

CHAPTER 6:

COST EFFICIENCY OF THE COMPANIES IN PRE AND POST RECESSION PERIODS

6.1 Introduction: Cost efficiency is the ability to minimize costs for a given output. Profit efficiency is the ability to maximize profit for a given output. The ultimate financial goal for the company is creating value. It can be achieved by having good management of resources and internal process. The more efficient the process the higher value of added goods or services produced (Heizer and Render, 2009). Yeh Quey-Jen (1996) states that it is important to take into account the homogeneity condition during the choice of DMUs to make the DEA result more realistic. Giving more emphasis on the criteria of homogeneity condition, the present study has considered the companies from the respective industries to run the DEA model.

In the previous chapter, we have analyzed and got the result of the impact of cost components on firm performance. We also got overviews of significant impact of cost components of the companies and respective industries. This chapter represents the analysis of cost efficiency of the companies. For measuring cost efficiency, DEA techniques have been used and we have computed scale efficiency, technical efficiency, and overall efficiency during pre and post-recession periods.

6.2 Objective: Our third objective is to examine the cost efficiency of the companies during pre and post-recession periods.

6.3 Hypothesis: The null hypothesis is as follows:

H_{02} : There is no change in the cost efficiency of the companies during pre and post recession periods.

6.4 Methodology Applied: To examine the cost efficiency in pre and post recession periods we have applied DEA models for efficiency measure in the selected periods. Slack-Based Measurement (SBM) has been used to adjust the flexibility within DEA model. Efficiency ratio has produced a value between 0 and 1. The amount 1 indicates that Decision Making Unit (DMU) is in full efficient condition. We already have discussed details about the methodology in *Chapter 3- Research Methodology*.

6.5 Analysis and Interpretation: In our study, we have examined the content of efficiency scores obtained by utilizing DEA –CCR and BCC models. DEA scores are derived by using DEA software ‘*DEA-Solver Learning Version 3*’ designed by Cooper, W W et al., 2007.

6.5.1 IT-Software Industry

We carried out efficiency analysis based on below mention selected input and output variables. In our study, we have selected the inputs and outputs variables as these variables are the major cost components of the respective industry.

BOX NO 6.1: INPUT AND OUTPUT VARIABLES FOR IT-SOFTWARE INDUSTRY

Input Variables	Output Variables
Employee Cost Misc.Expenses Operating Expenses Selling & Admn.expenses	Net Sales Other Income Reported Net Profit

The descriptive statistics of OTE (Overall Technical Efficiency) scores are presented in *Table 6.1* below. We have seen that about 28.57% of the selected companies in pre-recession periods and 38.10% of the selected companies as evidenced from the evaluation of 21 sample Software companies are found to be fully technical and scale efficient, i.e. CCR efficient. Moreover, mean score 76.69% implies that selected companies could have saved on an average 23.3 % of the present input consumption in pre-recession periods and 23 % post-recession periods.

PTE (Pure Technical Efficiency) indicates that 52.38% of selected companies in addition to 28.57% CCR fully efficient ones are fully technical efficient and scale efficiency with a mean score 86.62% in pre-recession periods against 76.69%.

Theoretically, $OTE \leq PTE$, here the PTE of sample companies are much more than OTE both in terms of average score and number of fully efficient companies during the study periods.

Scale efficiency (SE) as measured by OTE/PTE indicates that the only 28.57% of the selected software companies are fully scale efficient in pre-recession periods. We have observed, there exists a significant variation among the Software

companies with regards to scale efficiency in pre recession periods, and in post-recession period (38.10 %).

TABLE 6.1: DESCRIPTIVE STATISTICS OF EFFICIENCY SCORES OF SELECTED IT-SOFTWARE COMPANIES

	Overall Technical Efficiency (OTE) {CCR Models}		Pure Technical Efficiency (PTE) {BCC Models}		Scale Efficiency (SE)	
	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession
Average score	0.7669	0.7723	0.8586	0.8793	0.8971	0.8478
SD	0.2358	0.2266	0.2207	0.1955	0.1412	0.1773
Maximum	1	1	1	1	1	1
Minimum	0.3191	0.3455	0.3389	0.2594	0.3743	0.4661
No. of Efficient Cos.	6	8	11	10	6	8
DMUs	21	21	21	21	21	21
Efficiency %	28.57%	38.10%	52.38%	47.62%	28.57%	38.10%

Source: Compiled and calculated by the researcher

The relation among these three efficiency measures ($O TE = P TE \times S E$) popularly known as decomposition of efficiency depicts that overall inefficiency of the selected Software companies is mainly caused by operating at an inappropriate scale rather than inefficient management operation. Scale inefficiency, therefore, appears to affect the overall inefficiency of the software companies.

The present study has followed the BCC model to determine the nature of returns-to- scale of the Software companies. Scale inefficiency is found to be fully due to IRS (Increasing Returns to Scale) or DRS (Decreasing Returns to Scale).

Software companies having OTE equal to one in the *Table 6.1* are CCR efficient (6 companies pre-recession and 8 companies on post-recession). They together construct efficient frontier, i.e. providing best practices among the sample companies. Efficiencies of other 15 companies which are inefficient (pre-recession) and 13 companies (post-recession), i.e. $O TE < 1$, are measured relative to this frontier.

TABLE 6.2: EFFICIENCY SCORES OF THE SELECTED IT-SOFTWARE COMPANIES

DMUs	Overall Technical Efficiency (OTE) Score {CCR Models}		Pure Technical Efficiency (PTE) Score {BCC Models}		Scale Efficiency (SE) Score		RTS (Returns to Scale)	
	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession
3i Infotech	0.3191	0.8664	0.36715	0.8768	0.8691	0.9881	Decreasing	Increasing
Cyient	0.8678	0.7390	1	0.9172	0.8678	0.8057	Decreasing	Increasing
eClerx Services	1	1	1	1	1	1	Constant	Constant
Financial Tech.	1	1	1	1	1	1	Constant	Constant
Firstsour.Solu	0.3330	1	0.3389	1	0.9825	1	Increasing	Constant
HCL Technologies	0.6414	0.8621	1	1	0.6414	0.8621	Decreasing	Decreasing
Hexaware Tech.	0.4005	0.8163	0.4103	0.8360	0.9760	0.9765	Decreasing	Increasing
Infosys	1	1	1	1	1	1	Constant	Constant
KPIT Tech.	0.8454	0.4126	1	0.4340	0.8454	0.9508	Decreasing	Increasing
Lycos Internet	1	0.4661	1	1	1	0.4661	Constant	Increasing
Mindtree	0.7557	0.5165	0.9212	0.6423	0.8203	0.8042	Decreasing	Decreasing
Oracle Fin.Serv.	0.6276	1	0.7742	1	0.8106	1	Decreasing	Constant
Persistent Sys	0.8328	0.7533	0.8854	0.7818	0.9406	0.9636	Decreasing	Increasing
Polaris Consulta	0.8181	0.6605	1	0.7645	0.8181	0.8640	Decreasing	Decreasing
Rolta India	1	1	1	1	1	1	Constant	Constant
Tata Elxsi	0.8005	0.3455	0.8044	0.6661	0.9951	0.5187	Increasing	Increasing
TCS	0.9453	1	1	1	0.9453	1	Decreasing	Constant
Tech Mahindra	0.3743	0.5938	1	0.9377	0.3743	0.6332	Decreasing	Decreasing
Vakrangee	1	1	1	1	1	1	Constant	Constant
Wipro	0.8634	0.5136	1	1	0.8634	0.5136	Decreasing	Decreasing
Zensar Tech.	0.6795	0.6720	0.6876	0.8661	0.9883	0.7760	Decreasing	Increasing

Source: Compiled and calculated by the researcher

The empirical findings indicate that in pre recession period six Software companies namely eClerx Services, Lycos Internet, Financial Tech., Infosys, Rolta India and Vakrangee have exhibited maximum Scale efficiency level. In post recession periods eight software companies achieve highest SE.

The mean efficiency level for specific Software companies during the years 2003 to 2014 are given in *Table 6.1*. The empirical findings are seen to suggest that six software companies namely eClerx Services, Financial Tech., Infosys, Lycos Internet, Rolta India, Vakrangee have exhibited maximum Scale efficiency level in pre-recession periods. The results indicate that these Software companies have not slacked in their intermediation function and have been successful to fully maximize revenues while minimizing costs and subsequently lead to the perfect Scale efficiency. In post-recession periods, eight software companies have achieved highest SE.

Overall, the empirical findings from this study advocate that in the case of the software Industry, cost inefficiency has much more to do with the scale of production rather than the inefficient utilization of resources. The dominant effect of the scale inefficiency indicates that most of the companies have been operating at the ‘incorrect’ or non-optimal scale of operations. They either experience economies of scale (i.e. (IRS)) due to being at less than the optimum size, or diseconomies of scale (i.e. (DRS)) due to being at more than the optimum size. Thus, decreasing or increasing the scale of production could result in cost savings or efficiencies. Tata Elxsi is in increasing the return to scale in pre and post recession periods. HCL Technologies, Mindtree, Polaris Consulta, Tech Mahindra and Wipro were in DRS in pre and post recession periods. eClerx Services, Financial Tech., Infosys, Rolta India and Vakrangee are in constant return to scale.

From the above *table 6.2*, we have seen that cost efficiency of the 16 companies during pre and post recession periods are changing accordingly with different efficiency measurements (few of them are 3i Infotech, Cyient, Firstsour.Solu, HCL Technologies, etc.). Hence, the null hypothesis, H_{02} : there is no change in the cost efficiency of the companies during pre and post recession period is rejected. On the contrary, 5 companies, i.e. eClerx Services, Financial Tech., Infosys, Rolta India and Vakrangee are fully efficient during pre and post-recession periods, i.e. cost efficiency of the companies are not changing. Hence, the null hypothesis (H_{02}) is accepted here.

Input Output Improvement Plan for the Inefficient IT-Software Companies

Table 6.3 and 6.4 shows the input-output improvement plan for the inefficient Software companies, as per CCR efficiency scores in pre and post-recession periods. Input-output improvement plan is projected on the basis of average scores of 15 CCR inefficient Software companies in pre-recession periods and 13 inefficient companies in post-recession periods. Inefficient DMUs can become fully CCR efficient through the input output improvement plan. Average efficiency of 15 inefficient companies is 69%. Therefore, SBM inefficiency is 43.74% (100% - 56.26%) in pre-recession period. In post-recession period average score of 13 inefficient companies are 62% and overall technical inefficiency is 55.30% (100% - 44.70%). Actual input-output data are computed as the aggregate value of 15 & 13 inefficient Software companies.

TABLE 6.3: INPUT OUTPUT IMPROVEMENT PLAN FOR THE INEFFICIENT IT-SOFTWARE COMPANIES DURING PRE-RECESSION PERIODS Rs.Cr.

DMU		TCS	Wipro	Cyient	Tata Elxsi	KPIT Tech.	Polaris Consulta	Mindtree	Persistent Sys	Zensar Tech.	HCL Tech.	Oracle Fin.Serv.	Hexaware Tech.	3i Infotech	Tech Mahindra	Firstsour Solu.
Score		0.84	0.78	0.78	0.74	0.69	0.64	0.64	0.64	0.58	0.56	0.49	0.29	0.26	0.25	0.24
Input Inefficiency		0.16	0.22	0.22	0.26	0.31	0.36	0.36	0.36	0.42	0.44	0.51	0.71	0.74	0.75	0.76
Employee Cost	Original	3948.12	3863.79	98.91	112.83	76.80	467.15	166.23	106.81	117.28	906.61	488.41	137.25	107.01	533.56	125.17
	Slack	-713.09	0.00	0.00	0.00	0.00	0.00	-58.31	-33.58	0.00	-291.52	-186.05	-94.56	-65.87	-298.37	-85.61
	Projection	3235.03	3863.79	98.91	112.83	76.80	467.15	107.92	73.23	117.28	615.09	302.36	42.69	41.13	235.19	39.56
Miscellaneous Expenses	Original	168.91	209.10	2.95	3.98	3.11	12.77	3.95	5.67	4.99	82.78	40.04	26.16	36.21	196.67	34.07
	Slack	0.00	0.00	-1.43	0.00	-1.51	-5.27	-2.03	0.00	-1.32	0.00	0.00	-13.18	-23.86	-124.52	-21.93
	Projection	168.91	209.10	1.52	3.98	1.60	7.50	1.93	5.67	3.67	82.78	40.04	12.98	12.35	72.15	12.14
Operating Expenses	Original	1467.17	783.31	12.74	25.96	77.21	11.76	64.10	10.72	16.10	499.79	67.83	52.39	75.17	322.01	8.28
	Slack	-680.09	-604.22	-1.06	-18.51	-57.09	-6.80	-36.08	-9.89	-14.83	-437.25	-64.29	-51.80	-74.57	-318.88	-7.75
	Projection	787.08	179.08	11.68	7.45	20.12	4.96	28.02	0.82	1.27	62.53	3.54	0.59	0.60	3.13	0.53
Selling and Administration Exp	Original	654.85	1018.83	57.43	28.06	42.64	101.97	77.55	15.05	32.65	373.10	208.93	39.68	48.81	366.10	51.02
	Slack	0.00	-92.57	-17.60	-9.30	0.00	-43.85	0.00	-3.00	-16.65	-216.10	-148.89	-25.56	-33.91	-293.73	-38.85
	Projection	654.85	926.27	39.83	18.75	42.64	58.11	77.55	12.05	15.99	157.00	60.04	14.12	14.90	72.37	12.17
Net Operating Income	Original	8751.91	9625.71	232.36	232.33	238.86	694.97	372.05	192.82	207.16	2477.28	1109.15	290.63	272.45	1632.67	274.61
	Slack	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Projection	8751.91	9625.71	232.36	232.33	238.86	694.97	372.05	192.82	207.16	2477.28	1109.15	290.63	272.45	1632.67	274.61
Other Income	Original	180.76	200.26	6.94	1.28	6.27	9.46	10.00	6.70	9.46	171.79	33.53	31.51	60.51	31.09	8.00
	Slack	8.79	0.00	0.00	3.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.01	0.09
	Projection	189.55	200.26	6.94	4.63	6.27	9.46	10.00	6.70	9.46	171.79	33.53	31.51	60.51	48.09	8.09
Reported Net Profit	Original	2138.42	1858.14	35.53	32.44	29.82	53.48	43.41	41.04	27.35	581.39	259.04	44.92	41.01	157.96	24.35
	Slack	0.00	609.94	36.47	21.60	53.27	59.51	96.90	7.02	16.86	224.20	41.81	60.73	82.43	334.01	58.40
	Projection	2138.42	2468.07	72.00	54.04	83.09	112.99	140.32	48.06	44.22	805.59	300.85	105.65	123.43	491.98	82.75

Source: Compiled and calculated by the researcher

Note- Input projection in Total Column is presented with a negative sign and output projection with the positive sign as because of inputs to be reduced and output to be enhanced for efficiency improvement philosophy.

TABLE 6.4: INPUT OUTPUT IMPROVEMENT PLAN FOR THE INEFFICIENT IT-SOFTWARE COMPANIES DURING POST-RECESSION PERIODS

Rs.Cr.

DMU		HCL Tech.	Hexaware Tech.	3i Infotech	Persistent Sys	Zensar Tech.	Cyient	Tech Mahindra	Wipro	Polaris Consulta	Mindtree	KPIT Tech.	Lycos Internet	Tata Elxsi
Score		0.76	0.61	0.54	0.50	0.47	0.47	0.45	0.44	0.44	0.34	0.31	0.25	0.23
Input Inefficiency		0.24	0.39	0.46	0.50	0.53	0.53	0.55	0.56	0.56	0.66	0.69	0.75	0.77
Employee Cost	Original	3505.27	311.19	215.76	403.11	367.70	396.42	2785.47	12811.17	1138.00	1113.64	314.44	78.41	272.98
	Slack	0.00	-81.68	-111.09	-246.02	-262.66	-251.39	-1190.89	-7535.53	-1016.94	-928.86	-228.52	-71.48	-252.18
	Projection	3505.27	229.50	104.67	157.08	105.04	145.03	1594.57	5275.63	121.06	184.78	85.92	6.93	20.80
Miscellaneous Expenses	Original	179.25	30.53	94.22	37.18	11.61	176.08	102.57	884.23	31.29	122.09	37.44	15.30	13.28
	Slack	0.00	-15.39	0.00	-24.28	-1.93	0.00	-41.67	-430.20	-13.99	-99.78	-28.73	-10.11	-8.37
	Projection	179.25	15.14	94.22	12.90	9.68	176.08	60.90	454.03	17.30	22.31	8.71	5.19	4.91
Operating Expenses	Original	981.55	71.65	40.23	72.58	42.57	8.99	1804.65	2764.07	67.14	83.76	79.67	144.10	53.17
	Slack	-654.53	-58.05	-29.87	-52.31	-24.48	-7.21	-1414.53	-1994.03	-19.80	-29.15	-61.46	-130.88	-36.69
	Projection	327.02	13.60	10.37	20.26	18.09	1.78	390.12	770.04	47.33	54.60	18.21	13.22	16.47
Selling and Administration Exp	Original	1065.85	59.02	103.67	45.43	92.49	34.68	691.13	2781.82	125.72	197.35	56.07	16.57	71.82
	Slack	-294.32	-0.02	-62.41	0.00	-60.02	-23.19	-412.76	-1214.95	-76.10	-129.74	-27.94	-8.63	-59.45
	Projection	771.53	59.00	41.26	45.43	32.47	11.50	278.37	1566.87	49.62	67.61	28.13	7.94	12.37
Net Operating Income	Original	9078.46	669.85	467.27	770.91	661.22	819.32	6891.18	29066.07	1553.54	1843.90	642.88	403.77	516.19
	Slack	0.00	0.00	0.00	14.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Projection	9078.46	669.85	467.27	785.83	661.22	819.32	6891.18	29066.07	1553.54	1843.90	642.88	403.77	516.19
Other Income	Original	339.37	49.12	166.79	25.58	22.55	42.61	68.48	1041.52	33.91	42.87	9.38	4.59	5.50
	Slack	470.44	16.31	0.00	19.04	7.21	4.98	116.53	455.58	0.00	9.15	14.91	0.00	0.20
	Projection	809.81	65.43	166.79	44.62	29.77	47.59	185.01	1497.09	33.91	52.02	24.29	4.59	5.70
Reported Net Profit	Original	2481.99	184.22	-136.23	146.17	106.07	152.23	1037.45	5073.03	144.73	228.34	93.01	20.15	44.63
	Slack	0.00	0.00	306.71	0.00	0.00	0.00	0.00	0.00	26.05	0.00	0.00	10.50	0.00
	Projection	2481.99	184.22	170.48	146.17	106.07	152.23	1037.45	5073.03	170.78	228.34	93.01	30.65	44.63

Source: Compiled and calculated by the researcher

Note- Input projection in Total Column is presented with a negative sign and output projection with the positive sign as because of inputs to be reduced and output to be enhanced for efficiency improvement philosophy.

Selected Software companies as a whole have to reduce its all inputs level by 43.74% on an average in pre-recession periods against 55.30% in post-recession periods. This proportional reduction of each input by 43.74% & 55.30% removes the purely technical inefficiency of the selected software companies for the study. By the removal of this inefficiency, it will be weakly efficient [fulfill the ‘Farrell’ or ‘week’ efficiency (Cooper W. W. et al., 2007)].

It has to reduce in addition to 55.30 % in all inputs in Software Industry in post-recession periods. Moreover, we have seen in the above *tables*, that one company will become fully efficient company by reducing inputs and increasing outputs by the help of removing slack of particular variables. For example, 3i Infotech, it needs to reduce Employee Cost (Rs. 111.09 cr.), Operating expenses (Rs. 29.87 cr.), Selling and Adm. exp (Rs. 62.41 cr.) and able to generate Reported Net Profit by Rs.170 Cr. from Net loss (Rs. -136.23 cr.), this further reduction of these inputs in respect of presence of non-zero slacks removes mix inefficiency. Similarly, Selling and Adm. Exp of HCL Tech. may be reduced by Rs. -294.32 and Operating Expenses by Rs. 654.53 cr., for Hexaware Tech., Operating Expenses may be reduced by Rs. 58.05 cr.

6.5.2 Banking Industry

There is no consensus on what constitutes inputs and outputs of banks. However, in the context of banking efficiency measurement, there are mainly two approaches to deal with this problem, i.e. Production Approach and Intermediation Approach. The main difference between these two approaches is the use of deposit as input or output. In our study, we have selected the inputs and outputs variables (*Box 6.2*) for getting an appropriate results as per with other studies (Berger and Humphrey,1997), (Wu et al., 2006), (Mukherjee et al., 2002) and (Howland and Rowse, 2006).

BOX 6.2: INPUT AND OUTPUT VARIABLES FOR BANKING INDUSTRY

Input Variables	Output Variables
Interest Expended Other Expenses, prov. & contingencies Employee Cost Operating & Admn. Expenses	Interest Earned Other Income Reported Net Profit

The descriptive statistics of OTE (Overall Technical Efficiency) scores are presented in *Table 6.5* below. We have seen that about 71.43% of the selected companies in pre-recession periods and 61.90% of the selected companies as evidenced from the evaluation of 21 sample banks are found to be fully technical efficient, i.e. CCR efficient. Moreover, mean score 99.21% implies that selected banks could have saved on an average 1 % of the present input consumption in order to produce the present level of services in pre and post recession periods it decreases to 2%. The results also indicate that there is no significant efficiency variation among the selected banks with regards to OTE as evidenced by the range of efficiency scores between 94% and 100% and SD is 1.6% in pre-recession periods, on other hand in post-recession periods it scores between 93.5% and 100% and SD is 2.1%.

TABLE 6.5: DESCRIPTIVE STATISTICS OF EFFICIENCY SCORES OF SELECTED BANKING COMPANIES

	Technical Efficiency Score(CRS) OTE		Pure Technical Efficiency Score(VRS) PTE		Scale Efficiency Score SE	
	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession
Average Score	0.9921	0.9867	0.9942	0.9898	0.9979	0.9969
SD	0.0167	0.0216	0.0142	0.0186	0.0067	0.0064
Maximum	1	1	1	1	1	1
Minimum	0.9406	0.9355	0.9407	0.9373	0.9695	0.9756
No. of Efficient Branches	15	13	16	14	15	13
DMUs	21	21	21	21	21	21
Efficient Branch %	71.43%	61.90%	76.19%	66.67%	71.43%	61.90%

Source: Compiled and calculated by the researcher

PTE (BCC scores) indicates 76% selected banks in addition to CCR fully efficient ones are fully technical efficient and scale efficient with a mean score 99% in pre-recession periods against 98.98%. Theoretically, $O TE \leq P TE$, here the PTE of sample banks are much more than OTE both in terms of average score and number of fully efficient branches during the study periods. Asymmetry with regard to PTE is as expected but to a great extent is low in comparison to OTE during the study periods i.e. pre-recession & post-recession (PTE ranging between 94% and 100% with SD only 1.4% in pre-recession periods and PTE ranging between 93.7% and 100% with SD only 1.8% in post-recession periods).

Scale efficiency (SE) as measured by OTE/PTE indicates that the only 71.43% banks are fully scale efficient and there exists a significant variation among the banks with regards to scale efficiency in pre-recession periods and 61.90% in post-recession period.

Scale inefficiency is found to be fully due to IRS (Increasing Returns to Scale). 29% branches i.e. all the CCR inefficient banks are found to be operating at IRS or DRS (Decreasing Returns to Scale) and remaining 71% are operating at the most productive scale size (MPSS) in pre-recession periods against 61.9 % (MPSS) in post-recession periods.

Banks having OTE equal to 1 in the below *Table (6.6)* are CCR efficient. They together construct efficient frontier i.e. providing best practices among the sample banks.

TABLE 6.6: EFFICIENCY SCORES OF THE SELECTED BANKS

DMUs	Overall Technical Efficiency (OTE) Score {CCR Models}		Pure Technical Efficiency (PTE) Score {BCC Models}		Scale Efficiency (SE)Score		Returns to Scale (RTS)	
	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession
Allahabad Bank	0.94062	0.95363	0.94068	0.956871	0.99994	0.99662	Decreasing	Decreasing
Andhra Bank	1	0.9880	1	0.990996	1	0.99703	Constant	Decreasing
Axis Bank	1	1	1	1	1	1	Constant	Constant
Bank of Baroda	0.96859	1	0.974617	1	0.993821	1	Decreasing	Constant
Bank of India	0.99538	1	1	1	0.995385	1	Decreasing	Constant
Canara Bank	0.95773	1	0.98784	1	0.969528	1	Decreasing	Constant
Central Bank	0.99450	0.93561	0.994793	0.959053	0.999708	0.9755	Increasing	Decreasing
Corporation Bank	1	1	1	1	1	1	Constant	Constant
HDFC Bank	1	1	1	1	1	1	Constant	Constant
I O B	1	0.93553	1	0.937324	1	0.99809	Constant	Decreasing
ICICI Bank	1	1	1	1	1	1	Constant	Constant
IDBI Bank	1	1	1	1	1	1	Constant	Constant
Indian Bank	1	1	1	1	1	1	Constant	Constant
IndusInd Bank	1	1	1	1	1	1	Constant	Constant
Kotak Mah. Bank	1	1	1	1	1	1	Constant	Constant
Oriental Bank	1	0.98913	1	0.997331	1	0.99178	Constant	Decreasing
Punjab Natl. Bank	1	1	1	1	1	1	Constant	Constant
St Bk of India	1	0.98334	1	1	1	0.98334	Constant	Decreasing
Syndicate Bank	0.97657	0.96820	0.97992	0.968534	0.996585	0.99965	Increasing	Decreasing
UCO Bank	1	1	1	1	1	1	Constant	Constant
Union Bank (I)	1	0.96769	1	0.975726	1	0.99176	Constant	Decreasing

Source: Compiled and calculated by the researcher

The empirical findings are seen to suggest that 15 banks namely, Andhra Bank, Axis Bank, I O B, UCO Bank, Corporation Bank, HDFC Bank, ICICI Bank, IDBI Bank, Indian Bank, IndusInd Bank, Oriental Bank, Punjab Natl. Bank, St Bk of India, Union Bank (I) and Kotak Mahindra Bank have exhibited maximum Scale efficiency level in pre-recession periods. The results indicate that these banks have not slacked in their intermediation function and have been successful to fully maximize revenues while minimizing costs and subsequently lead to the perfect Scale efficiency. In post recession periods, 13 banks achieve highest SE, except few banks are inefficient in post-recession periods through they are full efficient in pre-recession periods, i.e. Andhra bank, IOB, Oriental Bank, St Bk of India and Union Bank (I), *vis a vis* few bank perform higher efficient than they were in pre

recession periods, i.e. Bank of Baroda, Bank of India and Canara Bank. 10 banks are really performing well in entire study periods, i.e. Axis Bank, Corporation Bank, HDFC Bank, ICICI Bank, IDBI Bank, Indian Bank, IndusInd Bank, Kotak Mah. Bank, Punjab Natl. Bank, UCO Bank and Vijaya Bank.

The dominant effect of the scale inefficiency indicates that most of the selected banks have been operating at the 'incorrect' or non-optimal scale of operations. They either experience economies of scale (i.e. (IRS)) due to being at less than the optimum size, or diseconomies of scale (i.e. (DRS)) due to being at more than the optimum size. Thus, decreasing or increasing the scale of production could result in cost savings or efficiencies. IOB, Andhra Bank, Oriental Bank, St Bank of India and Union Bank (I) were in CRS in pre-recession periods and unable to manage in post-recession periods and experiencing DRS.

From the above *table 6.6*, we have seen that cost efficiency of the 11 companies during pre and post recession periods are changing accordingly with different efficiency measurements. Hence, the null hypothesis, H_{02} : There is no change in the cost efficiency of the companies during pre and post a recession period is rejected. On the contrary, 10 Banks, namely- Axis Bank, HDFC Bank, Corporaion Bank, ICICI Bank, IDBI Bank, Indian Bank, IndusInd Bank, Kotak Mah. Bank, UCO Bank and PNB are fully efficient during pre and post-recession periods, i.e. cost efficiency of the companies are not changing, in that case, the null hypothesis (H_{02}) is accepted.

Input Output Improvement Plan for the Inefficient Banking Companies

Table 6.7 & 6.8 shows the input-output target or input-output improvement plan for the Bank as per SBM efficiency scores in pre and post recession periods. We run DEASB Model for Banking companies.

Input-output improvement plan is projected on the basis of average scores of 6 inefficient banks in pre recession periods and 8 inefficient banks in post-recession periods. Inefficient banks can become fully efficient through input output improvement plan. Average efficiency of 6 inefficient banks is 92.41%. Therefore, inefficiency is $100\% - 92.41\% = 7.59\%$ in pre-recession period. In post-recession

period average efficiency of 8 inefficient banks is 92.59% and SBM inefficiency is $100\% - 92.59\% = 7.41\%$.

TABLE 6.7: INPUT OUTPUT IMPROVEMENT PLAN FOR THE INEFFICIENT BANKING COMPANIES DURING PRE-RECESSION PERIODS

Rs. Cr.

DMUs		Bank of India	Bank of Baroda	Syndicate Bank	Central Bank	Canara Bank	Allahabad Bank
Score		0.97	0.93	0.92	0.92	0.91	0.90
Input Inefficiency		0.03	0.07	0.08	0.08	0.09	0.10
Interest expended	Original	4883.27	4704.19	2879.67	3580.80	6050.25	2481.14
	Slack	0.00	0.00	0.00	0.00	0.00	0.00
	Projection	4883.27	4704.19	2879.67	3580.80	6050.25	2481.14
Payments to/Provisions for Employees	Original	1360.07	1472.30	929.72	1218.87	1433.57	624.14
	Slack	0.00	-100.31	-170.84	-221.49	-267.12	-81.79
	Projection	1360.07	1371.99	758.88	997.37	1166.46	542.34
Operating Expenses & Administrative Expenses	Original	340.56	390.60	204.10	223.20	437.61	189.50
	Slack	0.00	0.00	-27.07	0.00	-14.53	-21.96
	Projection	340.56	390.60	177.02	223.20	423.08	167.53
Other Expenses, Provisions & Contingencies	Original	1230.47	1252.57	590.21	888.02	1413.07	578.49
	Slack	-133.86	-283.82	-4.49	-129.76	-224.78	-81.82
	Projection	1096.61	968.75	585.72	758.26	1188.29	496.67
Interest Earned	Original	7679.31	7757.26	4619.07	5807.61	9267.34	3874.49
	Slack	0.00	0.00	0.00	0.00	0.00	0.00
	Projection	7679.31	7757.26	4619.07	5807.61	9267.34	3874.49
Other Income	Original	1576.04	1579.63	686.27	800.05	1767.87	709.15
	Slack	0.00	0.00	93.24	161.26	0.00	0.00
	Projection	1576.04	1579.63	779.51	961.31	1767.87	709.15
Reported Net Profit	Original	1005.56	950.93	546.96	431.11	1299.24	600.36
	Slack	163.09	342.28	153.26	423.18	147.79	0.39
	Projection	1168.65	1293.21	700.23	854.28	1447.03	600.75

Source: Compiled and calculated by the researcher

Note- Input projection in Total Column is presented with a negative sign and output projection with the positive sign as because of inputs to be reduced and output to be enhanced for efficiency improvement philosophy.

TABLE 6:8: INPUT OUTPUT IMPROVEMENT PLAN FOR THE INEFFICIENT BANKING COMPANIES DURING POST-RECESSION PERIODS

DMU		Andhra Bank	Oriental Bank	Syndicate Bank	Union Bank (I)	St Bk of India	Allahabad Bank	Central Bank	I O B
Score		0.98	0.97	0.93	0.93	0.92	0.91	0.89	0.88
Input Inefficiency		0.02	0.03	0.07	0.07	0.08	0.09	0.11	0.12
Interest expended	Original	6714.70	10102.17	9380.59	13451.64	60788.42	9047.05	12613.01	11191.30
	Slack	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Projection	6714.70	10102.17	9380.59	13451.64	60788.42	9047.05	12613.01	11191.30
Payments to/Provisions for Employees	Original	1062.02	1233.42	1755.09	2274.69	15928.80	1584.74	2452.63	1906.95
	Slack	0.00	0.00	-38.86	0.00	-3510.63	-89.97	-402.61	-184.51
	Projection	1062.02	1233.42	1716.24	2274.69	12418.17	1494.77	2050.02	1722.44
Operating Expenses & Administrative Expenses	Original	367.00	508.70	446.87	728.91	4531.64	499.36	556.20	539.02
	Slack	0.00	-23.90	0.00	-41.24	-458.68	-68.31	-44.77	-12.67
	Projection	367.00	484.80	446.87	687.67	4072.96	431.05	511.43	526.35
Other Expenses, Provisions & Contingencies	Original	1103.05	1803.03	1744.40	2473.38	13300.52	1725.82	2096.64	2201.50
	Slack	-101.07	-113.75	-420.00	-548.59	-163.25	-316.45	-436.93	-754.75
	Projection	1001.99	1689.28	1324.40	1924.79	13137.27	1409.36	1659.71	1446.75
Interest Earned	Original	9764.09	13956.43	13672.28	19524.54	96450.68	13075.71	17196.30	15539.70
	Slack	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Projection	9764.09	13956.43	13672.28	19524.54	96450.68	13075.71	17196.30	15539.70
Other Income	Original	980.67	1346.06	1095.30	2226.14	15404.71	1538.48	1509.30	1650.79
	Slack	148.67	368.44	421.23	0.00	0.00	0.00	107.64	84.76
	Projection	1129.33	1714.51	1516.53	2226.14	15404.71	1538.48	1616.94	1735.54
Reported Net Profit	Original	1005.89	1189.48	1300.56	1920.78	10542.54	1270.34	527.84	887.40
	Slack	195.99	363.79	366.03	492.47	3724.81	334.36	919.09	890.92
	Projection	1201.89	1553.27	1666.59	2413.25	14267.35	1604.70	1446.93	1778.32

Source: Compiled and calculated by the researcher

Note- Input projection in Total Column is presented with a negative sign and output projection with the positive sign as because of inputs to be reduced and output to be enhanced for efficiency improvement philosophy.

Selected Banks as a whole has to reduce its all inputs level by 7.59% on an average in pre-recession periods against 7.41% in post-recession periods. This proportional reduction of each input by 7.59% & 7.41% removes the purely technical inefficiency of the selected Bank for the study. By the removal of this inefficiency, it will be become weakly efficient [fulfill the ‘Farrell’ or ‘week’ efficiency (Cooper W. W. et al., 2007)].

It has to reduce in addition to 7.41% in all inputs in banking Industry in post-recession periods. Moreover, we have seen in *table 6.8*, that one company will become fully efficient company by reducing inputs and increasing outputs by the help of removing slack of particular variables. For example, St Bk of India, it needs to reduce Employee Cost (Rs. 3510.63cr.), Operating Expenses (Rs. 458.68cr.), Other Expenses, Provisions & Contingencies (Rs. 163.25cr.) and able to generate Reported Net Profit by Rs.3724.81Cr. during post recession period, this further reduction of these inputs in respect of the presence of non-zero slacks removes mix inefficiency.

6.5.3 Finance Industry

We carried out the efficiency analysis of the companies based on selected input and output variables (*Box 6.3*).

BOX 6.3: INPUT AND OUTPUT VARIABLES FOR FINANCE INDUSTRY

Input Variables	Output Variables
Operating & Admin. expenses Misc. expenses Interest expenses Employee cost	Net Sales Other Income Reported Net Profit

The descriptive statistics of OTE (Overall Technical Efficiency) scores are presented in *Table 6.9*. We have seen that about 47.62% of the selected companies in pre-recession periods and 33.33% of the selected companies in post-recession periods as evidenced from the evaluation of 21 sample companies are found to be fully technical and scale efficient, i.e. CCR efficient. Moreover, mean score 68.96% implies that selected companies could have saved on an average 31.04 % of the present input consumption in order to produce the present level of services in pre and post recession periods. The results also indicate that there is high

significant efficiency variation among the selected companies with regards to OTE as evidenced by the range of efficiency scores between 20.52% and 100%, and SD 31.99% in pre-recession periods, on other hand, in post-recession periods it scores between 8.06% and 100% and SD is 37.71%.

TABLE 6.9: DESCRIPTIVE STATISTICS OF EFFICIENCY SCORES OF SELECTED FINANCE COMPANIES

	Technical Efficiency Score(CRS) OTE		Pure Technical Efficiency Score(VRS) PTE		Scale Efficiency Score SE	
	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession
Average Score	0.6896	0.5368	0.7899	0.8494	0.8518	0.6041
SD	0.3199	0.3771	0.2590	0.2008	0.2148	0.3620
Maximum	1	1	1	1	1	1
Minimum	0.2052	0.0806	0.2969	0.4031	0.4304	0.0808
No. of Efficient Branches	10	7	11	10	10	7
DMUs	21	21	21	21	21	21
Efficient Branch %	47.62%	33.33%	52.38%	47.62%	47.62%	33.33%

Source: Compiled and calculated by the researcher

PTE (BCC scores) indicates 52.38% selected companies in addition to 47.62% CCR fully efficient ones are fully technical efficient and scale efficient with a mean score 78.99% in pre-recession periods against 84.94% in post-recession periods. Theoretically, $OTE \leq PTE$, here the PTE, of sample companies are much more than OTE both in terms of average score and number of fully efficient during the study periods. Asymmetry, with regard to PTE is as expected but to a great extent is low in comparison to OTE during the study periods i.e. pre-recession & post-recession.

Scale efficiency (SE) as measured by OTE/PTE indicates that the only 47.62% of the selected companies are fully scale efficient and there exists a significant variation among the companies with regards to scale efficiency in pre-recession periods and 33.33% in post-recession period.

The relation among these three efficiency measures ($OTE = PTE \times SE$) popularly known as decomposition of efficiency depicts that overall inefficiency of the selected companies is mainly caused by operating at an inappropriate scale rather

than inefficient management operation. The present study has followed the BCC model to determine the nature of returns-to- scale of the Finance companies. 52.38% companies, i.e. all the CCR inefficient branches are found to be operating at IRS or DRS and remaining 47.62% are operating at the most productive scale size (MPSS) in pre-recession periods against 33.33% (MPSS) in post-recession periods.

Selected Finance companies having OTE equal to 1 are efficient. They together construct efficient frontier, i.e. providing best practices among the sample companies. Efficiencies of other 10 Finance companies which are inefficient (i.e. $OTE < 1$) are measured relative to this frontier in pre-recession periods against 7 companies in post-recession periods.

TABLE 6.10: EFFICIENCY SCORES OF THE SELECTED FINANCE COMPANIES

	Technical Efficiency Score(CRS) OTE		Pure Technical Efficiency Score(VRS) PTE		Scale Efficiency Score SE		Returns to Scale (RTS)	
	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession
DMUs								
Bajaj Holdings	1	1	1	1	1	1	Constant	Constant
Capri Global	1	1	1	1	1	1	Constant	Constant
Edelweiss.Fin.	1	0.2469	1	0.5877	1	0.4201	Constant	Increasing
H D F C	1	1	1	1	1	1	Constant	Constant
IFCI	1	1	1	1	1	1	Constant	Constant
Magma Fincorp	1	0.1197	1	0.4031	1	0.2969	Constant	Decreasing
Power Fin.Corpn.	1	1	1	1	1	1	Constant	Constant
Religare Enterp.	1	0.3523	1	1	1	0.3523	Constant	Decreasing
Rural Elec.Corp.	1	1	1	1	1	1	Constant	Constant
Tata Inv.Corpn.	1	1	1	1	1	1	Constant	Constant
SREI Infra. Fin.	0.6198	0.4362	0.6420	0.4383	0.9654	0.9952	Decreasing	Increasing
LIC Housing Fin.	0.6067	0.5576	0.7048	0.7740	0.8609	0.7204	Decreasing	Decreasing
I D F C	0.5320	0.5477	0.8781	0.9345	0.6059	0.5861	Decreasing	Decreasing
Sundaram Finance	0.4989	0.1950	0.7425	0.6733	0.6720	0.2896	Decreasing	Decreasing
Reliance Capital	0.4304	0.3677	1.0000	0.9091	0.4304	0.4045	Decreasing	Decreasing
Shri.City Union.	0.4123	0.0818	0.4710	0.7715	0.8754	0.1060	Decreasing	Decreasing
GRUH Finance	0.3485	0.7787	0.3512	1.0000	0.9925	0.7787	Decreasing	Increasing
Manappuram Fin.	0.2922	0.2580	0.2969	0.7298	0.9841	0.3535	Increasing	Decreasing
Shriram Trans.	0.2890	0.1680	0.6375	1.0000	0.4534	0.1680	Decreasing	Decreasing
Bajaj Fin.	0.2458	0.0806	0.4170	0.9973	0.5896	0.0808	Decreasing	Decreasing
Cholaman.Inv.&Fn	0.2052	0.0829	0.4470	0.6187	0.4591	0.1339	Decreasing	Decreasing

Source: Compiled and calculated by the researcher

The mean efficiency level for specific companies during the years 2003 to 2014 are given in *Table 6.10*. The empirical findings, suggested that 10 companies have exhibited maximum Scale efficiency level in pre-recession period. The results indicate that these companies have not slacked in their intermediation function and have been successful to fully maximize revenues while minimizing costs and subsequently lead to the perfect scale efficiency. In post-recession periods 7 companies achieve highest SE. Few companies are inefficient in post-recession periods through they are fully efficient in pre recession periods, i.e. Edelweiss Fin. and Religare Enterp. Few companies are relay performing well in entire study periods, i.e. Bajaj Holdings, Capri Global, H D F C, IFCI, Power Fin.Corp., Rural Elec.Corp. and Tata Inv.Corp.

From the above *table 6.10*, we have seen that cost efficiency of the 14 companies during pre and post recession periods are changing accordingly with different efficiency measurements. Hence, the null hypothesis, H_{02} : there is no change in the cost efficiency of the companies during pre and post-recession period is rejected. On the contrary, 7 companies, i.e. Bajaj Holding, Capri Global, HDFC, IFCI, Power Finance Corporation, Tata Inv.Corp., Rural Elec.Corp. are fully efficient during pre and post-recession periods, i.e. cost efficiency of the companies are not changing, in that case, the null hypothesis (H_{02}) is accepted.

Input Output Improvement Plan for the Inefficient Finance Companies

Table 6.11 and 6.12 shows the input-output target or input-output improvement plan for the selected companies as per Slack Base Model. Input output improvement plan is projected on the basis of average scores of 11 SBM inefficient companies in pre-recession periods and 14 inefficient companies in post-recession periods. Inefficient companies can become fully efficient through Input output improvement plan. The average score of 11 inefficient companies is 28.08%. Therefore, SBM inefficiency is $100\% - 28.08\% = 71.91\%$ in pre-recession period. In post-recession period, average efficiency score of 14 inefficient companies is 14.50% and overall technical inefficiency is $100\% - 14.50\% = 85.50\%$.

TABLE 6.11: INPUT OUTPUT IMPROVEMENT PLAN FOR THE INEFFICIENT FINANCE COMPANIES DURING PRE-RECESSION PERIODS

Rs.Cr

DMU		SREI Infra. Fin.	IDFC	LIC Housing Fin.	Sundaram Finance	Reliance Capital	Shri.City Union.	GRUH Finance	Bajaj Fin.	Shriram Trans.	Manappuram Fin.	Cholaman.Inv.& Fn
Score		0.58	0.41	0.40	0.36	0.34	0.23	0.22	0.18	0.14	0.13	0.10
Input Inefficiency		0.42	0.59	0.60	0.64	0.66	0.77	0.78	0.82	0.86	0.87	0.90
Operating & Administration Expenses	Original	19.52	15.54	68.49	37.17	36.78	55.64	5.97	52.24	90.09	5.65	68.62
	Slack	-15.58	-8.69	-60.43	-33.49	-32.10	-54.09	-5.27	-50.71	-84.55	-5.47	-66.43
	Projection	3.94	6.85	8.06	3.68	4.68	1.55	0.70	1.53	5.54	0.18	2.19
Miscellaneous Expenses	Original	11.26	72.05	77.59	41.71	33.93	23.94	6.12	58.28	105.50	1.51	48.07
	Slack	0	-40.54	-45.15	0	-7.94	-15.63	-4.20	-40.21	-90.26	-1.02	-42.04
	Projection	11.26	31.51	32.44	41.71	25.99	8.31	1.92	18.07	15.24	0.49	6.03
Interest	Original	136.58	598.56	911.00	282.70	183.45	113.71	72.12	73.22	469.29	7.90	155.37
	Slack	-28.10	-580.96	-848.63	-253.67	-167.90	-108.80	-71.35	-60.57	-463.15	-7.70	-152.94
	Projection	108.48	17.60	62.37	29.04	15.55	4.91	0.77	12.65	6.14	0.20	2.43
Employee Expense	Original	12.64	27.29	22.51	49.50	36.37	8.80	4.40	21.80	45.91	3.80	26.82
	Slack	-8.56	-7.59	0	-38.48	-22.82	-4.31	-2.41	-17.20	-30.15	-3.29	-20.59
	Projection	4.08	19.70	22.51	11.02	13.55	4.49	1.99	4.60	15.76	0.51	6.23
Operating Income	Original	241.91	1138.91	1355.32	603.05	777.06	257.80	116.74	250.74	925.37	29.90	366.03
	Slack	0	0	0	0	0	0	0	0	0	0	0
	Projection	241.91	1138.91	1355.32	603.05	777.06	257.80	116.74	250.74	925.37	29.90	366.03
Other Income	Original	11.32	21.80	22.72	25.01	17.29	5.57	1.26	10.79	12.14	0.22	3.15
	Slack	0	0	0	0	0	0	0.27	0	0	0.17	1.65
	Projection	11.32	21.80	22.72	25.01	17.29	5.57	1.53	10.79	12.14	0.39	4.80
Reported Net Profit	Original	49.83	375.13	227.51	110.15	420.58	36.75	22.31	37.85	138.64	6.86	36.65
	Slack	57.05	648.22	947.73	397.68	271.53	193.29	84.36	172.31	706.92	20.46	297.82
	Projection	106.88	1023.35	1175.24	507.83	692.11	230.04	106.67	210.16	845.56	27.32	334.47

Source: Compiled and calculated by the researcher

Note- Input projection in Total Column is presented with a negative sign and output projection with the positive sign as because of inputs to be reduced and output to be enhanced for efficiency improvement philosophy.

TABLE 6.12: INPUT OUTPUT IMPROVEMENT PLAN FOR THE INEFFICIENT FINANCE COMPANIES DURING POST-RECESSION PERIODS

Rs.Cr

DMU		I D F C	GRUH Finance	Reliance Capital	LIC Housing Fin.	SREI Infra. Fin.	Religare Enterp.	Sundaram Finance	Edelweiss.F in.	Manappuram Fin.	Shriram Trans.	Magma Fincorp	Shri.City Union.	Cholaman.I nv.&Fn	Bajaj Fin.
Score		0.31	0.31	0.28	0.27	0.18	0.14	0.10	0.09	0.09	0.08	0.05	0.05	0.04	0.04
Input Inefficiency		0.69	0.69	0.72	0.73	0.82	0.86	0.90	0.91	0.91	0.92	0.95	0.95	0.96	0.96
Operating & Administration Expenses	Original	62.99	14.30	210.73	149.21	53.34	57.92	81.19	26.88	191.55	303.65	141.86	258.65	221.84	251.95
	Slack	0.00	-8.63	-47.98	-83.48	-41.52	-34.98	-62.20	-24.10	-174.67	-238.80	-129.26	-236.22	-201.15	-228.70
	Projection	62.99	5.67	162.75	65.73	11.82	22.94	18.99	2.78	16.88	64.85	12.60	22.43	20.69	23.25
Miscellaneous Expenses	Original	312.10	5.44	487.95	89.06	20.35	273.86	90.39	8.50	49.16	727.66	80.36	223.53	255.24	358.55
	Slack	-261.85	-1.09	-363.06	-38.62	-11.28	-256.26	-75.82	-6.37	-36.21	-677.90	-70.69	-206.32	-239.37	-340.71
	Projection	50.26	4.35	124.89	50.44	9.07	17.61	14.57	2.13	12.95	49.76	9.67	17.21	15.88	17.84
Interest	Original	3257.28	306.74	1717.19	4200.14	786.49	53.62	852.76	115.84	636.64	2650.41	580.14	876.24	972.70	720.12
	Slack	-3145.81	-306.71	-1716.20	-4199.74	-786.42	-53.48	-852.64	-115.82	-636.54	-2650.02	-580.06	-876.10	-972.57	-719.98
	Projection	111.47	0.03	0.99	0.40	0.07	0.14	0.12	0.02	0.10	0.39	0.08	0.14	0.13	0.14
Employee Expense	Original	114.75	18.83	139.86	71.32	30.65	24.42	132.13	32.64	202.22	325.05	150.28	117.12	116.61	181.73
	Slack	-107.98	-18.30	-124.60	-65.16	-29.54	-22.27	-130.35	-32.38	-200.64	-318.97	-149.10	-115.02	-114.67	-179.55
	Projection	6.77	0.53	15.26	6.16	1.11	2.15	1.78	0.26	1.58	6.08	1.18	2.10	1.94	2.18
Operating Income	Original	5604.49	494.05	2932.49	5726.49	1029.45	109.67	1654.39	242.29	1470.84	5649.86	1097.49	1954.24	1802.52	2025.76
	Slack	0.00	0.00	11247.70	0.00	0.00	1889.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Projection	5604.49	494.05	14180.19	5726.49	1029.45	1998.92	1654.39	242.29	1470.84	5649.86	1097.49	1954.24	1802.52	2025.76
Other Income	Original	10.76	2.03	229.56	16.91	3.19	32.36	19.10	0.39	5.90	13.71	16.41	2.32	19.81	20.51
	Slack	77.41	5.97	0.00	75.79	13.48	0.00	7.68	3.53	17.91	77.75	1.36	29.32	9.37	12.28
	Projection	88.17	8.00	229.56	92.70	16.67	32.36	26.78	3.92	23.81	91.46	17.77	31.64	29.18	32.79
Reported Net Profit	Original	1349.16	108.99	521.07	903.82	84.73	-277.00	313.46	51.34	243.10	1099.61	90.26	310.86	160.58	347.84
	Slack	3668.84	343.58	12468.70	4341.93	858.30	2108.11	1202.05	170.61	1104.26	4075.95	915.10	1479.32	1490.62	1507.86
	Projection	5018.00	452.57	12989.77	5245.75	943.03	1831.11	1515.51	221.95	1347.36	5175.56	1005.36	1790.18	1651.20	1855.70

Source: Compiled and calculated by the researcher

Note- Input projection in Total Column is presented with a negative sign and output projection with the positive sign as because of inputs to be reduced and output to be enhanced for efficiency improvement philosophy.

Selected companies as a whole have to reduce its all inputs level by 71.91% on an average in pre-recession periods against 85.50% in post-recession periods. This proportional reduction of each input by 71.91% & 85.50% removes the purely technical inefficiency of the selected finance companies for the study. By the removal of this inefficiency, it will be become weakly efficient [fulfill the ‘Farrell’ or ‘week’ efficiency (Cooper W. W. et al., 2007)].

As we follow input-oriented DEA model, there are two sources of inefficiencies associated with inputs: purely technical inefficiency represented by the radial measure (1- efficiency score obtained) and mix inefficiency represented by excess input also termed as non-zero input slack. Whereas there exist only mix inefficiency in outputs represented by output shortfall also termed as output slack. Mix inefficiency arises from the wrong proportion in which inputs are utilized or outputs are produced. However, slack adjustments after radial adjustment, it makes all the selected companies are strongly efficient [fulfill the ‘Pareto- Koopmans’ or ‘strong’ efficiency, (Cooper et al., 2007)]. Moreover, we have seen in *table 6.12*, that one company will become fully efficient company by reducing inputs and increasing outputs by the help of removing slack of particular variables. For example, LIC Housing Fin, it needs to reduce Operating & Administration expenses (Rs.83.48cr.), Miscellaneous expenses (Rs.-38.62cr.), Interest (Rs. 4199.74cr.) and it able to generate Reported Net Profit by Rs.4341.93 Cr. this further reduction of these inputs in respect of presence of non-zero slacks removes mix inefficiency.

6.5.4 Refineries Industry

In our study of cost efficiency analysis of Refineries Industry, we have selected two inputs and two outputs variables as these variables.

BOX NO 6.4: INPUT AND OUTPUT VARIABLES FOR REFINERIES INDUSTRY

Input Variables	Output Variables
Raw Materials Selling & Admn.Expenses	Net Sales Reporred Net Profit

The descriptive statistics of OTE (Overall Technical Efficiency) scores are presented in *Table 6.13*. We have seen that about 43% of the selected companies in pre-recession periods and 29% of the selected companies as evidenced from the evaluation of 7 sample Refineries companies are found to be fully technical and scale efficient, i.e. CCR efficient. Moreover, mean score 94% implies that selected companies could have saved on an average 6% of the present input consumption in order to produce the present level of services in pre recession periods; and, mean score 95% implies that selected companies could have saved on an average 5 % post-recession periods. The results also indicate that there is no significant efficiency variation among the selected Refineries companies with regards to OTE as evidenced by the range of efficiency scores between 84% and 100% and SD 7% in pre-recession periods, on other hand in post-recession periods it scores between 88% and 100% and SD is 4%.

TABLE 6.13: DESCRIPTIVE STATISTICS OF EFFICIENCY SCORES OF SELECTED COMPANIES OF REFINERIES INDUSTRY

	Technical Efficiency Score(CRS) OTE		Pure Technical Efficiency Score(VRS) PTE		Scale Efficiency Score SE	
	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession
Average score	0.9441	0.9539	0.9686	0.9774	0.9754	0.9761
SD	0.0699	0.0435	0.0551	0.0389	0.0597	0.0289
Maximum	1	1	1	1	1	1
Minimum	0.8403	0.8889	0.8673	0.9054	0.8403	0.9171
No. of Efficient Branches	3	2	4	4	3	2
DMUs	7	7	7	7	7	7
Efficient Branch %	43%	29%	57%	57%	43%	29%

Source: Compiled and calculated by the researcher

PTE (BCC scores) indicates 57% selected companies in addition to 43% CCR fully efficient ones are fully technical efficient and scale efficient with a mean score 97% in pre-recession periods against 98%. Theoretically, $OTE \leq PTE$, here the PTE of sample companies are much more than OTE both in terms of average score and number of fully efficient companies during the study periods. Asymmetry with regard to PTE is as expected but to a great extent is low in comparison to OTE during the study periods, i.e. pre-recession & post-recession (PTE ranging between

86% and 100% with SD is 5% in pre recession periods, and PTE ranging between 90% and 100% with SD is ‘3.8%’ in post-recession periods).

Scale efficiency (SE) as measured by OTE/PTE indicates that the only 43% companies are fully scale efficient and there exists a significant variation among the companies with regards to scale efficiency in pre-recession periods and 29 % in post-recession period.

The present study has followed the BCC model to determine the nature of returns-to- scale of the companies. Scale inefficiency is found to be fully due to IRS. 43% companies, i.e. all the CCR inefficient companies are found to be operating at IRS or DRS, and remaining 57% are operating at the most productive scale size (MPSS) in pre-recession periods against 71% (MPSS) in post-recession periods.

Companies having OTE equal to 1 in *table (6.14)* are CCR efficient. They together construct efficient frontier, i.e. providing best practices among the sample Refineries companies. Efficiencies of other 4 refineries companies which are inefficient (i.e. OTE < 1) are measured relative to this frontier.

TABLE 6.14: EFFICIENCY SCORES OF THE SELECTED REFINERIES COMPANIES

	Technical Efficiency Score(CRS) OTE		Pure Technical Efficiency Score(VRS) PTE		Scale Efficiency Score SE		Returns to Scale (RTS)	
	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Pots Recession	Pre Recession	Post Recession
DMUs								
B P C L	0.9121	0.9303	0.9135	0.9392	0.9985	0.9905	Increasing	Decreasing
C P C L	0.9897	0.9645	0.9994	1	0.9903	0.9645	Increasing	Increasing
Essar Oil	0.8403	0.9144	1	0.9971	0.8403	0.9171	Increasing	Increasing
H P C L	0.8663	0.8889	0.8673	0.9054	0.9988	0.9818	Increasing	Increasing
IOCL	1	0.9791	1	1	1	0.9791	Constant	Decreasing
MRPL	1	1	1	1	1	1	Constant	Constant
Reliance Inds.	1	1	1	1	1	1	Constant	Constant

Source: Compiled and calculated by the researcher

The empirical findings are seen to suggest that three Refineries companies namely, IOCL, MRPL and Reliance Industries have exhibited maximum scale efficiency level in pre-recession periods. The results indicate that, these Refineries companies have not slacked in their intermediation function and have been successful to fully

maximize revenues while minimizing costs and subsequently lead to the perfect Scale efficiency. In post-recession periods two Refineries companies achieve highest SE.

Overall, the empirical findings from this study seem to suggest that in the case of the selected Refineries companies, cost inefficiency has much more to do with the scale of production rather than the inefficient utilization of resources. The dominant effect of the scale inefficiency indicates that most of selected companies have been operating at the ‘incorrect’ or non-optimal scale of operations. They either experience economies of scale (i.e. (IRS)) due to being at less than the optimum size, or of scale (i.e. (DRS)) due to being at more than the optimum size. Thus, decreasing or diseconomies increasing the scale of production could result in cost savings or efficiencies. Only two companies i.e. Reliance Inds. and M R P L are in constant return to scale in both pre and post recession periods.

From the above *table 6.14*, we have seen that cost efficiency of the 5 companies during pre and post recession periods are changing accordingly with different efficiency measurements. Hence, the null hypothesis, H_{02} : there is no change in the cost efficiency of the companies during pre and post a recession period is rejected. On the contrary, 2 companies, i.e. Reliance Inds. and MRPL are fully efficient during pre and post-recession periods, i.e. cost efficiency of the companies are not changing, in that case, the null hypothesis (H_{02}) is accepted.

Input Output Improvement Plan for the Inefficient Refineries Companies

Table 6.15 & 6.16 shows the input-output target or input-output improvement plan for the selected companies, as per SBM scores. Input output improvement plan is projected on the basis of average scores of 4 SMB inefficient companies in pre-recession periods and 5 inefficient banks in post-recession periods. Inefficient companies can become fully SBM efficient through the input-output improvement plan. Average score of 4 inefficient companies is 75%. Therefore, overall technical inefficiency is $100\% - 75\% = 25\%$ in pre-recession period. In post-recession period, the average score of 5 inefficient companies is 70% and overall technical inefficiency is $100\% - 70\% = 30\%$. Actual input-output data are computed as the

aggregate value of 4 and 5 inefficient companies during pre and post-recession periods.

TABLE 6.15: INPUT OUTPUT IMPROVEMENT PLAN FOR THE INEFFICIENT REFINERIES COMPANIES DURING PRE-RECESSION PERIODS (Rs.Cr)

DMU		CPCL	BPCL	HPCL	Essar Oil
Score		0.974858	0.747063	0.67378	0.607477
Input Inefficiency		0.025142	0.252937	0.32622	0.392523
Raw Materials expenses	Original	16080.04	66181.79	65761.61	461.56
	Slack Movement	0	0	-94.7246	0
	Projection	16080.04	66181.79	65666.88	461.56
Selling and Administration Expenses	Original	241.525	1890.948	2621.885	57.75667
	Slack Movement	-12.1449	-956.583	-1706.84	-45.3416
	Projection	229.3801	934.3652	915.0408	12.41504
Net Sales	Original	17496.78	71866.47	71125.75	545.5417
	Slack Movement	0	0	0	0
	Projection	17496.78	71866.47	71125.75	545.5417

Source: Compiled and calculated by the researcher

Note- Input projection in Total Column is presented with a negative sign and output projection with the positive sign as because of inputs to be reduced and output to be enhanced for efficiency improvement philosophy.

TABLE 6.16: INPUT OUTPUT IMPROVEMENT PLAN FOR THE INEFFICIENT REFINERIES COMPANIES DURING POST-RECESSION PERIODS

DMU		IOCL	BPCL	Essar Oil	CPCL	HPCL
Score		0.900811	0.697691	0.658869	0.64156	0.634499
Input Inefficiency		0.099189	0.302309	0.341131	0.35844	0.365501
Raw Materials expenses	Original	333144	173128.1	56503.24	35836.31	150885.8
	Slack Movement	0	0	0	0	0
	Projection	333144	173128.1	56503.24	35836.31	150885.8
Selling and Administration Expenses	Original	6304.667	3619.017	2465.185	298.9267	5056.905
	Slack Movement	-1250.7	-2188.12	-1681.9	-214.295	-3696.61
	Projection	5053.962	1430.894	783.281	84.63217	1360.3
Net Sales	Original	373785.6	186605.1	62923.83	37273.44	163355.4
	Slack Movement	0	0	0	0	0
	Projection	373785.6	186605.1	62923.83	37273.44	163355.4

Source: Compiled and calculated by the researcher

Note- Input projection in Total Column is presented with a negative sign and output projection with the positive sign as because of inputs to be reduced and output to be enhanced for efficiency improvement philosophy.

Selected Refineries Companies as a whole has to reduce its all inputs level by 24% on an average in pre-recession periods against 30% in post-recession periods. This

proportional reduction of each input by 24% and 30% removes the purely technical inefficiency of the selected Companies for the study. By the removal of this inefficiency, it will be become weakly efficient [fulfill the ‘Farrell’ or ‘week’ efficiency (Cooper W. W. et al., 2007)].

These slack adjustments after radial adjustment in of all the selected Refineries Companies are strongly efficient [fulfill the ‘Pareto- Koopmans’ or ‘strong’ efficiency, (Cooper et al., 2007)]. Overall input efficiently in post-recession periods of the IOCL is ‘Selling and Adm. Exp.’ as the potential reduction in this input, which could be reduced by Rs.1250.7cr.

6.5.5 Power Generation & Distribution Industry

In our study, we have selected the inputs and outputs variables as these variables as these are the major cost components of the respective industry.

BOX NO 6.5: INPUT AND OUTPUT VARIABLES FOR POWER GENERATION & DISTRIBUTION INDUSTRY

Input Variables	Output Variables
Electricity & Fuel Charge Operating Expenses Employee Cost Interest Expenses	Net Sales Other Income Reported Net Profit

The descriptive statistics of OTE (Overall Technical Efficiency) scores are presented in *Table 6.17*. We have seen that about 70.59% of the selected companies in pre and post recession period (as evidenced from the evaluation of 17 sample Power generation & Distribution companies) are found to be fully technical and scale efficient, i.e. CCR efficient. Moreover, mean score 92.60% implies that selected companies could have saved on an average 7.40 % of the present input consumption in order to produce the present level of services in pre-recession periods; and, mean score 97% implies that selected companies could have saved on an average 3 % post-recession periods. The results also indicate that there is no significant efficiency variation among the selected companies with regards to OTE as evidenced by the range of efficiency scores between 50% to 100%, and SD 14.53% in pre-recession periods, on other hand, in post-recession periods 76.27% to 100%, and SD is 6.13% only.

TABLE 6.17: DESCRIPTIVE STATISTICS OF EFFICIENCY SCORES OF SELECTED POWER GENERATION & DISTRIBUTION COMPANIES

	Technical Efficiency Score(CRS) OTE		Pure Technical Efficiency Score(VRS) PTE		Scale Efficiency Score SE	
	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession
Average score	0.9260	0.9706	0.9627	0.9869	0.9560	0.9828
SD	0.1453	0.0613	0.0830	0.0423	0.0914	0.0305
Maximum	1	1	1	1	1	1
Minimum	0.4953	0.7627	0.7507	0.8303	0.6597	0.9170
No. of Efficient Branches	12	12	13	15	12	12
DMUs	17	17	17	17	17	17
Efficient Branch %	70.59%	70.59%	76.47%	88.24%	70.59%	70.59%

Source: Compiled and calculated by the researcher

PTE (BCC scores) indicates 76.47% selected companies in addition to 70.59% CCR fully efficient ones are fully technical efficient and scale efficient with a mean score 96.27% in pre-recession periods; against 98.69% in post-recession periods. Theoretically, $OTE \leq PTE$, here the PTE of sample companies are much more than OTE both in terms of average score and number of fully efficient companies during the study periods. Asymmetry with regard to PTE is as expected but to a great extent is low in comparison to OTE during the study periods, i.e. pre-recession and post-recession (PTE ranging between 75% to 100%, with SD 4.5% in pre-recession periods, and between 81% to 100%, with SD 4.7% in post-recession periods).

Scale efficiency (SE) as measured by OTE/PTE indicates that the only 70.59% companies are fully scale efficient and there exists a significant variation among the companies with regards to scale efficiency in pre-recession periods and also same efficiency percentage in post-recession period.

The relation among these three efficiency measures ($OTE = PTE \times SE$) popularly known as decomposition of efficiency depicts that overall inefficiency of the selected companies is mainly caused by operating at an inappropriate scale rather than inefficient management operation. Scale inefficiency, therefore, appears to affect the overall inefficiency of the companies. The issue of scale inefficiencies is

explored by considering Returns-to-scale (RTS) properties of the companies. The present study has followed the BCC model to determine the nature of returns-to-scale of the selected companies. Scale inefficiency is found to be fully due to IRS. 29.41% of sample companies, i.e. all the CCR inefficient companies are found to be operating at IRS or DRS and remaining 70.59% are operating at the most productive scale size (MPSS) in pre and post recession periods.

Power generation & Distribution companies having OTE equal to 1 in the above Table 6.17 are CCR efficient. They together construct efficient frontier, i.e. providing best practices among the sample companies. Efficiencies of other 5 companies which are inefficient (i.e. OTE < 1) are measured relative to this frontier.

TABLE 6.18: EFFICIENCY SCORES OF THE SELECTED POWER GENERATION & DISTRIBUTION COMPANIES

DMUs	Technical Efficiency Score(CRS) OTE		Pure Technical Efficiency Score(VRS) PTE		Scale Efficiency Score SE		Returns to Scale (RTS)	
	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession
BF Utilities	1	1	1	1	1	1	Constant	Constant
CESC	0.4953	0.7627	0.7507	0.8303	0.6597	0.9187	Decreasing	Decreasing
Energy Devl.Co.	1	1	1	1	1	1	Constant	Constant
Guj Inds. Power	0.6535	1	0.7587	1	0.8614	1	Decreasing	Constant
India Power Corp	1	0.9331	1	1	1	0.9331	Constant	Decreasing
Indowind Energy	0.8596	1	0.8873	1	0.9688	1	Increasing	Constant
JSW Energy	1	1	1	1	1	1	Constant	Constant
Lanco Infratech	1	1	1	1	1	1	Constant	Constant
Monnet Inter	1	1	1	1	1	1	Constant	Constant
Neyveli Lignite	1	1	1	1	1	1	Constant	Constant
NHPC Ltd	1	1	1	1	1	1	Constant	Constant
NTPC	0.8471	1	1	1	0.8471	1	Decreasing	Constant
Potis Power	1	1	1	1	1	1	Constant	Constant
Power Grid Corpn	1	1	1	1	1	1	Constant	Constant
Reliance Infra.	1	0.9170	1	1	1	0.9170	Constant	Decreasing
T C P	0.8858	0.9634	0.9690	1	0.9141	0.9634	Decreasing	Decreasing
Tata Power Co.	1	0.9244	1	0.9478	1	0.9753	Constant	Decreasing

Source: Compiled and calculated by the researcher

From *table 6.18*, we have seen that 12 companies have exhibited maximum Scale efficiency level both in pre and post recession periods. The results indicate that these Power generation & Distribution companies have not slacked in their intermediation function and have been successful to fully maximize revenues while minimizing costs and subsequently lead to the perfect Scale efficiency.

The dominant effect of the scale inefficiency indicates that most of Power generation & Distribution companies have been operating at the ‘incorrect’ or non-optimal scale of operations. They either experience economies of scale (i.e. IRS) due to being at less than the optimum size, or diseconomies of scale (i.e. DRS) due to being at more than the optimum size. Thus, decreasing or increasing the scale of production could result in cost savings or efficiencies. Fifteen companies are in constant return to scale in both pre and post recession periods.

From the above *table 6.18*, we have seen that cost efficiency of the 8 companies during pre and post recession periods are changing accordingly with different efficiency measurements. Hence, the null hypothesis, H_{02} : there is no change in the cost efficiency of the companies during pre and post a recession period is rejected. On the contrary, 9 companies, i.e. Lanco Infratech, BF Utilities, Energy Devl.Co. JSW Energy, Neyveli Lignite, Monnet Inter, NHPC Ltd, Potis Power and Power Grid Corpn. are fully efficient during pre and post-recession periods, i.e. cost efficiency of the companies are not changing, in that case, the null hypothesis(H_{02}) is accepted.

Input Output Improvement Plan for the Inefficient Power Generation & Dist. Companies

Table 6.19 and 6.20 shows the Input-output improvement plan for the selected companies as per SBM efficiency scores. Input-output improvement plan is projected on the basis of average scores of 5 SBM inefficient companies in pre and post recession periods. Inefficient companies can become fully efficient through the input-output improvement plan. Average score of 5 inefficient Power generation & Distribution companies in pre-recession period is 60.74%. Therefore,

overall technical inefficiency is $100\% - 60.74\% = 39.26\%$ in pre-recession period. In post-recession period, average OTE of 5 inefficient companies is 83.13% and overall technical inefficiency is $100\% - 83.13\% = 16.87\%$. Actual input-output data are computed as the aggregate value of 5 inefficient companies both on pre-recession and post-recession periods.

TABLE 6.19: INPUT OUTPUT IMPROVEMENT PLAN FOR THE INEFFICIENT POWER GENERATION & DISTRIBUTION COMPANIES DURING PRE-RECESSION PERIODS
Rs.Cr

DMU		Indowind Energy	NTPC	T C P	Guj Inds. Power	CESC
Score		0.77	0.69	0.67	0.55	0.36
Input Inefficiency		0.23	0.31	0.33	0.45	0.64
Electricity & Fuel Expenses	Original	7.48	15973.73	10.00	438.21	958.90
	Slack Movement	0	-7545.71	-9.74	-141.24	-656.83
	Projection	7.48	8428.03	0.25	296.97	302.08
Operating Expenses	Original	8.08	806.40	117.49	32.45	193.45
	Slack Movement	-4.09	-547.24	0	-23.29	-182.28
	Projection	4.00	259.16	117.49	9.16	11.17
Employee Cost	Original	0.47	1273.40	6.49	16.25	311.16
	Slack Movement	-0.09	-137.90	-2.13	-7.13	-145.49
	Projection	0.37	1135.50	4.37	9.12	165.67
Interest	Original	3.01	2004.90	9.66	113.54	279.04
	Slack Movement	-0.64	0	0	-37.69	-131.84
	Projection	2.37	2004.90	9.66	75.84	147.20
Total Income	Original	29.18	29549.03	193.53	870.73	2566.75
	Slack Movement	0	0	0	0	0
	Projection	29.18	29549.03	193.53	870.73	2566.75
Reported Net Profit	Original	4.80	5795.83	24.27	99.01	178.34
	Slack Movement	4.15	0	9.16	197.09	0
	Projection	8.95	5795.83	33.43	296.10	178.34

Source: Compiled and calculated by the researcher

Note- Input projection in Total Column is presented with a negative sign and output projection with the positive sign as because of inputs to be reduced and output to be enhanced for efficiency improvement philosophy.

TABLE 6.20: INPUT OUTPUT IMPROVEMENT PLAN FOR THE INEFFICIENT POWER GENERATION & DISTRIBUTION COMPANIES DURING POST-RECESSION PERIODS

Rs.Cr

DMUs		T C P	Reliance Infra.	India Power Corp	Tata Power Co.	CESC
Score		0.93	0.87	0.86	0.80	0.71
Input Inefficiency		0.07	0.13	0.14	0.20	0.29
Electricity & Fuel Expenses	Original	21.15	4349.11	324.24	4863.49	2006.62
	Slack Movement	-6.32	0	-51.86	0	0
	Projection	14.84	4349.11	272.38	4863.49	2006.62
Operating Expenses	Original	195.68	4935.89	82.64	616.72	425.96
	Slack Movement	0	0	-34.58	-392.05	-301.33
	Projection	195.68	4935.89	48.05	224.67	124.63
Employee Cost	Original	13.93	727.54	36.82	447.33	535.36
	Slack Movement	0	0	0	-71.26	-75.42
	Projection	13.93	727.54	36.82	376.07	459.95
Interest	Original	11.32	552.65	13.28	546.34	326.61
	Slack Movement	0.00	-292.45	0	0	-105.79
	Projection	11.32	260.20	13.28	546.34	220.82
Total Income	Original	301.69	13286.43	520.12	8670.83	4494.62
	Slack Movement	0	0	0	0	0
	Projection	301.69	13286.43	520.12	8670.83	4494.62
Reported Net Profit	Original	27.08	1493.20	16.02	991.83	526.02
	Slack Movement	6.02	398.60	78.40	519.67	431.77
	Projection	33.10	1891.80	94.42	1511.50	957.78

Source: Compiled and calculated by the researcher

Note- Input projection in Total Column is presented with a negative sign and output projection with positive sign as because of inputs to be reduced and output to be enhanced for efficiency improvement philosophy.

As we follow input-oriented DEA model, there are two sources of inefficiencies associated with inputs, i.e. purely technical inefficiency represented by the radial measure (1- efficiency score obtained) and mix inefficiency represented by excess input also termed as non-zero input slack. Mix inefficiency arises from the wrong proportion in which inputs are utilized or outputs are produced. However, slack adjustments after radial adjustment make all the selected Power generation & Distribution companies are strongly efficient [fulfill the 'Pareto- Koopmans' or 'strong' efficiency, (Cooper et al., 2007)].

Selected Power generation & Distribution companies as a whole has to reduce its all inputs level by 39.29% on an average in pre recession periods against 16.86%

in post recession periods. This proportional reduction of each input by 39.29% and 16.86% removes the purely technical inefficiency of the selected companies for the study. By the removal of this inefficiency, it will be become weakly efficient [fulfill the ‘Farrell’ or ‘week’ efficiency (Cooper W. W. et al., 2007)].

Management of the selected Power generation & Distribution companies should consider this input-output target while planning for expansion. Thus, the selected companies which are using more Electricity & Fuel Expenses for providing their services with lower RNP are relatively more inefficient in pre & post-recession periods. For an example, CESC has to reduce Operating Expenses by Rs. 301.33 cr., Employee Cost by Rs. 75.42 cr. and Interest expenses by Rs. 105.79 cr. that will increase their Reported Net Profit by Rs. 431.77 cr.

6.5.6 Steel Industry

We carried out the efficiency analysis of companies under Steel Industry; based on below mention selected input and output variables.

BOX 6.6: INPUT AND OUTPUT VARIABLES FOR STEEL INDUSTRY

Input Variables	Output Variables
Raw Materials Power & Fuel Cost Other Manufacturing Expenses Selling and Administration Expenses	Net Sales Other Income Reported Net Profit

The descriptive statistics of OTE (Overall Technical Efficiency) scores are presented in *Table 6.21*. We have seen that about 66.67% of the selected companies in pre-recession periods and 47.62% of the selected companies in post-recession periods as evidenced from the evaluation of 21 sample companies are found to be fully technical and scale efficient, i.e. CCR efficient. Moreover, mean score 96.39% implies that selected companies could have saved on an average 3.61 % of the present input consumption in order to produce the present level of services in pre and post-recession periods. The results also indicate that, there is high significant efficiency variation among the selected companies with regards to OTE as evidenced by the range of efficiency scores between 7.37% to 100%, and SD 8.16% in pre recession periods; on other hand, in post-recession periods it scores between 7.9% to 100% and SD is 6.08%.

TABLE 6.21: DESCRIPTIVE STATISTICS OF EFFICIENCY SCORES OF SELECTED STEEL COMPANIES

	Technical Efficiency Score(CRS) OTE		Pure Technical Efficiency Score(VRS) PTE		Scale Efficiency Score SE	
	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession
Average score	0.9639	0.9576	0.9696	0.9892	0.9934	0.9676
SD	0.0790	0.0540	0.0707	0.0272	0.0143	0.0381
Maximum	1	1	1	1	1	1
Minimum	0.7374	0.8307	0.7576	0.8932	0.9427	0.8883
No. of Efficient Branches	14	10	16	17	14	10
DMUs	21	21	21	21	21	21
Efficient Branch %	66.67%	47.62%	76.19%	80.95%	66.67%	47.62%

Source: Compiled and calculated by the researcher

PTE (BCC scores) indicates 76.19% selected companies in addition to 66.67% CCR fully efficient ones are fully technical efficient and scale efficient with a mean score 96.96% in pre-recession periods against 98.92% in post-recession periods. Scale efficiency (SE) as measured by OTE/PTE indicates that the only 66.67% of the selected companies are fully scale efficient and there exists a significant variation among the companies with regards to scale efficiency in pre-recession periods and 47.62% in post-recession period.

The relation among these three efficiency measures ($OTE = PTE \times SE$) popularly known as decomposition of efficiency depicts that overall inefficiency of the selected companies is mainly caused by operating at an inappropriate scale rather than inefficient management operation. Scale inefficiency, therefore, appears to affect the overall inefficiency of the companies. The issue of scale inefficiencies is explored by considering returns-to-scale (RTS) properties of the companies. The present study has followed the BCC model to determine the nature of returns-to-scale of the companies. Scale inefficiency is found to be fully due to IRS. 33.33% companies, i.e. all the CCR inefficient branches are found to be operating at IRS or DRS and remaining 66.67% are operating at the most productive scale size (MPSS) in pre recession periods against 47.62 % (MPSS) in post-recession periods.

Selected companies having OTE equal to 1 in the below *Table 6.22* are CCR efficient. They together construct efficient frontier i.e. providing best practices among the sample companies. Efficiencies of other 7 companies which are inefficient (i.e. $OTE < 1$) are measured relative to this frontier in pre-recession periods, against 11 companies in post-recession periods.

TABLE 6.22: EFFICIENCY SCORES OF THE SELECTED STEEL COMPANIES

DMUs	Technical Efficiency Score (CRS)		Pure Technical Efficiency Score (VRS)		Scale Efficiency Score		Returns to Scale (RTS)	
	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession	Pre Recession	Post Recession
APL Apollo	1	1	1	1	1	1	Constant	Constant
Bhushan Steel	1	0.9484	1	1	1	0.9484	Constant	Decreasing
Godawari Power	1	0.9749	1	1	1	0.9749	Constant	Increasing
Jindal Saw	1	0.9208	1	1	1	0.9208	Constant	Decreasing
Jindal Stain.	0.7932	0.8576	0.8414	0.8932	0.9427	0.9601	Decreasing	Decreasing
Jindal Steel	0.9867	1	1	1	0.9867	1	Increasing	Constant
JSW Steel	1	1	1	1	1	1	Constant	Constant
Mah. Seamless	1	1	1	1	1	1	Constant	Constant
Monnet Ispat	1	1	1	1	1	1	Constant	Constant
Mukand	0.9747	0.9171	1	0.9823	0.9747	0.9337	Increasing	Increasing
Prakash Inds.	1	1	1	1	1	1	Constant	Constant
PSL	1	1	1	1	1	1	Constant	Constant
Ratnamani Metals	0.9879	1	0.9882	1	0.9998	1	Decreasing	Constant
SAIL	1	0.9897	1	1	1	0.9897	Constant	Decreasing
Sarda Energy	1	1	1	1	1	1	Constant	Constant
Surya Roshni	0.9556	0.9426	0.9585	1	0.9970	0.9426	Decreasing	Decreasing
Tata Steel	1	1	1	1	1	1	Constant	Constant
Usha Martin	0.8066	0.8307	0.8169	0.9352	0.9875	0.8883	Increasing	Increasing
Uttam Galva	1	0.9381	1	1	1	0.9381	Constant	Decreasing
Uttam Value Ste.	0.7374	0.8693	0.7576	0.9636	0.9733	0.9021	Increasing	Decreasing
Welspun Corp	1	0.9212	1	1	1	0.9212	Constant	Decreasing

Source: Compiled and calculated by the researcher

The empirical findings seem to suggest that, 14 companies have exhibited maximum Scale efficiency level in pre-recession period. The results indicate that these companies have not slacked in their intermediation function and have been successful to fully maximize revenues while minimizing costs and subsequently lead to the perfect scale efficiency. In post-recession periods, 10 companies achieve highest SE but few companies are inefficient in post-recession periods through they are full efficient in pre recession periods. Eight companies are relay performing well in entire study periods, i.e. APL Apollo, JSW Steel, Mah. Seamless, Monnet Ispat, Prakash Inds., PSL, Sarda Energy and Tata Steel.

Decreasing or increasing the scale of production could result in cost savings or efficiencies. Above eight companies were in CRS in both pre-recession and post-recession periods.

From the above *table 6.22*, we have seen that cost efficiency of the 13 companies during pre and post recession periods are changing accordingly with different efficiency measurements. Hence, the null hypothesis, H_{02} : There is no change in the cost efficiency of the companies during pre and post a recession period is rejected. On the contrary, 8 companies, i.e. Tata Steel, APL Apollo, JSW Steel, Mah. Seamless, Prakash Inds., Sarda Energy, Monnet Ispat, PSL are fully efficient during pre and post-recession periods, i.e. cost efficiency of the companies are not changing, in that case, the null hypothesis (H_{02}) is accepted.

Input Output Improvement Plan for the Inefficient Steel Companies

Table 6.23 and table 6.24 shows the input-output target or input-output improvement plan for the selected companies as per SBM efficiency scores.

Input-output improvement plan is projected on the basis of average scores of 7 inefficient companies in pre-recession periods and 9 inefficient companies in post-recession periods. Inefficient companies can become fully efficient through the input-output improvement plan. Average score of 7 inefficient companies is 75.09%. Therefore, inefficiency is $100\% - 75.09\% = 24.91\%$ in pre-recession period. In post recession period, average score of 9 inefficient companies is 79.10% and overall technical inefficiency is $100\% - 79.10\% = 20.89\%$. Actual input output data are computed as the aggregate value of 7 companies in pre-recession periods against and 9 inefficient companies in post-recession periods.

TABLE 6.23: INPUT OUTPUT IMPROVEMENT PLAN FOR THE INEFFICIENT STEEL COMPANIES DURING PRE-RECESSION PERIODS

Rs.Cr

DMUs		Ratnamani Metals	Jindal Steel	Surya Roshni	Mukand	Usha Martin	Jindal Stain.	Uttam Value Ste.
Score		0.93	0.85	0.81	0.77	0.71	0.62	0.56
Input Inefficiency		0.07	0.15	0.19	0.23	0.29	0.38	0.44
Raw Materials	Original	233.04	555.51	709.07	667.48	511.97	2318.87	811.14
	Slack Movement	0	-15.85	0	0	0	0	0
	Projection	233.04	539.66	709.07	667.48	511.97	2318.87	811.14
Power & Fuel Cost	Original	8.66	333.28	25.91	110.27	107.99	309.32	210.89
	Slack Movement	0	-169.59	-7.33	-22.00	-58.10	-215.51	-146.92
	Projection	8.66	163.69	18.58	88.27	49.89	93.81	63.98
Other Manufacturing Expenses	Original	21.92	376.83	40.83	417.01	139.75	252.54	168.66
	Slack Movement	0	-3.16	0	-276.37	-25.43	-44.20	-60.24
	Projection	21.92	373.67	40.83	140.64	114.32	208.34	108.42
Selling and Administration Expenses	Original	14.20	248.82	84.46	65.16	108.51	139.68	68.86
	Slack Movement	-4.03	-8.81	-40.49	-4.62	-46.87	-90.59	-47.33
	Projection	10.17	240.01	43.97	60.54	61.64	49.09	21.53
Net Sales	Original	353.29	2635.18	968.43	1440.29	1142.89	3342.33	1348.72
	Slack Movement	0	44.03	0	0	0	0	0
	Projection	353.29	2679.21	968.43	1440.29	1142.89	3342.33	1348.72
Other Income	Original	1.81	52.03	13.28	140.72	50.82	160.14	64.59
	Slack Movement	4.57	29.82	20.59	0	0	0	0
	Projection	6.38	81.85	33.87	140.72	50.82	160.14	64.59
Reported Net Profit	Original	34.54	579.86	14.69	49.58	62.65	209.02	-48.73
	Slack Movement	15.02	0	101.41	238.31	150.78	278.05	239.77
	Projection	49.56	579.86	116.10	287.89	213.43	487.07	191.04

Source: Compiled and calculated by the researcher

Note- Input projection in Total Column is presented with a negative sign and output projection with the positive sign as because of inputs to be reduced and output to be enhanced for efficiency improvement philosophy.

TABLE 6.24: INPUT OUTPUT IMPROVEMENT PLAN FOR THE INEFFICIENT STEEL COMPANIES DURING POST-RECESSION PERIODS

DMU		Godawari Power	Welspun Corp	Surya Roshni	Bhushan Steel	Uttam Galva	Jindal Saw	Usha Martin	Uttam Value Ste.	Jindal Stain.
Score		0.96	0.89	0.84	0.79	0.78	0.78	0.72	0.69	0.67
Input Inefficiency		0.04	0.11	0.16	0.21	0.22	0.22	0.28	0.31	0.33
Raw Materials	Original	918.61	4315.95	1779.15	4675.06	4037.81	3488.73	1065.52	3606.35	5346.05
	Slack Movement	0	-49.89	0	0	0	0	0	0	0
	Projection	918.61	4266.06	1779.15	4675.06	4037.81	3488.73	1065.52	3606.35	5346.05
Power & Fuel Cost	Original	60.93	138.83	46.57	567.24	182.80	203.83	309.98	309.38	797.42
	Slack Movement	-5.42	-23.13	-15.35	-29.98	-15.48	-71.32	-174.88	-231.15	-380.98
	Projection	55.51	115.70	31.22	537.26	167.32	132.51	135.10	78.23	416.44
Other Manufacturing Expenses	Original	98.30	507.18	68.68	250.12	89.34	314.57	487.85	239.32	602.40
	Slack Movement	-7.79	-138.53	-20.56	-99.45	-48.01	0	-99.30	-116.61	-497.79
	Projection	90.51	368.65	48.12	150.67	41.33	314.57	388.55	122.71	104.61
Selling and Administration Expenses	Original	22.99	189.41	169.12	604.18	204.37	344.59	187.33	112.64	291.71
	Slack Movement	0	0	0	-233.08	-52.03	-186.50	-67.95	0	0
	Projection	22.99	189.41	169.12	371.10	152.34	158.09	119.38	112.64	291.71
Net Sales	Original	1325.36	5980.64	2335.93	7986.08	5071.19	5383.13	2605.52	4413.86	7918.67
	Slack Movement	0	0	0	0	0	0	0	0	0
	Projection	1325.36	5980.64	2335.93	7986.08	5071.19	5383.13	2605.52	4413.86	7918.67
Other Income	Original	8.93	177.64	6.44	53.74	44.96	69.30	58.60	60.77	111.97
	Slack Movement	3.69	0	55.48	189.92	25.69	4.45	1.61	0	74.55
	Projection	12.62	177.64	61.92	243.66	70.65	73.75	60.21	60.77	186.52
Reported Net Profit	Original	73.18	206.45	51.34	711.09	75.71	348.57	47.82	-92.29	-366.30
	Slack Movement	0	0	58.13	348.26	235.55	180.11	315.59	215.33	1193.68
	Projection	73.18	206.45	109.47	1059.35	311.26	528.68	363.41	123.04	827.38

Sources: Compiled and calculated by the researcher

Note- Input projection in Total Column is presented with a negative sign and output projection with the positive sign as because of inputs to be reduced and output to be enhanced for efficiency improvement philosophy.

Selected companies as a whole have to reduce its all inputs level by 24.90% on an average in pre-recession periods against 20.89% in post-recession periods. This proportional reduction of each input removes the purely technical inefficiency of the selected Steel companies for the study. By the removal of this inefficiency, it will be become weakly efficient [fulfill the ‘Farrell’ or ‘weak’ efficiency (Cooper W. W. et al., 2007)].

However, slack adjustments after radial adjustment make all the selected companies are strongly efficient [fulfill the ‘Pareto- Koopmans’ or ‘strong’ efficiency, (Cooper et al., 2007)]. Here, Welspun Corp has to reduce Employee cost by Rs. 49.89 cr., Power & Fuel Cost by Rs. Rs. 23.13 cr, Other Manufacturing expenses by Rs. Rs. 138.53 cr. Again, for Bhushan Steel there is a chance to increase Reported net profit by Rs. 348.26 cr. by removing slack variables like, Selling and Administration expenses (Rs. 233.08 cr), Power & Fuel cost (Rs. 29.98 cr.) and Other Manufacturing expenses (Rs.99.45 cr.).

6.6 Summary: In this chapter, we have measured the cost efficiency by applying DEA models and got the cost efficient companies from the selected industries during the study periods. We have analyzed the scope of improvement in inputs and outputs plan during the pre-recession and post-recession periods. Moreover, we got overviews of cost reduction ideas of inputs cost variables, which will help to the management of companies to formulate appropriate cost reduction strategies. In the next chapter, we have analyzed and identify the strategies adopted by the companies during pre and post-recession periods.