P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.01.033

Data Envelopment Analysis (DEA): New Approach to Measure Financial Efficiency of Banks

Sneha R
Assistant Professor in Commerce and Management
International Institute of Business Studies-IIBS
Bangalore - 562157
E-mail:sneha.rajanna05@gmail.com

Abstract

Data Envelopment Analysis (DEA) is a popular non-parametric test approachused to measure the production frontiers of financial institutions such as Banks. DEAmeasuresthe optimal combinationofinputs thathelp firms realisehigherreturns.Understanding the relative efficiency and performance of banks compared tothe market over a period of time is extremely important for analysts, practitioners, andpolicymakersalike. Inthepresentcase,DEA isemployedtomeasurethefinancialefficiencyofthebanks, referred to as Decision Making Units (DMUs), and to understand how theseDMUsemploytheirinputstogainoptimaloutputs.Thebankperformanceisquantifiedintermsoftheirproductivityorefficiencywhichisgivenbytheratioofthetotaloutputsto total inputs.

***Keywords*:BusinessIntelligence,Publicsectorbanks,Oldgenerationprivate sector banks, New generation private sector banks, Data EnvelopmentAnalysis,Malmquist Productivity Index.**

Introduction

The banking sector plays a very crucial role in the economic growth in India. Theefficient banking sector is thus the fundamental requirement for smooth functioning of anyeconomy(Aroraet.al.).SoundnessiskeyforIndianfinancialsystemandsoundnessissynonymousforstability,profitability,efficiency,productivityandashockfreeenvironment(A.K. Mishra et.al. ,2013).If banks intermediate efficiently it positively affects to economicgrowth and banking failures results into systematic crises, so bank performances are at vitalinterestfordepositors,regulators,customersandinvestors(MDuygun-Fethi,2009).Measuringoperational efficiency of financial institutions is pivotal for academic researcher and policymakers, as aim of both is to assess the impact of market structure on financial system andimproveefficiencyoffinancialsystem(ShaikSaleemet.al.,2014).Themainobjectiveofliberalization Indian banking is stability, stand against external shocks and remain internallysoundandsensible.AsefficiencyinIndiancommercialbanksincreasesitleadstoreduction inspreads, this will stimulate industrial loan demand (lead to higher economic growth) andgreater mobilization of savings (Majid Karimjade,2012).Competition in banks and

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.01.033

bankingsystemforcescommercial banksto perform efficiently(I.A.Shah, 2012).

Intherecentyears,theburgeoningnon-performingassets(NPAs)havebecomeamatterof concern and scrutiny in India as the surge in NPAs impinge on the credit services of thebanks, make the banks vulnerable to external shocks, leave them with less cushion in case ofidiosyncratic shocks and thus, leading to the abrasion of their productive capital. In thisbackdrop,someverynormativequestionsbecomeinevitable.Last25years'Indiancommercialbankshavebeenobservingderegulation,technologicalinnovationandincreasedopportunitiesto finance Indian economy and emerging competition from private sector accompanied withforeign ownership banks. Government approach to liberalization is to spur competition whichfurtherinfluences to efficiencyinIndian commercial bankingsector.

The progress of the financial sector is deemed as sine qua non of robust economicgrowthanddevelopment.Additionally,banksplayacriticalroleinthefinancialmarkethence,anymanagementcrisiswouldbeentailedbyanunprecedenteddegreeoffinancialpredicament,socialcost,andthushasapotentialforeconomiccrisis.Banksplayaverycriticalroleinthe development process of an economy (Tsolas and Charles 2015) given that they channelize thefundsto theirmost productiveuses in theeconomy.

McKinsey's Report (2019) has raised concerns over the banks across the world asgrowth decelerates and has further stressed upon the urgency to consider a 'suite of radicalorganic or inorganic moves'. Drawing a parallel between the banks in emerging countries andindevelopednations,thereporthasidentifiedwaningReturnOnTangibleEquity(ROTE)from20%in2013to14.1%in 2018especially,on accountofdigitaldisruptioninemergingnationsincontrastwiththedevelopednations,wherethebankshavemanagedtostrengthenproductivity and have witnessed a surge in ROTE from 6.8 to 8.9% over the same period.Interestingly, India in this scenario is an interesting case with the World Bank anticipatingIndia's share in global investments to almost double by 2030 and designating the nation as a"Powerhouseinglobal savingsand investment".

With 158,373 functioning offices of commercial banks in India as on March, 2021,thereare14.1banksand20.95ATMsper1,00,000adultsinIndia(WorldBank,2019)makingthe Indian banking system one of the largest in the world. Adapting to the technological shiftglobally,since2015,Indianbankingsectorhastakenaquantumleapasthebankstransformedtheir business models from brick-and-mortar to digital modes of transaction. But, for a well-functioning banking sector what matters apart from the deposits is the mechanism throughwhich the savings are allocated as investments or credit. The banking sector in India ischaracterized by large chunks of non-performing assets which came into limelight post 2016when the asset quality review (AQR) was conducted. The AQR basically classifies the loansinto performing and non-performing. According to the central bank of the country, the RBI,thepercentageofthebadloansjumpedtoashigh as80%in thefinancialyear2016duesolelytotheAQR.Sincebadloansgreatlyinfluencetheefficiencyofthebanks,theAQRhasshownus how better our banking system is doing and also the need to monitor and evaluate theperformanceofthesebanks.TheAQRhasimpactedalmostalloftheIndianpublicsectorbankswhil

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.01.033

e only a few major private sector banks were impacted. Therefore, post AQR the gapbetweentheefficienciesofpublicandprivatesectorsbanksisboundtodecreasegiventhefactthatt hesebanksmayactivelydealwiththebadloansintheaftermathofAQR.TheburgeoningNPAshavebe comeamatterofconcernandscrutinybecauseitimpingesonthecreditservicesof the banks, make them vulnerable to external shocks, leaves them with less cushion in caseofidiosyncraticshocksand thus,leadingto theabrasion oftheir productivecapital.

While financial ratios indeed reflect the financial status, profitability and efficiency ofindividual banks, they are rendered ineffective when used to compare two or more banks thatdiffer in size, capital and scale of operations and often lead to misleading findings. Therefore,a non-parametric approach called Data Envelopment Analysis (DEA) is popularly used toassess the efficiency of banks and other financial entities that use similar business tools andoperatein the same environment (Maradin etal.,2018).

Sustainabilityisoneoftheconceptswhichhasbeenassociatedwithbankperformance;theref ore, assessing and predicting bank performance have become vital for managers whenexaminingthesuitabilityoftheirmanagerialdecisions.Additionally,studyingbankperforman cegreatlyfacilitatesmeasuringthesuccessofdecisionsmadebyabankascomparedto those of its counterpart during the same period. Furthermore, it allows one to learn how tomake better financial decisions that allocate financial resources in a more efficient manner.There is substantial body of published academic research that discusses different methods ofevaluating bank performance; Berger and Humphrey (1997) grouped them into two mainapproaches, namely, parametric and nonparametric. The most popular parametric method isknown as the stochastic frontier approach (SFA), whereas the most popular nonparametricmethodis data envelopment analysis (DEA).

Although using these methods could help researchers determine performance level,they are not sufficient to explain inefficiency or predict performance.Therefore, severalstudies, like that of Fethi and Pasiouras (2010), proposed a combination of measuring andexplainingbankperformanceusingDEAorSFAinthefirststagetomeasureperformanceandregr ession models as a second stage to explain it. Casu and Molyneux (2003); Ariff and Can(2008) and San *et al.* (2011) used Tobit regression in particular to explain bank performance.Other researchers used different regression models to explain bank performance; Anouze(2010); EmrouznejadandAnouze(2010) and Bou-Hamad *etal.* (2017) usedboostedgeneralizedlinearmodel,and Seol *etal.* (2007) useddecisiontrees,whereas Azadeh *etal.* (2011) usedtheartificialneuralnetworks(ANNs).Ontheotherhand, SunandLi(2008) and Wu and Hsu (2019) used decision tree techniques to introduce a multiple criteriadecision-making method to determine suitable warning mechanisms of corporate financialfailureordistress.Meanwhile, Lai *etal.* (2011) usedDEAtodevelopanintellectualbenchmarkingknowledge-basedsystemforbenchmarking,performanceevaluationandprocessimprovement.

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.01.033

However, no comparison of methods used in second DEA stage has been made, andmostofthesestudiesaimedonly toexplainthefactorsaffectingefficiency ratherthanpredictingfutureefficiencyofbanks.Predictingbankperformanceisextremelyimportant :badperformance may lead to bankruptcy, which negatively influences the economy of a country.Thus, conceiving a powerful predictive model for bank performance would be useful inavoidingorat least limitingsuchconsequences.

Dataenvelopmentanalysis(DEA)isalinear-programming-basedmethodforassessingtheperformanceofhomogeneousorganizationalunitsandisincreasingly beingusedinbanking. The unit of assessment is normally the bank branch. Studies are mostly centered onderivingasummarymeasureoftheefficiencyofeachunit,onestimatingtargetsofperformance for the unit, and on identifying role-model units of good operating practice.AdditionalusesforDEAinbankingincludethemeasurementofefficiencyinlightofresourceand output prices, the estimation of operating budgets that are conducive to efficiency, theassessment of financial risk at bank-branch level, and the measurement of the impact ofmanagerialchangeinitiatives on productivity.

The unit of assessment is normally the bank branch. Studies are mostly centered onderivingasummarymeasureoftheefficiencyofeachunit,onestimatingtargetsofperformance for the unit, and on identifying role-model units of good operating practice.AdditionalusesforDEAinbankingincludethemeasurementofefficiencyinlightofresourceand output prices, the estimation of operating budgets that are conducive to efficiency, theassessment of financial risk at bank-branch level, and the measurement of the impact ofmanagerialchangeinitiatives on productivity.

Therearehowevernumeroustechniquesthatarehelpfulinmeasuringtheefficiencyofthe banks. They range from the traditional ratio analysis to the regression based parametricmethods to the new non parametric frontier based methods. While the ratio analyses are thesimplest methods to analyses the efficiency scores of the banks they have various inherentlimitations that make them less valuable in presence of more advanced parametric and non-parametric techniques. The most widely used regression based parametric technique is thestochastic frontier analysis (SFA) while data envelopment analysis (DEA) is the widely usednon-parametric technique. The major differences between these two competing methods aretheassumptionsthatareimposedonthespecificationofthefrontier,theexistenceofarandomerror andthedistributionoftheinefficienciesandtherandomerror(BergerandHumphrey

1997). While SFA is a regression based approach and assumes an underlying functional form(Cobb Douglas, Translog, etc.) the DEA on the other hand is a non-parametric technique anddoes not assume any particular underlying functional form. The advantage of using non-parametric DEA technique over the deterministic SFA techniques is that the DEA is moreflexible in the sense that it allows use of multiple input and output vectors while calculatingthe efficiency scores of the decision making units unlike SFA where we can use only a singleoutput and single or multiple input variables. In addition, DEA also allows for accounting theundesirableoutputs (inputs) which cannot beaccountedfor in the SFA methods.

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.01.033

StructureofIndian BankingSystem

TheIndianbankingindustryiscentrallygovernedbytheReserveBankofIndia,whichis the central bank of the country. Its major functions are to oversee the commercial banks ofthe country and to carry out the monetary policy besides other huge responsibilities that anycentralbankshasineverycountry.AtalowerleveltheIndianbankingsystemischaracterizedbyth ecommercialandcooperativebanks,howeverthecommercialbanksarethesinglelargestassetholder saccountingforabout90%.TheIndiancommercialbanksarethenfurthercategorizedintoscheduleda ndun-scheduledcommercialbanks.Thescheduledbanksarethosebanks that are included in the second schedule of the Reserve Bank of India Act, 1934. Thescheduled commercial banks are further classified into three major categories based on theownership status: (1) public sector banks, (2) private sector banks and (3) foreign banks. Thepublicsectorbanksarelargelyownedbythegovernmentof India(morethan50%ofthestake)and are subjected to the regulations of the government. The private sector banks on the otherhandareownedprivately by theindividuals;however,they tooaresubjectedtoheavyregulationsof thegovernment (Banerjeeetal. 2004)

DataEnvelopmentAnalysis(DEA)

Dataenvelopmentanalysis(DEA)wasfirstintroducedintheliteraturein1978(Charnesetal.1 978).Itisanempiricallybasedmethodologythateliminatestheneedforsomeof the assumptions and limitations of traditional efficiency measurement approaches. It wasoriginally intended for use as a performance measurement tool for organizations that lacked aprofit motivation, e.g., not-for-profit and governmental organizations. However, since itsintroduction, it has been developed and expanded for a variety of uses in for-profit as well asnot-for-profitsituations.

Since the initial development of DEA by Charnes, Cooper, and Rhodes in 1978, therehavebeenseveralvariationsofthemodeldevelopedinresponsetonewandvariedneeds.Theinte nt here is to describe some of these models and what they were designed to do. Additionaldetails on the models can be found in the references. Also, see Ahn, Charnes, and Cooper(1988)foranalysesthatrelateresultsforthesedifferentDEAmodelsinarigorousmathematic almanner.

DataEnvelopmentAnalysis(DEA)isamethodologythathasbeenadoptedto“analysethe relative efficiency and managerial performance of productive (or response) units that havethe same multiple inputs and multiple outputs” (Jemric & Vujcic, 2002, p.170). It allows forthecomparisonofrelativeefficiencyofbanks;thereby,determinethemostefficientbank.DEAis considered a superior method for measuring the overall technical efficiency of banks. It isalsoalinearprogrammingtechniquethatevaluatestheefficiencyofmultipleDMUs(DecisionMak ingUnits) with measurements involvingmultiple inputsand outputs.

Further, DEA compares individual observation with the others in order to calculatepiece-wise discrete linear frontier. The most efficient units are those that lie on the linearfrontier, with each having an efficiency score of one. Inefficient units are considered to beinefficientbecausetheyeither usetoo muchinput and/ ordoes notproducesufficientoutput.

Though there exists a number of DEA models, the most basic ones are the

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.01.033

CRS(*Constant Returns to Scale or CCR*) model (Charnes, Cooper & Rhodes, 1978) and the VRS(*Variable Returns to Scale or BCC*) model (Banker, Charnes and Cooper, 1984). CRS modelsareusedwhen all the units areoperatingat an optimalscale.

The CCR and the BCC models measure different types of efficiencies. While CCRmeasures the overall efficiency of banks, BCC measures only pure technical efficiency. Theoverall efficiency can be further split into pure technical and scale efficiency. While puretechnical efficiency is related to the technical process, scale efficiency is related to the scalesize of the evaluated system. A bank is said to be scale efficient when its size of operations isoptimal and that any modifications on its size will render it less efficient. The CCR modeladopted in the study is used to measure the pure technical efficiency as well as the scaleefficiency of select banks. Pure technical efficiency (PTE) refers to deviations from theefficiency frontier resulting from the inefficient use of resources, i.e., PTE supposes that thefirms are operating under the supposition of CRS and scale efficiency (SE) refers to the lossesdueto lack of operatingwith CRS.

Whentheefficiencyortheperformanceoftheunitshastobeimproved,eithertheinputhas to be reduced or the output has to be increased so that the unit can reach the efficientfrontier. Therefore, DEA models have two orientations: input-oriented and output-oriented.Inputorientedmodelsareappliedtoseewhethertheunitthatisbeingevaluatedcanreduceitsinputs while keeping the outputs at current levels. In the case of input-oriented models, thelinearprogrammingmodelisconfiguredtodeterminehowmuchtheinputuseofafirmcanbecontractedif used efficientlyto achievethe same level of output.

In contrast, in the case of output-oriented models, the linear programming model isconfigured to determine a firm's potential output given its inputs if it operated efficiently asthe firms along the efficient frontiers. Thus, the input oriented models use only the fixedvariablesusedforoperation/productionandhencecannotbeusedtoestimatetheutilizationofcapacity or resources. Output-oriented models can however be used to measure capacityutilizationforagivensetofinputs.Theoutputorientedmodelsareideallysuitedtotestwhetherthe DMU under evaluation can increase its outputs while keeping the inputs at the currentlevels. In the present study, whether the overall efficiency of the banks can be increased withthehelpofbusinessintelligence(i.e.capacityutilization)wasevaluated.Theinputs,whichareproduced as a result of adopting business intelligence, are kept constant to study whether theefficiency of banks can be increased. Therefore, *output-oriented model* was developed in thestudy.

DEA is an alternative to regression analysis. While the latter depends on centraltendencies, the former is based on extreme observations. In a regression analysis, a singleestimatedregressionequationisassumedtobeappliedtoeachobservationvector;whereas,inDEA, each vector is analysed separately to produce individual efficiency measures relative tothe entire set that is evaluated. Further, unlike regression, DEA must need a priori assumptionsince it constructs the best efficiency function solely based on the observed data (Jemric &Vujcic,2002).

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.01.033

Overallefficiencyandproductivityofbankscalculatedusing CRSmethod

The performance of banks can be observed with the help of their efficiency andproductivity (in terms of managing the funds). Malmquist Productivity Index (MPI) wasadopted to observe the level of bank productivity based on changes in the efficiency andtechnology(i.e.businessintelligence)adopted.MPIisafunctionofdistancethatdescribesa technology by defining a set of input and output indices. Consider a function F that describesa technology of production. F is given by F(x, y) = 0, where x is the input vector given byX=(x1, x2, x3… xM) and y is the output vector given by Y=(y1, y2, y3… yS). Caves, Christensen,and Diewert (1982) provided an alternative interpretation to production technology based ontheconceptofdistancefunction.Accordingly,theoutputdistancefunctionisgivenby:

$$D_0(x,y)=D^{Min}\left[\mu:F\left(X,\frac{Y}{\mu}\right)=0\right] \quad \text{---(1)}$$

where μyis the minimum equi-proportional change in the output vector. It measures themaximumproportionalchangerequiredintheoutputtoplace(X,Y)intheefficiencyfrontier.That is, if the evaluated DMU (or the production unit) is efficient, D0 (X. Y) = 1 otherwise, itis <1.

Inordertocomparetheperformanceof aDMUin timeperiodtandt+1withreferenceto period t technology, the output based Malmquist productivity index is given as follows(Galagedera&Edirisuriya, 2004):

$$M_0^t(X_{t+1},Y_{t+1},X_t,Y_t)=\frac{D_0^t(X_{t+1},Y_{t+1})}{D_0^t(X_t,Y_t)} \quad \text{----(2)}$$

M0>1indicateshigherproductivityinperiodtthaninperiodt+1.Inordertoavoidthechoiceoftimeperiodarbitrarily,Färe,Grosskopf,NorrisandZhang(1994)proposedanoutput-basedMalmquistindex (TFP index)as followswhich hasbeen adoptedin thepresent study:

$$M_0^t(X_{t+1},Y_{t+1},X_t,Y_t)=\left[\frac{D_0^t(X_{t+1},Y_{t+1})}{D_0^t(X_t,Y_t)}*\frac{D_0^{t+1}(X_{t+1},Y_{t+1})}{D_0^{t+1}(X_t,Y_t)}\right]^{1/2}$$

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.01.033

$$= \frac{D_0^{t+1}(X_{t+1},Y_{t+1})}{D_0^{t}(X_t,Y_t)}\left[\frac{D_0^{t}(X_{t+1},Y_{t+1})}{D_0^{t+1}(X_{t+1},Y_{t+1})} * \frac{D_0^{t}(X_t,Y_t)}{D_0^{t+1}(X_t,Y_t)}\right]^{1/2} \qquad \text{---(3)}$$

The output orientation of the model given in (1) provides information as to how muchequi-proportional increase in output is necessary while maintaining the input levels at aconstant for an inefficient DMU to become an efficient DMU. From the (3) equation it can beseenthatMalmquistTotalFactorProductivityIndexcanbesplitintotwo:*relativeefficiency* betweenperiodstandt+1,givenby $\frac{D_0^{t+1}(X_{t+1},Y_{t+1})}{D_0^{t}(X_t,Y_t)}$ andshiftintechnology(i.e.*technical progress*)captured between thetwo timeperiodsevaluated at(X_t, Y_t) and (X_{t+1}, Y_{t+1})is given by$\left[\frac{D_0^{t}(X_{t+1},Y_{t+1})}{D_0^{t+1}(X_{t+1},Y_{t+1})} * \frac{D_0^{t}(X_t,Y_t)}{D_0^{t+1}(X_t,Y_t)}\right]^{1/2}$.

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.01.033

ForeachoftheDMUs,fiveMalmquistindicesweredefinedforperiodt+1relativetoperiodt,as follows.

Totalfactorproductivitychangeindex(TFPCI)= $$\frac{D_0^{t+1}(CRS)(X_{t+1},Y_{t+1})}{D_0^{t}(CRS)(X_{t},Y_{t})}\left[\frac{D_0^{t}(CRS)(X_{t+1},Y_{t+1})}{D_0^{t+1}(CRS)(X_{t+1},Y_{t+1})} * \frac{D_0^{t}(CRS)(X_{t},Y_{t})}{D_0^{t+1}(CRS)(X_{t},Y_{t})}\right]^{1/2}$$

RelativeefficiencyorTechnicalefficiencychangeindex(TECI)= $$\frac{D_0^{t+1}(CRS)(X_{t+1},Y_{t+1})}{D_0^{t}(CRS)(X_{t},Y_{t})}$$

Technologicalchange(orTechnicalprogresschange)index(TCI)= $$\left[\frac{D_0^{t}(CRS)(X_{t+1},Y_{t+1})}{D_0^{t+1}(CRS)(X_{t+1},Y_{t+1})} * \frac{D_0^{t}(CRS)(X_{t},Y_{t})}{D_0^{t+1}(CRS)(X_{t},Y_{t})}\right]^{1/2}$$

TECI can be further split into pure technical efficiency change (PTECI) and scaleefficiencychange(SECI).PuretechnicalefficiencyismeasuredbytheVRS(VariableReturnsto Scale)model. Hence, it is given by

Puretechnicalefficiencychangeindex(PTECI)= $$\frac{D_0^{t+1}(VRS)(X_{t+1},Y_{t+1})}{D_0^{t}(VRS)(X_{t},Y_{t})}$$

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.01.033

$$\text{Scaleefficiencychangeindex(SECI)} = \frac{Technicalefficiencychangeindex(TECI)}{Puretechnicalefficiencychangeindex(PTECI)}$$

Index values of <1 indicate that there is a decline in the efficiency, value equal to 1 indicatethatthereisstagnationinefficiencyandvalues>1indicatethatthereisgrowthintheefficiency duringthe period between t andt+1 from theprospectiveofperiod t technology.

Theindicatorsofbankperformancewerecalculatedannually.Thechangesinperformance were observed using the following metrics: TECI – Technical efficiency changeindex,TCI–Technologicalefficiencychangeindex,PTECI–Puretechnicalefficiencychangeindex,SECI–Scale efficiencychangeindex,TFPCI–Totalfactorproductivitychangeindex.

Since the initial development of DEA by Charnes, Cooper, and Rhodes in 1978, therehavebeenseveralvariationsofthemodeldevelopedinresponsetonew andvariedneeds. Theintent here is to describe some of these models and what they were designed to do. Additionaldetails on the models can be found in the references. Also, see Ahn, Charnes, and Cooper(1988)foranalysesthatrelateresultsforthesedifferentDEAmodelsinarigorousmathematicalmanner.

Conclusion

Banks are integrated component in the financial system such as nervous system inhumanbody,soitneedtoperformwithefficientlysoastoentirefinancialsystemcanperformefficiently.Bankefficiencyisveryimportantandcrucialissueespeciallyintransitioneconomies, where the banking sector faced a considerable change in ownership structure as aresultofprivatization,foreignbanksentryandcompetition,liberalization,changeinlegislativeenvironment and institutional rules. All these factors exerted some influence on the bankperformanceandefficiency.Inaddition,thetechnologicalchangesandknowledge,transferred normallywiththeincreaseinforeignownershipinthetransitioneconomies,alteredsignificantly the operational environment for the banking institutions and the technology ofbanks production, which in its turn changed the bank efficiency. Efficiency can be simplydefined as the ratio of output to input. More output per unit of input reflects relatively greaterefficiency. If the greatest possible output per unit of input is achieved, a state of absolute oroptimum efficiency has been achieved and it is not possible to become more efficient withoutnewtechnologyorotherchangesintheproductionprocess.Hence,DataEnvelopmentAnalysis(DEA)playsacrucialroleinmoderneratoanalyzeandmeasurethefinancialefficiencyofthebanks and to know the clear financial health ofthe organization.

References

1) Agnihotri,M.,&Bhavani,M.G.(2015)ImpactofCustomerRelationshipManagementPracticeson theProfitabilityOfUAEBanks.A ComparativeStudy.

2) Ariff,M.,&Can,L.(2008).CostandprofitefficiencyofChinesebanks:Anonparametricanalysis.ChinaEconomicReview,19(2), 260-273

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.01.033

3) Avkiran,N.(2006).Productivityanalysisintheservicesectorwithdataenvelopmentanalysis.Retrieved fromhttp://ssrn.com/abstract=2627576.

4) Banker, R. D., Chang, H., & Cooper, W. W. (1996). Simulation studies of efficiency,returns to scale and misspecification with nonlinear functions in DEA. Annals ofOperationsResearch, 66(4), 231-253.

5) Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimatingtechnicalandscaleinefficienciesindataenvelopmentanalysis. *Managementscience*,*30*(9), 1078-1092.

6) Banker, R. D., Gadh, V. M., & Gorr, W. L. (1993). A Monte Carlo comparison of twoproduction frontier estimation methods: Corrected ordinary least squares and dataenvelopmentanalysis.European Journalof OperationalResearch, 67(3),332-343.

7) Chansarn, S. (2008). The relative efficiency of commercial banks in Thailand: DEAApproach.InternationalResearchJournalof FinanceandEconomics,18(3),53-68.

8) Debnath, R. M., & Shankar, R. (2008). Measuring performance of Indian banks: anapplicationdataenvelopmentanalysis. *InternationalJournalofBusinessPerformanceManagement*,*10*(1), 57-85.

9) Dillon, A. and M. Morris. 1996. User acceptance of new information technologyTheoriesandmodels.AnnualReviewofInformationScienceandTechnology,Vol.31,pp. 332.

10) Emrouznejad, A., & Amin, G. R. (2009). DEA models for ratio data: Convexityconsideration. *Applied Mathematical Modelling*, *33*(1),486-498.

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.26.01.033

11) Karimzadeh,M.(2012).Efficiencyanalysisbyusingdataenvelopmentanalysismodel:Evidence from Indian banks. *International Journal of Latest Trends in Finance andEconomicSciences, 2*(3),228-237.

12) Mercan, M., Reisman, A., Yolalan, R., & Emel, A. B. (2003). The effect of scale andmodeofownershiponthefinancialperformanceoftheTurkishbankingsector:resultsofa DEA-basedanalysis.*Socio-EconomicPlanningSciences*, *37*(3),185-202.

13) Sanusi,N.A.,Kusairi,S.,Wahab,N.A.,&Hamzah,M.Z.(2011).Technicalefficiencyof Malaysian and Indonesian commercial banks: A data envelopment analysis (DEA)approach.Retrievedfromhttp://www.wbiconpro.com/607-Nur.pdf.

14) Seiford,L.M.,&Thrall,R.M.(1990).RecentdevelopmentsinDEA:Themathematical programming approach to frontier analysis. *Journal of Econometrics*,*46*(1),7-38.

15) Thagunna, K. S., & Poudel, S. (2013). Measuring bank performance of Nepali banks:A Data envelopment analysis (DEA) perspective. *International Journal of Economicsand Financial Issues*, *3*(1), 54.

16) Titko, J., Stankevičienė, J., & Lāce, N. (2014). Measuring bank efficiency: DEAapplication.*Technologicaland EconomicDevelopment ofEconomy*, *20*(4),739-757.

17) Wernz, C., H. Zhang, and P. Kongkiti, *International study of technology investmentdecisions at hospitals*. Industrial Management & Data Systems, 2014. 114(4): p. 568-582.

18) Zhou,Z.,Xiao,H.,Jin,Q.,&Liu,W.(2018).DEAfrontierimprovementandportfoliorebalancing:AnapplicationofChinamutualfundsonconsideringsustainabilityinformationdisclosure.*EuropeanJournalof OperationalResearch*,*269*(1),111-131.

19) Zikmund, W., Babin, B., Carr, J., & Griffin, M. (2012). Business research methods:Cengage Learning. *H4B.JournalofSmall BusinessManagement*,*44*(2), 268-284.