Performance Measurement of Indian Banks using Data Envelopment Analysis

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***Abstract*—In the paper an attempt was made to study the performance of Indian Banks with the help of CAMEL rating system, taking eighteen banks (eight being Private Sector Banks and ten being Public Sector Banks) over the period of ten years from (2004 to 2013) and then finding out their efficiency of banks with the help of DEA in terms of gaining confidence from investors and ranking them accordingly. Our finding suggests that private sector banks are in advantage situation and thereby hinting at the possibility of further improvisation of most of the public sector banks. Private sector banks show marked consistency in their efficiency level during the period under study.**

***Index Terms*—DEA, CAMEL rating, Indian banks.**

I. Introduction

Banking Sector is considered a main driving force for industries in a particular economy, which tries to absorb shocks of varying magnitude in different time horizon.

The Indian banking system has witnessed a very long history where the Indian Central Bank, The Reserve Bank of India (RBI) came into operation from 1935 but only after independence RBI was given broad regulatory authority over commercial banks in India. Real development in Indian economy started only after nationalization since private banks was not lending much who need the most as many banks failed in different countries leading varying degree of crisis leading to the strangling of economic growth for this reason CAMEL rating system serves as a barometer to gauge the financial and operational soundness of banks to mitigate such crisis in near future. This paper deals with the performance of Indian, Private and Public Sector banks using CAMEL rating and then finding out their value (financial soundness) translation in terms of gaining confidence from investors and ranking them accordingly with the help of Data Envelopment Analysis (DEA).

The efficiency measure within a group of companies can be carried out by three methods, namely ratio analysis, parametric method and non-parametric method. Ratio analysis indicates a simple relationship between two terms. The parametric method includes Stochastic Frontier Approach (SFA), Thick Frontier Approach (TFA) or Distribution Free Approach (DFA). And non-parametric method includes Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH). The main difference between parametric and non-parametric approach is the former measure economic efficiency (i.e. The level of input & output based on price or cost) but later measures technical efficiency (which involves a level of input or output).

II. Literature Review

[1] Rajiv Banker and *et.al.* (1986) compared econometric model of translog cost function and DEA in Hospital production. In their research it is evident that translog cost function follows constant return whereas the DEA suggest both increasing and decreasing returns to scale but in their results both models agrees that taking care of children are more resource intensive than devotion to adults or to elderly.

[2] Charnes, A., Cooper, W.W., Rhodes (1978) were first to introduce DEA. Initially efficiency measure was evaluated for not-for-profit entities. They developed objective determing weight similar to ordinary linear programming method and constructed scale measuring efficienty for each of participating unit later coined as Decission Making Units (DMU's).

[3] Mishra, A. K., Harsha, G., Anand S. and Dhruva, N. R., (2012) measured the performance of 12 public & private sector banks over a period of twelve years for which CAMEL rating was used. In their study individual parameter of CAMEL were ranked for Indian Banks and final composite rank was computed taking average ranks of all five parameters of CAMEL and they have concluded that private banks are performing better than public sector banks for the period ranging from 2000 to 2011.

[4] Md. Anwarul Kabir and Suman Dey (2012) measured the performance of Selected Private, Commercial Banks in Bangladesh (EXIM & IFIC) using the CAMEL rating for the period of four years. Their finding revealed that in some parameter EXIM was better and in other parameters IFIC was better.

[5] Filiz Kardiyen, H. Hasan Örkcu (2006) compared Principal Component Analysis (PCA) and DEA for ranking of fifteen countries which are members of the Europen Union in 2002 in financial aspect taking multiple inputs and outputs which yielded constant & valuable results. Then rank correlation test was conducted which showed high correlation between the two methods and at the end simulation study was carried out

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containing 1000 repetitions for different numbers of DMUs and different number of input-output variables and the result was positive.

[6] Karimzadeh, Majid (2012) had studied the efficiency of Indian commercial banks for the period of ten yeas using DEA. VRS and CCR were used to find the performance of eight banks and found out that Bank of india and ICICI Bank are efficient. Form his study it is evident that Public Sector Banks are more efficient than Private Banks.

[7] Lin, W., Liu, C., Chu, C., (2005) had made an attempt to measure the efficiency of shipping industry with financial indicators. In their study 14 shipping companies were taken to find their efficiency level using DEA.

[8] Misra S. K., and Aspal, P. K., (2013) measured the financial soundness of State Bank Group (All seven State Banks) for the period of two years and used CAMEL rating approach. They concluded that tough in some parameters some State Bank were top performing in that particular year, but overall the overall performance of the State Bank group is same this may be because of the adoption of modern technology, banking reforms and recovery mechanism however they gave more emphasis on SBI to improve further.

[9] Trivedi. K. R., in his paper "A Camel Model Analysis of Scheduled Urban Co-operative Bank in Surat City–A case study of Surat People's Co-operative bank" had evaluated the financial performance of the Surat People Co-operative Bank using a CAMEL model. In his study ten years data were analyzed by calculating twenty eight ratios and fount out the liquidity portion was below satisfactory and needed to improve.

JJL Cronje in his paper "An assessment of financial ratio analysis and data envelopment analysis in comparing the relative profitability of banks" compared the application of financial ratio and DEA in bank profitability measure by taking twelve South African Banks and one foreign Banks in South Africa from 2006 by using two methods. In the first method researcher took single input and multiple output and find out the Efficiency score of Banks, but in the second method CRS and VRS DEA output technique was applied to find out the efficiency of Banks. Cronje concluded that multiple input and output DEA technique is better than financial profitability analysis.

Alexis Derviz & Jiří Podpiera (2004) investigate the determinants of the movements in the long-term Standard & Poors and CAMELS bank ratings in the Czech Republic when most of the assets of banks were privatized during the period from 1998 to 2000. They employed logit model to analyze the monthly long-run S&P rating and analyses of the quarterly CAMELS rating.

Kosmidou, K., and Zopounidis C., (2008) evaluates the performance and efficiency of the commercial and cooperative banks in Greece from 2003 to 2004. Their finding indicates that commercial banks are attracting more & more customers by increasing their accounts thereby becoming more competitive and maximizing their profits, whereas the cooperative banks in Greece, already have major market share and are enjoying considerable increased profits are deteriorating in financial fronts.

III. Objective of Study

- To find out the efficiency of Indian Banks using Data Envelopment Analysis (DEA) based on the performance of Indian Banks and its stock market return.
- To compare the overall performance of Banks in India.

IV. Research Methodology

[6] DEA is an operation research technique in finding out the efficiency of different homogenous companies known as Decision Making Units (DMU) when there are multiple inputs or outputs. It's a non-parametric approach where its initial use was to find the operational efficiency. [2] In the DEA methodology, formally developed by Charnes, Cooper and Rhodes (1978), efficiency is defined as a ratio of weighted sum of outputs to a weighted sum of inputs, where the weights, structure is calculated by means of mathematical programming and constant returns to scale (CRS) are assumed later it in 1984, Banker, Charnes and Cooper developed a model with variable returns to scale (VRS). The variable returns-to-scale (VRS) score represents a more strict "local" definition of efficiency, devoid of the scale effect. Fig. 1 shows the frontier Model for DEA.

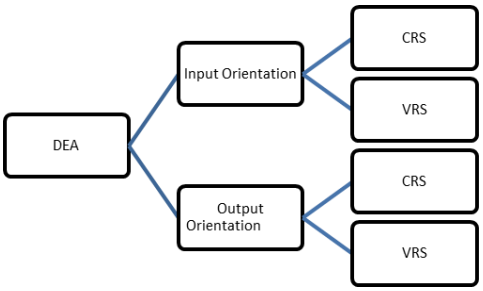

Figure 1. Basic frontier Model for DEA

We have applied input oriented DEA- VRS model. In general

$$Efficiency = \frac{Output}{Input} \quad (1)$$

When there is one output and input, but DEA can also be applied when the input-output transformation is not known and allows for the following relative efficiency measurement.

$$Efficiency = \frac{Weighted\ Sum\ of\ Outputs}{Weighted\ Sum\ of\ Inputs} \quad (2)$$

Input and output selection could be always be logical and meaningful as efficiency is the ratio of output & input The sample size (no of DMU's) used in this analysis is followed a thumb rule coined different researcher. Golany and Roll (1989) establish a rule of thumb that the number of units should be at least twice the number of inputs and outputs considered. Bowlin (1998) mentions the need to have three times the number

of DMUs as there are input and output variables. n ⩾ max {2*m*s; 3(m + s)} where n denotes the number of sample unit, 's' for number of outputs and 'm' is number of Inputs. As for our case for five inputs and one output no of DMU' s ⩾ max {10; 18} i.e. 18.

These numbers should probably be used as minimums.

[2] The input-oriented VRS technique requires the solution of the following LP problem due to Banker, Charnes, Cooper, 1978 is

Min θ

Subject to

$$\sum_{j=1}^{n} w_j x_i^j \le \theta x_i^t; i = 1,2,3 \dots m$$
$$\sum_{j=1}^{n} w_j y_r^j \ge y_r^t; r = 1,2,3 \dots s \quad (3)$$
$$\sum_{j=1}^{n} w_j = 1;$$
$$w_j \ge 0 (j = 1,2,3, \dots, n);$$

where w_j is the weight of the j^{th} DMU, x_i^j is value of the i^{th} input variables for j^{th} DMU, y_r^j is value of the r^{th} output variables for j^{th} DMU and x_i^t is the value of i^{th} input variable for t^{th} DMU. Number of inputs is m, number of outputs is s and the number of DMU is n. Here the value of θ signifies the efficiency of the DMU.

In DEA, DMU's are ranked according to efficiency score (according to value of θ). Problems arise if value of θ is equal to one (cent percent) for more than one DMU's in that case further Super Efficiency analysis was found out to find the most efficient DMU. Super efficiency analysis was developed by Anderson & Peterson (1993).

If 'it' is considered of an efficient unit having θ is equal to one, then Super efficiency is represented as

Min θ

Subject to

$$\sum_{j=1}^{n} w_j x_i^j \le \theta x_i^t; i = 1,2,3 \dots m$$
$$\sum_{j=1}^{n} w_j y_r^j \ge y_r^t; r = 1,2,3 \dots s \quad (4)$$
$$\sum_{j=1}^{n} w_j = 1;$$
$$w_j \ge 0 (j = 1,2,3, \dots, n);$$

where $j \neq t$.

To find the performance of the Indian Banks (which are being traded in the National Stock Index) over the period of ten years, we have used globally accepted CAMEL Rating System as inputs.

[8]. As the name suggests CAMEL stands for Capital adequacy, Asset quality, Management soundness, Earnings and Liquidity, which are explained as below are the components in which the banks are assessed.

A. *Capital Adequacy*

Capital Adequacy Ratio is the ratio which determines the bank's capacity to meet its liabilities and other risks such as credit risk, operational risk, etc. In the simplest formulation,

$$CAR = \frac{(\text{Tier 1 Capital} + \text{Tier 2 Capit}}{\text{Risk weighted Assets}} \quad (5)$$

where Tier 1 Capital is (paid up capital + statutory reserves + disclosed free reserves) - (equity investments in subsidiary + intangible assets + current and losses)

And Tier 2 Capital is Undisclosed Reserves, General Loss reserves, hybrid debt capital instruments and subordinated debts where risk can either be weighted assets.

B. *Assets Quality*

It measures the asset quality is to ascertain the component of Non-Performing Assets (NPAs) as a percentage of the total assets. Thus, asset quality indicates the type of the debtors the bank is having.

$$\text{Net NPA to Net advances} = \frac{\text{Closing Balance of Net NPA}}{\text{Advances}} \quad (6)$$

C. *Management Soundness*

To find the Management efficiency following Ratio is calculated

$$\text{Market Value to Equity Capital} = \frac{\text{No of Shares} * \text{Market Price}}{\text{Net Worth}}$$
$$\text{Total Advances to Total Deposits} = \frac{\text{Total Advance}}{\text{Total Deposit}}$$
$$\text{Profit per Employee} = \frac{\text{Net Profit}}{\text{No of Employee}} \quad (7)$$

D. *Earnings*

Earning quality reflects the quality of a bank's profitability and its ability to earn consistently over a period of time. This parameter is measured on the basis of three ratios given below

$$\text{Interest Income to Total Income} = \frac{\text{Interest Earned}}{\text{Total Income}}$$
$$\text{NonInterest Income to Total Income} = \frac{\text{Other Income}}{\text{Total Income}}$$
$$\text{Net Profit to Avg Assets} = \frac{\text{Net Profit for the year}}{\text{Total Assets}} \quad (8)$$

E. *Liquidity*

A high liquidity ratio indicates that the bank is more affluent. To measure the liquidity two ratios are considered as given below:

$$\text{Liquid assets to Total Assets} = \frac{\text{Cash \& Balance with RBI} + \text{Balance with Bank}}{\text{Total Assets}}$$
$$\text{Liquid assets to Total Deposits} = \frac{\text{Cash \& Balance with RBI} + \text{Balance with Bank}}{\text{Total Deposits}} \quad (9)$$

After finding out all the CAMEL parameters which depicts the financial health of the Banks, Data Envelopment Analysis (DEA) was applied to find out the efficiency Indian Banks with respect to its stock market

return. This exercise was carried out to find the investors' confidence with respect to the financial soundness of the Indian Banks.

Yearly returns in case of Banks were calculated from the formula

Return = Ln (P_1 / P_0) *100 where P_1 is present year closing price (i.e. The closing price of current financial year) and P_0 is previous year closing price (i.e. The closing price of previous financial year) Then average return of all ten years of Indian Banks was taken as output parameter for further DEA analysis.

V. Sample

In our study eighteen Banks (eight Private Sector and ten Public Sector Banks) were taken into consideration.

Data was collected from published Banks annual reports which are available from individual banks' websites over a period of ten years from 2004 to 2013. Table I shows the different input variables and output variable for DEA analysis

TABLE I. Variable Specification

Input	Output
Capital Adequacy Ratio (C)	Stock Market Return (average of last 10 years)
Asset Quality Management (A)	
Management Quality Parameter (M)	
Earnings Quality Parameter (E)	
Liquidity Parameter (L)	

TABLE II. Variable Specification

Banks	C (I_1)	A (I_2)	M (I_3)	E (I_4)	L (I_5)	Stock Return
SBI	0.3198	0.0205	0.8415	0.3363	0.1050	0.3089
BOB	0.3268	0.0080	0.6271	0.3365	0.1329	0.3784
PNB	0.3316	0.0082	0.7244	0.3370	0.0988	0.4238
Canara	0.3486	0.0114	0.5335	0.3358	0.0895	0.2944
BOI	0.3372	0.0164	0.6282	0.3360	0.1131	0.2700
UCO	0.3228	0.0221	0.4840	0.3352	0.0894	0.2028
Union	0.3374	0.0139	0.6174	0.3364	0.0836	0.3324
Oriental	0.3348	0.0102	0.5834	0.3363	0.1033	0.4437
Andhra	0.3386	0.0059	0.6532	0.3374	0.1007	0.2599
IDBI	0.3397	0.0143	0.9419	0.3353	0.0994	0.3834
HDFC	0.3183	0.0032	1.6092	0.3382	0.1107	0.2436
Axis	0.3078	0.0064	1.1763	0.3373	0.1160	0.6318
ICICI	0.3419	0.0136	1.2136	0.3372	0.1137	0.3644
Kotak Mahindra	0.3536	0.0106	2.2689	0.3376	0.0799	0.3508
Federal	0.3372	0.0116	0.6625	0.3368	0.0871	0.4075
Karurvysya	0.3616	0.0064	0.6892	0.3383	0.0757	0.2270
Indusind	0.3256	0.0148	0.9434	0.3365	0.1077	0.7086
Dhanlaxmi	0.3146	0.2279	0.5208	0.3341	0.1169	0.1622

VI. Result & Discussion

After finding out the CAMEL parameters and respective stock market return as listed in Table II, which served as input and output parameters respectively, for DEA (input oriented VRS Model) analysis, to find the technical efficiency of the Indian Banks. Super Efficiency Model was applied to find the most efficient bank among the banks having an identical score of one. The following results were computed using Lingo 13 demo version. Sample program for input oriented VRS Model for first DMU is given in Appendix A. Super Efficiency was carried out where Banks initially showed the efficiency of cent per cent. Sample program for Super Efficiency is given in Appendix B. The following Table II and Table III shows the ranking of Indian Banks in terms of its efficiency level.

TABLE III. Efficiency Table (Input Oriented VRS)

Banks		Efficiency	Super-Efficiency	Ranking
SBI	DMU1 (W1)	0.998205		17
BOB	DMU2 (W2)		1.027888	10
PNB	DMU3 (W3)		1.012273	13
Canara	DMU4 (W4)		1.079105	7
BOI	DMU5 (W5)	0.998297		16
UCO	DMU6 (W6)		1.020318	15
Union	DMU7 (W7)		1.170727	12
Oriental	DMU8 (W8)		1.097766	5
Andhra	DMU9 (W9)		1.001685	6
IDBI	DMU10 (W10)		1.001685	14
HDFC	DMU11 (W11)		1.84375	2
Axis	DMU12 (W12)		2.013145	1
ICICI	DMU13 (W13)	0.99478		18
Kotak Mahindra	DMU14 (W14)		1.045293	8
Federal	DMU15 (W15)		1.038872	9
Karurvysya	DMU16 (W16)		1.248349	3
Indusind	DMU17 (W17)		1.246873	4
Dhanlaxmi	DMU18 (W18)		1.022716	11

According to our finding Axis bank is a most efficient bank, and then comes HDFC and Karurvysya whereas ICICI had taken a backseat, marginally better were SBI and Canara Bank.

VII. Conclusion

Out of top nine banks six banks are private banks and there are public sector banks, which conclude that private banks are a better performer. Axis bank had topped the overall list and then comes HDFC in efficiency scale. ICICI Bank is the only private bank, which has below average ranking and taken back most seats, but in public sector banks Oriental & Andhra Banks are efficient and SBI and BOI were most inefficient.

Appendix A Sample Program for Input Oriented VRS Mode of State Bank of India (DMU 1)

Min = theta;

0.3198*w1 + 0.3268*w2 + 0.3316*w3 + 0.3486*w4 + 0.3372*w5 + 0.3228*w6 + 0.3374*w7 + 0.3348*w8 + 0.3386*w9 + 0.3397*w10 + 0.3183*w11 + 0.3078*w12 + 0.3419*w13 + 0.3536*w14 + 0.3372*w15 + 0.3616*w16 + 0.3256*w17 + 0.3146*w18 <= 0.3198*theta;

0.0205*w1 + 0.0080*w2 + 0.0082*w3 + 0.0114*w4 + 0.0164*w5 + 0.0221*w6 + 0.0139*w7 + 0.0102*w8 + 0.0059*w9 + 0.0143*w10 + 0.0032*w11 + 0.0064*w12 + 0.0136*w13 + 0.0106*w14 + 0.0116*w15 + 0.0064*w16 + 0.0148*w17 + 0.2279*w18 <= 0.0205*theta;

0.8415*w1 + 0.6271*w2 + 0.7244*w3 + 0.5335*w4 + 0.6282*w5 + 0.4840*w6 + 0.6174*w7 + 0.5834*w8 + 0.6532*w9 + 0.9419*w10 + 1.6092*w11 + 1.1763*w12 + 1.2136*w13 + 2.2689*w14 + 0.6625*w15 + 0.6892*w16 + 0.9434*w17 + 0.5208*w18 <= 0.8415*theta;

0.3363*w1 + 0.3365*w2 + 0.3370*w3 + 0.3358*w4 + 0.3360*w5 +0.3352*w6 + 0.3364*w7 + 0.3363*w8 + 0.3374*w9 + 0.3353*w10 + 0.3382*w11 + 0.3373*w12 + 0.3372*w13 + 0.3376*w14 + 0.3368*w15 + 0.3383*w16 + 0.3365*w17 + 0.3341*w18 <= 0.3363*theta;

0.1050*w1 + 0.1329*w2 + 0.0988*w3 + 0.0895*w4 + 0.113*w5 + 0.0894*w6 + 0.0836*w7 + 0.1033*w8 + 0.1007*w9 + 0.0994*w10 + 0.1107*w11 + 0.1160*w12 + 0.1137*w13 + 0.0799*w14 + 0.0871*w15 + 0.0757*w16 + 0.1077*w17 + 0.1169*w18 <= 0.1050*theta;

0.3089*w1 + 0.3784*w2 + 0.4238*w3 + 0.2944*w4 + 0.2700*w5 + 0.2028*w6 + 0.3324*w7 + 0.4437*w8 + 0.2599*w9 + 0.3834*w10 + 0.2436*w11 + 0.6318*w12 + 0.3644*w13 + 0.3508*w14 + 0.4075*w15 + 0.2270*w16 + 0.7086*w17 + 0.1622*w18 >= 0.3089;

w1 + w2 + w3 + w4 + w5 + w6 + w7 + w8 + w9 + w10 + w11 + w12 + w13 + w14 + w15 + w16 + w17 + w18 = 1;

w1 >= 0; w2 >= 0; w3 >= 0; w4 >= 0; w5 >= 0;
w6 >= 0; w7 >= 0; w8 >=0; w9 >= 0; w10 >= 0;
w11 >=0; w12 >=0; w13 >=0; w14 >=0; w15 >=0;
w16 >= 0; w17 >= 0; w18 >= 0;

APPENDIX B SAMPLE PROGRAM FOR SUPER EFFICIENCY (BANK OF BARODA DMU 2) BEING FIRST DMU HAVE CENT PERCENT EFFICIENCY

Min = theta;

0.3198*w1 + 0.3316*w3 + 0.3486*w4 + 0.3372*w5 + 0.3228*w6 + 0.3374*w7 + 0.3348*w8 + 0.3386*w9 + 0.3397*w10 + 0.3183*w11 + 0.3078*w12 + 0.3419*w13 + 0.3536*w14 + 0.3372*w15 + 0.3616*w16 + 0.3256*w17 + 0.3146*w18 <= 0.3268*theta;

0.0205*w1 + 0.0082*w3 + 0.0114*w4 + 0.0164*w5 + 0.0221*w6 + 0.0139*w7 + 0.0102*w8 + 0.0059*w9 + 0.0143*w10 + 0.0032*w11 + 0.0064*w12 + 0.0136*w13 + 0.0106*w14 + 0.0116*w15 + 0.0064*w16 + 0.0148*w17 + 0.2279*w18 <= 0.0080*theta;

0.8415*w1 + 0.7244*w3 + 0.5335*w4 + 0.6282*w5 + 0.4840*w6 + 0.6174*w7 + 0.5834*w8 + 0.6532*w9 + 0.9419*w10 + 1.6092*w11 + 1.1763*w12 + 1.2136*w13 + 2.2689*w14 + 0.6625*w15 + 0.6892*w16 + 0.9434*w17 + 0.5208*w18 <= 0.6271*theta;

0.3363*w1 + 0.3370*w3 + 0.3358*w4 + 0.3360*w5 +0.3352*w6 + 0.3364*w7 + 0.3363*w8 + 0.3374*w9 + 0.3353*w10 + 0.3382*w11 + 0.3373*w12 + 0.3372*w13 + 0.3376*w14 + 0.3368*w15 + 0.3383*w16 + 0.3365*w17 + 0.3341*w18 <= 0.3365*theta;

0.1050*w1 + 0.0988*w3 + 0.0895*w4 + 0.113*w5 + 0.0894*w6 + 0.0836*w7 + 0.1033*w8 + 0.1007*w9 + 0.0994*w10 + 0.1107*w11 + 0.1160*w12 + 0.1137*w13 + 0.0799*w14 + 0.0871*w15 + 0.0757*w16 + 0.1077*w17 + 0.1169*w18 <= 0.1329*theta;

0.3089*w1 + 0.4238*w3 + 0.2944*w4 + 0.2700*w5 + 0.2028*w6 + 0.3324*w7 + 0.4437*w8 + 0.2599*w9 + 0.3834*w10 + 0.2436*w11 + 0.6318*w12 + 0.3644*w13 + 0.3508*w14 + 0.4075*w15 + 0.2270*w16 + 0.7086*w17 + 0.1622*w18 >= 0.3784;

w1 + w3 + w4 + w5 + w6 + w7 + w8 + w9 + w10 + w11 + w12 + w13 + w14 + w15 + w16 + w17 + w18 = 1;

w1 >= 0; w3 >= 0; w4 >= 0; w5 >= 0; w6 >= 0; w7 >= 0; w8 >=0; w9 >= 0; w10 >= 0; w11 >=0; w12 >=0; w13 >=0; w14 >=0; w15 >=0; w16 >= 0; w17 >= 0; w18 >= 0;

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