considered as average ratio values of four best performing banks (one each from four ownership banking groups) in that ratio. Best performing bank is nothing but a bank having highest (or lowest in case of ratio indicating lower the ratio better the performance) value in the respective ratio. The bank whose actual performance equal to or more than (or less than in case ratio indicating lower the ratio better the performance) the best possible performance is assigned efficiency score equal to or more than one which is similar with Andersen and Petersens' super-efficiency score. The justification for calculating best possible performance (BPP) in this manner is to capture the differences among the banking groups in various respects – objectives, ownership pattern, Government's agent, age of operation, area of operation, use of technology, political influence, professional attitude, and labor union and so on.

Step II –Averaging relative values of each ratio of each bank results its composite score. This composite score indicates profitability and riskiness of the banks.

Profitability and riskiness measured as such are named in this efficiency study as profit efficiency (PE) and risk efficiency (RE) in tune with technical efficiency of DEA methodology. These two efficiencies may be jointly named as financial efficiency (FE).

Now we discuss briefly the micro parameters selected for profit and risk efficiency measurement.

ROA and ROE

ROA and ROE are both commonly and widely used variables to measure the profit performance of banking. ROA shows the profit earned per rupee of assets. ROA reflects the ability of the firm to generate profit on its resources. It depends on bank's policy as well as economic and government regulation policy. ROE, on the other hand, reflects how efficiently a bank's management is using its shareholders' funds. ROE depends on ROA as well as degree of financial leverage.

Many regulators believe that ROA is the best measure of bank profitability. Rosly and Abu Bakar[68] 2003 points out that ROA are the best measure of banking profitability to most analysts. Riverd and Thomas[69] suggest that bank profitability is best measured by

ROA as ROA is not distorted by high equity multiplier. However, most of the studies use ROA to measure bank profitability and therefore financial leverage i.e. fund management efficiency to increase return of owners is ignored in their study. Besides, ROA may be biased due to income from off-balance sheet activities as it is not reflected in the balance sheet. Higher ROA does not necessarily mean higher return to owners. But ultimate objective of the banks in a very competitive market is to earn a strong return for its owners with a reasonable risk to improve market holdings.

Since return on assets tends to be lower, most banks utilize financial leverage heavily to augment return on equity in a competitive level (Hassan and Basir[70] 2003). ROE considers financial leverage but disregards risk associated with leverage high return on equity indicate higher profitability but there may be high financial risk and therefore should not be good measure of bank profitability. So in my study, profit efficiency is estimated by combining ROA and ROE in order to capture both operating efficiency as well as fund management efficiency.

Capital Adequacy Ratio (CAR)

It measures the amount of banks capital in relation to risk weighted assets. It determines the capacity of banks to withstand the unexpected losses arising out of operations. Higher the capital adequacy ratio a bank has, greater the ability it has to absorb unexpected losses before becoming insolvent. Thus CAR which took into account the element of risk involved in both balance sheet as well as off-balance sheet business, emerged as a well recognized and universally accepted measure of riskiness and soundness of the banking system. CARs of all the banks groups in India have improved significantly over the study period. All the sample banks have reached double digit CAR, a commendable achievement except DLB (9.21%) which is just above the minimum requirement of CAR (9%), one percentage point above the Basal II norms.

Asset Quality

The efficiency of a bank is seriously affected if its asset quality is poor. Non-performing assets requires provisioning which results higher cost, lower profit (increasing losses) leading capital erosion. We select net NPA to net advance ratio as

measure of credit risk. The higher this ratio the larger the credit risk is. In India, non-performing assets of the commercial banks gradually declined over the years. [Net NPA was 8.1% (1996-97) it is now just 1% (2007-08)]. Income recognition, asset classification and provision norms are the major contributors of the improvement of the asset quality of the banks in the post reform period. Besides the various steps such balance sheet clearing through compromise settlement of chronic NPAs, corporate debt restructuring, setting up of debt recovery tribunals and introduction of SARFAESI act, macro economic development over the years and improvement in bank management quality are also responsible for declining the NPA level of the Indian banks. It is also noticeable that performance comparison based on particular NPA ratio cannot produce justified conclusion. SBI of 150 years and KMB of 5 years journey in banking operation with different perspective of commitment and obligation towards the society and with different political influence are obviously different in terms of NPA performance. In spite of that, after 15 years of post reform era, when all the banks are capable to reduce their NPA level (most significant improvement has been observed in respect of nationalized banks) NPA ratio may be considered for performance evaluation. We select Net NPA to net advance ratio for measuring credit risk efficiency to assess the management quality mainly i.e., from bad management point of view.

Operational Efficiency Ratio

This ratio is now a days a greater consideration by the researchers to evaluate operational performance of the banking. The higher the ratio the greater the operational risk is. In a computerized banking arena, this ratio is coming down year by year across all the bank groups to prove tight management of institution and profit planning.

Liquidity Ratio

We select 'Cash and Balances with RBI to Total Asset Ratio' to measure risk from the liquidity aspect. The higher this ratio, the stronger is a position to absorb liquidity shocks. Major studies selects credit deposit ratio for measuring liquidity risk. Credit deposit ratio as measure of liquidity (the lower the ratio, the higher is liquidity efficiency) disregards its ability to measure the soundness of the banking (the higher the

ratio the better is the soundness of the bank). The study would like give more weightage to this ratio as a measure of soundness of banking in this very competitive market and selects cash and balances with RBI to total asset as a liquidity measuring variable.

Risk Index (RI)

Risk index suggested by Hannan and Hanweck[71] (1998), is a measure of riskiness of banks. Risk Index = [E (ROA) + Capital] / SD_{ROA}

Where E *(ROA) expected returns on Assets*

Capital is the inverse of Equity multiplier i.e. Net Worth / Total assets

SD_{ROA} is the Standard Deviation of ROA

RI, expressed in units of standard deviations of ROA, is a measure of how much a bank's accounting earnings can decline until it has a negative book value. The RI equation is an appealing risk measure because it includes ROA: the most widely accepted accounting measure of overall bank performance, the variability of ROA which is a standard measure of risk in financial economics, and book capital adequacy which represents an industry standard for bank safety and soundness. These three parameters of RI are widely used consideration of the recent banking evaluation. Therefore this RI should be an important consideration in the field of efficiency evaluation. RI scores indicate the level of risk efficiency. A lower risk index score implies a riskier bank while a higher implies a safer bank. RI is calculated taking last four years data including the year of calculation.

Year wise profit efficiency and risk efficiency score of the individual banks are given in Annexure: 5. (E). Table 5.21 and Table 5.22 provide the descriptive statistics of profit efficiency and risk efficiency respectively.

Table: 5.21

Descriptive Statistics of Profit Efficiency				
	Mean	Std. Deviation	Minimum	Maximum
2005	0.571	0.361	-0.584	1.087
2006	0.613	0.286	0.038	1.044
2007	0.682	0.203	0.225	1.068
2008	0.727	0.215	0.261	1.073
Grand Frontier	0.648	0.218	0.187	1.026

Mean scores suggest that profitability of the Indian banks is steadily increasing over the years under study with an average of 64.8%. SD of the profit efficiency is also decreasing and indicates that all the banks are in the profit making approach. No one bank in the sample makes loss after 2005. So, deregulation policy brings positive impact on profitability in Indian banking sector.

Table: 5.22

Descriptive Statistics of Risk Efficiency				
	Mean	Std. Deviation	Minimum	Maximum
2005	0.611	0.224	0.377	1.418
2006	0.645	0.174	0.433	1.204
2007	0.654	0.122	0.465	0.927
2008	0.669	0.144	0.442	0.949
Grand Frontier	0.645	0.141	0.451	1.008

Descriptive Statistics of Risk Efficiency suggests that the Indian banks are gradually becoming more efficient in risk management i.e. safer as indicated by steady increasing trend in mean scores and decreasing trend in SD and range of risk efficiency scores.

5.4.2.2: Overall Ranking

Now we go for overall rankings for each year and for the study period based on composite index obtained for each bank. Composite index calculation procedures are discussed in earlier of this section of analysis.

Table: 5.23

Bank Wise Overall Ranking

Banks	2005	2006	2007	2008	2005-08
ALB	22	20	8	12	18
ANB	4	16	19	17	17
BOB	25	26	34	30	28
BOI	34	31	30	16	30
BOM	30	32	31	28	32
CAB	23	11	21	23	21
COB	10	14	13	7	13
DEB	31	25	27	29	29
IDL	7	7	5	11	9
IOB	16	10	3	9	8
OBC	2	8	18	22	12
PNB	14	13	16	15	16
SYB	27	24	26	21	25
UCB	29	33	35	36	35
UBI	11	18	11	8	11
VJB	9	23	23	25	20
SBI	24	21	25	27	24
SBJ	18	22	20	24	22
SBM	12	15	15	19	19
SBT	15	19	7	3	3
BOR	35	36	24	33	34
CUB	13	6	10	5	6
DLB	36	35	36	34	36
FDB	26	12	4	6	14
IVB	35	28	33	32	33
JKB	19	17	12	14	15
KTB	6	3	14	18	7
KVB	17	5	2	1	2
LVB	28	34	32	31	31
SIB	32	29	29	20	27
AXB	20	9	9	4	10
CBP	21	27	22	33	26
HDB	1	1	1	2	1
ICB	5	4	6	10	5
IIB	8	30	28	26	23
KMB	3	2	17	13	4

Table: 5.24

Overall Rank-wise Banks (2005-08)

Rank	Banks	Rank	Banks	Rank	Banks	Rank	Banks
1	HDB	10	AXB	19	SBM	28	BOB
2	KVB	11	UBI	20	VJB	29	DEB
3	SBT	12	OBC	21	CAB	30	BOI
4	KMB	13	COB	22	SBJ	31	LVB
5	ICB	14	FDB	23	IIB	32	BOM
6	CUB	15	JKB	24	SBI	33	IVB
7	KTB	16	PNB	25	SYB	34	BOR
8	IOB	17	ANB	26	CBP	35	UCB
9	IDL	18	ALB	27	SIB	36	DLB

HDB is the most efficient bank based on composite index of the three parameters over the study period and least efficient DLB. Though ICB, KMB. KTB rank within the first ten banks as per overall rankings (2005-08), year wise overall rankings indicate that their ranking positions are gradually deteriorating particularly in 2007 and 2008 where as ALB, BOI, COB, UBI, SBT, CUB, FDB, KVB, and AXB are gradually improving their ranking position during the study period. Sample banks based on overall rankings (2005-08) can be grouped as follows-

Table: 5.25

Bank Groups as per Overall Rankings (2005-08)

Bank Groups	Public Banks (number of Banks)	Private Banks (Number of Banks)
First 12 banks (Highly Efficient Banks)	6 (30%)	6 (37.5%)
Next 12 banks (Medium Efficient Banks)	9 (45%)	3 (19.25%)
Last 12 banks (Low Efficient Banks)	5 (25%)	7 (43.75%)
Total Sample Banks (36)	20 (100%)	16 (100%)

From this facts, it is clear that private banks dominates both in highly and low efficient bank groups but public banks in the medium efficient group. On the whole among the first 24 efficient banks there are 15 banks, i.e. 75% of the public banks and 9 banks i.e. 56% from private sector banks. Public banks are ahead of private banks as far as overall efficiency (DEA plus Financial) is concerned.

Box No: 5.3

First 10 Banks

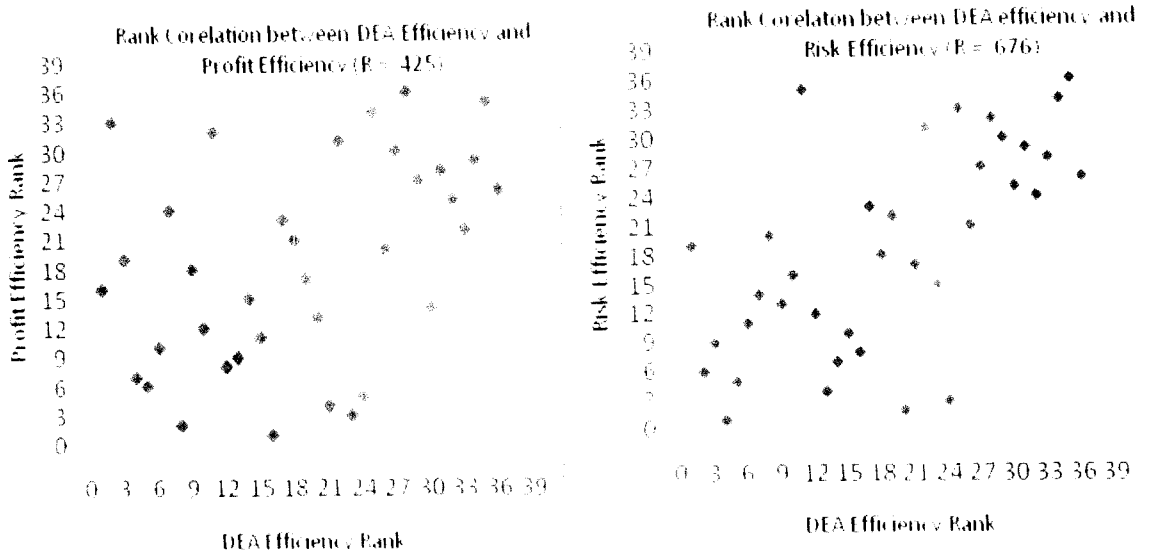
Technical Efficient Banks	Profitable Banks	Secured Banks
1 ICB	1 IOB	1 HDB
2 IDL	2 CUB	2 PNB
3 KMB	3 SBM	3 ANB
4 HDB	4 ALB	4 KTB
5 KVB	5 ANB	5 KVB
6 SBT	6 KVB	6 IDL
7 JKB	7 HDB	7 COB
8 CUB	8 AXB	8 IOB
9 OBC	9 KTB	9 KMB
10 UBI	10 SBT	10 FDB

Note: first ten banks are based on the scores over the study period of the respective three parameters considered for overall rankings 2005-08.

5.5: Financial Efficiency vs. Technical Efficiency

For overall rankings, the study has relied on technical as well as financial efficiency. Technical efficiency (TE) is measured by the economic measure – DEA and financial efficiency (FE) i.e., profit and risk efficiency by the accounting measure – financial ratios (see Box No: 5.2). In this section we are trying to examine whether the banks which are financially efficient are technically efficient or not. This relationship also helps to gain insight into various financial dimensions and to explore the financial operational strategy that makes the banks technically efficient

Figure: 5.9



Note: DEA efficiency = super efficiency (grand frontier), profit and risk efficiency are the average efficiency over the study period. R- Rank Correlation.

The analysis from Figure: 5.9 suggest that there is a positive and significant relation between TE and FE. From this finding, it can also be said that efficiency of economic measures substantiate the results arrived at through the accounting measures.

Table: 5.26

Mean Scores of Profit and Risk Efficiency between Efficient and Inefficient Bank Groups with F-value

DEA Groups	N	Profit Efficiency		Risk Efficiency				
		ROE	ROA	CAR	AQY	LDY	MQY	RI
Efficient banks	16	0.674	0.807	0.860	0.602	0.711	0.931	0.420
Inefficient banks	20	0.601	0.547	0.789	0.539	0.675	0.772	0.210
Total	36	0.634	0.663	0.820	0.567	0.691	0.842	0.303
F value		0.958	**13.351**	**9.873**	0.202	0.559	**17.929**	**5.871**
Sig		0.335	**0.001**	**0.003**	0.656	0.460	**0.000**	**0.021**

Note: DEA groups are based on grand frontier scores. Efficiency of each component is calculated by averaging the scores of four years of the respective component. N = Number of banks

Table 5.26 shows the mean scores between DEA efficient and inefficient bank groups on the various components based on which profit and risk efficiency over the study period are calculated. Financial analyst, bankers, bank supervisor and many researchers widely use these indicators to measure a bank's financial health. Table 5.26

clearly shows that efficient banks i.e., fully technically efficient banks have higher efficiency in all the components of financial health. F value in one-way ANNOVA indicates that there is a significant difference in mean financial attributes indicated by the four factors namely ROA, CAR, MQY and RI between these two groups of banks.
So, relationship with other performance metrics reveals that efficient banks in comparison to inefficient banks have

- ✓ Greater Utilization of Assets (ROA)
- ✓ Higher Capital Adequacy Ratio (CAR)
- ✓ Lower operating cost to operating income (MQY)
- ✓ Lower risky (RI)

Thus, this analysis summarizes that banks which has higher net worth (i.e. lower financial leverage) with higher management skill or operational skill tend to invest more fund in loans to earn more income for profit maximization and such a financial operating strategy makes them DEA efficient. On the whole, well capitalized profitable Indian banks are the efficient banks over the study period.

5.6: Categorization of Banks: Risk-Return Matrix

Categorization of banks and ranking helps to obtain an enhanced picture of the sample banks' performance and to highlight the potential performance improvement that management might be able to implement, accelerating overall efficiency.

For categorization, the relationship between Technical Efficiency, Profit efficiency and Risk Efficiency is explored. Previous study shows the relationship between efficiency and profitability of units with the help of 'efficiency-profitability matrix' as suggested by Boussifiane and Dyson[72] (1991); Camanho and Dyson[73] (1999); Avkiran[74] (2006) and Kumar[75] (2008). But in this study we use 'risk- return matrix' for efficient banks and inefficient banks separately, which facilitates categorization of efficient and inefficient banks. Efficient banks and inefficient banks are identified on the basis of grant frontier results (2005-08) under CCR model. For risk-return matrix, four

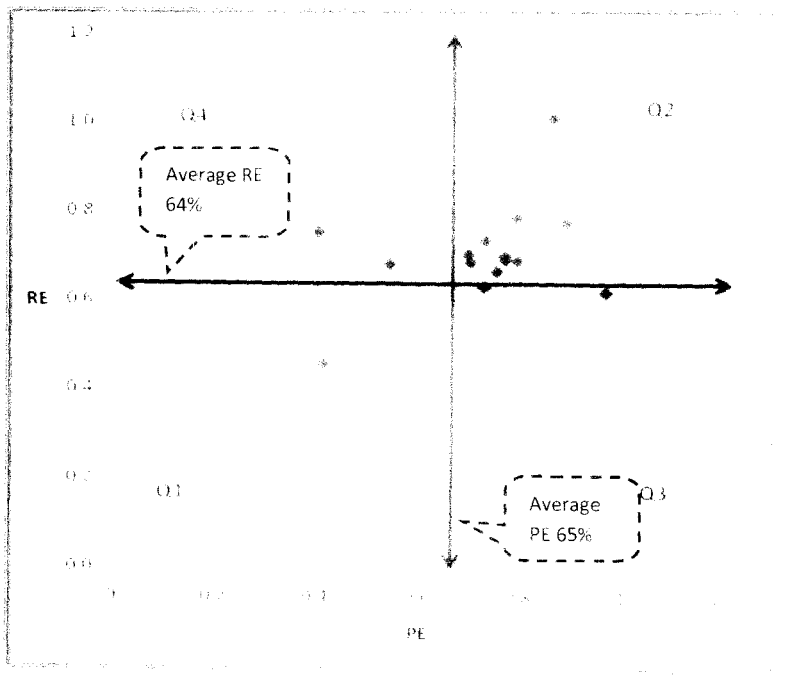
years average scores of profit efficiency (PE) and risk efficiency (RE) are considered. This analysis also helps to examine whether risk and return efficiency (i.e. financial efficiency) are sensitive to technical efficiency (CCR efficiency).

5.6.1: Categorization: Efficient Banks

The following risk-return matrix (Figure 5.10) is divided in four quadrants where 16 fully (100%) technical and scale efficient banks of different profiles are likely to exist. These four quadrants divide the efficient banks into four categories.

Figure: 5.10

Risk-return Matrixes for Efficient Banks



RE- Risk Efficiency, PE -Profit efficiency, Average is calculated based on total number of sample banks.

Banks in Quadrant 2 (Q2) are actually all round efficient banks ,super star banks since they are efficient in all the three parameters of efficiency (TE, PE and RE). Thus these banks are most suitable for others to benchmark and can become role models for inefficient banks and other efficient banks.

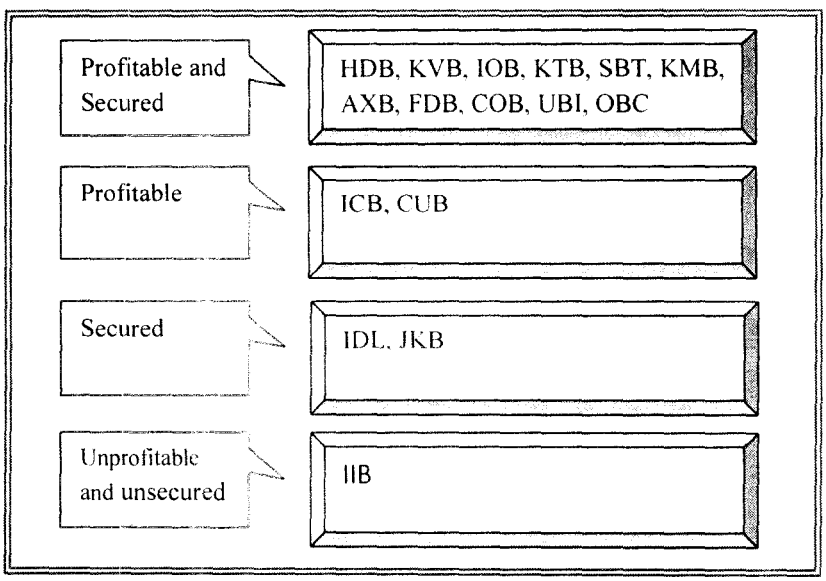
Banks of Q3 are profitable and technically efficient banks but are relatively risky banks i.e., efficient banks with relatively high profit high risk banks. They should follow efficient banks falling under Q2 and Q4 for improving their risk management ability.

Banks in Q4 are the banks that are efficient both from the point of view of conversion of input into output (TE) and risk management (RE) but are relatively less profitable. That is efficient banks with relatively low risk low profit banks. These banks are actually conservative banks. They should concentrate on lending activities rather than savings. They can adopt a different product mix for improvement of the profitability level. They can extend their business by opening new branches to capture the more business. They should follow efficient banks falling under Q2 and Q3 for improving their profitability position.

Q1 banks are only technically efficient but inefficient both in profitability and risk management i.e. lower profit higher risk banks. This is not expected. They are actually marginally efficient banks or efficient banks by default. Their efficiency strength is low. Therefore the possibility of being struck off the 'DEA- efficient' status of these banks is very high.

Box: 5.4

Four Categories of Efficient Banks

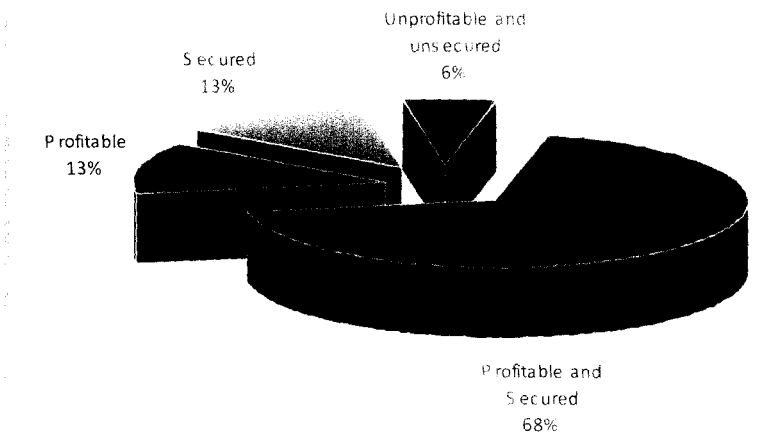


Note: Banks are arranged as per overall ranking position (2005-08)

Here it is pointed out that the precise boundary positions between quadrants are subjective. Thus, ICB and CUB of Q3 are lying just below the risk free zone. Thus, they may be treated as all round efficient banks. Only that their risk management is relatively low by some little extent in comparison to the banks of Q2.

Figure: 5.11

Category Wise Number of Efficient Banks (%)



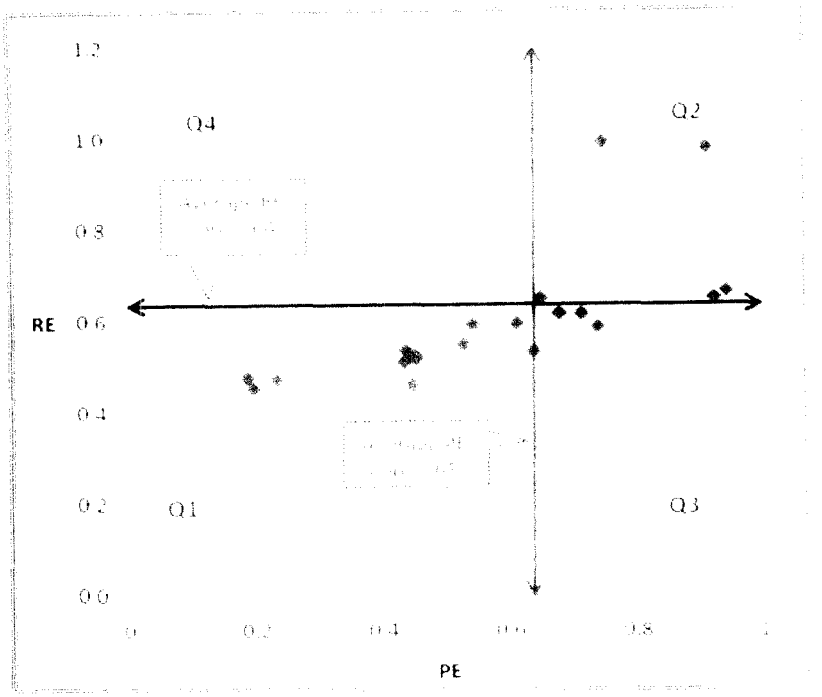
From the above figure 5.11 it is very clear that the majority of efficient banks are in quadrant 2. This implies that distribution of efficient banks with respect to risk-return matrix is skewed to right upper quadrants (Q2). This finding proves that technically efficient (DEA) banks are also financially efficient ones. It is also observed 81.3% (Q2+Q3) of the efficient banks are profitable and 81.3% (Q2+Q4) are low risky banks. So most of the efficient banks are profitable and safer indicating higher profitability and lower risk is related with higher technical efficiency.

5.6.2: Categorization-Inefficient Banks

In the same way same risk-return matrix divides the 20 inefficient banks (OTE<1) into four categories.

Figure: 5.12

Risk-return Matrix for Inefficient Banks



Banks in the Q2 have the highest level of technical, profitability and risk efficiencies within the inefficient banks group. These banks are actually marginally inefficient banks having OTE more than 90%. They are the prime candidates for a technical efficiency improvement effort.

The banks of Q3 are the lucky ones which are inefficient in utilizing their resources and are relatively risky but profitable. Their higher profitability may be for using higher financial leverage in capital structure. They are probably very aggressive in credit activities and this aggressiveness leads to higher variation in ROA. They can increase their efficiency level by strengthening capital position leading to greater profit.

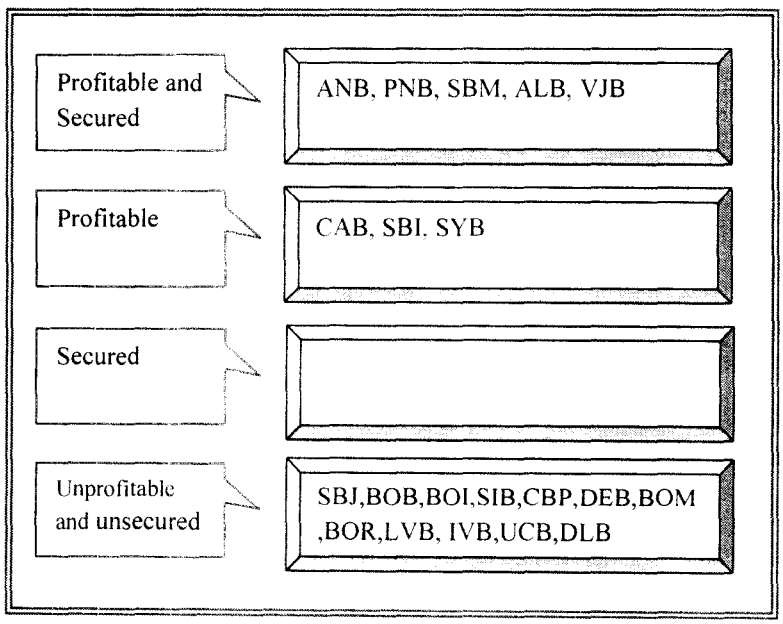
Q4 banks are the banks which are inefficient in resource utilization and less profitable but they have relatively stronger so far as risk management point of view. They may be conservative banks. It may happen that they may not use capital properly. There may be unnecessary block up of capital which may cause lower profitability. They should be very careful in lending activities rather than in savings. They should also explore off balance sheet activities for generating more revenue. Thus the banks of this category

should concentrate over the cost revenue management aspect leading to efficiency improvement.

The banks that fall in the first quadrant (Q1) are most inefficient in respect of three efficiency parameters. These banks are probably under-resourced and lack of skilled management. But they have the greatest potentiality for improvement in efficiencies by increasing management efficiency and using additional resources particularly more capital. For improvement of efficiency, they follow two stage peer banks -first banks of Q2 of inefficient banks group and then banks of Q2 of efficient banks group. First stage helps them how to increase profit and risk efficiency even being technically inefficient and second stage makes them technically efficient with higher profit and higher risk efficiency.

Box: 5.5

Four Categories of Inefficient Banks

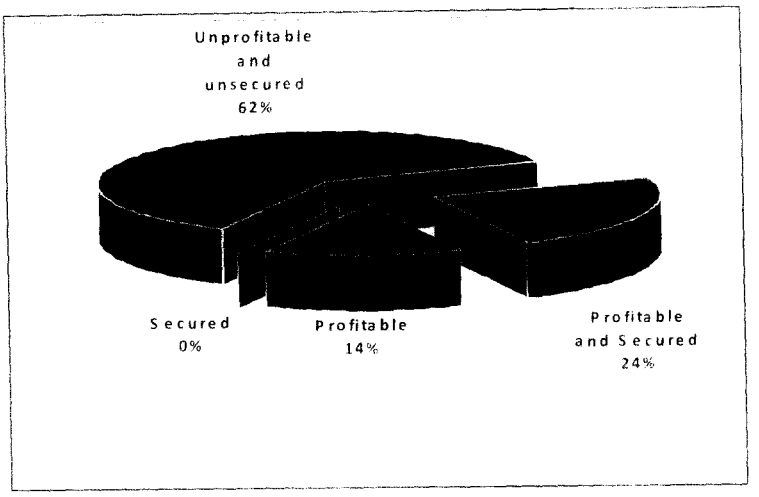


Note: Banks are arranged as per overall ranking position (2005-08)

CAB and SBI can also be placed into profitable and secured category since they are just lying below the risk free line.

Figure: 5.13

Category Wise Number of Inefficient Banks (%)



From the above figure 5.13 it is very clear that the most of the inefficient banks are in the groups of Q1 (most inefficient banks). This finding again proves that DEA efficiency is responsive to risk and return efficiency. On the whole 62% (Q1+Q4) of the inefficient banks are relatively less profitable, whereas, 75% (Q1+Q3) of the inefficient banks are risky. Most of the inefficient banks are facing the problem of risk management particularly in terms of operational inefficiency, instability in profit earning with low capital position in comparison to the efficient banks. Indian banking regulators should take this consideration for taking regulatory measures in order to improve their efficiency level. Thus, the categories of banks using risk-return matrix separately for efficient and inefficient banks helps to find out extreme and non-extreme group of banks from a sample of 36 banks.

Box: 5.6

Two Extreme Groups of Banks

Most Efficient Banks	HDB, KVB, IOB, KTB, SBT, KMB, AXB, FDB, COB, UBI, OBC
Most inefficient Banks	SBJ,BOB,BOI,SIB,CBP,DEB,BOM ,BOR,LVB, IVB,UCB,DLB

Note: Banks are arranged as per overall ranking position (2005-08)

11 banks out of 16 efficient banks over the study period lies on Q2 in Figure 5:11 and can be termed as most efficient banks. They are relatively profitable, secured and technically efficient banks i.e., all round efficient banks. 12 banks out of 20 inefficient banks over the study period lying on Q1 in Figure 5.12 can be termed as most inefficient banks. They are unsound in every respect. It is pointed out that BOI out of most inefficient bank group has been steadily improving its overall efficiency over the study period and has obtained 100% efficiency in PTE in 2008.

Table: 5.27

Mean scores of Profit and Risk Efficiency between two Extreme groups of Banks with F value

Groups	Profit Efficiency		Risk Efficiency				
	ROE	ROA	CAR	AQY	LDY	MQY	RI
Most Efficient Banks	0.735	0.864	0.860	0.728	0.699	0.945	0.468
Most Inefficient Banks	0.456	0.405	0.773	0.352	0.628	0.720	0.108
Difference	0.279	0.459	0.087	0.376	0.071	0.225	0.360
F value	14.837	66.112	7.445	13.571	2.314	24.370	10.249
Sig	0.001	0.000	0.013	0.001	0.143	0.000	0.004

There is a significant difference between these two groups of banks in all the micro parameters (except LDY i.e., liquidity) of profit and risk efficiency. This finding supports the earlier observation of positive significant relation between technical efficiency and financial efficiency and validates the finding of two extreme groups of banks from the sample banks.

This risk-return matrix highlights the importance of using more than one performance measure in order to obtain a better assessment of a bank as it is not possible to account for all aspects of banks' performance using a single indicator. From this analysis it becomes evident that some financial performance enhancement can still be achieved by the efficient banks. Inefficient banks can achieve higher overall performance by improving technical efficiency.

With this analysis, the study has finally concluded that these all round efficient banks are the India's efficient banks of 'Today'. From the trend of magnitude of

frequency in reference sets and year wise overall ranking position over the study period, the study is likely to predict that seven banks from the all-round efficient banks group viz. HDB, KVB, SBT, KMB, FDB, COB, UBI and three other banks viz. IDL, CUB and ICB which are on the verge of achieving the all round efficient bank status are the India's efficient banks of 'Tomorrow' unless there is a radical shift in their fortune.

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Chapter -VI

Summary of

Recommendations and Conclusions

6.1: Introduction

Banking Industry in India has travelled a long way to assume its present status. Banking is the major component of the financial sector in India. Banks are the highest financial intermediaries in our economy. Being a bank based financial system; the banking performance has an obvious impact on the economy in India. It has undergone a major structural transformation after the initiation of financial liberalization in India. Deregulation, financial innovation, securitization, globalization, customers' satisfaction and advances in technology are quickly changing the nature of Indian commercial banking. A keen competition rages among the banks operating in India particularly after the emergence of new private banks and more foreign banks. The relative importance of the public sector banks has been declining. The share of public banks in the asset, deposit and credit has been declining which implies decreasing concentration and increasing competition. The banks have been trying to find new avenues not only to retain the present customer strength but also attracting new customers by offering hassle-free services. Competition from global banks and rural banking & microfinance are now the major issues to be addressed by the Indian banking industry for its growth.

Banking operation in India has already gained tremendous momentum. The focus of all banks in India has shifted their approach to 'cost', determined by revenue minus profit. This means that all the resources should be used efficiently to better the productivity and ensure a win-win situation. This present competitive Indian banking scenario raises certain questions in our mind.

Are Indian banks efficient or inefficient in utilizing their available resources?

Which banks will be able to maintain sustainable growth and development?

Thus, this study has measured and examined the relative technical efficiency of the banks in India during 2004/05–2007/08. The data set is a panel of 36 banks listed in the stock exchange. In order to measure bank efficiencies, it has utilized the non-parametric Data Envelopment Analysis (DEA) approach. Considering the banking operation pattern, objectives of individual banks and the regulatory agency (RBI), the

study has specified four inputs and four outputs following intermediation approach [***Inputs*** - i) No. of Branches ii) No. of Employees iii) Operating Expenses and iv) Deposit, ***Outputs*** -i) Net Interest Income ii) Non-interest Income iii) Priority Sector Advance and iv) Net Profit].

Having obtained the efficiency scores, the study has investigated the various insights to DEA efficiencies and has aspired to make a humble attempt for comprehensive rankings of the Indian banks.

The present study will seek to answer the following questions:

1. Are Indian banks technically efficient in utilizing the available resources?
2. Which banks are fully efficient? Which banks are inefficient in converting inputs to outputs?
3. What is the main source of inefficiency of the Indian banks?
4. What is the nature of Returns-to scale of the Indian banks?
5. Is the strength of efficiency of the Indian banks stable?
6. What should be the input output improvement plan for inefficient banks to become fully efficient ones?
7. Is public sector banks pushed to the back side?
8. Is bank size a matter for technical efficiency gain?
9. Which are the super-efficient banks?
10. What is the overall ranking position of the selected banks based on overall efficiency (technical efficiency (DEA) plus financial efficiency)?
11. What should be the financial strategy for improvement of DEA efficiency?
12. Which are the India's efficient banks today and tomorrow?

6.2: Findings of the study

The study has been carried out with a broad objective to analyse the technical efficiency of the Indian listed banks with the framing of the above mentioned questions. The major findings of this study are summarized below.

6.2.1: Technical Efficiency Level of Indian Banks

The empirical results do confirm that majority of Indian banks efficiently managed their financial resources and the mean overall technical efficiency of the Indian domestic commercial banks (based on sample) during study period is 93.4 %. Therefore, Indian banks could have saved on an average 6.6% of present level of inputs used to produce the present level of outputs. Average pure technical efficiency (i.e. managerial performance) and scale efficiency (operation of banks with appropriate size) are also quite high, which are 95.8% and 97.8% respectively. So, Indian banks are quite technically efficient i.e. converting inputs to outputs in an efficient way during the study period.

Three DEA efficiencies (OTE, PTE and SE) of almost all banks are found to be increasing in trend during the study period.

The study also finds that there is mismatch between pure technical efficiency and scale efficiency. 56% of the sample banks which are CCR inefficient have to face this problem. Average scale efficiency of 31% of the sample banks is10% higher than pure technical efficiency while, pure technical efficiency of balance 25% of the sample banks is about 3% higher than SE. This large difference between pure technical efficiency and scale efficiency can not increase OTE level of the Indian banks beyond 93.4%.

The study also observes that during strong economy, banks are getting the advantage of scale efficiency. Mean Scale efficiency over the study period is highest and stable with lowest asymmetry compared to that of OTE and PTE.

6.2.2: Efficient and Inefficient Banks

One of the greatest advantages of the DEA technique is to categorize the banks under evaluation into two groups- efficient and inefficient. Efficient means efficiency score equal to100% i.e. 100% utilization of the given inputs to produce given outputs in an input-oriented DEA model technique. Inefficient means efficiency score less than 100% i.e. less than 100% utilization of the given inputs to produce given outputs. The study brings the following outcomes.

1. 44% of the sample banks are fully (100%) CCR and BCC efficient where as 14% are fully BCC efficient but not fully CCR efficient. 39% are both CCR and BCC inefficient during the study period.

2. The study has traced out that there are 9 (25% of the sample banks) top performing banks namely COB, IDL, OBC, SBT, CUB, KVB, HDB, ICB and KMB which are fully efficient under both CCR and BCC model during all the years under study. And 9 least performing banks are BOB, BOM, DEB, SYB, UCB, BOR, DLB, IVB and SIB which are CCR as well as BCC inefficient during all the years under study.

6.2.3: Main Source of Overall Technical Inefficiency

There is a relation among these three types of DEA efficiencies – OTE, PTE and SE. which is popularly known as decomposition of efficiency in DEA literature. Following relationship demonstrates a decomposition of efficiency.

OTE = PTE × SE

Most of the inefficient banks in Indian are facing the relation with **OTE< PTE≤ SE** during all the years under study. From this decomposition of efficiency, it is observed that the main source of overall technical inefficiency (OTIE) of the Indian banking is pure technical inefficiency (PTIE) or managerial inefficiency since mean scale efficiency (SE) is more than mean pure technical efficiency (PTE) during all the years of the study. In other words Scale efficiency contributes more towards overall technical efficiency. But

the contribution of SE over PTE towards OTE is not so high since mean SE is more than mean PTE by only on an average 2% over the study period.

The study finds that 44% of the sample banks over the study period are 100% technical and scale efficient (i.e. PTE = SE = 1 and OTE = 1). 56% have overall technical inefficiency. Out of 56%, inefficiencies of 28 % banks are caused mainly by the operation of the banks with inappropriate size rather caused by managerial inefficiency and remaining 28% are caused primarily by managerial inefficiency rather scale inefficiency.

The study also finds that overall technical inefficiency of the banks which are suffering mainly from operation with inappropriate size i.e. scale inefficiency is lower than those banks suffering mainly from inefficient management.

So, it can be concluded that most of the inefficient banks (CCR) have to face the greater problem of managerial underperformance i.e., inefficient operation of banks themselves rather disadvantageous conditions under which they are operating.

6.2.4: Returns-to-scale (Scale of operation)

Scale inefficiency appears to affect the overall inefficiency of Indian banks. Therefore, the issue of scale inefficiencies is explored with greater detail by considering returns-to-scale (RTS) properties of the individual banks.

With the analysis of returns to scale properties of the individual banks, the study has found that over the study period, 45% banks shows constant returns-to-scale (CRS) i.e. operating at most productive scale size (MPSS), 44% decreasing returns-to-scale (DRS) and 11% only increasing returns-to-scale (IRS) in their production technologies. About 14% banks operating at DRS or IRS are very close to 100% scale efficiency. Thus 59% (45% +14%) banks are scale efficient. These findings support the hypothesis that during strong economy banks are getting the advantage of economies of scale i.e. higher scale efficiency.

On an average 55% branches of the banks with DRS are located at rural and semi urban areas where as it is only 41% for CRS banks and 48% for DRS banks. SBI, BOB and BOI belonging to DRS group are suffering from scale inefficiency largely. Their scale inefficiencies are .098, .088 and .086 respectively (from the highest side). The case of SBI is more serious among them. More than 69% (SBI), 64% (BOI) and 60% (BOB) branches are located in rural and semi urban branches. Thus, banks with DRS are operating relatively at the disadvantageous condition than the banks of CRS and IRS.

Another observation is that number of banks with DRS is more than that of IRS through out the study period. Thus DRS is observed to be the predominant form of scale inefficiency in India.

We can conclude that most of the Indian banks during the study period are operating at correct scale. Thus, there is a little scope of improvement of overall technical efficiency by removing scale inefficiency. Dominance of banking operation at rural and semi urban areas is the major contributor of scale inefficiency of the Indian banks.

6.2.5: Stability of the Efficiency Strength

The banks which provide the best practice input utilization or efficient frontier form reference sets of the inefficient banks. In DEA literature these banks are called peer banks and inefficient banks should follow their good operating practice in order to improve efficiency. Magnitude of frequency in reference sets measures the extent of robustness of efficient banks relative to other efficient banks.

By counting the frequency in reference set, the study has discriminated 16 CCR efficient banks as under (based on grand frontier scores)-

Highly efficient banks (f>5) => IDL, SBT, CUB, KVB, HDB and KMB

Efficient banks (f<5) => COB, OBC, UBI, FDB and ICB

Efficient Banks by Default (f=0) => IOB, JKB, KTB, AXB, IIB

Out of the six banks in highly efficient banks group, efficiency strength of IDL, HDB and KMB is found to be very stable since they are in the highly efficient group in all the years under study. COB, OBC, UBI, FDI and ICB are inconsistent in their robustness of efficiencies. IOB, JKB, KTB, AXB, IIB would likely to drop from the efficient frontier if there is even a small increase (decrease) in the value of any input (output) variables.

The study also segregates 20 inefficient banks on the basis of distribution of efficiency scores into three groups.

Marginally Inefficient (.90 - <1) => PNB, SBJ, CAB, SBM, VJB, CBP, ALB, SBI,

Inefficient (.80 - <.9) = LVB, SIB, DEB, I VB, BOM, BOI, BOB, UCB, SYB

Distinctively Inefficient (<.80) => DLB, BOR

We can say that 17% to 31% Indian banks are (relatively) more stable to maintain their 100% efficiency position. 25% to 31% banks are utilizing their resources in a very inefficient way and they could achieve 14% to 30% reduction in the usage of their resources.

6.2.6: Input Output Improvement Plan of Inefficient Banks

An inefficient DMU becomes efficient by improving its input and output. This input output improvement plan i.e. input and output target is called in DEA literature as CCR / BCC projection. This projection shows how inefficient banks become fully efficient by indicating the level of inputs to be reduced and level of outputs to be increased. Based on the CCR projection the study has found inefficient bank wise input output improvement plan (See Table 5.11). The study has also shown inefficient bank wise reference banks i.e. peer banks. Inefficient banks should follow their operating practice to project themselves into efficient frontier.

However, in order to be efficient, Indian inefficient banks have to reduce on an average over the study period the present level of inputs used (selected for this study) by 34.9%. 23.6%, 13.9% and 12.6% for Input-I (No of Branches), Input-II (No of Employees), Input-III (Operating Expenses) and Input-IV (Deposit) respectively. These

projections include two types of adjustments – 11.9% reduction for each input for radial adjustment and the balance for slack adjustment. Radial adjustment removes purely technical inefficiency and slack adjustment mix inefficiency.

Present levels of outputs are to be increased by 2.1%, 11.1%, 2.7% and 10.3 % for Output-I (Net Interest Income), Output-II (Non-interest Income), Output-III (Priority Sector advance) and Output-IV (Net Profit) respectively. These projections include only slack adjustments since the study has followed input-oriented model.

By the magnitude of amount of inputs reduction and output augmentation, the study has found input wise utilization efficiency and output wise production efficiency of the Indian banks. Most efficiently used input is 'Deposit' (being the lowest reduction required ranks first) followed by 'operating Expenses', 'Employees' and 'Branches'. Most efficient produced output is output- I (being lowest augmentation required ranks first) followed by output-III, IV and II.

Therefore, the study has come to conclusion that lack of proper utilization of two categories of inputs viz., branches and employees rather than operating expenses and deposit along with two categories of outputs mainly lower exposure to off balance activities and lower profitability make the Indian banks technically inefficient.

6.2.7: Ownership and Efficiency

During the study period it is find out that there no significant difference in terms of mean efficiency scores between public and private banks. On the whole, new private banks are most efficient followed by state banks, nationalized banks and then old private banks.

Private Banks are ahead of public banks when it is compared in terms of number of fully efficient banks.

Only nationalized banks group is experiencing a steady increasing trend in overall technical efficiency over the study period.

The study has found that pure technical inefficiency is the main source of overall technical inefficiency and this is mainly because banks belonging to OPBs and then NBs.

Thus, we can say that the ownership pattern dose not have any significant impact on efficiency variation among the banks under study.

6.2.8: Bank Size and Efficiency

There is no significant difference among the three groups of banks by size in terms of mean efficiency score and number of 100% efficiency banks during all the years under study. On the whole, an analysis of efficiency by size reveals that the medium sized banks appear to be the most efficient followed by large and then small size banks. There is a clear indication of higher efficiency gain by the large size banks in a steady way during the study period in India. By this steady momentum of efficiency gain, large size banks reach the highest score in OTE and PTE in 2008. So, larger banks are more efficient than smaller banks. This finding leads us to conclude that the entry of foreign banks should not substantially affect the performance of the banking sector in India.

6.2.9: Rankings: Super-efficiency

The super-efficiency model is almost identical to the basic DEA models with the exception that the efficient DMUs being evaluated are allowing efficiency score greater than or at least equal to the value of 1(one). Input oriented SEM provides a means of evaluating the extent to which an efficient DMU is able to increase its inputs level without violating its status as an efficient DMU. Super-efficiency score therefore provides a measure of stability of the 'efficient' status of the efficient DMUs. The first five super-efficient banks over the study period are ICB, KMB, IDL, HDB and JKB. Super-efficiency score wise other banks are presented in Table: 5.18.

6.2.10: Overall Rankings – Super-efficiency plus Financial Efficiency

One of the major limitation of DEA score is that it is very sensitive to the specification of input output variables. The DMU which is efficient with the given input output specification; it may be inefficient with other specifications. Thus, in order to

make rankings more viable and justified, the study has considered three efficiency parameters viz. DEA super-efficiency, profit efficiency and risk efficiency. The five efficient and least efficient banks as per overall rankings over the study period are

DMUs	Rank	DMUs	Rank
HDB	1	BOM	32
KVB	2	IVB	33
SBT	3	BOR	34
KMB	4	UCB	35
ICB	5	DLB	36

Overall rankings of all other banks in the sample for the study period as a whole are given in Table: 5.24.

6.2.10: Financial efficiency vs. DEA efficiency

A significant positive relationship between DEA efficiency and financial soundness i.e. financial efficiency is found in this study as per significant rank correlation between them. Comparison between DEA efficient and inefficient in terms of mean scores on various financial performance metrics indicates that efficient banks relative to inefficient ones have greater utilization of assets, higher capital adequacy ratio, and lower operating cost to operating income and lower risky On the whole, weal capitalized profitable Indian banks are found to have higher technical efficiency over the study period.

6.2.12: Efficient Banks: Today and Tomorrow

11 banks out of 36 banks under study are found in this study as all round efficient banks. These banks are profitable, secured and fully technical and scale efficient over the study period relative to other banks in the sample. They are HDB, KVB, IOB, KTB, SBT, KMB, AXB, FDB, COB, UBI, and OBC. Thus, these banks are the leading Indian banks of 'Today'. The trend of magnitude of frequency in reference sets and the year wise overall ranking position over the study period suggest that nine banks viz. HDB, KVB, SBT, KMB, FDB, COB, UBI, IDL, CUB and ICB are likely to maintain sustainable growth and development in future and they are India's efficient banks of 'Tomorrow'.

6.3: Concluding Remarks

The present study intends to measure and examine the relative technical efficiency of the Indian banking sector during the post reform period covering from 2004-05 to 2007-08. The study has estimated the technical efficiency scores using non-parametric frontier methodology- Data Envelopment Analysis (DEA). This study is not only endeavours to measure the extent of technical efficiency but also to provide strict ranking to these banks in a comprehensive manner.

The empirical results show (as per grand frontier scores) that the level of overall technical efficiency (OTE) of the Indian banking sector over the study period is 93.4% with a range of 64.4% to 100% and 16 banks out of 36 banks are found to be 100% efficient. Thus; average inefficiency in resource utilization is 6.6% implying that the Indian banks could have saved 6.6% of the present level of inputs used to produce the existing level of outputs produced. Study has also observed from yearly efficiency scores that most of the banks under study have improved OTE during the study period. Decomposing efficiency indicates that pure technical inefficiency i.e. management inefficiency is the major source of overall technical inefficiency. Thus, Indian banks can achieve higher efficiency gain through improving managerial efficiency rather scale efficiency. Returns to scale analysis reveals the most of the banks are operating at correct scale. Decreasing returns to scale is observed as the predominant form of scale inefficiency. Input output improvement plan of inefficient banks reveals that the Indian banks are more efficient in using deposit and operating expenses rather than branches and employees as inputs and more efficient in producing net interest income and priority sector advance rather than non-interest income and net profit as outputs. This suggests that most of the inefficient banks need to utilize properly their branches and employees and to enhance the level of non-interest income and profitability for projecting themselves onto the efficient frontier.

Efficiency analysis by ownership type reveals that ownership pattern has no effect on the level of efficiency. However, new private banks as a group are the most efficient

followed by state banks, nationalized banks and old private banks group. Further the study has also shown that there is no significant difference between the three groups of banks by size. Given these empirical results, the issue of the relationship between size and efficiency remains unresolved in India. Over the study period, an analysis of efficiency by size reveals that the medium sized banks appear to be the most efficient in terms of OTE (more than 2% of large size and 4% of small size). But a close examination indicates the large size banks are in a more favorable position as indicated by the slow but steady positive efficiency growth of OTE. In this growth journey, large size banks reach the highest score in 2008. This suggests that larger banks in India tend to achieve higher efficiency gain in the years coming.

ICB bank, KMB, IDL and HDB banks are first four super-efficient banks during the study period. Their super-efficiency scores suggests that they can maintain their 100% overall technical efficiency even after increasing their present level of inputs by about on an average 25%. But, the first four banks as per overall rankings are HDB, KVB, SBT, and KMB and four least efficient banks are IVB, BOR, UCB and DLB banks. The study has revealed that there is a significant positive relation between financial efficiency and technical efficiency. Thus, banks which are technically efficient are also financially sound with greater profitability and lower risk. The analysis of risk-return matrix for efficient banks and inefficient banks separately facilitates to categorize two extreme groups of sample banks- most efficient and most inefficient. Most efficient banks i.e., all round efficient banks are HDB, KVB, IOB, KTB, SBT, KMB, AXB, FDB, COB, UBI, and OBC. Most inefficient banks i.e., relatively unprofitable, unsecured and technically inefficient banks are SBJ, BOB, BOI, SIB, CBP, DEB, BOM, BOR, LVB, IVB, UCB, DLB. With this analysis the study has finally concluded that these all round efficient banks are the India's efficient banks of 'Today'. From the trend of magnitude of frequency in reference sets and the year wise overall ranking position over the study period, the study is likely to predict that six banks from the all-round efficient banks group viz. HDB, KVB, SBT, KMB, FDB, COB, UBI and three other banks viz. IDL, CUB and ICB which are on the verge of achieving the all round efficient bank status are the India's efficient banks of 'Tomorrow' unless there is a radical shift in their fortune.

The practical implication of the research findings is that this study provides inefficient bank wise input output improvement plan which can make them technically efficient. The study suggests which banks should go for scaling down or scaling up their activities in order to take the advantages of economics of scale. The study also provides efficient bank and inefficient bank wise their respective peer banks.

6.4: Suggestive Measures

Based on the observation of this present study and the present banking scenario in India, this study frames the following recommendations for the improvement of the technical efficiency of the individual banks and banking industry in India.

1) The study recommends that the banks in a strong economy should be very careful about the managerial performance rather than scale performance for efficient resource utilization.

2) RBI should continue the reform measures particularly on the existing policy of reducing non-performing assets, rationalization of staff and branches, and capital adequacy norms which will help Indian banks to obtain efficiency gains. RBI can take the measures to make the Indian banks more competitive since the existing level of competition among the banks in India brings positive development, particularly for public banks and forces the banks to operate efficiently. Thus, the permission of overall investment of 74 per cent (maximum) in the equity of private banks of India by the foreign banks as per road map started from April 2009 will make the Indian banks internationally competitive. It will bring higher efficiency gain among the banks, which will ultimately make the Indian banks as leading global banks.

3) Banks, particularly BOM, DEB, SYB, UCB,VJB,IVB,SIB can improve OTE by improving PTE without alteration of scale of operation as a short run efficiency measure and the banks ANB, BOB,BOI, SBI, LVB can improve OTE only by improving SE as a long run measure of efficiency.

4) BOB, BOI, BOM, SYB, SBI should go for scaling down their activities in order to take the advantage of economies of scale. SBI, BOI and BOB particularly should be

very careful about opening of new branches at rural areas. These banks may follow the practice of PNB in this regard. Scaling up of activities for BOR, DLB, IVB, and LVB should be the appropriate strategy to avail the advantage of scale of operation.

5) Inefficient Indian banks in general need to concentrate more on the utilization of their physical capital in terms of branches and employees (from input side) and enhancement of non-interest income and profitability (from output side) for projecting themselves onto the efficient frontier.

6) Banks should use information technology more in providing their services with maintaining higher capital adequacy. They should concentrate more on lending rather deposit mobilization and off balance sheet activities to earn more income for profit maximization. Such a financial operating strategy will make the Indian banks technically efficient.

7) Sample banks in general should follow the strategy of ICB for proper utilization of physical capital (branches and employees), IDL for their strategy of using operating expenses and KMB for appropriate utilization of loanable fund i.e. deposit.

8) For improvement of efficiency (OTE), banks particularly ALB, ANB, BOB, BOI, PNB, IVB, SIB are suggested to give more concentration in lending to earn more revenues rather than savings. For better performing of lending activities, these banks need more technology upgradation. They may have to be to some extent aggressive in lending activities as their asset quality is high i.e. much lower NPA ratio relative to others even efficient banks. Their strong capital position (higher Net worth to Total Assets) will support their aggressiveness in loan application; otherwise they will become more conservative banks.

9) The study has predicted 10 banks (mentioned above) which are Indian efficient banks of tomorrow. All other banks in the sample banks should follow their good practice to improve their efficiency.

10) Lastly, categorization of banks of different types made in this study can help regulatory authorities in determining the future courses of action to be pursued to

strengthen the Indian banking sector further. Regulatory authorities should take care to improve the efficiency level of the most inefficient domestic Indian banks by closely monitoring their operations which ultimately helps to achieve a strong and efficient financial system in India.

At this place, it is worth mentioning that the study has chosen only four years period for analysis when Indian economy was strong and stable. The banks which are found to be efficient are efficient only relatively to the other banks in the sample. The lack of relevant studies on Indian banking efficiency has made our analysis difficult. We tried to solve this problem by reviewing the studies in other countries. According these limitations some suggestions for further research can be proposed. First of all, the time span of the research may be extended, in order to understand banking performance during the strong and weak economy. Secondly, the analysis may go further by looking into determinants of technical efficiency by considering bank-specific and economic factors. In this regard we advise to use Tobit regression model for this analysis. Finally, we sincerely hope that this research opens a broad horizon for further researches to evaluate the efficiency of Indian banking Sector, using frontier approach and in turn will contribute for the development of Indian banks.

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Annexure

Annexure: 4 (A)

Summary of Literature Survey of Inputs and Outputs Variables

Author(s)	Input Variables	Output Variables	Period of Study
Indian Context -			
Ketkar & Noulas (1996)	1.Capital 2.No. of Employees 3.Deposit	1.Advances, 2.Deposit 3.nvestments	1993
Bhattacharyya A., C.A.K. Lovell & P. Sahay (1997)	1.Interest Expense, 2.Operating Expense	1.Deposits 2.Advances 3.Investments	1986-91
Saha & Ravisankar (2000)	1.No. of Branches 2.No. of Employees 3.Establishment & Non-establishment Expenditure	1.Advances 2.Deposit 3.nvestments 4. Spread 5.Total Income 6.Interest Income 7. Non-Interest Income	1991-92 - 1994-95
Ketkar, Noulas & Agarwal (2003)	1.Capital 2.No. of Employees 3.Deposit	1.Advances, 2.Deposit 3.nvestments	1990-95
Sathye M (2003)	Model –A 1.Interest Expenses 2. Non-interest Expenses	1.Net Loan 2.Non-interest Income	1997-98
	Model –B 1.Deposit 2. Staff	1.Net-Interest Income 2.Non-interest Income	
Mohan & Ray (2004)	1.Operating Costs, 2.Deposits	1.Investments, 2.Loans, 3.Non-interest Income	1992-00
Reddy Amarender Reddy (2004)	1.Ffixed assets, 2.Interest expended 3.wages	1.Total income, 2.Liquid assets 3.Total advances	1996-02
Das A, A. Nag and S Ray (2004)[53]	1.No. of Employees, , 2.Fixed Assets, 3.Equity	1.Performing Loans 2.Non-interest Income	1997-03
Ketkar, Agarwal, Singh & Mitra (2005)	Model-1 1.Deposit 2.Staff 3.No. of Branches	1.Advances 2. Investments	1996-03
	Model 2 1..Staff 2.Fixed Assets 3.No. of Branches	1.Advances 2. Investments 3.Deposit	
Chakrabarty & Chwala (2005)	Model A 1Inierest Expenses 2.Operating Expenses	1.Advances 2. Investments 3.Deposit	1990-02
	Model A 1Inierest Expenses 2.Operating Expenses	1Interest Income 2.Non-interest Income	

Debasish (2006)	1. Total deposits received (balance sheet items) 2. Total liabilities (working funds + other liabilities) 3. Labour related administrative costs (Gross wages) 4. Capital related administrative cost (amortization, office maintenance and office supplies, etc.) 5. Operating Expenses 6 .Fixed Assets (balance sheet item) 7 Total borrowings 8 Net worth 9 Net NPA (Non-Performing Assets	1 Total loans extended 2 Total investments 3 Net profits 4 Interest and related revenues 5 Non-interest income (commissions for provision of services and related revenues) 6 Short-term securities issued by official sectors (CNB bills and MOF treasury bills) 7 NIM (Net Interest margin)	1997-2004
Ray (2007)	1.Labor 2.Physical capital 3. Borrowed funds (including deposits) and 4.equity.	1.Credits (adjusted for nonperforming loans) 2.Investments and 3. Other incomes.	1997-2003
Ketkar and Ketkar (2008)	Model-1 1.No. of Bank Branches 2.Equity 3.Total operating expenses 4.Deposits	1.Loans 2.Non-interest Income	1996-03
	Model 2 No. of Bank Branches 2.Equity 3.Total operating expenses	1.Loans 2. Non-interest Income 3.Deposit	
Kumar and Gulati (2008)	1.Physical Capital (Fixed Assets) 2. Labor (Number of Employees) 3.Loanable Fund (Deposit+ Borrowing)	1.Net interest Income 2. Non—interest Income	2004-05
Reserve bank of India (2008)	1.Fixed assets 2. Labor 3.Depodit and borrowing	1.Credit 2.Investment 3. Assets equivalent of Off balance sheet exposure.	1991-2007
Ompakash et al (2008)	1.Interest Expenses 2.Operating	1.Interest Income 2.Fee based 3.Income Investment Income	1999-03
Kumar and Gulati (2009)	1.Physical Capital (Fixed Assets) 2. Labor (Number of Employees) 3.Loanable Fund (Deposit+ Borrowing)	1.Net interest Income 2. Non—interest Income	1992-93 to 2005-06
Global context -			
Miller et al. (1996) USA	1.Total transactions deposit, 2.Ttotal non-transaction deposit, 3.Total interest expenses	1.Commercial and industrial Loan, 2.Consumer, 3. Real estate loans,	1984 - 1990

	4.Ttotal non-interest expenses	4.Investment, 5. Total interest income and 6.Total non-interest income	
Jackson et al. (2000) Turkis	1.The number of employees 2.The sum of non-labour operating expense, direct expenditure on buildings and amortization expenses	1.Loans 2. Demand deposits 3.Time deposits	1999
Casu et al. (2003), European banks	1.Total Cost, 2.Total Deposit	1.Total Loans 2.Other Earring Assets	1993 – 1997
Chansarn Supachet (2008), Thailand	1.Interest expenses in million baht 2.Labor-related expenses (gross wages) in million baht 3. Capital-related expenses (premises and equipment expenses) in million	1.Interest and dividend incomes in million baht 2.Non-interest incomes in million baht	2003-06
	1. Total deposits in million baht 2. Total expense (Interest and non-interest expenses) in million baht	1.Total loans in million baht 2. Net investments in million bah	
Malak REDA (2008) Egypt	1.Labour (the number of fulltime employees on the payroll) 2.Capital (the book value of premises and fixed assets) (3) Loan able funds (the sum of deposit (demand and time) and non-deposit funds)	1. Loans and Overdrafts 2.Off-balance sheet items 3.Other earning assets	1195-2003
Roberta B. Staub (2009) Brazil	1.Interest expenses, 2.Operational expenses net of personnel expenses (proxy for capital expenses) 3.Personnel expenses (labor)	1.investments, 2.Total loans net of provision loans 3.Deposits	2000-2007
Usman et al. (2010) Pakistan	1. Operating Fixed Assets, 2. Deposit 3. No of Employees 4. Bills Payable 5. Borrowing	1. Lending to Financial Institutions 2.Investment 3. Advance	2001-08
Asror NIGMONOV (2010) Uzbekistan	1Fixed assets 2.Operational expenses 3.Total Deposits	1.Total credits - Reserve for possible loan losses 2.Net non interest income 3.Other non-interest income (Dividends, Forex operations, etc)	2004-06
Mohammad Hanif Akhtar (2010), Soudi banks	1.Deposits, 2.Physical capital 3.Operating expenses, and the outputs are:	1.Lloans and advances 2.Investments 3. Non-interest income.	2001-2006
AlKhathlan et al. (2010) Soudi banks	1.Operating expenses 2.Eequity capital 3.Deposits	1.Loans and advances (net)	2003-08

Annexure: 4 (B)

Sample banks with their codes

SN	Banks	Code	Estd.	SN	Banks	Code	Estd.
1	Allahabad Bank	ALB	1865	21		BOR	1943
2	ANDHRA BANK	ANB	1923	22		CUB	1904
3	Bank of Baroda	BOB	1908	23		DLB	1927
4	Bank of India	BOI	1906	24		FDB	1944
5	BANK OF MAHARASHTRA	BOM	1935	25	ING Vysya	IVB	1930
6		CAB	1906	26	J&K Bank	JKB	1938
7	Corporation Bank	COB	1906	27		KTB	1924
8	देना बैंक DENA BANK	DEB	1939	28	Karur Vysya Bank	KVB	1916
9	IDBI BANK	IDL	1964	29	LAKSHMI VILAS BANK	LVB	1926
10		IOB	1937	30	SOUTH INDIAN Bank	SIB	1929
11		OBC	1943	31	AXIS BANK	AXB	1994
12	punjab national bank	PNB	1895	32		CBP	2005
13	State Bank of India	SYB	1925	33	HDFC BANK	HDB	1994
14	यूको बैंक UCO BANK	UCB	1943	34	ICICI Bank	ICB	1994
15	Union Bank	UBI	1920	35	IndusInd Bank	IIB	1994
16	विजया बैंक VIJAYA BANK	VJB	1931	36	kotak	KMB	2003
17	भारतीय स्टेट बैंक State Bank of India	SBI	1806				
18	State Bank of Bikaner and Jaipur	SBJ	1963				
19	State Bank of Mysore	SBM	1913				
20		SBT	1945				

Annexure: 5. (A)

Summary Statistics on Input/output Data

	Inputs				Outputs			
2005								
	Input -	Input -	Input -3	Input -4	[illegible]	[illegible]	[illegible]	[illegible]
Max	9036	205515	1007418	36704753	1394464	711991	5786482	430453
Min	53	1313	6261	233884	7310	1471	42208	-3818
Average	1255	19394	108609	4169179	145672	74549	830360	48725
SD	1637	34347	171454	6186299	232289	124850	1054102	77000
2006								
Max	9143	185388	1172509	38004605	1558913	743520	8001288	440668
Min	78	1385	7018	253268	8300	2191	56714	907
Average	1222	20307	128159	4908487	170553	74697	1160322	54307
SD	1615	30983	201620	6712796	263644	134279	1499199	82617
2007								
Max	9270	185388	1182352	43552109	1605420	592916	10201585	454130
Min	109	1385	8775	308796	9676	2963	70775	1614
Average	1284	20307	142424	6149775	200412	79640	1488859	66151
SD	1627	30983	214638	7961413	282422	129450	1879399	88169
2008								
Max	10183	185388	1260861	53740395	1702122	881075	11923051	672911
Min	180	1385	9654	360843	10480	3622	90877	2527
Average	1395	20307	163759	7529107	216061	121272	1747677	89272
SD	1760	30983	237737	9531838	302346	194649	2162980	127256

Annexure: 5. (B)

Correlations between input and output variables

	Inputs				Outputs			
	Input - 1	Input - 2	Input - 3	Input - 4	Output - 1	Output - 2	Output - 3	Output - 4
2005								
Input -1	1	0.948	0.902	0.919	**0.928**	**0.829**	**0.84**	**0.922**
Input -2		1	0.97	0.981	**0.988**	**0.92**	**0.911**	**0.951**
Input -3			1	0.992	**0.989**	**0.982**	**0.973**	**0.971**
Input -4				1	**0.994**	**0.967**	**0.963**	**0.974**
Output -1					1	0.956	0.957	0.964
Output -2						1	0.982	0.94
Output -3							1	0.954
Output -4								1
2006								
Input -1	1	0.966	0.885	0.909	**0.932**	**0.781**	**0.891**	**0.827**
Input -2		1	0.964	0.968	**0.987**	**0.899**	**0.942**	**0.915**
Input -3			1	0.989	**0.988**	**0.978**	**0.971**	**0.975**
Input -4				1	**0.988**	**0.955**	**0.989**	**0.975**
Output -1					1	0.941	0.967	0.958
Output -2						1	0.937	0.972
Output -3							1	0.976
Output -4								1
2007								
Input -1	1	0.968	0.84	0.887	**0.908**	**0.623**	**0.886**	**0.809**
Input -2		1	0.929	0.945	**0.968**	**0.755**	**0.942**	**0.891**
Input -3			1	0.985	**0.984**	**0.939**	**0.98**	**0.983**
Input -4				1	**0.985**	**0.907**	**0.995**	**0.98**
Output -1					1	0.872	0.985	0.969
Output -2						1	0.9	0.947
Output -3							1	0.982
Output -4								1
2008								
Input -1	1	0.978	0.819	0.922	**0.901**	**0.678**	**0.919**	**0.852**
Input -2		1	0.893	0.958	**0.951**	**0.766**	**0.952**	**0.906**
Input -3			1	0.966	**0.977**	**0.964**	**0.96**	**0.985**
Input -4				1	**0.981**	**0.899**	**0.992**	**0.977**
Output -1					1	0.892	0.97	0.979
Output -2						1	0.9	0.949
Output -3							1	0.973
Output -4								1

Annexure: 5. (C)

Bank-wise Efficiency Scores

DMUs	Yearly Frontier												Grand Frontier		
	2005			2006			2007			2008			2005 -08		
	OTE	PTE	SE	OTE	PTE	SE	OTE	PTE	SE	OTE	PTE	SE	OTE	PTE	SE
ALB	0.848	0.877	0.967	0.901	1	0.901	1	1	1	1	1	1	0.93	0.951	0.978
ANB	1	1	1	0.879	0.918	0.958	0.887	0.927	0.957	0.892	0.926	0.963	0.913	0.968	0.943
BOB	0.878	0.972	0.904	0.817	0.869	0.94	0.827	0.906	0.913	0.809	0.882	0.917	0.838	0.918	0.912
BOI	0.762	0.819	0.931	0.78	0.867	0.9	0.814	0.899	0.905	0.95	1	0.95	0.85	0.93	0.914
BOM	0.746	0.748	0.997	0.873	0.907	0.963	0.852	0.856	0.996	0.904	0.915	0.989	0.858	0.872	0.984
CAB	0.897	1	0.897	1	1	1	0.984	1	0.984	0.937	1	0.937	0.962	1	0.962
COB	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DEB	0.772	0.772	1	0.904	0.951	0.95	0.936	0.946	0.989	0.832	0.833	0.999	0.874	0.886	0.986
IDL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
IOB	0.975	1	0.975	0.99	1	0.99	1	1	1	0.983	1	0.983	1	1	1
OBC	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PNB	0.928	1	0.928	0.963	1	0.963	0.961	1	0.961	0.963	1	0.963	0.999	1	0.999
SYB	0.848	0.879	0.964	0.863	0.893	0.966	0.825	0.846	0.976	0.862	0.894	0.964	0.822	0.853	0.963
UCB	0.775	0.779	0.996	0.796	0.844	0.944	0.84	0.84	1	0.826	0.867	0.952	0.838	0.859	0.975
UBI	1	1	1	1	1	1	1	1	1	0.998	1	0.998	1	1	1
VJB	1	1	1	0.939	0.947	0.992	0.94	0.954	0.985	0.962	0.964	0.998	0.944	0.945	0.999
SBI	0.891	1	0.891	0.931	1	0.931	0.832	1	0.832	0.865	1	0.865	0.903	1	0.903
SBJ	1	1	1	1	1	1	0.96	0.969	0.991	0.933	0.934	0.998	0.983	1	0.983
SBM	0.977	0.977	1	0.959	1	0.959	0.932	0.934	0.998	0.852	0.858	0.993	0.946	0.972	0.974
SBT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BOR	0.632	0.641	0.986	0.562	0.643	0.873	0.746	0.755	0.988	0.651	0.657	0.991	0.646	0.647	0.998
CUB	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DLB	0.702	1	0.702	0.736	1	0.736	0.733	1	0.733	0.783	1	0.783	0.735	1	0.735
FDB	0.894	0.898	0.995	0.986	0.987	0.999	1	1	1	1	1	1	1	1	1
IVB	0.818	0.819	0.999	0.912	0.929	0.982	0.904	0.928	0.974	0.839	0.874	0.96	0.86	0.866	0.994
JKB	0.981	1	0.981	1	1	1	1	1	1	1	1	1	1	1	1
KTB	1	1	1	1	1	1	1	1	1	0.914	0.914	1	1	1	1
KVB	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LVB	0.94	0.982	0.957	0.793	0.96	0.826	0.909	0.979	0.929	0.878	1	0.878	0.894	0.956	0.935
SIB	0.799	0.8	0.999	0.851	0.865	0.983	0.896	0.912	0.983	0.932	0.937	0.995	0.883	0.883	1
AXB	0.92	1	0.92	1	1	1	1	1	1	1	1	1	1	1	1
CBP	0.988	1	0.988	0.84	0.843	0.997	1	1	1	0.849	0.928	0.914	0.943	0.974	0.968
HDB	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ICB	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
IIB	1	1	1	0.919	1	0.919	0.988	1	0.988	1	1	1	1	1	1
KMB	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Annexure: 5. (D).

Bank wise Nature of Returns to Scale

DMUs	Yearly Frontier				Grand Frontier
	2005	2006	2007	2008	2005-08
ALB	DRS	DRS	CRS	CRS	DRS
ANB	CRS	DRS	DRS	DRS	DRS
BOB	DRS	DRS	DRS	DRS	DRS
BOI	DRS	DRS	DRS	DRS	DRS
BOM	DRS	DRS	DRS	DRS	DRS
CAB	DRS	CRS	DRS	DRS	DRS
COB	CRS	CRS	CRS	CRS	CRS
DEB	IRS	DRS	DRS	IRS	DRS
IDL	CRS	CRS	CRS	CRS	CRS
IOB	DRS	DRS	CRS	DRS	CRS
OBC	CRS	CRS	CRS	CRS	CRS
PNB	DRS	DRS	DRS	DRS	DRS
SYB	DRS	DRS	DRS	DRS	DRS
UCB	DRS	DRS	IRS	DRS	DRS
UBI	CRS	CRS	CRS	DRS	CRS
VJB	CRS	DRS	IRS	IRS	DRS
SBI	DRS	DRS	DRS	DRS	DRS
SBJ	CRS	CRS	DRS	IRS	DRS
SBM	DRS	DRS	DRS	IRS	DRS
SBT	CRS	CRS	CRS	CRS	CRS
BOR	IRS	IRS	IRS	IRS	DRS
CUB	CRS	CRS	CRS	CRS	CRS
DLB	IRS	IRS	IRS	IRS	IRS
FDB	IRS	IRS	CRS	CRS	CRS
IVB	IRS	IRS	IRS	IRS	DRS
JKB	IRS	CRS	CRS	CRS	CRS
KTB	CRS	CRS	CRS	IRS	CRS
KVB	CRS	CRS	CRS	CRS	CRS
LVB	IRS	IRS	IRS	IRS	IRS
SIB	DRS	IRS	IRS	IRS	IRS
AXB	DRS	CRS	CRS	CRS	CRS
CBP	IRS	DRS	CRS	IRS	IRS
HDB	CRS	CRS	CRS	CRS	CRS
ICB	CRS	CRS	CRS	CRS	CRS
IIB	CRS	IRS	IRS	CRS	CRS
KMB	CRS	CRS	CRS	CRS	CRS

Annexure: 5. (E)

Profit and Risk efficiency scores

Banks	Profit Efficiency					Risk Efficiency				
	2005	2006	2007	2008	Average (2005-08)	2005	2006	2007	2008	Average (2005-08)
ALB	0.936	1.003	0.839	0.914	0.923	0.525	0.624	0.762	0.685	0.649
ANB	1.087	0.922	0.843	0.799	0.913	0.970	1.087	0.927	0.923	0.977
BOB	0.470	0.539	0.517	0.646	0.543	0.511	0.590	0.601	0.658	0.590
BOI	0.268	0.555	0.740	0.993	0.639	0.430	0.517	0.563	0.615	0.531
BOM	0.390	0.126	0.611	0.684	0.453	0.519	0.508	0.543	0.518	0.522
CAB	0.680	0.829	0.689	0.660	0.715	0.539	0.629	0.652	0.634	0.613
COB	0.610	0.730	0.736	0.855	0.733	0.675	0.688	0.707	0.858	0.732
DEB	0.187	0.229	0.548	0.854	0.454	0.437	0.529	0.538	0.562	0.516
IDL	0.344	0.433	0.421	0.415	0.403	0.772	0.758	0.779	0.696	0.751
IOB	0.921	1.044	1.068	1.073	1.026	0.654	0.702	0.711	0.814	0.720
OBC	1.084	0.768	0.666	0.294	0.703	0.680	0.772	0.720	0.565	0.684
PNB	0.766	0.732	0.694	0.810	0.751	1.219	1.204	0.827	0.708	0.990
SYB	0.621	0.774	0.781	0.785	0.740	0.477	0.573	0.614	0.671	0.584
UCB	0.560	0.304	0.421	0.506	0.448	0.451	0.447	0.489	0.444	0.458
UBI	0.744	0.647	0.689	0.933	0.753	0.509	0.576	0.654	0.915	0.664
VJB	0.933	0.324	0.713	0.632	0.651	0.690	0.644	0.643	0.616	0.648
SBI	0.672	0.676	0.620	0.750	0.680	0.500	0.654	0.681	0.622	0.614
SBJ	0.589	0.415	0.730	0.714	0.612	0.523	0.573	0.686	0.585	0.592
SBM	0.964	0.978	0.889	0.943	0.943	0.593	0.620	0.771	0.670	0.664
SBT	0.715	0.750	0.764	0.854	0.771	0.610	0.591	0.676	0.882	0.690
BOR	0.310	0.158	0.977	0.666	0.528	0.414	0.477	0.711	0.585	0.547
CUB	0.807	0.969	1.025	1.066	0.967	0.495	0.618	0.651	0.701	0.616
DLB	-0.584	0.279	0.422	0.668	0.196	0.421	0.437	0.473	0.474	0.451
FDB	0.438	0.936	0.939	0.767	0.770	0.468	0.670	0.706	0.949	0.698
IVB	-0.168	0.038	0.361	0.517	0.187	0.377	0.510	0.489	0.526	0.476
JKB	0.279	0.453	0.645	0.798	0.544	0.843	0.595	0.632	0.652	0.680
KTB	0.727	0.809	0.729	0.904	0.792	0.835	0.917	0.736	0.647	0.784
KVB	0.725	0.933	0.900	1.002	0.890	0.576	0.697	0.868	0.945	0.772
LVB	0.052	0.370	0.225	0.286	0.233	0.437	0.441	0.509	0.496	0.471
SIB	0.066	0.384	0.588	0.714	0.438	0.409	0.522	0.552	0.652	0.534
AXB	0.731	0.804	0.828	0.816	0.795	0.644	0.654	0.670	0.782	0.688
CBP	0.322	0.558	0.521	0.340	0.435	0.580	0.512	0.480	0.461	0.508
HDB	0.807	0.863	0.884	0.909	0.866	1.418	0.891	0.898	0.825	1.008
ICB	0.818	0.762	0.669	0.666	0.729	0.516	0.688	0.644	0.664	0.628
IIB	0.951	0.170	0.268	0.261	0.413	0.486	0.433	0.465	0.442	0.457
KMB	0.726	0.799	0.574	0.694	0.698	0.784	0.877	0.523	0.623	0.702