Measurement of Banks Efficiency with Data Envelopment Analysis: A Review of Academic Literature

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In this ever changing scenario, banking services play significant role to every one of us. Today's more open and stiff competition in banking milieu has heightened the assessment requirement of resources used by banks for doing quality & profitable banking business. Reforms initiated since Liberalisation, Privatisation, Globalisation were intended to impart efficiency, productivity, profitability. Service industries attract more and more attention of scholars to analyze resource utilisation capability & efficiency of banks from time to time. Data Envelopment Analysis is a very powerful linear programming/mathematical and benchmarking technique which was originally developed by Charnes, Cooper & Rhodes.DEA applied to evaluate the relative efficiency of homogenous DMUs (Decision Making Units) using multiple input and output data. It compares service units considering all resources used, services provided, identified most efficient units or best practice units, distinguish the efficient commercial banks from inefficient ones in which real efficiency units improvements are possible. This paper presents an academic literature reviewed on DEA results with various approaches, techniques and models for the period from 1978-2016 at international level. Eminent scholars used DEA with various methods & orientation to set the benchmark for inefficient decision making units as compare to efficient units among same & comparative banks. From literature review this paper demonstrated that DEA technique has used by researchers with models-input oriented (BCC), output oriented-(CCR), neural network, techniques- bootstrapping, Monte Carlo, simulation, approaches- intermediation, production, value added, two stage, three stage and different types of efficiencies- allocative, cost, profitability, marketability, technical, scale, revenue and operating efficiency.

Key Words: *Academic Literature,Benchmarking, Commercial Banks, Data envelopment analysis, Decision making units, Efficiency.*

JEL Classification: G2, G20, G21

1. INTRODUCTION

Commercial banks play a vital role in the economy for the two reasons: they provide major source of financial intermediation and their checkable deposit liabilities represent the bulk of the nation's money stock. Evaluating their overall performance, efficiency and monitoring their financial conditions is important to depositors, owners, potential investors, managers and of course, regulators. Efficiency and quality of banking services occupy important place to every one of us now a days. Top bank management wants to identify and eliminate the underlying causes of inefficiencies, thus helping their firms to gain competitive advantage, or, at least, meet the challenges from others. Banks are increasingly using DEA as a tool for assessing, monitoring and improving the performance. The capability of dealing with multi input/output settings without any specific assumption or relationships between inputs & outputs provides DEA the

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superiority over other analytical tools related to assess bank's overall efficiency. To remain competitive in this ever changing scenario, there is significant need to evaluate the resource utilisation skills of banks from time to time. Data Envelopment Analysis is a very powerful service management and benchmarking technique originally developed by Charnes, Cooper and Rhodes (1978) to evaluate nonprofit and public sector organisations. The main contribution of this paper is the analysed the literature used by different eminent scholars for the assessment of banking efficiency and identification of appropriate inputs and outputs.

PLAN OF THE PAPER

The following Section 2 describes the characteristics of DEA and procedure required to apply it on bank branches. Section 3 analysed the DEA implementation by various eminent scholar. Section 4 describes basic efficiency concept of DEA. Section 5 deals with the process of identifying the outputs and inputs for the DEA evaluation. Section 6 reports the results of the DEA evaluation of the branches. In the concluding section, we review the potential strengths and limitations of using DEA to evaluate bank branch efficiency.

2. WHAT DOES DEA DO?

DEA differs from a simple efficiency ratio in that it accommodates multiple inputs, outputs and provides significant additional information about where efficiency improvements can be achieved and magnitude of these potential improvements. Moreover, DEA gives the benefit of the doubt to each branch or service unit in calculating the efficiency value. In addition, DEA will not erroneously locate an efficient unit as inefficient.

(a) DEA compares service units considering all resources used & services provided, identified most efficient units or best practices units (branches, departments, individuals) and the inefficient units in which real efficiency improvements are possible. This is achieved by comparing the mix and volume of services provided, resources used by each unit compared with those of all the other units.

(b) DEA calculates the amount and type of cost and resource savings that can be achieved by making each inefficient unit as efficient as the most efficient or best practice-units.

(c) Specific changes in the inefficient service unit are identified. DEA estimates the amount of additional service an inefficient unit can provide without the need to use additional resources.

(d) Provide information about performance of service units that can be used to help transfer system & managerial expertise from better managed, improving the productivity of the inefficient units, reducing operating costs & increasing profitability.

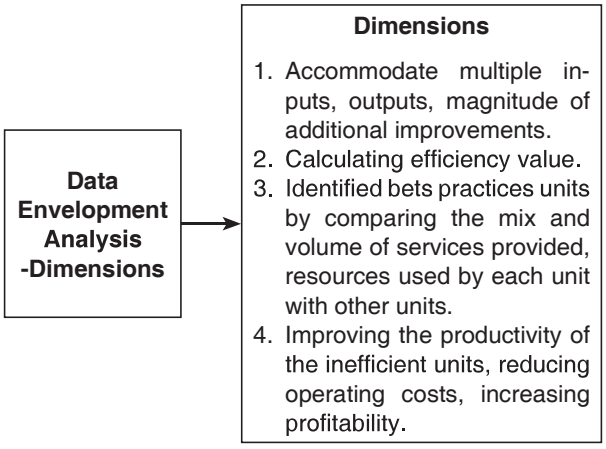

Figure 1. Dimensions of DEA

The Mathematical Formulation of DEA

The linear programming technique is used to find the set of coefficients (μ's and *v2019*s) that will give the highest possible efficiency ratio of outputs to inputs for the service unit being evaluated.

DEA Mathematical Model:

j = number of services units (SU) being compared in the DEA analysis:
SUj = service unit number j
θ = efficiency rating of the service unit being evaluated by DEA
Yrj = amount of output r used by service unit j
Xrj = amount of input i used by service unit j
i = number of inputs used by the SUs
r = number of outputs generated by the SUs
μr = coefficient or weight assigned by DEA to output r
vi = coefficient or weight assigned by DEA to input i

The data required to apply DEA are the actual observed outputs produced ***Yrj*** and the actual inputs used **X**ij, during one time period for each service unit in the set of units being evaluated. Hence, **X**ij is the observed amount of the ***i*** th input used by the j th service unit, and ***Yrj*** is the amount of the **r** th output produced by the **j**th service unit.

3. DATA ENVELOPMENT ANALYSIS

The first and very crucial step in conducting a DEA is the determination of inputs and outputs. DEA is a better way to organise and analyse data since it allows efficiency to change over time and requires no prior assumption on the specification of the best practice frontier. DEA is a leading approach for the efficiency analysis in banking industry and seeks to determine which of the n DMUs define an envelopment surface that represents best practice, referred to as the empirical production function or the efficient frontier. Units that lie on the surface are deemed efficient in DEA while below the surface termed as inefficient. It can help in capture the crucial input allocation and output product mix of the competitive environment for comparison, DEA can indeed effectively classify the data into meaningful groups from which the characteristics between the groups can be easily identified through subsequent peer group analysis (Yeh, 1996).The identification of efficient peers for each inefficient unit is one of the most valuable outcomes of a DEA assessment. The higher a branch's efficiency, the better it is at converting its resources and the potential (Thanassoulis, 1999). Moreover, DEA is a based on a concept of efficiency that is widely used in engineering and natural sciences. Under certain circumstances, an economic efficiency standard- similar to engineering standard can be defined and used to compare the relative efficiencies of economic entities. For example, a firm can be said to be efficient relative to another if it produces either the same level of output with the same or fewer inputs or more outputs with the same or fewer inputs. A single firm is considered "technically efficient" if cannot increase any output or reduce any output without reducing other outputs or increasing other inputs. Consequently, this concept of technical efficiency is similar to engineering concept. The somewhat broader concept of "economic efficiency" on the other hand is achieved when firms find the combination of inputs that enable them to produce the desired level of output at minimum cost. In the context of the deterministic frontier data envelopment analysis is by far the most used technique. DEA modelling allows the analyst to select inputs and outputs in accordance with a managerial focus. This is an advantage of DEA since it opens the door to What-if analysis. Furthermore, technique works with variables of different units without the need for the standardization explained by (Sathye, 2003). DEA is sensitive to variables selection. As number of variables increases, the ability to discriminate between the DMUs decreases. The more variables added the greater become the chance that some inefficient unit dominates in the added dimension and becomes efficient. The CCR model has an assumption of constant returns to scale (CRS) for inputs and outputs. To take into consideration variable returns to scale (VRS) (Mostafa, 2009). The BCC

model evaluates whether increasing, constant,or decreasing returns to scale would boost the efficiency observed. In the case of constant returns to scale, the output changes proportionally to input, as it also does in the CCR model. But with variable returns to scale, a change in the input leads to a disproportional change in the output. The use of the CCR and BCC models together helps determine the overall technical and scale efficiencies of the firm and whether the data exhibits varying returns to scale (Sarkis, 2000).

4. BASIC EFFICIENCY CONCEPT-DEA

The discussion of DEA approach will be undertaken in the context of technical efficiency in the microeconomic theory of production. In microeconomics, the production possibility set consists of the feasible input and output combination that arise from available production technology. The production function (production transformation as it is called in case of multiple outputs) is mathematical expressions for a process that transforms input into output. DEA provides similar notion of efficiency. DEA assumes that all firms face the same unspecified technology which defines their production set of possibility. The objective of the DEA is to determine which firms operate on their efficiency frontier which firms do not. DEA partitions the input and outputs of all firms into efficient and inefficient one. The efficient input –output combination yield on implicit production frontier against which each firm's input-output combination is evaluated. If the firm input-output combination lies on the frontier it is efficient if lies below the frontier it is inefficient one.

The principal difference is that DEA production frontier is not determined by some specific equation. Equation is generated from the actual data for the evaluated firms (Which in DEA terminology are typically are typically called DMUs or decision making units). DEA establishes a "benchmark" efficiency score of unity that no individual firm's score can exceed. Efficient firms receive efficiency scores of unity, while inefficient firms receive DEA score less than unity.

The input and output variables use in DEA assessments in banking depend on whether we want to assess the unit's production efficiency or its intermediation efficiency. From, the production perspective, the bank unit uses labor, capital, space, and so forth to service accounts reflected by transactions of various types, such as taking deposits, processing loan and insurance applications.

From the intermediation perspective, the bank unit is an intermediary collecting funds in form of deposits and "intermediating" them to loans and other income-earning activities. Like liquidity efficiency reflects the bank's exposure to financial risk and market efficiency reflects the unit's effectiveness in converting its labor, capital, space, market potential into sales of products.

The higher a branch's market efficiency the better it is converting its resources and the potential in its environment into loans, deposits, and other revenue generating financial products. The combined effects of two efficiencies determine bank's efficiency. In DEA unit is allocatively efficient if it delivers its output levels at minimum cost and technically efficient if it delivers its output levels using lowest levels of inputs. The BCC-(Banker, Charnes and Cooper) model used for assessment of input oriented efficiency, and The CCR-(Charnes, Cooper and Rhodes) model help for the evaluation of output oriented efficiency.

5. DEA INPUT AND OUTPUT VARIABLES

(i) Wu et al, (2006)-inputs (Personnel and General expenses); outputs (Deposits, Revenue, Loans),

(ii) Yeh, (1996)-inputs (Interest expenses, Non-interest expenses, Total deposits); outputs (Interest income, Non-interest income, Total loans),

(iii) Thanassoulis (1999)-inputs (Labour, floor space); outputs (Transactions),

(iv) Mostafa (2009)-inputs (Assets and Equity); outputs (Net profit, Return on assets and Return on equity),

(v) Staub et al (2010)-inputs (Operational expenses net of personnel expenses, Personnel expenses, Interest expenses), outputs (Total loans net of provision loan, Investments, Deposits),

(vi) Paradi (2011); inputs (Intermediary Model (Cash balances, Fixed Assets/Accruals, other liabilities, Net non-performing loans, Loan loss experience and Profitability Model (employee expenses, occupancy/ computer expense, loan losses, cross charges, other expenses); outputs (Wealth management, Homeowner mortgages, Customer lending, Customer Deposits, Commercial loans, Commercial Deposits),

(vii) Athanassopoulos and Giokas (2000)-inputs(Labour hours, Branch size, Computer Terminals); outputs (Credit Transactions, Deposits Transactions and Foreign receipts),

(viii) Luo (2003)-inputs(no. of employee, total assets, equity, revenue, profit); outputs (market value, Earning per share, Stock price),

(viii) Camanho and Dyson (2005)-inputs (no. of branches & account managers, No. of Administrative & Commercial staff, No. of tellers, operational costs); outputs (no. of General service transactions),

(ix) Camanho and Dyson (1999)-inputs (no. of employees, Floor space of the branch, Operational costs, no. of External ATMs); outputs (no. of general studies transactions, No. of transactions in external ATMs, No. of all types of accounts, Value of savings and Value of loans),

(x) Saha and Ravisankar (2000)-inputs (Interest expenditure, non-establishment expenditure (excluding interest expenditure), no. of branches, no. of employees); outputs (deposits, advances, investments, spread, total income, interest income, non-interest income and funds),

(xi) Mercan (2003)- inputs (personnel expenses, Total expenses); outputs (earning assets, total assets, total liabilities),

(xii) Mathews (2013)-inputs (Operational expenses, fixed assets); outputs (net-interest income and Non-interest income),

(xiii) Sathye (2001)-inputs (price of labour, price of capital, price of loanable funds); outputs (demand deposits, labour),

(xiv) Berger et al (2008)-inputs (Interest expenses/total deposits, non-interest expense/fixed assets); outputs (total loans, total deposits, liquid assets),

(xv) Jemric and Vujcic (2002)-inputs (Interest cost, Commissions for services & related cost, labour related administrative costs, capital administrative cost); outputs (interest revenue, non-interest revenue),

(xvi) Yang (2009)-inputs (sales FTE, support FTE, service FTE, other); outputs (no. of transactions in variable rate, new interest bearing, new menu account, fund transfer, cash advance, withdrawal account),

(xvii) Sherman and Ladino (2015)-inputs (customers service-tellers, sales service-platform, manager, expenses-including personnel & rent, office square feet); outputs (deposit withdrawals, checks cashed, bank checks traveler checks bond, night deposits, loans-mortgage and consumer: referrals applications closings, new account: time, savings, certificates of deposits, Zenios, Agathocleous and Soteriou (2015)-inputs (managerial personnel, clerical personnel, computer

terminals; outputs (current account, saving account, foreign currency and commercial account, credit applications), Al-Faraj, Alidi and Bu-Bshait (1993)-inputs (no. of employees working in the branch, the percentage of employees with college degree, average no. of years of experience, an index-for location, highest authority, expenditure on decoration, average monthly salary, operational expenses); outputs (monthly average-net profit, balance of current account, balance of savings account, balance of other accounts, mortgages, no. accounts), Oral and Yolalan (1990)-inputs (no. of personnel, no. of on-line terminals, no. of commercial accounts, no. of savings account, no. of credit applications); outputs (the amount-of time spent on general service transactions, credit transactions, deposit transactions, foreign exchange transactions), Mukherjee, Nath and Pal (2002)- inputs (net worth of banks, borrowings of banks, operating expenses, no. of employees, no. of bank branches); outputs (deposits, net profit, advances, non-interest income, interest spread), Schaffnit, Rosen and Paradi (1997)-inputs (tellers, typing, accounting, supervision, credit); outputs (transactions- counter, sales, counter sales, deposit sales, personal sales, commercial loans, and accounts-term, personal, commercial), Miller and Noulas (1996)-inputs (total transaction deposits, total non-transaction deposits, total interest expense, total non-interest expense); outputs (commercial and industrial loans, consumer loans, real estate loans, investments, total interest income and total non-interest income). Rashid and Rustam (2014)-inputs (operating expenses, no. of employees); outputs (operating income, profit after tax). Shahroodi and Bahraloloom (2014)-inputs (training, experience, commission and facilities); outputs (customer satisfaction, market, income and ROA). Yang (2009)-four inputs (sales FTE, service FTE, support FTE and other FTE) and nine outputs (No. of transactions to set up new variable rate consumer loan, No. of transactions to open new interest bearing current accounts, No. of transactions to open a new menu account, No. of transactions to process branch deposit to Menu accounts, No. of transactions to process withdrawal from menu accounts, No. of transactions to update passbook from menu accounts in branch, No. of transactions to transfer funds in branch, No. of transactions to process visa cash advance, No. of transactions to process commercial deposits).

6. DATA ENVELOPMENT ANALYSIS: REVIEW OF LITERATURE&MODEL RESULT DISCUSSION

DEA has been widely studied, used and analysed by academics that understand the importance of scarce resources utilisation with maximum outputs and minimum inputs. Charnes, Cooper and Rhodes (1978)concerned with developing measures of 'decision making efficiency' with special reference to possible use in evaluating public programs and introduced a new kind of production function, new methods of securing estimates from empirical data. Sherman and Gold (1985)evaluated the operating efficiency of bank branches and proved that DEA results provide meaningful insights not available from other techniques that focus on ways to improve productivity and also suggested DEA is a beneficial complement to other techniques for improving bank efficiency. In Turkey,Oral and Yolalan (1990)empirically evaluated the operating efficiencies of set of 20 branches of a major Turkish commercial bank (offering relatively homogenous products in a multi-market business environment) with data envelopment analysis. The result of the study indicated that this kind of approach is not only complementary to traditionally used financial

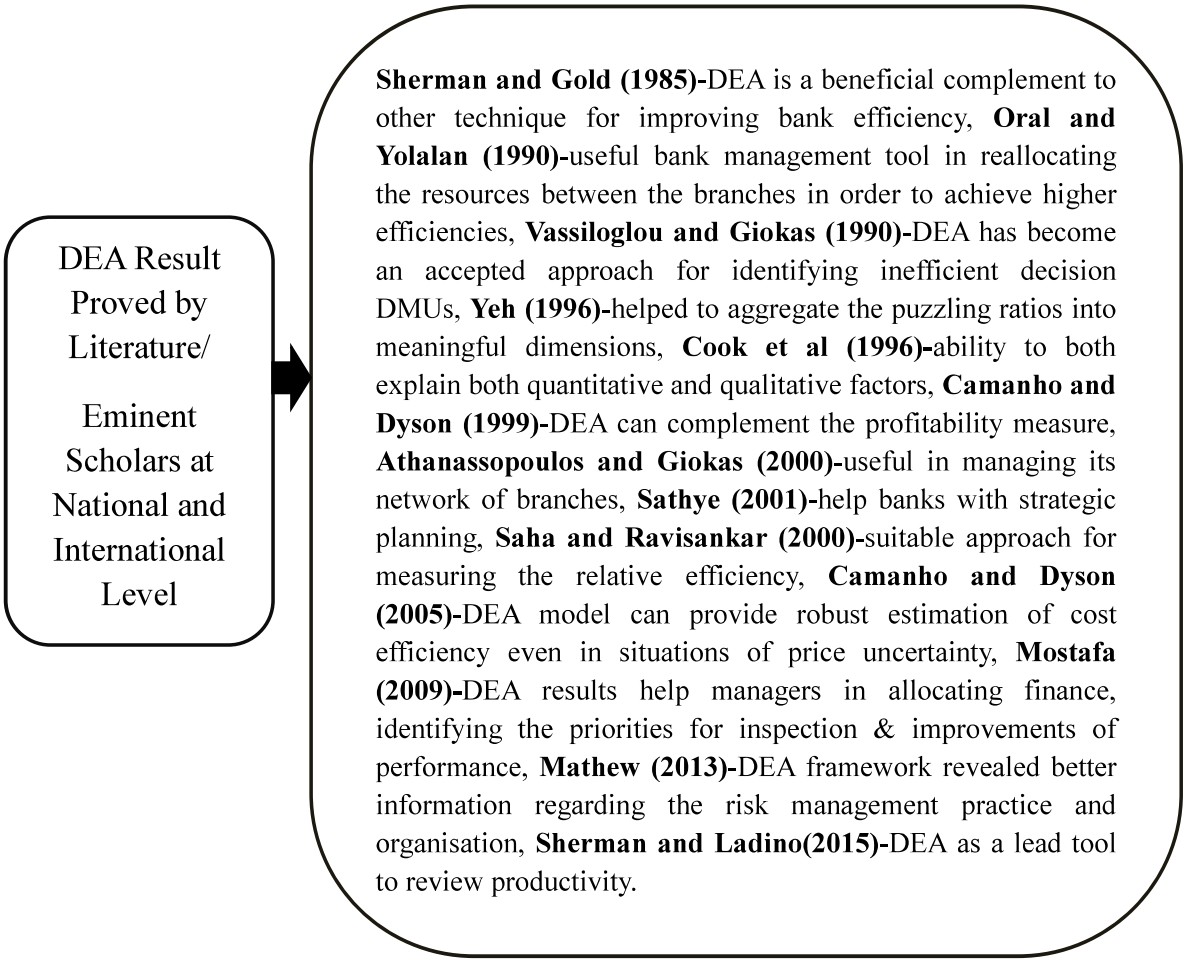

Figure 2. DEA Literature

ratios but also a useful bank management tool in reallocating the resources between the branches in order to achieve higher efficiencies. It has been observed that the service-efficient bank branches were also most profitable ones, suggesting the existence of a relationship between service efficiency and profitability. In Greece, Vassiloglou and Giokas (1990)presented systematic application of DEA carried out at the commercial banks of Greece in accessing the relative efficiency of bank branches. DEA has become an accepted approach for identifying inefficient decision making units in an organisations. Yue (1992) described the data envelopment analysis that used previously to analyse the relative efficiencies of industrial firms, universities, hospitals, military operations, and more recently 60 commercial banks in Missouri for the period from 1984 to 1990. In Saudi Arabia, Al-Faraj, Alidi and Bu-Bshait (1993) evaluated the relative efficiency of set of branches of largest commercial banks in Saudi Arabia to identify the inefficient branches, pinpoint the shortfall. Miller and Noulas (1996)considered the relative technical efficiency of 201 large banks from 1984 to 1990. The study found that bank technical inefficiency averages just 5 percent, much lower than found in existing estimates, larger & more profitable banks have higher levels of technical efficiency. It can be concluded that larger banks are more likely to operate under decreasing returns to scale. In Taiwan, Yeh (1996)applied technique of

data envelopment analysis in conjunction with financial ratios to evaluate the relative efficiency of bank performance in Taiwan. The result described, during the 1980s in Taiwan, banks were more aggressive in their loan applications and DEA with financial ratios helped to aggregate the puzzling ratios into meaningful dimensions. Cook et al (1996) viewed input as an ordinal input ranking of DMUs and also extended to the more general case mix of qualitative and quantitative (inputs and outputs). They reported that the ability to model both quantitative and qualitative factors in DEA structure extends its usefulness to the broader range of problems. In (1997) Berger and Humphrey summarised and critically reviewed the empirical estimates of financial institution efficiency and investigated that various efficiency methods do not necessarily yield consistent results. Schaffnit, Rosen and Paradi (1997) presented best practices analysis of Ontario based branches of a large Canadian bank using data envelopment analysis. The result suggested that the most efficient branches tend to be more profitable and deliver better quality service and also identified a strong effect of a branch's neighborhood density on its performance. Thanassoulis (1999) study centered on summary measure of efficiency of each unit, estimated targets of performance for the unit and identified role-model units of good operating practice. In Portugal, (1999) Camanho and Dyson proved that DEA can complement the profitability measure currently used at banks in Portugal. Overall, the study reported the usefulness of DEA as a tool to inform banks managers both with respect to the optimal strategies regarding the development of the branch network and to set targets to improve both efficiency and profitability. In Greece, Athanassopoulos and Giokas (2000) found that DEA methodology found very useful in managing its network of branches in Greece. The most important use is in benchmarking and learning from the management practices employed at different bank branches. In Australia, Sathye (2001) investigated the X-efficiency (technical and allocative) of Australian banks and found that sample banks have low level of overall efficiency compared with the banks in European countries and U.S. The result indicate that source of overall inefficiency, technical component more important than allocative and further efficiencies can be attributed to wasting of inputs rather than choosing the incorrect input combinations. It would help banks with strategic planning. In India, (2000) Saha and Ravisankar Empirically suggested that DEA could be suitable approach towards measuring the relative efficiency of Indian banks. This study mainly confined to the post-reform period with 1991-92 as point for account reporting format & prudential norms related to capital adequacy, income recognition, and assets classification. The findings of this paper presented that DEA study are consistent with the market perceptions about selected sample banks. In Croatia, Jemric and Vujcic (2002) analysed bank efficiency between 1995 and 2000 with DEA. They measured the relative efficiency of banks as per size, ownership structure, date of establishment and quality of assets. The result demonstrated that foreign-owned banks performed most efficient, new banks more efficient than old, smaller banks globally efficient and large banks appeared to be locally efficient.In India, Mukherjee, Nath and Pal (2002) explored the linkage between performance benchmarking and strategic homogeneity of Indian commercial banks. The study revealed that public sector banks outperform the private and foreign banks in this rapidly evolving and liberalizing sector and also found that almost all of them were overstaffed (in terms of business per employee and profit per employee) with percentage of non-performing assets (ratio of net NPA net advances). Manandhar and Tang (2002) developed a framework for incorporating the effectiveness of service delivery system into a DEA framework in the form of internal service quality. This paper also suggested the simultaneous benchmarking of the performance of bank branches along

multiple dimensions (internal service quality, operating efficiency, profitability)using modified DEA formulation. In U.S, Luo (2003) investigated the profitability and marketability efficiency of 245 large banks in U.S and tested whether banks performed differently in different geographic locations. The findings indicate that the location of banks generally seems not related to either profitability (inputs are: employee, assets, stockholder's equity & outputs are: revenue, profit) or marketability efficiency(inputs are: market value, EPS, stock price and Outputs are: revenue & profit) further evidenced that overall technical efficiency of the profitability performance can predict the likelihood of the bank failure. In Turkey Mercan investigated in (2003) that average financial performance index for all commercial banks kept increasing until 1993, however foreign and privately owned Turkish banks outperformed their state-owned competitors. He proved with studied the impact of ownership and size differences on behaviour and performance of Turkish banks (public, private and foreign). In India Das et al, (2005) empirically analysed and estimated the various efficiency scores of banks during 1997-2003 using DEA. It observed from the result that Indian banks still not much differentiated in terms of input or output oriented technical efficiency & cost efficiency. Finally, the median efficiency scores of Indian banks, in general, and of bigger banks in particular have improved during the post-reform period. In same year (2005), Camanho and Dyson developed the method for the estimation of upper and lower bounds for the cost efficiency measure in situations of price uncertainty. They proved that DEA models can provide robust estimation of cost efficiency even in situations of price uncertainty. In Canada, Wu et al (2006) integrates the two-stage DEA (input-oriented CCR model)- NN(neural network)to examine the relative branch efficiency of big Canadian bank. They compared the results with the corresponding efficiency ratings obtained from DEA and neural network. Their result indicate that DEA property of unit invariant is similar to property of scale preprocessing required by NNs validates the rationale to implement a comparison between pure DEA results and DEA NN result. In (2008)Berger et al summarised and critically reviewed empirical estimates of financial institution efficiency and find that various efficiency methods do not necessarily yield consistent results. They further suggested that some ways regarding methods to bring more consistent, accurate and useful. Hermes and Hong Nhung (2008)investigated the impact of financial liberalisation on bank efficiency, using data for a sample of over 4,000 bank-year observations from ten emerging economies for the period from 1991-2000. They used data envelopment analysis to calculate bank efficiency at the individual bank level. The result revealed that there is strong support for the positive impact of financial liberalisation programmes on bank efficiency. In Arab countries, Emrouznejad and Anouze (2009) benchmarked and compared relative efficiency of top 85 Arab banks using DEA and found that there is potential for significant improvements in Arab banks. In (2009) Mostafahas investigated the efficiency of top Arab banks with two quantitative methodologies-data envelopment analysis and neural network. He reported that DEA scores computed with the CRS assumption are less than or equal to the corresponding VRS efficiency scores. DEA results can also be used by bank managers to support their objectives, such as allocating finance or identifying the priorities for inspection & improvement of performance. Berger et al (2009) in China analyzed cost and profit efficiency of 38 Chinese commercial banks (big four, non-big four state owned, private domestic and foreign banks) with 266 observations over 1994-2003 and employed DEA. They found that big four banks were far least efficient, foreign banks were most efficient and minority foreign bank was associated with significantly improved efficiency. In 2009, In Canada (Yang) introduced an operational efficiency model which adopts production approach and also emphasized on guidance on

what to manage & how to accomplish the changes with the application of data envelopment analysis. The result of research explained that 240 branches of big Canada Bank of Greater Toronto Area operate fairly efficiently on whole although there is still room for improvement. In Brazil, Staub et al (2010) investigated the cost, technical, allocative efficiencies scores of Brazilian banks for the period from 2000-07. In study they employed three different panel data specifications and inferred that non-performing is most important indicator of efficiency level as well as market share. Brazilian banks were found to have low level of economic (cost) efficiency compared to banks in Europe and in the U.S. Moreover, state owned banks performed more cost efficient than foreign, private domestic and private with foreign participation. In (2011), Paradi developed two-stage DEA approach for simultaneously benchmarking the performance of operating units along different dimensions, a modified slacks-based measure model applied for the first time to aggregate the obtained efficiency scores from stage one and generate composite performance index for each unit. They also investigated branch scale efficiency, impacts of geographical location and market size on bank performance. Three important branch performance dimensions (production, profitability and intermediation) were evaluated. The result show that poor performance in one aspect does not predict similar poor results in the other two aspects. Strong correlation between the results of the profitability model and bank's current internal measures confirms the reliability of DEA models from bank's point of view. Dyson and Shale (2010) discussed the number of applications of DEA and nature of uncertainty in those applications, reviewed the key approaches to handing uncertainty (DEA, imprecise DEA, bootstrapping, Monte Carlo simulation, chance constrained DEA). They suggested that about the challenges facing an operational research analyst in real world situations. In China, Mathew (2013)surveyed the Chinese banks risk managers, construct metrics of risk management practice and risk management organisation. They investigated that there is no significant direct relationship between two constructed measures. They argued that the information content in risk management practice and risk management organisation is indirect and is better revealed within a network DEA framework. In Iran Shahroodi and Bahraloloom (2014) evaluated the overall efficiency of 29 Iranian banks' branches & proved that the combination of integrated approaches with financial indicators-Balanced Score Card and Data envelopment analysis caused the weaknesses of each model covered by the strength of other. In same year, Rashid and Rustam in Pakistan investigated that foreign banks are more efficient in minimization of inputs and maximization of output as compared to local banks. They proved it while assessed the relative efficiency of 17 (local banks) & 6 (foreign banks) with non-parametric test-DEA and also applied BCC (Banker, Charnes and Cooper) for input oriented efficiency and CCR (Charnes, Cooper and Rhodes).Sherman and Ladino (2015) used DEA as a lead tool to review productivity. The result identified the relatively efficient best-practice branches, the less-productive branches and the magnitude of the excess resources used by less productive branches. The findings indicate that the bank could make substantial productivity improvements and cost reductions. Zenios, Agathocleous and Soteriou (2015) established the efficiency in translating resources into work and to establish the effects of the environment on the measured efficiency. The analysed result showed that tourist branches were on average more efficient than urban branches during the peak tourist season.

CONCLUSION

Banks act as fuel for smooth and healthy functioning of nation's financial system. The position of banking sector in any country represents economy's exact picture and functions. Globalisation extremely redefining

banking taxonomy which further transformed the face and operating environment of banking industry. These results provide very valuable guidance for financial regulators, policy makers and bank managers.

Data Envelopment Analysis can be adapted to help improve service productivity, identify new strengths and weaknesses that can be derived from DEA along with gaps. This analytical paper through the highlights on previous studies on Data Envelopment Analysis for the assessment of different types of efficiencies of commercial banks of different countries. Finally, DEA (non-parametric) technique found to be very useful in evaluation of different types of efficiencies, with different techniques, models and approaches. In this paper, demonstrated the DEA applications, benefits, approaches investigated as well practically proved by research scholars at international level and observed that DEA-complement the profitability measure, managing branch networks of large banks, effective in strategic planning, relevant approach for relevant efficiency, robust estimation in circumstances of uncertainty, help in reallocating resources, inspection & improvements of performance, lead tool to review productivity.

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