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EMPIRICAL ANALYSIS OF FINANCIAL HEALTH OF SCHEDULED COMMERCIAL BANKS IN INDIA

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ABSTRACT

Banks play an important role in any economy whether it is a developed or an emerging economy. To maintain the sustainability in the market, financial health of banks should be monitored. Liberalization in Indian economy has brought competition among banks, at domestic level as well as foreign level. Indian banking industry also has to compete with non banking financial corporations, mutual funds and other financial institution. As consequence to this profitability of banking sector is squeezed and Indian banking industry is compulsorily required to work efficiently. As banking industry plays an important role in financial market it is important to find out whether banks are working efficiently or not. With the aim to measure efficiency of commercial banks in India, DEA has been applied. In the study, with a total of four inputs and three outputs variables, 70 banks have selected. As the key findings of the study that out of 70 banks, 33 banks reported as efficient banks and remaining 37 banks are considered as inefficient banks. Results indicate that schedule commercial banks in India are utilizing their 96% of resources to produce desired outputs. On the basis of peer count and efficiency scores, Bank 32, (Jammu & Kashmir Bank Limited) referred to table 1 ranked first with peer for 15 inefficient banks. Bank 69 (SBER Bank) referred to table 1 ranked last with lowest efficiency score 0.672.

KEYWORDS: *Financial Health, Data Envelopment Analysis, Efficiency Scores, Input-Output Variables.*

Introduction

Banks play an important role in any economy whether it is a developed or an emerging economy. To maintain the sustainability in the market, financial health of banks should be monitored. Earlier the banking business in India of accepting deposits and lending at administered rates was considered comfortable but after deregulation of interest rates and liberalization has changed the banking scenario in India. Liberalization in Indian economy has brought competition among banks, at domestic level as well as foreign level. Indian banking industry also has to compete with non banking financial corporations, mutual funds and other financial institution. As consequence to this profitability of banking sector is squeezed and Indian banking industry is compulsorily required to work efficiently. As banking industry plays an important role in financial market it is important to find out whether banks are working efficiently or not (Dash & Charles, 2009)[1].

The evolution of a fast-paced dynamic environment in the financial services sector has highlighted the significance of competition and efficiency. Due to intense competition both among domestic and foreign banks, rapid speed of innovations and introduction of new financial instruments, changing consumer's demands have changed the way a bank does business and services its customers. In cut throat competitive environment the only firm could survive that works on efficiency level (Akhtar,

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2002)[2]. Indian economy is one of the fastest developing economies of the world. Indian economy is based on the performance of Indian financial system and therefore the performance of financial system of a nation determines its economic growth indicators (Chandrasekaran & Madhanagopal, 2013)[3]. As banking sector is an integral part of Indian economy therefore it is important to measure performance of banking sector. The Indian banking system is still dominated by the public sector banks, and there is an emerging need to develop a comprehensive framework for measuring their efficiency in transforming their resources for better performance. Such type of performance benchmarking has become extremely relevant for their success.

Earlier many studies have been done in performance analysis of financial institution around the world. Mostly studies dealt with financial ratios, Regression analysis and other parametric analysis. Although previous studies also have suggested that data envelopment analysis is well suited framework for performance analysis and it offers advantages over other traditional methods. Data Envelopment Analysis is a linear programming-based technique for evaluating the performance efficiency of a set of peer units. These peer units are called Decision-Making Units (DMUs). The technique measures that how efficiently a DMU used its available resources or termed inputs to generate desired outputs (Ramanathan, 2003)[4]. "DEA does not require any underlying assumption of a functional form relating to inputs and outputs. Given the set of inputs and outputs of different firms, it constructs its own functional form" (Kumar & Vincent, 2011)[5]. In DEA, the performance of DMUs is determined by using the concept of efficiency or productivity. Efficiency is equal to ratio of total sum of 'Weighted Outputs' to total sum of 'Weighted Inputs'.

Efficiency = Weighted Sum of Outputs/ Weighted Sum of Inputs

On the basis of the DMUs' input–output vectors, a production frontier is established that can be considered as best practice. Hence, the DMUs on this production frontier are considered as efficient and the remaining DMUs as inefficient. The limit of inefficiency is measured as the distance from the best practice production frontier (Homburg 2001)[6].

Efficiencies estimated using DEA are relative, that is, relative to the best performing DMU (or DMUs if there is more than one best-performing DMUs). The best-performing DMU is assigned an efficiency score of 1 or 100%, and the performance of other DMUs vary, between 0 and 1 or 100% relative to this best performance (Ramanathan, 2003)[4]. DMU, whose efficiency score is 1 or 100 % is considered as efficient unit; whereas, DMU, whose efficiency score is less than 1 or 100% is considered as inefficient unit. On the basis of efficiency score using DEA, here DMUs can be segregated into two groups that are efficient DMUs and inefficient DMUs. The bank that attains the efficiency scores of 1 lie in the efficient frontier and the bank that does not achieve the efficiency score of 1 lie below the efficient frontier (Shree *et al.* 2015)[7]. The present study aims to measure the efficiency of schedule commercial banks in India and rank them on the basis of the DEA.

Review of Literature

In the aftermath of liberalization, deregulation and vital changes in financial institution around the world, there is a recent boom in activities related to evaluate efficiency of financial institutions. Numerous studies have been done in this arena. To evaluate efficiency of financial institutions, researchers have applied parametric (SFA, DFA and TFA) and non parametric (DEA and FDH) techniques for their studies. Especially Data Envelopment Analysis and Stochastic Frontier Analysis techniques are widely popular for these kinds of studies. Several studies have been done in well developed economies; in contrast to that fewer studies have been done in developing economies like India.

Berger & Humphrey (1997)[8], surveyed 130 studies that apply frontier efficiency analysis to financial institutions in 21 countries. With the aim to summarize and critically review empirical estimates of financial institution efficiency, researchers have outlined the results of selected studies that apply five different frontier approaches including both parametric and non parametric. Results found that the various efficiency methods do not necessarily yield consistent results.

Sathye (2003)[9], examined the efficiency of banks in developing country i.e. India by using DEA. The efficiency scores measured for three group of banks, public, private and foreign banks in India. The study reveald that the mean efficiency score of Indian banks compared well with the world mean efficiency score and the efficiency of private sector commercial banks was lower than public sector banks and foreign banks in India.

Mohan & Ray (2004)[10], attempted a comparision among public, private and foreign banks operating in India and also compared the revenue maximisation efficiency of banks during 1992-2000. For the computation, 58 banks selected for the study which includes 27 public sector banks, 20 private sector banks and 11 foreign banks. Loans, investments and other income are chosen as outputs and deposits and operating costs as inputs. The finding showed that public banks significantly performed better than private banks on revenue maximizing efficiency but there is no difference between public banks and foreign banks.

Brissimis et al. (2008)[11], examined the relationship between banking sector reform and bank performance of 10 European Union countries. Bank performance measured in terms of efficiency, total factor productivity growth and net interest margin. Researchers developed an empirical model of bank performance by using recent econometric techniques. The model is applied to bank panel data. The results indicated that both banking sector reform and competition had positive impact on bank efficiency

Gupta et al. (2008)[12], analyzed the performance of Indian banking sector. The performance has been measured and compared in two stages, productive efficiency through the DEA technique and finding the dterminants of productive efficiency through TOBIT model. The study showed that SBI and its group have the highest efficiency, followed by private banks, and the other nationalized banks.

Kumar & Gulati (2008)[13], evaluated the technical efficiency of 27 pubic sector banks operating in India and provided ranking to these banks on the basis of outcomes of DEA. The cross-section data for the financial year 2004/2005 were used for obtaining technical efficiency scores. Findings revealed that only 7 banks out of 27 found as efficient bank and thus gives efficiency frontier. Andhra bank observed as the most efficient bank followed by Corporation bank. Addition to the results SBI group found more efficient than nationalized banks.

Fethi & Pasiouras (2010)[14], presented a comprehensive review of 196 studies containing operational research (O.R.) and artificial intelligence (A.I.) techniques in the assessment of bank performance. They concluded that most of the studies applied data envelopment analysis in the estimation of bank efficiency and productivity growth.

Hsiao et al. (2010)[15], investigated the effect of the first financial restructuring (FFR) on the operating efficiency of commercial banks in Taiwan. For the analysis they applied data envelopment analysis (DEA) to operations data for 40 commercial banks for the study period of 6 years, 2000–2005. Results were found that the banks had lower operating efficiency on average during the reform period (2002–2003) compared to the pre-reform period (2000–2001), improved operating efficiency was reflected in the post-reform period (2004–2005).

Karimzadeh (2012)[16], examined the eficiency of Indian commercial banks during 2000-2010 with using DEA. Researcher has computed cost efficiency, technical efficiency and allocative efficiency on the sample of 8 schedule commercial banks. Both the VRS and CRS model applied for the study and results found that Bank of India and ICICI bank were more efficient as compare to other banks in India and result confirmed that selected Public Sector Banks were more efficient than Private sector banks during the study period in India.

Roy (2014)[17], analyzed the efficiency of Indian banking sector by using Data Envelopment Analysis. The study has been done across three economic eras (Pre Basel, Basel I and Basel II) and across the different ownership structure (Nationalized banks, Private sector banks, foreign banks and SBI & Its Associates banks). Variables for the study were selected on the basis of intermediation approach. Researcher tried to identifiy whether inefficiency arises ought to managerial incompetence or improper size of and resource allocation. Results found that the main reason for inefficiency in Indian Banking sector is improper size allocation.

Sinha (2016)[18], presented a paper on benchmarking the performance of Indian banking sector through dynamic-slacks based DEA model. The study benchmarkes the performance of public sector banks, private sector banks and foreign banks operating in India for the study period 2006-07 to 2010-11. The study included 62 commercial banks and for the selection of input output variables intermediation approach considered. The results indicate that mean technical efficiency of the 62 commercial banks had a n increasing tendency between 2006-07 and 2009-10 but declined in 2010-11. The group-wise analysis showed that in terms of efficiency, the foreign banks performed better, followed by public and private sector banks.

Objectives of the Study

- To identify input and output variables through review of literature.

- To check validity of chosen input and output variables for DEA through isotonicity test.
- To evaluate the financial health in terms of DEA scores of schedule commercial banks in India and provide ranking to them on the basis of DEA model.

Methodology

Selection of Input-Output variable: Selection of input – output variables in application of DEA is a subjective matter. There are no specific rules have determined for the selection. There are mainly two approaches used for selecting the inputs – outputs variables for banking industry, popularly known as production approach and intermediation approach (Berger & Humphrey 1997)[8].

As per **Berger & Humphrey, (1997)[8]**, the production approach is more suitable for evaluating efficieny of banks branches and the intermediation approach is more appropriate in evaluating efficiency at bank level.

As suggested in previous studies**,** we have selected intermediation approach for the study. According to this approach banks have treated as financial intermediateries who used certain set of inputs to generate certain set of outputs. Considering this approach input and output variables have been chosen at restricted level. For DEA, choice of input- output varaibles should be kept at reasonable level because inclusion of more number of variables decreases the discriminatory power of DEA model. As a consequences some inefficient units may become efficient **(Smith, 1997)[19]**. Considering this the choice of variables have kept at reasonable level and the following variable are used for the study in table 1:

Table 1: Input Output Variables

S.No.	Input Variables	Output Variables
1.	Net Worth	Net Profit
2.	Interest Expenses	Interest Income
3.	Operating Expenses	Loans & Advances
4.	No. of Branches	

Statistical Tool

To evaluate the financial health of Indian banking industry, Data Envelopment Analysis has been applied in the study. The orientation of DEA is on the basis of two approaches- Input orientation and Output orientation. Input oriented DEA model aims to produce observed outputs with minimum level or reducing inputs. In this approach there are no changes have been made in output level. Here, the inputs are multiplied by efficiency, as of this characteristics it is called input oriented model. Output oriented model, on the other hand produce maximum outputs at a given level of inputs. In this approach changes have been made to output level and resources level or inputs remain constant. This approach is called output oriented model (Ramanathan 2003[4], Roya, 2014)[20]. An input oriented Charnes, Cooper and Rhodes (CCR) constant return to scale (CRS) model has been applied for the study. Detail description of the model has been given at the end notes of the paper.

Period of the Study

The data were collected for the study period of 2011-12 to 2015-16. Further average of five years of variables has been calculated for the analysis. Here average of five years seems more appropriate for the study rather than one year data as average gives more clarity regarding the data.

Sample Design

The data for input- output variables are gathered from the electronic database, PROWESS provided by Centre for Monitoring Indian Economy (CMIE). Indian banking industry is segregated into schedule commercial banks and unscheduled commercial banks. For the study, sample consist public sector banks, private sector banks and foreign sector banks as part of schedule commercial banks in India. There are 27 public sector banks in India that segregated into 21 nationalized banks and 6 SBI and its associate banks. Private sector banks in India are also divided into 12 old private sector banks and 9 new private sector banks and 44 banks are there as foreign banks.

There is a rule of thumb exists to determine the minimum size of DMUs. **Homburg (2001)[6]** have suggested in their study that the number of DMU should be atleast twice of the number of inputs plus outputs. **Nunamaker (1985)[21] and Raab & Litchy (2002)[22]** suggested a rule of thumb to ascertain the minimum size of sample DMUs in DEA study. As per the researchers the sample size should be at least three times larger than the sum of the number of inputs and outputs.

In our study, with a total of four inputs and three outputs, we ended up with a reasonably good sample size of 70 banks. For the sample size, we have selected 23 banks from public sector, 18 banks from private sector and 29 banks from foreign sector. Table 2 displays the descriptive statistics for inputs outputs variables.

Table 2: Descriptive Statistics for Inputs and Outputs of Sample Banks

	Variables	Minimum	Maximum	Average	SD
Inputs	Net Worth	560.98	1152599.60	102813.00	178278.07
	Interest Exp.	2.30	859620.24	74277.23	125314.63
	Operating Exp.	111.88	1191993.02	97368.81	169250.38
	No. of Branches	1.00	15767.40	1264.98	2270.12
Outputs	Net Profit	0.10	119511.32	10743.40	21234.98
	Interest Income	71.98	1357219.46	111315.43	192817.49
	Loans and Advances	46.92	11868323.48	887492.90	1658526.97

Source: Own Calculation

Isotonicity Test

In order to check the validity of input output variables of DEA model, **Avkiran (1999)[23]** has suggested an isotonicity test. The test involves calculations of inter-correlation between inputs and outputs variable whether increasing amount of inputs lead to greater output. As per the DEA isotonicity test, only those variables should select for the study whose inter-correlation values are statistically significant **(Chandrasekaran & Gopal, 2013)[24].** Following table 3 displays Pearson correlation coefficients for inputs- outputs variable of DEA.

Table 3: Pearson Correlation Coefficients for Inputs and Outputs Variables of DEA

	Net Worth	Interest Exp.	Operating Exp.	No. of Branches	Net Profit	Interest Income	Loans & Advances
Net Worth	1						
Interest Exp	.914	1					
Operating Exp	.932	.997	1				
No of Branches	.850	.976	.973	1			
Net Profit	.945	.773	.806	**.696**	1		
Interest Income	.940	.995	.999	.970	.821	1	
Loans and Advances	.932	.992	.997	.971	.805	.997	1

Source: Own Computation

As per the table, it is observed that all the correlation values between inputs- outputs variable are positive and statistically significant at the 0.01 level (2 tailed). Here it is observed that between input-output variables Pearson correlation is ≥ .80. Although between no. of branches and net profit, correlation value is .696 but it is shown statistically significant in the output results of SPSS 21. Thus these variables are also considered for the analysis. Hence, all the present input and output variables passed the test and included for the analysis.

Analysis & Discussion

The present study employed an input oriented DEA model with constant return to scale (CRS). The efficiency scores of DEA and benchmarking are summarized in the following table 4.

Table 4: Efficiency Scores and Benchmarking of Commercial Banks based on DEA Model

Bank No.	Bank Name	Efficiency Score	Reference Set						Peer Count	Rank
B1	State Bank of India	1	B1						(0)	27
B 2	State Bank of Bikaner & Jaipur	1	B2						13	2
B 3	State Bank of Hyderabad	0.994	B11	B41	B23	B2			0	38
B 4	State Bank of Mysore	0.975	B6	B11	B2				0	43
B 5	State Bank Patiala	0.974	B15	B2	B6	B11	B21		0	45
B 6	State Bank of Travancore	1	B6						5	11
B 7	Allahabad Bank	0.975	B11	B32	B21				0	43
B 8	Andhra Bank	0.995	B2	B21	B32				0	36
B 9	Bank Of Baroda	1	B9						5	11

B 10	Bank of India	1	B10						1	21
B 11	Bank of Maharashtra	1	B11						6	9
B 12	Canara Bank	0.963	B15	B2	B21	B13	B6	B41	0	47
B 13	Corporation Bank	1	B13						2	18
B 14	Dena Bank	0.934	B20	B11	B21	B32			0	54
B 15	IDBI	1	B15						8	6
B 16	Indian Bank	1	B16						(0)	27
B 17	Oriental Bank of Commerce	0.995	B6	B41	B21	B15			0	36
B 18	Punjab & Sind Bank	0.994	B11	B21	B23				0	38
B 19	Punjab National Bank	1	B19						(0)	27
B 20	Syndicate Bank	1	B20						3	16
B 21	UCO Bank	1	B21						9	5
B 22	Union Bank of India	0.996	B41	B13	B10	B2	B6	B20	0	35
B 23	Vijaya Bank	1	B23						4	15
B 24	Axis Bank	1	B24						(0)	27
B 25	Catholic Syrian Bank Ltd	1	B25						(0)	27
B 26	City Union Bank Ltd	0.985	B41	B32	B2	B29			0	42
B 27	DCB Bank Ltd	0.904	B2	B41	B29				0	61
B 28	Federal Bank	0.905	B32	B60	B9	B54			0	59
B 29	HDFC Bank	1	B29						7	8
B 30	ICICI Bank	0.915	B9	B54	B47	B32	B29		0	57
B 31	Indusind Bank	0.926	B32	B29	B51	B41			0	55
B 32	J&K Bank Ltd	1	B32						15	1
B 33	Karnataka Bank Ltd	0.905	B21	B32	B41	B2			0	59
B 34	Karur Vysya Bank	0.953	B2	B32	B21	B41			0	50
B 35	Kotak Mahindra Bank Ltd	0.924	B29	B51	B32	B41			0	56
B 36	Laxmi Vilas Bank	0.936	B20	B23	B2				0	53
B 37	Nainital Bank	0.939	B29	B51	B32				0	52
B 38	RBL	0.829	B29	B15	B51	B9	B32		0	68
B 39	South Indian Bank	0.987	B41	B23	B2				0	41
B 40	Tamilnad Mercantile Bank	0.99	B2	B32	B41				0	40
B 41	Yes Bank Ltd	1	B41						13	2
B 42	AB Bank Ltd	0.952	B56	B59	B51				0	51
B 43	Abu Dhabi Commercial Bank	0.885	B15	B51	B50	B47	B53		0	64
B 44	Bank of America	1	B44						2	18
B 45	Bank of Bahrain & Kuwait	0.891	B60	B51	B54	B32			0	63
B 46	Bank of Ceylon	1	B46						(0)	27
B 47	Bank of Nova Scotia	1	B47						5	11
B 48	Bank of Tokyo-Mitsubishi	1	B48						(0)	27
B 49	Barclays Bank	0.963	B53	B54	B44				0	47
B 50	BNP Paribas	1	B50						3	16
B 51	Citibank	1	B51						13	2
B 52	Credit Agricole	0.833	B51	B47	B60	B57			0	66
B 53	DBS Bank Ltd	1	B53						5	11
B 54	Deutsche bank	1	B54						8	6
B 55	Hongkong & Shangai banking Corporation	0.904	B53	B51	B41				0	61
B 56	HSBC Bank Oman	1	B56						1	21
B 57	JP Morgan Chase Bank	1	B57						2	18

B 58	KrungThai Bank	1	B58						1	21
B 59	Mashreq Bank	1	B59						1	21
B 60	Mizuho Bank Ltd	1	B60						6	9
B 61	Royal Bank of Scotland	0.997	B15	B51	B50	B53			0	34
B 62	Shinhan Bank	0.957	B32	B60	B58	B51			0	49
B 63	Societe Generale	0.821	B15	B50	B54	B47	B9		0	69
B 64	Standard Chartered Bank	0.969	B47	B54	B15	B51	B9		0	46
B 65	JSC VTB Bank	1	B65						1	21
B 66	United Overseas Bank	0.878	B70	B60					0	65
B 67	Australia & Newzealand Banking Group	0.831	B54	B44					0	67
B 68	Credit Suisse AG	0.914	B57	B51	B53				0	58
B 69	SBER Bank	0.672	B60	B65	B54				0	70
B 70	National Australia Bank	1	B70						1	21
	Efficient Firms	**33**								
	% of Efficient Firms	**47.14**								
	Average efficiency Score	**0.962285**								

Source: Calculations in DEAP 2.1 version software

Efficient but not peer to inefficient banks

The above table demonstrates that the average efficiency score of commercial banks in India is 96% (0.9623). It indicates that commercial sector banks in India use 96% of the resources to produce the given output. Inefficient banks can improve their efficiency if they utilize their unused resources properly. In DEA, a bank is considered an efficient if its efficiency score is 1 otherwise it is considered as inefficient bank. The table reveals that out of 70 banks, 33 banks reported efficiency score equal to 1, thus these banks may consider as efficient banks. Remaining 37 banks are considered as inefficient banks.

The above table also demonstrates the reference set of the inefficient banks. A set of corresponding efficient banks act as reference banks or peer for inefficient banks. Inefficient banks can improve their performance following their reference banks. For example, B3 is an inefficient bank and it has four reference banks as B11, B41, B23 and B2. B3 can follow any of these four banks for improvement. Ranking for efficient banks given on the basis of their peer count that is, first rank is given to that efficient bank which act as a peer for maximum number of inefficient banks. For inefficient banks ranking are done on the basis of their efficiency score. As per he above table, B32 (J&K Bank Ltd) is given first rank as it is peer for 15 inefficient banks , B2, B41 and B51 (State Bank of Bikaner & Jaipur, Yes Bank Ltd and Citibank) ranked second with 13 peers. B1, B16, B19, B24, B25, B46 and B48 (State Bank of India, Indian Bank, Punjab National Bank, Axis Bank, Catholic Syrian Bank Ltd, Bank of Ceylon and Bank of Tokyo-Mitsubishi) are efficient banks but they are not reference or peer banks for any inefficient banks so they have given twenty seventh rank. B69 (SBER Bank) stands last rank i.e. 70^{th} rank with the least efficiency score of 0.672.

Conclusion

The present study has been carried out with the purpose to measure performance or efficieny of schedule commercial banks in India for the study period of 2011-12 to 2015-16. For the computation of efficiency 70 banks from different ownership (Public, private and Foreign) has been selected . Following previous studies, Data Envelopment Analysis is chosen for the analysis as this non-parametric technique is widely popular for efficiency analysis and it is easy to calculate. For the study input oriented CCR DEA model is applied. Although DEA has some limitation regarding the selection of input-output variables, when the number of input- output variables increased the discriminatory power of DEA to segregate DMUs in efficienct and inefficient decreased. As the key findings of the study that out of 70 banks, 33 banks reported as efficient banks and remaining 37 banks are considered as inefficient banks. Results indicate that schedule commercial banks in India are utilizing their 96% of resources to produce desired outputs. On the basis of peer count and efficiency scores, Bank 32, (Jammu & Kashmir Bank Limited) referred to table 1 ranked first with peer for 15 inefficient banks. Bank 69 (SBER Bank) referred to table 1 ranked last with lowest efficiency score 0.672.

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End Notes

CCR Model: This model is named after the researchers. They introduced a measure of efficiency for each DMU as a maximum of a ratio of weighted outputs to weighted inputs. Say we have a population of productive units DMU_1, DMU_2, ……., DMU_n. Assumes each unit produces s outputs while consuming m inputs. Here an input matrix can be formed like this: X= [xij, i= 1,2,3,…, m, j= 1,2,3,…., n] and an output matrix Y= [yij, i= 1,2,….,s, j=1,2,….,n]. The q-th line i.e. X_q and Y_q of these matrixes thus shows quantified inputs/outputs of unit DMUq. This is expressed as:

$$\text{Weighted Sum of Outputs/ Weighted Sum of Inputs} = \sum_{i=1}^{s} u_i y_{iq} / \sum_{j=1}^{m} v_j x_{jq}$$

Where:

v_j = Weights assigned to inputs,

u_i = Weights assigned to outputs.

The essences of DEA models in measuring the efficiency of productive unit DMU_q lies in maximizing its efficiency rate with subject to the condition that the efficiency rate of any other units in the population must not be greater than 1 and the weights of all inputs and outputs must be greater than zero **(Vincova, 2005)**[25]. It is formally expressed by mathematical programming model:

$$\text{maximize} \quad \sum_i u_i y_{iq} / \sum_j v_j x_{jq}$$

$$\text{Subject to} \quad \sum_i u_i y_{ik} / \sum_j v_j x_{jk} \leq 1 \quad k=1,2,\ldots..n$$

$$u_i \geq 0 \quad i= 1, 2,\ldots.,s$$

$$v_j \geq 0 \quad j= 1,2,\ldots,m$$

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