CHAPTER 2

REVIEW OF LITERATURE

2.1 INITIAL DEVELOPMENTS (1957-1990)

The main principles of Data Envelopment Analysis, using the efficiency frontier estimation approach, were firstly pioneered by M.J. Farrell in the measurement of Productive Efficiency in 1957. M.J. Farrell assumed that the efficiency of an organization was inspired by the works of Koopmans (1951) and Debreu (1951). His great contribution is in construction of a LP model using actual input-output data of a sample of firms, the result which made a numerical measure of the Technical Efficiency of an individual firm in that sample.

The economic theory of production is heavily based on the conceptual use of the pareto-efficiency frontier of production possibility sets to define the production function. The work of R. Shephard (1953), (1970) under restrictions on the mathematical structure of production possibility sets and cost relations developed an elegant transform theory between production aspects and cost aspects Charnes et al (1982).

Koopmans (1951) defined Technical Efficiency of input on the basis of disposability condition, i.e., the vector of inputs is technically efficient if and only if, increasing any output and decreasing any input is possible only by decreasing some other output or increasing some other input. This is the definition of Technical efficiency in absolute term. Farrel (1957) reoriented the direction of development towards the various types of efficiencies referred to as technical, scale, and allocative efficiencies.
Debreu (1951) gave a measure of technical efficiency in terms of maximum possible proportionate reduction of all variable inputs or maximum possible proportionate expansion of all output, which is called radial measure. In econometric modelling the above three approaches are considered by the researchers for studying economic efficiency and technical efficiency measures.

Charnes et al. (1978 and 1979) have made pioneering contributions for the study of DEA. Based on the works of Farrell (1957) the theory relating to DEA has emerged as an analytical tool for measuring the productive efficiency.

Banker (1984) for the first time has developed procedures for estimating most productive scale size using DEA. Banker et al. (1984) have introduced a new separate variable which makes it possible to determine whether operations are conducted in regions of increasing, constant, or decreasing returns to scale (in multiple input and multiple output situations).

The elaborated models for DEA were evolved during 1980's Banker et al. (1984) constructed models for estimating technical and scale efficiencies in respect of DEA the contributions made by above researchers revolutionized the basic ideas of DEA.

Banker and Morey (1986) adapted the mathematical programming treatment of DEA models to allow a partial analysis of efficiency on the basis of exogenously and non-exogenously fixed inputs and outputs.

Thanassoulis et al. (1987) have studied the potential usefulness of DEA involving multiple inputs and multiple outputs. It may be noted the nature of information obtainable for decision making units has further strengthened the theoretical framework.
Dyson and Thanassoulis (1988) discussed in detail the various issues relating to weight flexibility in DEA. They suggested that a procedure in which constraints can be placed for the case where the DMUs to be assessed used only single output.

Wong and Beasley (1990) for the first time developed a method for restricting weight flexibility in data envelopment analysis. Seiford and Thrall (1990) discussed the mathematical programming approach to frontier estimation examined the effect of convexity requirements on returns to scale. They have also made methodological extensions and proposed alternative models.

Smith (1990) extended the traditional ratio analysis by incorporating any number of dimensions of performance using DEA and applied the same to financial statement analysis.

Technical Efficiency, which reflects the ability of a Decision-Making Unit (DMU) to achieve maximum output from a given set of inputs and Allocative Efficiency, which reflects the ability of a DMU to use the inputs in optimal proportions. Fare, Grosskopf and Nelson (1990) providing the best-practice benchmarks as monitoring tool in agency problems.

Seiford and Thrall (1990) discussed the mathematical programming problem approach to frontier estimation and examined the effect of model orientation on the efficient frontier and the effect of convexity requirements on return to scale. They have also made methodological extensions and proposed alternative models.
Thompson et al. (1990) explained the Assurance Region (AR) concept and defined two types of Assurance Regions. In type I Assurance Region, the restrictions on input and output weights are separable, but the constraints of type II Assurance Region create relations between input and output weights.

2.2 FURTHER DEVELOPMENTS (1991 TO 2000)

Boussofiane et al. (1991) have studied the difficulties involved in comparing decision making units in the presence of multiple inputs and multiple outputs.

Kornbluth (1991) investigated the policy effectiveness of player teams in a business game.

Yue (1992) discussed the applications of DEA in engineering and the natural sciences. Anderson and Peterson (1993) developed a modified version of DEA based upon comparison of efficient DMUs relative to reference technology spanned by all other units. In this work they have provided a framework for ranking efficient units and made comparisons with rankings.

Lovell and Pastor (1995) analyzed the envelopment form of DEA due to the fact that translation invariance does not hold entirely for any corresponding deal multiplier model. They have modified the existing radial DEA so that it nearly satisfies both properties via., invariant and translation invariant and introduced new additive DEA models that satisfy both properties.

Fare and Grosskopf (1995) employed DEA for approximating production possibility sets or input/output correspondences.
Sengupta (1996) developed a method for characterizing the empirical distribution of efficient units in DEA and presented two empirical applications based on Cost frontier and Production frontier approach.

Zhu (1996) on the basis of Russel measure developed some weighted non-radial CCR models by specifying a proper set of "preference weights" that reflect the degree of disability of the potential adjustments of current inputs or output levels. This approach gives a scalar efficiency score for DMU to secure comparability.

Seiford (1996) traced the evolution of DEA from the initial publication by Charnes et al. (1978) to the current state of the art. This important work includes an evolution map which illustrates the DEA growth, the timing of the major events, and the interconnection and influences between the topics.

Coelli (1996) developed a computer program to conduct DEA for the purpose calculating efficiencies in production.

Pastor et al. (1997) applied DEA to analyze the performance of banks in US and selected countries of Europe.

Ali and Lerme (1997) developed models that address the measurement of comparative advantage and disadvantage entirely in terms of proportional changes in levels of output, input activities. The assessment of comparative advantage and disadvantage establishes a framework competitive analysis and the feasibility and desirability of strategy.

Athanassopoulos (1997) in his DEA study of Greek bank branch network considers the relationship of the DEA productivity scores with quality. Efficiency Review of financial institutions is described in Berger and Humphrey (1997),
Schaffnit et al. (1997) use data from large Canadian bank to show that branch efficiency has a positive effect on profit.

Coelli, Rao and Battese, (1998) specified that a firm can achieve productivity gains by producing either greater output from a given level of inputs or to produce a given level of outputs by using a minimum amount of inputs.

Comanho and Dyson (1999) described an application of DEA to the performance assessment of Portuguese bank branches and show how DEA can complement the profitability measure.

Joaquin Maudos and Jose M. Pastor (1999) analyses the cost and profit efficiency of a sample of fourteen countries of European Union, as well as Japan and USA. The results obtained shows that USA and Europe gains profit efficiency than Japanese banking system. The result also shows that the inequalities of profitability between countries would be considerably reduced if inefficiency where eliminated, efficiency gains becomes a very important scores of improvements in profitability.

Ikhide (2000) used operating ratios and parametric approach to measure efficiency for the periods 1993-1998 and found substantial existence of economies of scale in Namibian banks. DEA model can be structured either to minimize inputs or to maximize outputs.

Berger et al. (2000) suggests two theories namely the global advantage theory and home field advantage theory. The global advantage theory suggests that foreign banks benefit more from competitive advantages relative to their domestically-owned peers.
2.3 SIGNIFICANT DEVELOPMENTS IN DEA DURING 2001 TO 2010

Cooper et al. (2001) surveyed recently developed analytical tools for studying the sensitivity of DEA results to variations in the data. DMUs are identified into efficient and inefficient performers. They have developed newer methods, and determined ranges within which all data may be varied for any DMU before reclassifications from efficient to inefficient status (or vice-verse) occurs. They also discussed the effects associated with deleting or adding DMUs.


Tone (2001) proposed a Slack-Based Measure (SBM) of efficiency in DEA and stated that this measure deals directly with the input excesses and the output shortfalls of the DMUs.

Chen and Ali (2002) presented mathematical properties which characterize the inherent relationships between DEA frontier DMUs and output-input ratios. They have shown that top ranked performance by ratio analysis is Data Envelopment Analysis frontier point.

Isik& Hassan (2002) claimed that the Technical efficiency is related to managerial factors, while Allocative efficiency is often associated with regulatory factors.

Cinca et al., (2002) estimated the efficiency of DMUs using alternative specification methods and should rely on the average estimated efficiency.
Casu and Molyneux (2003) studied efficiency of 750 selected European banks through intermediation approach.

Zhu (2003) developed models to identify the benchmark in selecting a positive scalar used in converting weak ordinal relations into strong ones. The author has shown that extreme efficient DMUs remain efficient when weak ordinal input/output relations are replaced by strong ones.

Lovell and Rouse (2003) proposed a new super-efficiency model and have given empirical example for comparing two super efficiency models.

Kaplan and Atkinson (2003) determined three dimensions of performance namely service, quality and cost. They created key performance reaches the expected standards.


Asmildet al.(2004) implements DEA window and Malmquist index to analyze the performance of Canadian banking industry over time.

Sufian, (2004) states that Pure technical efficiency is the measurement of technical efficiency devoid of the scale efficiency or the firm's size efficiency effects.

Sarrico and Dyson (2004) have shown that the use of simple virtual restrictions and virtual assurance regions are preferable to the use of the more generally advocated Wong and Beasley's proportional virtual weights restrictions.
They concluded that the use of virtual assurance regions applying to the target unit of assessment can be a natural representation of preference structure and translate established patterns between input-output divide.

Prasuna (2004) analyzed the performance on Indian banks by adopting the CAMEL Model. The performances of 65 banks were studied for the period 2003-04 and the author inferred that the competition was tough and consumers benefited from better services quality, innovative products and better bargains.

Yun et al. (2004) suggested a model called Generalized DEA (GDEA) model in a unified way. By establishing the theoretical properties on relationships among the GDEA model and those DEA models, they have proved that GDEA models make it possible to calculate the efficiency of DMU incorporating various preference structures of decision makers.

Gstach (2005) presented a statistical framework for estimating output specific efficiencies for the two-output case upon a DEA frontier estimate.

Coelli et al (2005) introduced cost minimization DEA model to calculate cost efficiency. The overall cost efficiency is defined as the ratio of minimum cost of producing the outputs to observed cost of producing the outputs for the evaluated DMU (Coelli et al 2005).

The output-oriented DEA model under the assumption of variable return to scale is used for calculating output technical efficiency and revenue efficiency. Coelli et al (2005) presented a revenue maximization DEA problem to calculate revenue efficiency. The overall revenue efficiency is defined as the ratio of observed revenue to maximum revenue for the evaluated DMU.
Coelli et al (2005) specified the profit maximization DEA problem to calculate the profit efficiency. The overall profit efficiency can be defined as the ratio of observed profit to maximum profit for the evaluated DMU.

Ing. Kristina Vincova,(2005) described basic DEA model the study explains the models differ in the efficiency rating . Besides Input and output oriented CCR model has been explained with the numerical examples and graphical illustration of productive unit was also unit line.

Heinz Herrmann TLH (2006) carried a study German universal bank and analyze their level of efficiency based on both efficiency models namely stochastic frontier approach and Data envelopment analysis.

Banker and Chang (2006) conducted simulation experiments to evaluate the performance of two alternative uses of the super efficiency in DEA. In this attempt the first is for outlier identification and the second is for ranking efficient units. It is also stated that when data are contaminated with outliers, the use of super efficiency model to identify and remove outliers’ results in more accurate efficiency estimates than those obtained from the conventional DEA estimation model.

The findings of Havrylchyk (2006) suggest that foreign banks can produce higher profits due to modern information technologies and better risk management.

Kaliba and Engle (2006) estimate technical, allocative and cost efficiency of a sample of small and medium-sized cat fish farms in Chicot country, Arkansas. These authors then regress the cost efficiency score in Tobit model on operator characteristics, farm practices, and institutional support services to determine whether these factors lead to a higher level of efficiency.
Appa and Williams (2006) provided alternative framework for solving DEA models in comparison with the standard LP based approach that solve one LP for each DMU, delivers more information. Using Fourier-Motzkin elimination method they have established the returns to scale status of each DMU and calculated cross efficiencies.

Cook and Zhu (2006) developed a general framework for modelling and treating qualitative data in DEA and provided a unified structure for embedding rank order data into DEA framework.

Asmild et al. (2007) discussed in detail the various aspects involved in measuring overall efficiency and effectiveness using DEA.

English et al., (1993); Al-Sharkaset al.,(2008) states that the Allocative efficiency measures the proportional reduction in cost if the bank chooses the right mix of input to be used.

Ibrahim H.Osman et.al(2008) applied DEA Approach to measure the relative performance of Lebanese banks during 1997-2004. In the study DEA efficiency scores is computed for each bank decomposed into technical and scale efficiencies and tracked on a yearly basis.

Mohammed Khaled I. Bader et al (2008) measured and compared the cost, revenue and profit efficiency of 43 Islamic and 37 conventional banks over the year 1990-2005 in 21 countries using Data envelopment Analysis. The study assesses the average and overtime efficiency of Islamic and conventional banks based on their size, age and region. The result of this study indicates that there is no significant difference between the overall efficiency estimates of conventional versus Islamic banks.
Irsova (2009) compared two methods in bank efficiency, stochastic frontier approach and DEA, which are supported by the meta-regression part including several studies on the USA and transitional countries.

Hirofumi Fukuyama and William L. Weber (2009) extended standard slack based efficiency measures by introducing an index of output slacks-adjusted cost efficiency. Output slack adjusted cost efficiency was further decomposed into the product of cost allocation efficiency and an index of cost efficiency biased due to the existent of the slack in the output constraint defining the DEA technology. The author of the study estimated each efficiency measure using data of Japan securities firms operating the period 2004-2006. The authors also developed and estimated the value biased technical efficiency Index. And it was shown to equal the product of an index of output technical efficiency bias an index of input cost slack biased and radial value-based index input technical efficiency index.

2.4 CONTEMPORARY DEVELOPMENTS (2010 TO 2018)

Castelli et al. (2010) classified the contributions of DEA literature assessing Decision making Units (DMUs) whose internal structure is known.


Richard Mulwa and Ali Emrouznejad (2011) illustrate in the measurement of productive efficiency using Nerlovian indicator and metafrontier with data envelopment analysis techniques. Also, the author illustrates how profit efficiency of firms operating in different regions can be aggregated in to one overarching frontier. To illustrate these concept sugarcane productions in three regions in Kenya has been
consider and used. Results of this study indicates that the sources of inefficiency in all regions are both technical and allocative. But allocative efficiency contributes more to the overall Nerlovian inefficiency or efficiency indicator.

FadzlanSufian,FakarudinKamarudin and Nor HalidaHaziatonMohd Noor (2012) provides a new empirical evidence of revenue efficiency in the Malaysian Islamic banking sector during the period 2006-2010. It is also examining the internal and external factors influencing the revenue efficiency of Islamic banks.17 domestic and foreign Islamic banks are considered for this study and Data envelopment analysis method is employed to compute the revenue efficiency levels. The results indicate that the domestic Islamic banks gets lower efficiency level than foreign Islamic banks.

DariushKhezrimotlagh (2012) in his paper illustrated that a rash method can be used to evaluate the cost efficiency of Decision MakingUnits. It is also proved that with possessive AM there is no require using cost efficiency model. This study mainly focuses on cost efficiency model though AM is able to improve for calculating revenue efficiency and profit efficiency.

R.Pahlavan,M.Omid and A. Akram (2012) has been attempted to assign the technical efficiency and return to scale for green house Cucumber production Eyran using Data envelopment analysis. Input oriented CRS and VRS models of DEA were applied to calculate the average values of Technical,Pure Technical and Scale Efficiency. The result of this analysis revealed that on average about 30% of the total input energy could be saved without reducing the cucumber yield from its present level.
Das and Kumhakar (2012) used hedonic aggregator function to study the productivity and efficiency of Indian banks. From this study they observed the efficiency of public sector bank exceeds the efficiency of private sector banks in the post-reform period 1996-2005.

Paradin and Zhu (2013) investigated 80 published DEA applications in 24 countries that emphasized bank branches. They discussed the key issues in designing DEA models in the relevant studies. They made suggestions on how to design DEA for further experiments.

Fakarudin Kamarudin and Mohamed Hisham Yahya (2013) compared the cost, revenue and profit efficiency of Islamic and Conventional banks in Malaysia over the period 2006-2009. A sample of 39 banks were selected and data envelopment method was used performing the level of efficiencies. The result of the empirical investigation shows that the level of Cost and Profit for Malaysian Islamic are lower compare the Malaysian conventional banks. The study also indicates that the different levels between Cost and Profit efficiency in the Malaysian banking sector are not influenced by revenue efficiency, but rather are subject to influence by internal and external factors.

Fadzlan Sufian et al. (2013) examine the revenue efficiency of Malaysian Islamic banking sector during the period of 2006-2010. The DEA method is employed to compute the revenue efficiency levels. Empirical investigation indicates that the domestic Islamic banks exhibits lower efficiency levels compare to foreign counterparts. In addition, the empirical findings suggest that the foreign Islamic banks exhibits higher efficiency levels for all three efficiency measures namely Cost, Revenue and Profit.
Besides additionally the authors attempted a series of parametric and non-parametric tests to examine whether the domestic and foreign Islamic banks in Malaysia are drawn from the same population.

Nikita Agarwal et al (2014) attempted to study the performance of Indian bank with the help of CAMEL rating system, eighteen banks including eight private sector and ten public sector banks over the period of ten years are considered for this study than the authors of the study evaluated the efficiency of banks by using data envelopment analysis in terms of gaining confidence from investors and ranking them accordingly. Findings of these studies indicate private sector banks are in advantage situation and show marked consistency in their efficiency level during the study period.

Yu et al. (2014) has proposed an alternative approach through DEA for handling multiple inputs and multiple outputs in evaluating the efficiency of Taiwan public listed companies.

A.R.Jayaraman and M.R. Srinivasan(2015) provided the wholistic approach to measure the profit efficiency of banks, with desirable and undesirable outputs, using Nerlovian profit indicator approach. Using directional distance function, the profit inefficiency of banks was decomposed into technical and allocation inefficiency. Analysis of this study reveal that profit inefficiency of banks is primarily due to allocative inefficiency and authors suggested that the banks need to focus on optimal utilization of input- output mix to enhance profit efficiency.

Nand Kumar and Archanasingh (2015) used CCR model and BCC model to estimate the technical and scale efficiency of commercial banks in India during the period 2006-2010. The empirical investigation of the study indicates that the
deregulation of banking sector has led to an increase in the efficiency of commercial bank in India. It is found that the increase in efficiency of banks in India is not only because of increasing in pure technical efficiency but also due to increase in its scale efficiency. The estimated results also show that performance of private sector banks has been better than public sector banks and the source of inefficiency is mainly due to its scale rather than pure technical inefficiency.

Saha et al. (2015) found that size, capital and profit of Malaysian banking system have significantly positive relationship with efficiency but expenses and non-performing loans have significantly negative relationship with the efficiency.

Saravanan and Prakash (2015) evaluate the pure technical efficiency of Public Sector banks in India and identified 7 banks are efficient.

Tata Hari Krishna and Nimmagadda VijayaSai (2016) analyzed the financial efficiency of commercial banks in India through the hybrid DEA method. This study is based on panel data of bank for the period from 2011-2015. There are many methods for ranking DMU in DEA analysis. But in this study the authors proposed a method based on the TOPSIS for ranking efficiency DMU in Data envelopment analysis.

Ombir Singh and Sanjeev Bansal (2016) investigated and compared the performance of the Indian public sector banks (PSBs) based on revenue maximizing efficiency in the deregulation period from 2001-2013. Using DEA, the authors evaluated efficiency estimates namely Overall technical efficiency, pure technical efficiency and scale efficiency of individual banks. The empirical results indicate the presence of managerial and scale inefficiencies in the study also assets the impact of different environmental factors, like profitability, the level of non-performing assets,
size etc. On the efficiency of PSBs, through Tobit regression analysis, the author of this study observed that banks with high profitability, low level of non-performing assets, and relatively larger size are more technically efficient.

Qamruzzaman Md and Jianguo WEI (2016) identified financial efficiency level of financial institutions (banks) in Bangladesh over the period 2011-2015. Their study revealed that above 62% of the banks performing efficiently under CRS assumption and 75% banks performing efficient under VRS assumption in respect of both input and output orientation.

Mojtaba Ghiyasi (2017) addressed the inverse DEA problem in the study when the price information is available. A theoretical foundation of the problem was also developed in this study few numerical examples along with empirical application were illustrated. Models proposed in the study have MOLP structure and are radial based on a technology with constant returns to scale technology.

### 2.5 APPLICATIONS OF DEA IN VARIOUS SECTOR

Sherman and Gorld (1985) applied DEA in banking sector as the first and evaluated operating efficiency of 14 saving bank branches.

Berger and Humphrey (1997) examine the efficiency of 130 financial institutions partly to address to impact of foreign ownership. The findings of this study indicate that the relative efficiency of foreign versus domestic ownership appears to depend on the host and home country conditions.

Parker and Wul (1998) discuss the performance related to privatization. For the above discussion they assessed the performance of British steel industry before and after privatization in 1998. This study confirms the existence of efficiency gains before privatization.
Prakash and Jayarani (2013) studied the performance evaluation of public sector banks in India through DEA technique and identified 17 banks are technically efficient.

Tektas and Tosun (2010) analyzed the performance of Turkish Food and Beverages companies based on DEA. They have identified the best practice supply chains as well as the inefficient once and their causes using DEA. They have discussed in detail Food and Beverage company’s global competitiveness as well as the improvement opportunities.

Ozden and Senkayas (2012) analyzed the structure of the effectiveness and productivity of Turkish food industry and concluded that small enterprises are much more efficient than public enterprises. It is also stated that public enterprises suffer from a decrease in efficiency resulting from scale economies.

Selamat and Nasir (2013) analyzed the efficiency of agriculture sector in Malaysia. They have evaluated technical efficiency and Technological change amongst selected agricultural firms in Malaysia. They have identified the influencing factors contributing to efficiency of agriculture sector.

Rani et al.(2014) applied an integrated approach based on simulation and DEA methodologies for improving the performance of Small Medium Enterprises (SME) food production system in Malaysia. They have concluded that the study will be useful for strengthening and to increase the efficiency of food production system.

Olanrewaju et al. (2015) assessed the possible energy potential in Food and Beverage Industry using Index Decomposition Models (IDM), Artificial Neural Network (ANN) and DEA. They have combined the strength of those models to allow biases in the other. The study revealed that the integrated model applied to the
food and beverage revealed that approximately 11% of energy consumed could be saved.

Danijela et al.(2011) conducted a study to evaluate the efficiencies of ports on the territory of Serbia in order to identify the sources of inefficiencies and formulate proposals for developing the services of the ports and their operations through a four-year Window Analysis with port efficiency trends and average efficiencies.

GordanaSavic et.al (2012) conducted DEA window analysis for the efficiency assessment of banks in Serbia based on panel data for the period from 2005 to 2011. This analysis provides trends of efficiency and the rank of each bank evaluated in terms of its profit and operating effectiveness.

After analyzing the effects of various indicators on the efficiency of twenty-two commercial banks in Nepal, BiweshNeupane (2013) declared that the productivity change of commercial banks in Nepal has improved over the sample period and the increase in productivity change in Nepalese commercial banks is due to the technical progress rather than efficiency components.

IvetaRepkova (2014) performed DEA Window Analysis based on unbalanced panel data with undesirable output, to estimate the efficiency of the Slovak commercial banks during the period 2003-2012. In this Analysis, it is interesting to note that the largest banks in the Slovak banking market were lower efficient than medium-size and small banks.

Kutlar et al (2015) obtained technical efficiency and allocative efficiency scores of 23 commercial banks which operate in Turkey uninterruptedly between 2003-2012. DEA Window Analysis specifies that public banks with high amount of
deposits tend to have higher efficiency scores while private banks have lower efficiency scores. The Malmquist Index is used to analyze total factor productivity and it increases merely by two thousandth (0.002) for all the enterprises.


Prakash, V., Annapoorni, D.,(2015) evaluated technical efficiency of district headquarters hospital in the state of Tamil Nadu, India using data envelopment analysis and fixed a benchmark for inefficient hospitals.

Annapoorni D and Prakash V (2016) applied principal component analysis combined with data envelopment analysis to reduce the data to a parsimonious set of inputs and outputs and found exact number of efficient units in hospital data.

2.6 CONTRIBUTIONS IN DEA WITH RESPECT TO ECONOMIC EFFICIENCY

Kaur and Kaur (2010) using DEA studied the impact of merges on the cost efficiency of Indian commercial banks. This study import that the stronger banks should not merge with the weaker banks.

Ray and Das (2010) studied the cost and profit efficiency of Indian banks during the post reform periods. Their study reveals that public sector banks are more efficient than private sector banks and small banks and also the study contains a strong evidence of ownership explaining the efficiency differential of banks.
Gholamhossein Mahdavi et al. (2012) investigated cost, revenue and profit efficiency of automobile and parts industry of companies listed in Tehran stock exchange during the year 2006-2009. Further the study explored potential relationship between a few variables namely size, operating costs and profitability etc. and different efficiency measures of cost, revenue and profit efficiency. It was found that there is a positive correlation between the size of a company and it is revenue efficiency and profit efficiency.

Aswini Kumar Mishra et al (2013) initially used CAMEL approach over the period of 12 years to analysis the soundness of 12 public and private sector banks based on market cap. The study established that private sector bank is at the top of the list, with their performances in terms of soundness being the best. Secondly the author measures the efficiency of 12 public and private sector banks using Data envelopment analysis techniques. DEA provides significant insights on efficiency of different banks and places private sector ones at the advantage situation and thereby hints out the possibility of further improvisation of most of the public sector banks.


Said Seif Mzee and Masoud Rashid Mohamed (2014) investigated the cost and profit efficiency and management behavior of 25 Tanzanian commercial banks. The study also examines the influence of ownership, bank profile, size and corporate structure on bank efficiency. The finding of this study provides interesting results taking all banks together, Banks in Tanzanian commercial banks found to be more profit efficiency than cost efficiency, while domestic, listed and new banks are found to be more cost efficient than their counter parts where on bank management
behavior. The result show that inefficiency of bank in Tanzanian is not cost by neither banks’ bad management hypothesis.

Diego Prior et al (2016) explicitly explores the seriousness about to confine the analysis to one side of banks activities only, comparing the efficiencies obtained by either minimizing the costs and maximizing revenues. The authors focused on Spanish banking sector for their analysis. This study indicates savior’s biasedness of the analysis if only the partial efficiency measurement is conducted. So, the authors extended the analysis of efficiency to considered both sides namely cost and revenues.

Tugba Eyceyurt Batir et al (2017) evaluate technical, allocative and cost efficiency of conventional and participation banks in turkey through Data envelopment analysis. The main purpose of this study is analyzing efficiency of banking system in turkey and compare the efficiency of participation banks and conventional banks. Besides to determine the factors influencing the efficiency Tobit regression analysis is used in this study. From the results the authors observed that average participation of bank efficiency is higher than the average conventional bank efficiency each year. It’s also found from Tobit regression analysis while expenses and loan quality have a significantly negative relationship with efficiency of conventional banks they have a significantly positive relationship with the efficiency of participation bank.

Jayarani and Prakash (2017) evaluated efficiency estimates in respect of Cost, Revenue and Profit of Indian private sector banks during the period 2015-2016 under VRS assumption. Empirical investigation of this study indicates that a greater number of DMUs are profit efficient and the level of average cost efficiency is
higher than the level of average Revenue efficiency and the average profit efficiency.

Jayarani and Prakash (2017) compared cost and revenue efficiency of public sector banks in India for the period 2015-2016. For this study, 27 public sector banks in India are considered and BCC model in respect of both input and output orientation are applied here. The result of empirical investigation indicates that cost efficient DMUs are technically and allocatively efficient. Besides, technical efficient DMUs are not necessarily cost efficient and allocative efficient.

Ashrafi.A and MansouriKaleibar.M (2017) proposed generalized cost, revenue and profit efficiency models in Fuzzy DEA. The practical application of this models is illustrated by a numerical example the models in this paper are developed under the CRS assumption.

Kumari I.G.S. (2017) investigated the financial performance of foreign commercial banks in Srilanka. Though there are many studies related to the financial performance of banking sector using the various statistical methods in this study the CAMEL rating system is used to study the financial performance of foreign commercial banks in Srilanka three foreign banks are selected for the analysis and data was calculated for the time period 2008-2014. In this study reveals the fact that foreign sector banks are good in the performance of Capital adequacy ratio and Earning while other variable show an average performance.

AshwinPurohit and PrincikaBothra (2018) attempted to measure the financial position of top two major banks in India. In this study one public sector bank and one private sector bank are selected has a sample and an evaluation has been carried out by using CAMEL parameters.