CHAPTER 2
REVIEW OF LITERATURE

In this chapter, an attempt has been made to review the empirical studies related to scale economies, x-efficiency and total factor productivity growth of banks. The chapter has been divided into two broad sections. Section I provides the review of studies on scale economies and x-efficiency of banks at national and international level. Section II reviews the empirical studies on efficiency and total factor productivity growth of banks related to India and rest of the world. The final section presents some concluding remarks.

SECTION I

Glass and Mckillop (1991) fitted Translog function to measure efficiency of Irish banking sector for the period 1972-90. They considered advances and investments as output and labor, capital and deposits as input variables. The empirical findings provided the evidence of diseconomies of scale for most of the sub-periods considered in the study. The banks reported 0.024 level of overall scale efficiency, 0.169 level of product specific scale economies with reference to securities held while 0.018 to advances outstanding during the study period. Irish banking industry did not seem to enjoy cost benefits in producing advances and securities jointly. The contribution of technology was estimated to be quite high at the rate of 6.1 percent per annum to total factor productivity growth. The average value of non-neutral technical change turned out to be (-0.11) for the entire study period, which may be attributed to the inefficient adoption of labor saving technology. Finally, the results led to conclude that new employment packages should be introduced to reduce the labor costs from 63-64 percent to 52 percent.

Gropper (1991) fitted Translog functional form to investigate the changes in scale economies of commercial banks in America for the period 1979-1986. Besides total cost, he defined outputs in terms of investments, total loans and trust accounts and inputs in terms of labor, capital and funds. The findings
indicated significant scale economies for small-sized banks (less than $100 million in total assets) but significant diseconomies of scale for large-sized banks in earlier sample years. The branch banks, having less than 100 million total assets, reported significant economies of scale. The similar but somewhat less strong pattern of scale economies was observed in unit banking states. This may be due to the difference in the size of unit banking and branch banking states. He also found that the level of scale economies has increased over the study period. Further, the empirical findings reported that large banks might get cost advantage over that, which existed in previous years due to recent regulatory and technological changes.

Yue (1992) employed Data Envelopment Analysis (DEA) approach to measure efficiency of 60 Missouri banks for the period 1984 to 1990. Banks' outputs have been proxied in terms of interest income, non-interest income and total loans and inputs in terms of interest expenses, non-interest expenses and transaction and non-transaction deposits. He applied two models viz., CCR model and additive model to estimate efficiency of Missouri banks. It has been observed that five of Missouri banks are technologically efficient; however, these banks did not find to be operating at the most efficient scale of operation. The efficiency scores estimated from both of the models did not indicate scale inefficiency as the major source of overall technical inefficiency. Nevertheless, managerial incapabilities emerged to be the responsible factor of technical inefficiency.

Fukuyama (1993) employed DEA approach to measure the extent of technical efficiency and scale efficiency of 143 banks in Japan. The banks have been categorized into three ownership groups viz., city banks, regional banks and former sogo banks. To view this objective, he incorporated labor, capital and funds from customers as input variables and loans and revenue from business activities as output variables for the year 1990. Japanese banks experienced average technical efficiency to the tune of (0.8645), which in turn highlighted about (14 percent) level of inefficiency in the utilization of
critical inputs to produce outputs. The average scale efficiency estimate (0.9844) of banks indicated negligible that is, less than (2 percent) level of scale inefficiency. Thus, a considerable amount of technical inefficiency has occurred due to the managerial inefficiency rather than scale related problems. As for returns to scale, about 81 percent sample banks were found to be operating at increasing returns to scale (IRS) and 12 percent at diminishing returns to scale (DRS). City banks appeared to be best performers on each dimension. Regional banks performed better than former Sogo banks for pure technical efficiency and overall technical efficiency, but ranking was noted to be reversed in scale efficiency estimates. Moreover, scale efficiency estimates were found to be weakly associated with bank size. On the other hand, the relationship of PTE and overall TE with bank size has not been clearly indicated.

Ray and Sanyal (1994-95) analyzed the cost behavior of commercial banks in India for the year 1990. They fitted Translog Cost Function on the cross sectional data set of 16 banks having assets size ranging from Re 3.40-Re 80.50 trillion. To view this objective, they considered input prices of labor, capital and deposits and outputs viz., total deposits, loans and investments. The overall scale expansion of sample banks was estimated to be highly cost efficient. The sample banks were observed to get substantial scale economies over the study period. However, economies of scale were noticed to be inversely associated with size of banks. The expansion of output with existing branches was observed to be more cost effective rather than expansion of output with new branches for a moderate scale of operation. Branch expansion was found to be cost inefficient measure due to the heavy burden on cost structure of banks but observed to be desirable for cost efficiency in case of substantial growth programme. The results also indicated upward revision of wages as cost-neutral in the sense that it leaves the marginal cost of output unaffected.
Favero and Papi (1995) constructed DEA model to measure technical and scale efficiency on a cross section of 174 Italian banks in 1991. They adopted both the asset approach and intermediation approach to accomplish the objective. As per asset approach, outputs are defined in terms of loans, investments and non-interest income and inputs in terms of labor, capital, loanable funds and financial capital. The second definition differed from the first one in that the status of current accounts and saving deposits (constituents of loanable funds) has been shifted from inputs to outputs. The CRS efficiency score worked out to be 0.878 as per intermediation approach and 0.794 as per asset approach while the VRS efficiency came out to be 0.909 for intermediation approach and 0.839 for asset approach. The results did not report much sensitivity to the definition of inputs and outputs. The results also provided the evidence of small deviations in the efficiency scores obtained under CCR and BCC model. Thus, Italian banks did not register considerable amount of scale inefficiency during the study period.

Zaim (1995) employed DEA model to study the impact of liberalization on the economic efficiency of commercial banks in Turkey. He incorporated total of demand deposits, time deposits, short-term loans and long-term loans as output variables and total number of employees, interest expenses, depreciation expenses and expenses on materials as input variables for the period 1981 to 1990. The results reported on an average 10 percent increase in the level of technical efficiency; however, decline in average technical efficiency differences of the banks from the period 1981 to 1990. The proportion of banks that operated at optimal scale increased from 59 percent in 1981 to 68 percent in 1990 through considerable scale adjustments. The findings indicated pure technical component (i.e., 0.833 in 1981 and 0.936 in 1990) as the major determinant of technical inefficiency of commercial banks in Turkey relative to the scale component (0.972 in 1981 and 0.976 in 1990). The rate of change of technical efficiency turned out to be greater in private sector banks as compared to state and foreign banks. As for cost efficiency, the empirical findings illustrated that Turkish banks have
registered substantial fall in costs that is, from 75 percent in 1981 to 38 percent in 1990. The effect of technical inefficiency and allocative inefficiency on cost increases was found to be different for private banks and state banks. A considerable portion of cost inefficiency was noted to be due to allocative inefficiency for state banks. However, technical inefficiency was found to be the responsible for cost inefficiency among private banks. Finally, the results led to conclude that deregulation has succeeded in stimulating Turkish banks to enhance the level of economic efficiency.

Bhattacharya, Lovell and Sahay (1997) conducted a study to measure the productive efficiency of 70 Indian commercial banks for the period 1986-1991. They employed DEA using interest and operating expenses as input variables and advances, investments and deposits as output variables. They also applied SFA to measure the variation in efficiency to a set of temporal, ownership and random noise components. Public banks turned out to be the best performers while foreign banks the least efficient banks in the utilization of critical resources. The average efficiency of PSBs was estimated to be highest (87 percent) followed by private banks (75.88 percent) and foreign banks (75.37 percent) during the study period. Domestic banks showed less variation in their efficiency scores while the opposite was true for foreign banks. Most of the banks were observed to operate at diminishing returns to scale. Furthermore, the results recorded (5.7 percent) portion of variation in efficiency, that is, unexplained by temporal and ownership form effects. The empirical findings also provided the evidence of temporal improvement in the average efficiency of foreign banks, almost negligible improvement of (0.07 percent) in private banks and a temporal decline of (2.69 percent) in the performance of PSBs during the study period.

Chatterjee (1997) made an attempt to identify the scale economy aspect of commercial banks in India for the year 1994-95. He considered two measures of scale economy viz., ray scale economy (under constant output mix) and expansion path scale economy (under changing output mix). To view this
objective, he fitted Translog function on total cost, factor prices of labor, capital and purchased funds and two outputs viz., total advances and total investments. The empirical findings provided the evidence of substantial scale economies among sample banks. The results also illustrated that it would be more cost effective to expand the business with existing branches keeping output mix unaltered. In addition, only the small-sized and medium-sized private sector banks would enjoy cost efficiency by opening up new branches to handle the business under constant output mix. The scope for increased cost efficiency was estimated to be narrow in case of changing output mix with new branches. The empirical findings reported that private banks of all sizes and small PSBs would get benefits from the output expansion with existing branches. However, the banks of any size-group did not provide the evidence of scale economies on the inclusion of branches with output variables. Finally, the study recommended the mergers and regrouping of the banks to realize maximum benefits of scale economies.

De Young (1997) employed Distribution Free Approach to estimate x-efficiency of 618 U.S commercial banks for the period 1984 through 1994. He also applied diagnostic test to reveal the point at which adding an additional year of data no longer improves the resultant estimates of x-efficiency. He considered labor, physical capital and borrowed funds as input and total loans, transaction deposits and fee based income as output variables. The diagnostic test indicated that data of six years is adequate for distribution free approach, where x-efficiency estimates contain small amount of random error. However, the use of data for more than 8 years violated the assumption of constant bank level efficiency and introduced bias in the efficiency estimates over the time. The results reported average x-efficiency within the range of 77 to 79 percent from $t = 1$ to $t = 4$ settled at 80 percent efficiency (approx) for $t > 5$.

Altanbus and Chakravarty (1998) conducted a study to detect inefficiency estimates of 13603 banks in Europe. To view this objective, they fitted
Fourier Flexible Form over the period 1988-1995. The empirical findings reported that mean inefficiency score of European banking sector has turned out to be (0.24893) with dispersion measure of (0.04403). Commercial banks reported higher level of dispersion in inefficiency estimates (0.05590), followed by saving banks (0.01754). Saving banks were found to be homogenous, which reflect most probably the sale of narrower range of products. The results provided the evidence of country differences in the level of x-efficiency, which may be attributed to the difference in the structure of banking system and removal of cross border restrictions. Finally, the authors argued that comparison of banks efficiency across national frontier entails an examination of the difference between countries’ institutional structure of the banking system.

Fat and Hua (1998) investigated the impact of x-efficiency on the share prices of banks in Singapore. They applied non-parametric, DEA technique on three input and two output variables for the period 1992-96. The efficiency scores have been further modified and ranked according to Andersen and Petersen’s Model. The empirical findings reported that banks have experienced remarkable level of x-efficiency (95.3 percent) with standard deviation measure of (0.953) during the study period. The average profit efficiency of six Singapore listed banks was estimated to be (82.6 percent) for the period 1992-96. The results further reported average scale p-efficiency in tune of (95 percent), scale x-efficiency (97 percent) and pure technical profit efficiency (87 percent) among banks in Singapore. Thus, the inefficient production of profits rather than wrong scale of operations were found to be responsible for profit inefficiency. Besides this, larger banks appeared to be more profit and cost efficient than smaller ones. Finally, the results led to conclude that change in share prices or market tends to over-react to year-on-year changes in profit efficiency rather than cost efficiency.

Das (1999-2000) employed DEA approach to measure the performance of PSBs in India for the year 1998. To view this, he used deposits, borrowings
and number of employees as input variables and margin and other income as output variables. The overall average efficiency of PSBs turned out to be 57.18 percent for the year 1998. A considerable amount of efficiency was estimated to be due to technical component (81.44 percent) than allocative component (70.08 percent). Alternatively, PSBs indicated the scope of producing 1.23 times as much output from the same level of inputs. State Bank of India group appeared to be excellent performer in each of DEA efficiency estimates. SBI group performed well with efficiency measure of (96.5 percent) followed by NBs group (75.1 percent). SBI group registered less variation in each of the DEA efficiency estimates relative to NBs. Corporation Bank and Oriental Bank of Commerce emerged to be best performers. However, Indian Bank, United Commercial Bank and United Bank of India proved to be worst performers, which may be attributed to the shift in accounting practices and high level of non-performing assets. Finally, the empirical findings suggest PSBs to concentrate on business with existing level of non-profit liabilities and branches.

Aslan (2002) applied Stochastic Frontier Approach (SFA) to study the impact of deregulation and financial crisis on the productive efficiency of 35 private and 6 foreign Turkish banks for the period 1992-98. A production function technology of three outputs viz., total loans, securities, commission and fee income and three inputs viz., labor, capital and deposits has been conceptualized. He put greater reliance upon management efficiency, which accounts for a higher proportion of costs. The overall mean efficiency turned out to be 73 percent and equivalently the wastage of 27 percent of costs relative to best practice one. The efficiency score of Turkish banks was found to be lower than U.S. and South Korean banks, which may be attributed to Asian financial crisis. The subsequent regression estimates reported financial and currency crisis as the major determinant of overall efficiency. The unstable economic environment was held responsible for a remarkable change in efficiency scores. Finally, the empirical findings
suggested Turkish banks to understand the determinants of inefficiency and adopt appropriate policies to even out cost inefficiencies.

Grigorian and Manole (2002) employed data envelopment analysis to explore efficiency estimates of banks from 17 transition countries for the period 1995-98. They incorporated labor, fixed assets and interest expenses as input and revenues, deposits with net loans and liquid assets as output variables. The results reported more disadvantageous position of the banks in Commonwealth of Independent States (CIS) on the basis of service-based index. Although, the banks in CE (Central Europe) and SEE (Southern and Eastern Europe) did not experience significant lag in terms of revenue generating capacity but the banks in central Europe were found to be efficient in both the terms of revenue generating capacity and ability to provide services to their clients except in the year 1997. The banks in CIS countries have been observed to grow on average (30 percent) followed by SEE countries (16 percent) and CE countries (11 percent) on the basis of service based index.

Kumar and Verma (2002-03) applied DEA to measure the extent of technical inefficiency, benchmarks and targets of PSBs in India. They proxied bank inputs in terms of labor, physical capital and loanable funds and outputs in terms of spread and non-interest income for the year 2001. The overall level of technical inefficiency turned out to be 17 percent, indicating the scope of producing 1.21 times more output from the same level of inputs. SBI group outperformed NBs in terms of operating efficiency. State Bank of India, Corporation Bank and Oriental Bank of Commerce were found to be highly efficient whereas United Bank of India was found to be poor performer as per benchmarking exercise. From the target setting exercise, it has been observed that the inefficient banks will have to reduce physical capital, staff and loanable funds by 52 percent, 22 percent and 21 percent, respectively to attain the level of best practice ones. The relationship of bank size and technical efficiency highlighted that large-
sized banks are more effective in utilizing critical inputs in the production process as compared to small-sized and medium-sized banks. The relationship of efficiency and profitability noted that about 63 percent of PSBs have the potential of increase in the profitability level through efficiency improvement. The Corporation Bank, Oriental Bank of Commerce, State Bank of Patiala, State Bank of Indore, State Bank of Bikaner and Jaipur and State Bank of Hyderabad were found to be the banks with high efficiency and high profitability. In addition, Corporation Bank emerged to be an ideal benchmark on both the efficiency and profitability dimensions of performance.

**Pastor (2002)** conducted a study to examine credit risk and efficiency in European banking system for the period 1988-94. He applied a new three stage sequential technique based on DEA model and on the decomposition of risk into its internal and external factors to obtain efficiency measures adjusted for risk and environment. To view this objective, he considered the sample of 1144 French, 387 Italian, 524 Spanish and 543 German commercial banks. A production function technology of three outputs, two inputs and environment variables has been conceptualized. The results were found to be consistent with all the methods except for single stage method. The efficiency in risk management improved in Spanish banking system, deteriorated in France and remained stable in Italy and Germany. The estimate of average portion of risk management due to internal factors was found within the range of 13 percent to 26 percent. The results also provided that Italian banking industry has recorded higher proportion of bad loans (87 percent) due to internal factors as compared to Spain and Germany (73 percent). The measurement of efficiency without adjusted for risk was estimated to be considerably different from adjusted for risk efficiency especially in case of ‘Efficient in Risk Management’ countries such as Spain and Germany. The efficiency adjusted for risk and environment favorably affected the position of those countries having unfavorable environment effect such as Italy and to lesser extent Spain (with an environment effect of
0.83 and 0.96 respectively) whereas it unfavorably affected German banking sector (with an environment effect of 1.02). The average efficiency of French banking sector did not seem to suffer from any alteration (with an environment effect of 0.99).

Ray and Sanyal (2002) fitted Translog cost function to measure x-efficiency of 27 PSBs in India. They used loans and other earning assets as output variables and labor, capital and physical capital as input variables for the period 1990-91 to 1995-96. The findings reported an improvement in x-efficiency only in case of 13 banks while 14 banks showed deterioration from their respective positions. The trend of improvement was observed to be significant at more than 95 percent level for three banks (State Bank of India, Central Bank of India and Bank of India). However, the trend of deterioration was found to be significant at 95 percent level of significance for UCO Bank. Overall x-efficiency clustered in a narrow range of 25-40 percent for 17 banks and 40-50 percent for 9 sample banks. The variant part of x-efficiency turned out to be statistically significant than invariant part. The empirical findings reported that PSBs have experienced invariant TE to the tune of (75 percent), which may be attributed to short time lag in the diffusion of new technology. Bank of Maharashtra emerged to be the most efficient bank with efficiency measure of 55 percent. In contrast, Syndicate Bank emerged to be the least efficient bank with efficiency measure of 29 percent. The relationship between size and x-efficiency revealed that x-efficiency is unrelated to the size of banks. The upper limit of average x-efficiency worked out to be 86 percent for small-sized, 89 percent for large-sized and 92-95 percent for medium-sized banks. Furthermore, they observed that lower limit falls with an enlargement of bank size while irregularity persists over its upper limit for variant part of x-efficiency.

Altanbus, Carbo and Molynieux (2003) conducted a study to measure efficiency of European and U.S banks for the period 1990-2000. This study covered the sample set of 10274 commercial, 8042 saving and 7425
cooperative banks in view of this objective. They fitted Tranlog function in which total cost and total profit regressed on the input prices, outputs and time trend. The findings reported that saving banks are more cost efficient than their private sector counterparts in all sample countries (apart from in Finland, Netherlands and Portugal). The empirical findings provided the little evidence that private commercial banks are more cost efficient than the mutual sector banks. The commercial banks were found to more profit efficient than their mutual sector competitors (apart from in Finland, Netherlands and Portugal). The greater profit efficiency of CBs might be due to some kind of market power and to revenue generating factors. On the other hand, lower level of cost efficiency of CBs over the mutual saving and cooperative banks might be attributed to high quality services, risk management procedures and greater brand. Large banks, of each ownership type, emerged to be more profit efficient but less cost efficient as compared to small banks from the same ownership category.

Hasan and Marton (2003) made an attempt to measure the efficiency of Hungarian banking sector for the period 1993 to 1997. To view this, they fitted Translog function with total cost, total profit, input prices of labor and borrowed funds and outputs viz., total loans, investments, fee related income and total interest bearing borrowed funds. The sample banks reported (28.76 percent) level of cost inefficiency and (34.50 percent) profit inefficiency for the entire study period. The banks, having no foreign involvement, reported higher cost inefficiency (33.84 percent) and profit inefficiency (38.02 percent) than cost inefficiency (26.07 percent) and profit inefficiency (31.84 percent) of foreign counterparts’. Banks, with at least 75 percent foreign involvement, appeared to be the most efficient group, with cost inefficiency score of (24.73 percent) and profit inefficiency score of (30.03 percent). The banks with 25 percent foreign involvement were found to be relatively less efficient among foreign-based groups with cost inefficiency score of (28.30 percent) and profit inefficiency score of (35.13 percent). These scores were noted to be still lower than the inefficiency score of Hungarian–owned
domestic bank group. Therefore, the empirical findings provided that the extent of foreign involvement variable is significantly associated with lower inefficiency. The higher level of efficiency experienced by foreign banks in Hungary can be attributed to better local market conditions to exploit comparative advantages in terms of lower costs. The merged institutions revealed negative association with inefficiency estimates and got substantial benefits in new banking environment. Despite much development of the banking sector in various dimensions, the empirical findings indicated underdevelopment of Hungarian banking system in terms of provision of credit to enterprises.

Isik and Hasan (2003) conducted a study to measure efficiency for various ownership forms of banks in Turkey. They employed DEA using three input and four output variables for three years viz., 1988, 1992 and 1996. The empirical findings highlighted that Turkish banks have experienced average cost efficiency in order of about (72 percent), allocative efficiency (87 percent), technical efficiency (82 percent), pure technical efficiency (92 percent) and scale efficiency (88 percent). Thus, technical inefficiency is found to be the major responsible factor of cost inefficiency, driven mainly by scale related problems. As for ownership analysis, public sector banks and foreign banks emerged to be better performers in terms of cost efficiency and technical efficiency as compared to private sector banks. Public sector banks were also noted to be allocatively efficient banks on account of lower factor prices than that of its counterpart group.

Li, Hung and Chiu (2003) derived a theoretical framework to predict ranking in the TE of 4 public, 15 mixed and 24 private banks in Taiwan after deregulation. Translog distance function has been fitted to estimate technical efficiency (TE) and to study the relationship among TE and government shareholding for the period 1997-99. To view this objective, they incorporated bank staff, fixed assets and total deposits as input and loans, investments and non-interest income as output variables. The mixed banks
experienced highest level of TE to the tune of (0.958) followed by PSBs (0.953) and private banks (0.926) in both the years of 1997 and 1999. The mixed banks reported average technical efficiency at the level of (0.941) followed by private banks (0.932) and PSBs (0.930) in the year 1998. Commercial banks in Taiwan on an average, showed worse performance after Asian financial crisis in the year 1997. The results suggested that public banks in Taiwan could improve their TE by mixed ownership at diminishing rate (where government shareholding ranges between 0.1 percent to 99.9 percent). Finally, the study recommended that loan quality could be incorporated to make the estimation more accurate.

Sathye (2003) employed non-parametric DEA technique to measure the productive efficiency of 27 PSBs, 33 private sector and 34 foreign banks in India. He constructed two DEA models to show how efficiency scores vary with the use of alternative set of input and output variables. Model A considered interest expenses and non-interest expenses as input and interest income and non-interest income while Model B used deposits and staff as input variables to produce net loans and non-interest income as outputs for the year 1998. Indian banking industry, on an average, achieved (83 percent) level of TE as per Model A and (62 percent) as per Model B. PSBs recorded highest level of average technical efficiency (0.89), followed by foreign banks (0.84) and private sector banks (0.78) as per Model A. But the ranking reversed in Model B, where foreign banks observed to be most efficient with efficiency measure of (0.80) followed by PSBs (0.60) and private banks (0.45). Thus, the results provided that efficiency scores are highly sensitive to the alternative set of input and output variables. Moreover, the empirical findings provided the evidence of higher efficiency scores with the use of interest income and non-interest income as output variables. Thus, the study recommended bringing down the existing level of non-performing assets and curtailing establishment expenses through voluntary retirement scheme (VRS) for bank staff over a period of time so as to enhance the income levels and subsequently to achieve world best practice.
Bos and Kool (2004) estimated stochastic profit and cost frontiers for a balanced panel data set of 401 banks in Netherlands to measure efficiency. A production function technology of five input and four output variables has been specified for the year 1998-99. The empirical findings registered average profit efficiency to the tune of (0.945) and cost efficiency (0.913) with bank specific input prices. The results suggested that banks could, on an average, increase their profit efficiency by (5.5 percent) and cost efficiency by (8.7 percent) per annum. It has also been observed that least profit efficient banks can increase their profit efficiency by (26.8 percent) and the worst performing banks can improve (39.3 percent) on its current cost efficiency. The total profit efficiency did not alter much under the influence of market specific output prices. However, average cost efficiency increased by 6.1 percent with market specific input prices. The large majority of sample banks were found to operate very closely to the frontier when using bank specific input prices. This empirical finding provided the signal that input prices does have direct impact on costs rather than profits.

De, Prithwis Kumar (2004) empirically examined the relationship between ownership, reforms and efficiency for three categories of public, private and foreign banks in India. He applied SFA model to measure both the time-variant and time-invariant measure of TE for the period 1985 to 1995-96. He defined labor, physical capital and purchased funds as inputs and gross income ($Y_1$) and total earning assets ($Y_2$) as output variables. On time-variant efficiency measures, out of 18 banks, only 14 banks improved their efficiency scores in the post-liberalization period. Bank of Tokyo gained the most in TE; however, Vijaya bank attained the least in post-reforms era. State Bank of India, the largest public sector bank, improved its technical efficiency from 47 percent in pre-reforms period to 50 percent in post-reforms period. The average time-variant TE score worked out to be (58.21 percent) for output measure ($Y_1$) and (79.43 percent) for output measure ($Y_2$) during the study period. The empirical findings reported that foreign banks have achieved the highest average efficiency compared to privately owned
and publically owned banks. However, the variations in efficiency scores were estimated to be highest for foreign banks and lowest for PSBs for both the output measures, which may be due to the fact that PSBs are more familiar to the regulatory system. Further, the disaggregated analysis highlighted highest level of efficiency in case of Bank of Nova Scotia whereas lowest level of efficiency in case of Central Bank of India for output measure \((Y_1)\). Moreover, it has been observed that only 23 banks out of 65 banks have reported an improvement in efficiency scores in post-reforms periods in comparison of pre-reforms period. The average time-invariant technical efficiency for the banking industry as a whole worked out to be (64.32 percent and 82.90 percent) for output measures \((Y_1)\) and \((Y_2)\) respectively. The average time-invariant technical efficiency for the banking industry as a whole has estimated to be higher than that of time-variant technical efficiency scores. As for ownership-wise analysis, foreign banks emerged to be top performers irrespective of output measure. PSBs as a group recorded lowest efficiency at the level of 55 percent for output measure \((Y_1)\) whereas private banks reported the lowest efficiency at the level of 79 percent for output measure \((Y_2)\). Besides this, foreign banks captured top positions in ranking on both the time-variant and time-invariant efficiency measures. Overall, the findings did not provide the evidence of an improvement in the efficiency of Indian banking industry after liberalization in 1991-92.

Haunar (2004) employed DEA to detect the extent of cost efficiency differences among German and Austrian banks. He incorporated labor and aggregate funds as input variables and loans and securities as output variables for the period 1995-1999. The average cost efficiency of all the sample banks was estimated to be 0.63 for the period 1995-1999. Therefore, the results imply that the cost inefficiency of about (27 percent) has occurred due to the use of wrong mix of inputs at the given prices rather than the wastage of resources. German banks achieved significantly higher level of cost efficiency (66 percent) followed by Austrian banks (42 percent).
Austrian smaller and German larger banks emerged to be more efficient than other ones. Medium-sized banks on average appeared to be more scale efficient than small-sized and large-sized banks. Besides this, the findings provided no evidence of an improvement in average productivity growth in response to deregulation and merger wave of 90s over the study period. Neither cost efficiency nor scale efficiency and technology inhibited significant changes in TFP growth of banks over the period of time. Finally, the findings recommended the rationale for mergers and acquisitions among banks with similar product portfolios due to increasing economies of scale and decreasing economies of scope in German and Austrian banking sector.

Matousek (2004) conducted a study to measure cost efficiency and scale economies of 1174 banks in eight accession countries namely Czech Republic, Poland, Hungary, Slovenia, Slovakia, Latvia, Estonia and Lithonia. To view this objective, Full Distribution Approach has been applied on unbalanced panel data set for the period 1994-2001. Total cost has been taken as dependent variable and regressed on the input prices of labor and physical capital. The empirical findings provided the evidence of decline in scale economies with bank size. Economies of scale were estimated to be exhausted at the level above US $1000 thousands. The findings indicated the dominance of increasing returns to scale (IRS) among small-sized banks having total assets in the range of US$ 100-300 thousand. On the other hand, gradual decreasing returns to scale (DRS) started to set in when total assets of the banks reach to the threshold limit of US $1000 thousands. The magnitude of x-inefficiency was estimated to be lowest in foreign banking segment than its counterparts. Small banks as well as foreign banks recorded higher efficiency than large banks in all the sample countries. The study led to conclude that further mergers among large CBs can harm the efficiency of banking system as optimal size of the banks seems to be not more than US $ 1000 thousands.
Shanmugam and Das (2004) fitted SFA to measure technical efficiency of various ownership categories of commercial banks in India for the period 1992-99. They incorporated labor, capital, deposits and borrowings as input variables to produce loans, investments, interest-margin and non-interest income as per intermediation approach. The results provided the evidence of larger gaps between the actual and potential performance of banks due to technical inefficiency. The efficiency of raising the interest margin was estimated to be time-invariant while efficiencies of raising other outputs like non-interest income, investments and credits were noticed to be time-variant. Indian banking industry displayed considerable progress in terms of efficiency of raising non-interest income, investments and credits but failed to raise interest margin since 1992. SBI group and foreign banks were observed to be more efficient as compared to their counterparts. The reform period indicated a relatively high efficient period for augmenting investments especially in private sector.

Das, Nag and Ray (2005) employed Data Envelopment Analysis to examine efficiency of commercial banks in India for the period 1997-2003. A production function technology of four inputs viz., borrowed funds, number of employees, fixed assets and equity and three outputs viz., investments, performing loan assets and non-interest fee based incomes has been specified. The results reported that gradual liberalization in 1990s has strengthened and improved the level of operational efficiency of the financial system. Indian banks were not found to be much differentiated in terms of input-oriented or output-oriented technical efficiency and cost efficiency, which may be due to the fact that the input and output prices are yet to be determined by the free play of market forces of demand and supply. In contrast, banks were observed to be sharply differentiated in terms of revenue efficiency and profit efficiency. Bank size, ownership and the fact of being listed on stock exchange were some of the factors, which had a positive impact on average profit efficiency and to some extent on revenue efficiency scores after 1999-2000. Finally, the study reported that median
efficiency scores of Indian banks in general and of bigger banks in particular has improved considerably during the post-reform period. Thus, it can be concluded that liberalization has imparted positive impact on the performance of Indian banking sector.

**Fries and Taci (2005)** adopted SFA to examine cost efficiency of 289 banks in 15 East European countries for the period 1994-2001. They incorporated labor and capital as input variables to produce loans and deposits. An average-sized bank in the sample was found to be operated at a point that is close to constant returns to scale (CRS). Small banks were observed to be operated with significant unrealized economies of scale. This suggested that consolidation of small banks would enhance the level of cost efficiency in banking. The cost efficiency scores recorded substantial increase in initial stage of reforms, which started to decline in advanced stage of reforms. The non-linear relationship among cost efficiency estimates and reforms reflected the transition from defensive restructuring to deeper restructuring (i.e. from cost cutting to innovations), which increases the quality and value added of the banking services. Private sector banks performed better with average cost efficiency measure of (75 percent) than that of state owned banks (53 percent). However, significant variations have been noticed among the average efficiency scores of private sector banks. Privatized banks with majority of foreign ownership were found to be more cost efficient, followed by newly established domestic as well as foreign owned private banks. Privatized banks with majority of domestic ownership were observed to be least cost efficient but still better than state owned banks.

**Singh and Kumar (2005)** employed Data Envelopment Analysis to measure efficiency of various categories of banks in India for the year 2002-03. They considered deposits and operating costs as input and loans, investments and other incomes as output variables. They also estimated stochastic coefficient production approach by taking spread as the function of deposits, borrowings and labor input variables. The empirical findings reported deposits as the
major determinant of spread with input value of (0.59214) followed by borrowing (0.14982) and labor (0.10951). The mean TE measure worked out to be (99.65 percent) for deposits, (87.48 percent) for borrowings and (68.45 percent) for staff. Therefore, all the banks have been observed with efficient use of deposits but not the borrowings and staff as for input use efficiency. SBI and its associates were found to be relatively more efficient with regard to borrowing and staff use followed by nationalized banks and foreign banks. The average input use efficiency of borrowings and staff worked out to be lowest in private banks. As per DEA efficiency estimates, foreign banks emerged to be most economically efficient banks as compared to its counterparts. The average efficiency of PSBs (0.63) has estimated to be much higher than private sector banks (0.40) but lower than foreign banks (0.71). The same observation has been also noted to be true in technical efficiency and allocative efficiency estimates. Finally, the results suggested that banks should go for a system-wide analysis to performance evaluation of banking in general and efficiency evaluation in particular, which can provide long-term sustainable solutions and policy implications.

Sanjeev, Gunjan M (2006) adopted DEA to evaluate the technical efficiency of public, private and foreign banks operating in India for the period 1997-2001. The inputs used in the study are interest expenses and non-interest expenses while interest income and non-interest income have been taken as outputs. The empirical findings indicated that the efficiency of CBs has improved during the study period. Foreign banks appeared to be top most performers with average technical efficiency measure of (64 percent). On the other hand, public sector banks were found to be least efficient banks with technical efficiency measure of (31 percent). The decline in the dispersion of TE scores indicated that banks have become more competitive in response to liberalization and deregulation. The highest level of standard deviations in technical efficiency scores has been observed by foreign banks (0.22) however, the lowest by private banks (0.05). The empirical findings further provided the evidence of negative relationship between non-performing
assets (NPAs) and technical efficiency scores in Indian banking industry. Thus, the results suggested loan managers to sharpen their skills in order to improve loan quality. Finally, the study implies that the banks have responded positively to the reform measures.

**SECTION II**

**Hunter and Timme (1991)** fitted Translog function to study the impact of technological change on the size of firm, efficient scale of output and product mix of large U.S commercial banks for the period 1980-86. They used total loans and produced deposits as output and labor, capital and funds as input variables. Overall, the sample banks experienced significant technological change over the study period. The sample banks experienced (−0.96) percent level of TE change and indicated the reduction in costs by approximately (1 percent) per year due to innovation. Larger banks experienced more technical change and rapid proportionate reduction in real costs than smaller banks. The banks within the assets range of (0.75$ billion to 5$ billion) reported significant scale of output to become cost efficient. Contrarily, the banks within the assets range of (10$ billion to 25 $ billion) provided the evidence of slight diseconomies of scale. Technical change was found to be responsible factor for efficient scale size. The empirical findings violated the Galbraith–Schumpeter hypothesis (GSSB) as larger banks could not innovate at a faster rate than the smaller banks. Therefore, the empirical findings suggested that these banks couldn’t use innovation alone to outpace smaller banks in the long run. Further, technological change was observed to be biased with regard to scale and product mix. Finally, the empirical findings suggested somewhat more concentrate banking structure for significantly lower costs.

**Berg, Forsund and Jansen (1992)** studied the impact of deregulation on the productivity growth of Norwegian banks for the period 1980-89. They employed Malmquist Index by incorporating labor and materials as input and short-term loans, long-term loans and produced deposits as output variables.
The results displayed considerable variations among average and best practice productivity growth rates. Overall, the empirical findings reported little productivity growth at the frontier. However, there was substantial improvement in the relative efficiency of banks during the study period. The results also reported that productivity level of banks has become more equal which indicates that deregulation may have created a more competitive industry. The productivity growth was noted to be rapid in largest banks, which may be attributed to the utilization of excess capacity to some extent, increased domestic competition resulting from deregulation and their effort to become competitive internationally. The regress in total productivity prior to deregulation period may be ascribed to the building up of idle capacity in the advent of deregulation. The productivity growth registered slight decline on the inclusion of loan loss variable in output list. This decrease in total growth has been observed due to the negative frontier growth and poor catching up effect. Overall, the findings reported striking impact of deregulation on the productivity growth of Norwegian banks.

Bhattacharyya, Bhattacharyya and Kumbhkar (1997) fitted Translog model to examine productivity growth on panel data set of PSBs in India for the period 1970 to 1992. They incorporated labor and physical capital as inputs; loans, branches and deposits as outputs and the sum of paid up capital and reserve capital as quasi-fixed factor. They estimated two intermediate models, one with only autocorrelation correction Model A and other with heteroskedasticity correction Model B. The average annual TFP growth rate of PSBs was estimated to be 1.81 percent as per Model A and 2.05 percent as per Model B. Model B not only exhibited higher rate of TFP growth, but also significantly lower rate of scale related growth as compared to Model A. As per Model B, productivity growth was observed to be declined in initial years of nationalization and it was until 1975 that the overall productivity index showed an upward trend. The system regained its base 1970 level of productivity only after 1977. In addition, the effect of technological change was observed to be unfavorable during the first few years. This downward
trend reversed after 1973, technology attained its base 1970 level only after 1975. The results suggest that it took the CBs a few years to absorb the shock of nationalization. But after getting over this initial shock, technology started improving at a constant pace more or less. A positive estimate of scale efficiency index provided the evidence of TFP growth augmented by output expansion. Finally, the study concluded that deregulation or economic liberalization is likely to boost the level of productivity growth and technological progress.

Griliches and Lovell (1997) studied the impact of deregulation on productivity change of saving and commercial banks in Spain for the period 1986-1993. DEA based Malmquist index has been applied on two input and three output variables to accomplish the objective. The results provided the evidence of productivity growth rates in excess of 2 percent per year within each sector. The sample banks experienced productivity growth due to the improvement in the performance of best practice ones in each sector and decline in the dispersion of productivity measures of remaining saving banks. The dispersion in managerial inefficiency was found to be more serious in commercial banks as compared to saving banks sector. The empirical findings reported that scale economies have made a minor contribution to the productivity growth. However, it affected the productivity growth of very large and small banks of each type (both saving banks and commercial banks). The superior productivity performance of saving banks sector over the CBs sector may be attributed to the expansion of several large CBs operating in the region of diminishing returns to scale (DRS). The results reported highest rate of productivity growth in case of those saving banks and CBs that succeeded in reducing their operating expenses, whether or not they shed labor. Banks, which increased their operating expenses, experienced no productivity growth. The isolation of managerial inefficiency from the existed institutional efficiency reported saving banks as the more efficient form of organizational structure. However, the elimination of managerial inefficiency narrowed down the level of institutional efficiency
differentials during the study period. The results reported, on an average, less than (1 percent) per annum rate of potential productivity growth. The potential productivity growth (out of managerial efficiency) was noted to be much slower than actual productivity growth. Therefore, most of the measured productivity growth was found to be associated with managerial efficiency component of generalized Malmquist productivity indices.

Altanbus Goddard and Molyneux (1999) conducted a study to analyze the impact of technical change on the costs of 15 national banking markets in Europe. They applied Stochastic Cost Function based on Fourier Flexible Functional Form, in which total costs depend upon the input prices of labor, loanable funds and physical capital and outputs viz., loans, securities and off balance sheet business. To view this, they considered sample set of 3779 observations for the period 1989-1996. The empirical findings provided the evidence of reduction in total costs on account of technological progress, which accelerated to 3.6 percent by the year 1996 contrary to 2.8 percent in the year 1989. The pure and scale augmenting components of technological change emerged to be the dominant components for the reduction in costs. Besides this, smaller banks were found to be highly engaged in off balance sheet business during early to mid 1990s, which was predominantly undertaken by largest banks at the start of the study period. Thus, the results reported reduction in the efficient scale of operation for off balance sheet business. As for input cost shares, the results indicated fall in its coefficient due to the downward trend of European national interest rates during early 1990s. The fall in the interest cost share coefficient matched with a corresponding increase in the share of labor cost. Thus, labor cost savings failed to make a major contribution to the overall cost savings. Large banks were found to get more benefits from cost savings in lieu of effective adoption of new technology as compared to smaller counterparts.

Mendas and Rebelo (1999) conducted a study to examine efficiency, technological change and productivity of Portuguese banks for the period
1990-95. Translog Variable Cost Function and a Stochastic Frontier Model has been applied using deposits and loans as output and deposit, labor and other materials as input variables. The average inefficiency of Portuguese banks worked out to be 0.057 for the study period. This suggested that banks could save 5.7 percent of variable costs to capture the position on best practice frontier. Despite intense competition, the sample banks did not reveal better performance over the last few years. Larger banks (having net assets more than 1000 million cantos) were found to be more efficient relative to average sized banks (more than 100 million and less than 300 million cantos). Cost efficiency and scale economies did not seem to be correlated with size. The optimal size of banks was noticed to be somewhere in the asset range of 50-100 million cantos. As for technological progress, the empirical findings provided the evidence of technological regress among sample banks over the study period. The average annual real growth rate of costs was estimated to be (6 percent) due to technological recess. Moreover, technological progress/regress did not seem to be related with the size of banks. Further, the investment in new technology and diversification of products did not register positive influence on cost reductions.

Drake (2001) applied non-parametric, DEA technique on panel data set of nine U.K banks for the period 1984-1995 to estimate relative efficiencies and productivity change. He adopted two DEA models and considered inputs viz., fixed assets, labor and deposits and outputs viz., loans, other income, liquid assets+investments as per Model A. As per Model B, he considered fixed assets and number of employees as input variables and loans, other income, deposits and liquid assets + investments as output variables. The results provided the evidence of increasing returns to scale for smaller banks but strong evidence of diminishing returns to scale for big four UK banks during the study period. The alternative use of input and output specification produced somewhat different results of scale efficiency estimates. The minimum efficient scale of operation in UK banking was most probably estimated to be in real asset range of 18.5 dollar billion to 25 dollar billion.
It has been also observed that scale inefficiencies are more severe problems in UK banking than x-inefficiencies (pure technical inefficiency). Besides this, large banks were found to be more pure technical efficient than their smaller counterparts especially in later years of study period. The DEA based MPI suggests that UK banking as a whole experienced productivity growth over the study period driven exclusively by positive frontier shifts rather than negative catch up effect. The productivity estimates obtained as per Model 2 (PA) were noted to be considerably higher than those based upon Model 1(IA). Further, most of the sample banks realized productivity gains on account of negative catch up effect and positive frontier effect. Much of the frontier shifts may be attributed to various efforts undertaken in the elimination of excess capacity in the face of intensified competition in UK financial services.

Kumbhakar, Vivas, Lovell and Hasan (2001) examined the impact of deregulation on the performance of Spanish saving banks for deregulatory period (1986-1990) and post-deregulatory period (1991-1995). They employed flexible variable profit function on three inputs, two outputs and two quasi input variables towards this objective. The time varying output technical inefficiency models reported deterioration in technical efficiency over the study period. The overall mean technical inefficiency and profit technical inefficiency was estimated to be varying from 19.79 to 20.76 percent and from 25.28 to 30.91 percent respectively over the study period. All the models provided the evidence of technological progress. The overall mean technical progress was noticed to be within the range of 4.31 percent to 5.86 percent during these periods. The positive productivity growth of Spanish saving banks occurred more due to technical change and profit technical efficiency change. The period-wise analysis substantiated that Spanish saving banks have experienced slightly higher productivity growth at the rate of (1.90 percent) per annum in post-deregulation period than deregulation period (1.15 percent) per annum. Finally, the results led to
conclude that competition and deregulation have prompted the banking institutions into a more competitive industry.

Das (2002) conducted a study to explore the relationship among risk, capital and productivity growth of PSBs in India for the period 1995-96 to 2000-01. A production function technology of four inputs viz., deposits, borrowings, fixed assets and contingencies and provisions and two outputs viz., bank credit and investment has been specified. The results provided that higher productivity leads to decrease in credit risk and it has positive impact on bank capitalization. This supported the fact that poor performers are more prone to risk taking than better-performing banking institutions. The results also highlighted positive effect of productivity on capital, which can be attributed to regulatory pressure, especially for the banks, which fall short of the prescribed minimum capital adequacy standards. Further, it has been observed that higher capital leads to a rise in productivity of medium-sized banks. For the large and small banks in particular, higher loan growth translated into lower productivity levels. Small-sized banks experienced improvement in productivity growth on account of investment in risk free bonds, less priority sector lending and increased government shareholding. The empirical findings suggested larger banks to have limited government shareholding to improve productivity levels.

Dogan and Fausten (2002) constructed DEA based Malmquist index to measure productivity growth and technical change of Malaysian banking sector. The sample period, they considered, is 1989-98, divided into two sub-periods of 1989-93 and 1994-98. To view this objective, interest expenses and personnel expenses have been used as input variables and investments, loans and deposits as output variables. The results revealed considerable variability in average efficiency and relative performance of least efficient banks for the entire study period. However, no sustained and stable year-to-year trend is discernable during the entire study period, but the point observations for the initial year and terminal years of the study period reported long-term improvement in average efficiency. All the sample banks
experienced decline in mean productivity by (3.3 percent) due to technical change (-4.4 percent), change in pure technical efficiency (0.9 percent) and change in scale efficiency (0.3 percent) during first sub-period. The decline in mean productivity due to the technological regress was moderated later due to improvement in technical efficiency and scale efficiency. The empirical findings reported an erosion in mean productivity by (5.6 percent) on account of technological change (-6.0 percent) somewhat counterbalanced by pure technical efficiency increases (0.3 percent) in second sub-period. Scale efficiency did not seem to contribute anything to the changes in mean productivity during this sub-period.

Carbo, Gardner and Williams (2003) used Fourier Flexible Cost Function approach to estimate technical change for a large sample of European saving banks between 1989 and 1997. A production function technology of three inputs viz., labor, funds and physical capital and three outputs viz., loans, investments and off balance sheet activities has been conceptualized. The results reported that on an average, technical progress has reduced the total cost of European banks by (3.4 percent) per annum while pure TE change reduced the total cost at a diminishing rate from 2.04 percent in 1989 to 1.52 percent in 1997. Therefore, technical progress played a key role in reducing the total cost of large saving banks due to its greater influence on input prices. However, technological arrangements did not uniformly reduce total cost of all the sample banks. Large saving banks showed more efficiency in altering their input mix in response to change in technology. Thus, large banks emerged to be market leader however, small banks to be market borrowers. Finally, the study concluded that large banks have gained more from technological progress, which may be a dominant factor for promoting consolidation in European banking system.

Kumbhakar and Sarkar (2003) analyzed the relationship between deregulation and total factor productivity (TFP) growth of PSBs in India over the period 1985-1996. They defined bank inputs in terms of labor, capital and equity and outputs in terms of loans, deposits and branches. They
used generalized shadow cost function and tested whether regulation has led to distortions in input uses in Indian banking and whether such distortions have declined overtime. The results indicated the presence of significant distortion in input uses of PSBs under the impact of regulation. Further, it resulted in over employment of labor relative to capital throughout the study period. The results noted that magnitude of distortion has declined at marginal rate over the sample years. Thus, the empirical findings provided the evidence of lower productivity levels in PSBs as compared to private banks. The results also reported that private sector banks have improved their performance over the PSBs due to the freedom to expand output while public sector banks did not seem to respond well to deregulation measures. Overall, the results indicated the presence of weak ownership effect on the performance of Indian banking sector.

Galagedra and Edirisuriya (2004) employed DEA based Malmquist productivity index to investigate efficiency and total factor productivity growth of commercial banks in India over the period 1995-2002. Using total deposits and operating expenses as input variables and other earning assets as output variables, no significant growth in productivity (0.6 percent) has been registered. The rate of increase in productivity growth though small was due to technical efficiency, which may be further attributed to scale efficiency (1.6 percent) than that of managerial efficiency (0.1 percent). They also found that there has been no growth in productivity of private sector banks whereas public sector banks witnessed a modest positive productivity change through 1995-2002. The results also highlighted that Indian banking industry is progressing towards the competitive industry as compared to pre-deregulation period. However, the pace of progress did not seem to be satisfactory. The study also illustrated that changes in the national and international market environments and the introduction of new technologies have forced authorities to relax controls over the Indian banking industry to make it more competitive and efficient. Finally, the study suggested that deregulation and more competition should be allowed
within the banking sector for the banks to become more efficient and productive.

Margano (2004) conducted a study to estimate cost efficiency, scale economies, technological progress and productivity growth of banks in Indonesia. He considered the sample set of 28 state and local government banks, 28 joint venture/foreign banks and 78 private national banks. To view this, he applied Flexible Fourier Form of cost function for three inputs viz., labor, funds and capital and two outputs viz., aggregate loans and securities. The average efficiency of Indonesian banking sector worked out to be 79.68 percent for pre-Asian crisis period (1993-97) and it declined to 53.4 percent in post-Asian crisis period (1998-2000). The empirical findings reported an increase in cost efficiency only by 1.26 percent per annum from 1998 to 2000 as compared to 6.33 percent from 1993 to 1997. The ownership-wise analysis reported that joint venture/foreign banks and private banks are more cost efficient than PSBs in both the periods. The level of average scale economies increased to 0.90574 in post-crisis period contrary to 0.83535 in pre-crisis period. The empirical findings provided the evidence of scale economies in public and private banks but diseconomies of scale in joint venture/foreign banks. Besides this, small banks having assets less than 500 billion rupiah provided the evidence of scale economies in both the pre-crisis and post-crisis period. The empirical findings also reported that on average, Indonesian banks have benefited from technological progress and reduced the average cost by 2.98 percent in pre-crisis period. However, technological progress raised the average cost by 6.4 percent in post Asian-crisis period. The empirical findings reported the existence of technical progress for all sized class banks in pre-crisis period but the converse was found to be true in post-crisis period. Further, the results reported that average TFP growth of banks has declined by 1.5 percent in pre-Asian crisis period and by 6.4 percent in post-crisis period. The worse position of Indonesian banking sector in post Asian-crisis period was observed due to the poor performance of joint venture/foreign banks. This may be attributed to the fact that joint
venture/foreign banks have less information on the quality of borrowers. Besides this, smaller banks displayed better performance in terms of productivity growth than that of largest banks. Overall, sample banks were found to be less productive in post-crisis period except in case of those banks having assets more than 999.9 billion rupiah.

Mohan and Ray (2004) conducted a study to measure and compare the productivity growth of PSBs relative to old private and foreign banks in India for the period 1992-2000. They applied Tornquist and DEA based Malmquist productivity index using interest and operating costs as input and loans, investments and non-interest income as output variables as per Model A. Tornquist TFP growth has been also computed using deposit and operating cost as input variables with same set of output variables that of Model A. According to the empirical findings, foreign banks performed well with technical efficiency measure of (0.9403), followed by PSBs (0.8787) and private sector banks (0.6473). The productivity estimates delineated that foreign banks tend to operate at (-3.07 percent) average growth rate relative to PSBs (0.77 percent) and private banks (0.49 percent) as per Tornquist Index applied on Model A. As per Model B, private banks experienced productivity growth at the rate of (0.72 percent) followed by foreign banks (-0.11 percent) and PSBs (-0.58 percent). Total factor productivity growth turned out to be low with the use of loans and investments as output variable. As per Malmquist index, foreign banks recorded total factor productivity growth at the rate of (9.22 percent) per annum followed by PSBs (0.80 percent) and private banks (-1.76 percent) per annum. Further, the results provided that TE change has imparted most favorable influence on foreign banks (0.331 percent) marginal decline in case of PSBs (-0.075 percent) and significant decline in private banks (-3.416 percent). Overall, PSBs experienced highest total factor productivity growth as per Tornquist index but lowest growth as per Malmquist index approach as compared to its counterparts. Finally, the study justified the privatization of PSBs on account of considerable performance gaps among various categories of banks.
Zhao, Casu and Ferrari (2007) employed DEA based Malmquist productivity index to study the impact of deregulation on total factor productivity growth of commercial banks in India. The study is based upon the panel data set of 27 PSBs, 20 domestic private and 18 foreign banks for the period 1992 and 2004. They proxied inputs in terms of total operating costs and outputs in terms of performing loans, other earning assets and fee based income as per Model A. In Model B, same set of input and output variables has been incorporated that of Model A, except the variable total loans has been replaced with performing loans to investigate the risk taking behavior of market participants. The average overall efficiency of Indian banking industry worked out to be (78 percent) for the entire study period, which suggested that banks can go for average reduction in input usages by (22 percent) through best practices to become fully efficient. The magnitude of input waste was estimated to be significantly lower in second sub-period (1998-2004) as compared to first sub-period (1992-97). Foreign banks displayed excellent performance with overall efficiency measure of (81 percent) followed by PSBs (78 percent) and private banks (75 percent) for the entire study period. The period-wise analysis highlighted that foreign banks have achieved highest level of TE (82 percent), followed by PSBs (71 percent) and private banks (71 percent) during the first sub-period. The same observation did not find to be true in second sub-period where PSBs emerged to be top most performers with technical efficiency measure of (84 percent) followed by foreign banks (80 percent) and private banks (78 percent). The substantial amount of technical inefficiency in Indian banking industry has been observed due to scale related problems rather than pure technical inefficiency. PSBs and private banks showed more serious scale related problems as compared to foreign banks. As far as productivity is concerned, Indian banking industry registered an average annual TFP growth rate of 5.1 percent over the entire study period, attributed more to technological progress (4.3 percent) rather than an improvement in technical efficiency (0.8 percent). All sample banks witnessed substantial increase in the TFP
growth rate of (8.7 percent) in second sub-period as against (0.2 percent) in first sub-period. The TFP growth and growth of its indices reported positive upshot of reforms especially in second sub-period. The findings also provided that various ownership groups have experienced productivity gain either due to positive catching up effect or positive frontier effect. Furthermore, most of the foreign banks emerged to technological innovators, which highlight their important role in the introduction of new technology in Indian banking industry. Finally, the empirical findings suggested an urgent need of professional risk management under the new operational environment.

Rezvanian, Rao and Mehdian (2008) employed DEA based MPI to study the effect of different types of ownership on efficiency change, technological change and productivity growth of Indian banking industry. The study is based on the sample of 20 PSBs, 19 private banks and 16 foreign banks operating in India during the period 1998 to 2003. In view of this, they considered advances, securities and other earning assets as output variables and borrowed funds, labor and fixed assets as input variables. A substantial amount of overall efficiency has been observed due to allocative efficiency rather than technical efficiency. Foreign banks reported highest level of overall efficiency to the tune of (65 percent), followed by private banks (39 percent) and PSBs (36 percent). The estimated inefficiencies of private sector banks (61 percent) and PSBs (64 percent) have been observed both due to input over utilization and input mix sub-optimization. The analysis of sources of overall efficiency demonstrated that foreign banks have achieved highest level of TE (80.9 percent), followed by PSBs (58.6 percent) and private sector banks (55 percent). On the other hand, average allocative efficiency has noted to be (80.6 percent) for foreign banks, followed by private banks (73.6 percent) and PSBs (64.3 percent). Thus, the results highlighted technical inefficiency as the main cause of overall inefficiency among PSBs and private sector banks. Further, scale related problems were found to the major source of technical inefficiency existing among PSBs and
foreign banks than managerial incapacities. However, the opposite was noted to be true for private sector banks. As for returns to scale, most of the sample banks were found to operating below their optimal level. The results suggested that these banks could improve their cost efficiency by expanding their size of operation. Besides this, all the sample banks experienced an improvement in productivity growth. However, an improvement in productivity growth of foreign banks was estimated to be significantly higher than those of private banks and public banks. Foreign banks experienced total factor productivity growth on account of an improvement in TE as well as technological progress. Contrarily, PSBs and private banks observed productivity growth exclusively due to technological progress rather than improvement in technical efficiency. Finally, the results suggested that Indian Government should encourage Indian banking industry to enhance its performance and efficiency by setting out the policies to support entry and presence of foreign banks and to encourage mergers and acquisitions among the banks in India.

**Concluding Remarks:** A review of the studies on the efficiency and productivity growth of banking sector demonstrates that the results of efficiency and productivity growth may differ due to the difference in choice of techniques, different set of input and output variables, measurement of those variables, types of data and number of other factors about the applied techniques. As far as techniques of measurement are concerned, parametric and non-parametric approaches have been widely applied in literature. It has been observed that the results may differ significantly between parametric and non-parametric approach mainly due to the intrinsic features of these models. The application of non-parametric approach (DEA methodology) will lead to results that are more effective over the parametric approach (SFA methodology) due to the advantages of DEA as the performance evaluation criteria compared to parametric approach.

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