PERFORMANCE MEASUREMENT OF INDIAN STEEL INDUSTRY ON THE BASIS OF DATA ENVELOPMENT ANALYSIS

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Abstract: All players involved in a business must need to measure business firm's efficiency. In this study data envelopment analysis (DEA) has been conducted for efficiency assessment. The DEA approach can manage several inputs and outputs. The current study presented the DEA model for assessing performance. This study selected panel data of 8 steel companies from India belongs to public and private sector to express the advantage of DEA model in measuring competence with quantitative supervision for strategy formulation and for analysing the performance of such selected steel companies.

Keywords: Steel Industry, Performance, Data Envelopment Analysis

Introduction

The steel industry is continuously adapting and refinement itself to become more competitive in the market. It is an energetic and innovative sector. It makes them more competitive in the market by increasing new advanced steel grades and production measures. It produces improved and additional cost-effective product outline for the varying market place. Today the growth in world steel demand is directed by the developing countries. For any modern economic growth, steel is a very essential and it is measured to be the backbone of human civilization. Mostly industrialized economies are depending on a well-built steel industry. Again the economic development of a country has been mostly figured by their steel industries potency in preliminary phase of expansion. The quantity of steel consumption has strong effect on economic development of a country.

Major impetus for growth in steel sector comes with the economic liberalization of 1991. The new economic policy broadcast in 1991 was a significant milestone which brought out a sea change in the Indian steel industry. In the post-liberalization era, the construction of the steel industry underwent a sea change with the arrival of major steel producers in the private sector with the world class technologies and competence. The industry was delicensed and opened for private participation. Government taken industrial policy and other inventiveness at the time of liberalization gives an

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impetus to the private sector for entrance and development of them in the steel industry. Whereas the existing units also updated or stretched out them by setting up of a huge number of fresh or Greenfield steel plants in different parts of the country based on up to date and cost effective technologies and skill.

Global and domestic demand of steel is continuously increasing so steel industry in India is on an upswing. India's speedy fiscal development and rising demand by various segments of our country and other country put on the Indian steel industry on world map.

All players involved in a business must need to measure business firm's efficiency. The DEA approach is conducted here to manage several inputs and outputs. The DEA model is presented in this study for measuring efficiency of the selected companies. Present study uses panel data of 8 public and private sector steel companies in India for 15 years (from 2002 to 2016) to express the advantage of DEA model in measuring companies and industrial efficiency through supervision for strategy generation and for analysing the performance of such selected steel companies. The selected steel companies are SAIL, Tata Steel, JSW Steel, Bhushan Steel, RINL, Essar Steel, Jindal Steel and Bhushan Power.

Objectives of the Study

This studies objective is to assess financial efficiency of chosen steel companies in India through the post-liberalization era. Another objective of DEA analysis is to determine its utility and also determines efficiency level of the companies. Because for growth and sustainability of any industry efficient running of companies is very much needed, so that in this study the researcher measure the financial efficiency of selected steel companies through DEA model for analysing their performance, future growth and sustainability. Findings of this analysis can facilitate to describe suggestion for management in companies and the government. In conclusion, this study affirms the relevance of DEA to measure company efficiency through BCC DEA model.

Literature Review

Chandra *et al.* (1998) made their study for efficiency evaluation of Canadian textile companies by using the DEA CCR technique. Here the numbers of labour and average annual investment were used as inputs; whereas the annual sales values were used as outputs.

Erkut and Hatice (2007) for analysing the performances of 500 industrial enterprises in Turkey, they taken two inputs and three outputs variables and applied super slack model of DEA for analysing efficiency of those companies. This analysis result exposed that only nine firms performed efficiently during 2003.

Joshi and Singh (2009) consider ready-made garment industry for measuring the operational efficiency by using DEA model. They conclude that, under constant returns to scale (CRTS) selected companies can increase 25% of their present output with same input level.

El-Mashaleh *et al.* (2010) for evaluating the safety performance of 45 construction contractors used DEA CCR model. This study revealed that better safety performance achieved by eight contractors only.

Sharma, Momaya, and Manohar (2010) estimate efficiency and competitiveness of the Indian telecom industry. Their findings of this study validate the hypothesis of competitiveness implications for leadership in the industry and government.

Liu *et al.* (2010) measuring comparative efficiency of production companies of China and Turkey by using DEA analysis. The author used canonical correlation analysis. They conclude that, Chinese production companies are more extremely efficient than Turkish production companies.

Tahir and Yusof (2011) try to identify the technical and scale effectiveness by using DEA BCC and DEA CCR models. For this analysis purpose they selected 14 Malaysian public sector companies with inputs oriented assumptions. Total expenses and total assets, were treated as input variables whereas sales revenue was taken as output variable. Their study concluded that out of 14 companies only one company was efficiently running.

Yu, Barros, Tsai and Liao (2014) had taken financial ratio analysis as an efficiency measuring technique. They also used DEA analysis for measuring efficiency of selected companies. For this analysis panel data was collected by them from 24 public sector Taiwan companies. This analysis wish to show advantages of DEA model comparing with ratio analysis in measuring efficiency of the selected companies with quantitative leadership in favour of strategy generation.

In concluding part we can say that, these studies insist the use of DEA to measure companies or industrial efficiency by considering various models and procedures. The number and type of inputs and outputs may vary.

Research Gap

From the in-depth study of the relevant literature available, the researcher has observed that studies are few on different aspects of efficiency measurement of both public sector and private sector steel companies in India. Most of the studies have attempted to assess the efficiency measurement based on a very small sample and various industries other than steel industry. The researcher feels that in order to make the study meaningful and comprehensive it is necessary to take a larger sample. This particular industry has been identified as a priority sector in the context of infrastructure development of India, particularly during the post-liberalization period, thus deserving in-depth research in the field.

Research Methodology

DEA is a linear programming method which is used for measuring efficiency of several decision making units (DMUs). DEA used when the manufacturing procedure presents several inputs and outputs composition. The competence of DMUs is estimated through judging their efficiency by the most excellent working

DMU. Those units which lie down on the efficiency boundary are known as top performing unit. Those units which are not on the efficiency boundary are considered as inefficient. The CCR model is first model created by Charnes in the year 1978. The BCC model is second model which is created by Banker in the year 1984. The constant returns to scale (CRS) is the basic theory behind CCR model and the basic theory based on which BCC model established is variable returns to scale (VRS). CCR model evaluate overall efficiency score. BCC model evaluate pure technical efficiency score. The CRS technique converted into VRS technique by dividing technical efficiency into technical and scale efficiency mechanisms in BCC model. It helps to examining scale effects also. Here the sources of inefficiency also shown through this breakdown. Main reasons of it may be either incompetent utilisation of resources or by detrimental situations or together. Capability of a company to create highest outcome that is achievable is demonstrates by Technical efficiency. A firm's return to scale represents its scale efficiency, whether it is functioning at growing, declining or optimal scale. A little raise in the input x when results a significant raise in the average output is known as growing return to scale. When the average productivity unaffected with the increase in input x, is signify as Constant returns to scale. These circumstances make a firm scale competent. A raise in input x when directs to a turn down in standard outcome is signify as declining returns to scale. These scores are characteristically described on the interval [0, 1]. The Variable Returns to Scale (VRS) technique of DEA formulation which is applied in present study is as follows:

$$\text{m}$$

$$, \alpha$$

such that

$$Y\alpha \geq Y_m$$

$$X\alpha \leq X_m$$

$$\Sigma_{n-1}^{N} \alpha_n = 1$$

$$\alpha \geq 0; \_{m} \text{ unrestricted.}$$

$\_$ is the twin variable corresponding to the equality constraint that standardized the weighted sum of inputs of the original problem.

α is the twin variable corresponding to the other inequality constraints of the ancient. It works as a weight for the firms.

n stands for the number of DMUs, n = 1, 2, …., N.

m stands for the m^{th} Decision Making Unit (DMU).

X stands for the matrix of inputs. Y stands for the matrix of outputs.

The constraint $\Sigma_{n-1}^{N} \alpha_n = 1$ is termed a convexity constraint, and was introduced by Banker in the year 1984.

Result Analysis and Interpretations

DEA Analysis (Table-1)

BCC DEA model used here to measures technical and the scale efficiency of 8 steel companies and for 15 years are computed. Here Gross sales and PBIT are

taken as Output variables and short term funds and long term funds are taken as input variables. Results for the steel companies are presented in Table 1(shown in appendix 1).

The CRS results shows that Bhushan steel, RINL and Bhushan power are considered technically efficient in few years as these three companies are put down on the CRSTE boundary by achieving efficiency score one. On the other hand, CRS technique can be converted into VRS technique if we lighten up the assumption, then technical efficiency is divided into technical and scale efficiency and as a result, SAIL, Tata Steel and Jindal steel came out to be technically efficient including the above 3 steel companies in so many years. Such finding means that the inefficiency revealed by these companies under CRS is scale inefficiency as its scale efficiency score is less than one. Another important observation about Bhushan steel, RINL and Bhushan Power is that, it is shows constant returns to scale with VRS structure. Whereas all company in maximum years showing decreasing return to scale. From the analysis we can conclude that if the size of operation decreases and if we minimised the cost and used optimal fund utilisation methods then it can reach scale efficiency. The IRS results find that every companies are coming out to be technically efficient in lots of years as these are put down on the IRSTE boundary by achieving efficiency score one. For other years where VRSTE came out to be less than 1 indicating certain percent failure of effectiveness in input use. The findings tell us moderate amount of profits and the level of gross sales can be strictly constant with certain percentage of the capital investment. But additional development of operations can help these companies to grow as it shows rising returns to scale. Again, result shows that in case of few companies for several years, the inefficiency shows 40 percent or more representing huge extent for additional efficient operation of capital invested. These companies alternatively have to either overthrow the size of operations or minimisation of cost and optimum fund utilisation methods to attain scale efficiency. It is notified that SAIL, Tata Steel, JSW Steel, Jindal Steel and Essar Steel are showing more than 40 percent inefficiency in very few years. This low level of efficiency results high level of investment and low market share. The growing returns to scale point out by our examination recommend that these companies have to increase their extent of business and vice-versa.

The DEA approach review for all firms have a satisfactory level of efficiency, where CCR results varying from 0.15 to 1.00, while BCC efficiency results varying from 0.22 to 1.00. So we can recommends that the companies have to reduce their inputs cost for attaining the similar output level. Occasionally the average scale efficiency, CCR and BCC score of a variety of steel companies achieved 1.00, this point out that this companies are on most favourable efficiency level, while the other companies are remain incompetent, even though those companies average scale efficiency, CCR and BCC scores are

near about to 1.00. The result shows that mainly big companies and their subordinate companies are functioning at a below the optimal efficiency level. As a result, essential mechanism has been applied to recover those companies functioning performance and effectiveness. This observed outcome from the table recommends that some development measures have to be taken for inefficient companies. The management must be improved by reducing short term funds and long term funds and focusing more on revenue creation i.e increase in gross profit and PBIT.

DEA Analysis (Table-2)

BCC DEA model used here to measures technical and the scale efficiency for 8 steel companies and for 15 years are computed. Here Gross sales and PBIT are taken as Output variables and Total current liabilities and total debt are taken as input variables. Results for the steel companies are presented in Table 2 (shown in appendix 2).

The CRS results shows that RINL and Bhushan power are considered technically efficient in few years as these two companies are put down on the CRSTE boundary by achieving efficiency score one. On the other hand, CRS technique can be converted into VRS technique if we lighten up the assumption, then technical efficiency is divided into technical and scale efficiency and as a result, SAIL and Tata Steel came out to be technical efficient including the above 2 steel companies in few years. Such finding means that the inefficiency revealed by these companies under CRS is scale inefficiency as its scale efficiency score is less than one. Another important observation about RINL and Bhushan Power is that, it is shows constant returns to scale with VRS structure. From the analysis we can conclude that if the size of operation decreases and if we minimised the cost and used optimal fund utilisation methods then it can reach scale efficiency. The IRS results find that every companies are coming out to be technically efficient in lots of years as these are put down on the IRSTE boundary by achieving efficiency score one. For other years where VRSTE came out to be less than 1 indicating certain percent failure of effectiveness in input use. The findings tell us moderate amount of profits and the level of gross sales can be strictly constant with certain percentage of the capital investment. But additional development of operations can help these companies to grow as it shows rising returns to scale. Again, result shows that in case of few companies for several years, the inefficiency shows 40 percent or more representing huge extent for additional efficient operation of capital invested. These companies alternatively have to either overthrow the extent of business or minimisation of cost to attain scale efficiency. It is notified that all selected steel companies are showing more than 40 percent inefficiency in very few years. This low level of efficiency results high level of investment and low market share. The growing returns to scale point out by our examination recommend that these companies have to

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The above discussion recommends that firms need to trim down their inputs cost, while preserving the identical output level. Occasionally the average scale efficiency, CCR and BCC score of a variety of steel companies achieved 1.00, this point out that this companies are on most favourable efficiency level, while the other companies are remain incompetent, even though those companies average scale efficiency, CCR and BCC scores are near about to 1.00. The result shows that mainly big companies and their subordinate companies are functioning at a below the optimal efficiency level. As a result, essential mechanism has been applied to recover those companies functioning performance and effectiveness. This observed outcome from the table recommends that some development measures have to be taken for inefficient companies. The management must be improved by reducing total current liabilities and total debt and focusing more on revenue creation i.e increase in gross profit and PBIT.

DEA Analysis (Table-3)

BCC DEA model used here to measures technical and the scale efficiency for 8 steel companies and for 15 years are computed. Here Gross sales and PBIT are taken as Output variables and Total interest expenses and total operating expenses are taken as input variables. Results for the steel companies are presented in Table 3 (shown in appendix 3). The CRS results shows that Bhushan steel, RINL and Bhushan power are considered technically efficient in few years as these three companies are put down on the CRSTE boundary by achieving efficiency score one. On the other hand, CRS technique can be converted into VRS technique if we lighten up the assumption, then technical efficiency is divided into technical and scale efficiency and as a result, SAIL, Tata Steel and Jindal steel came out to be technical efficient including the above 3 steel companies in so many years. Such finding means that the inefficiency revealed by these companies under CRS is scale inefficiency as its scale efficiency score is less than one. Another important observation about Bhushan steel, RINL and Bhushan Power is that, it is shows constant returns to scale with VRS structure. Whereas all company in maximum years revealing decreasing return to scale. From the analysis we can conclude that if the size of operation decreases and if we minimised the cost and used optimal fund utilisation methods then it can reach scale efficiency. The IRS results find that every companies are coming out to be technically efficient in lots of years as these are put down on the IRSTE boundary by achieving efficiency score one. For other years where VRSTE came out to be less than 1 indicating certain percent failure of effectiveness in input use. The findings tell us moderate amount of profits and the level of gross sales can be strictly constant with certain percentage of the capital investment. But additional development of operations can

help these companies to grow as it shows rising returns to scale. Again, result shows that in case of few companies for several years, the inefficiency shows 40 percent or more representing huge extent for additional efficient operation of capital invested. These companies alternatively have to either overthrow the size of operations or minimisation of cost and optimum fund utilisation methods to attain scale efficiency. It is notified that SAIL, Tata Steel, JSW Steel, Jindal Steel and Essar Steel are showing more than 40 percent inefficiency in very few years. This low level of efficiency results high level of investment and low market share. The growing returns to scale point out by our examination recommend that these companies have to increase their extent of business and vice-versa.

DEA approach review for all firms has a satisfactory efficiency level where CCR results varying from 0.15 to 1.00, while BCC efficiency results varying from 0.22 to 1.00. So we can recommends that the companies have to decrease their inputs cost for attaining the similar output level. Occasionally the average scale efficiency, CCR and BCC score of a variety of steel companies achieved 1.00, this point out that this companies are on most favourable efficiency level, while the other companies are remain incompetent, even though those companies average scale efficiency, CCR and BCC scores are near about to 1.00. The result shows that mainly big companies and their subordinate companies are functioning at a below the optimal efficiency level. As a result, essential mechanism has been applied to recover those companies functioning performance and effectiveness. This observed outcome from the table recommends that some development measures have to be taken for inefficient companies. The management must be improved by reducing short term funds and long term funds and focusing more on revenue creation i.e increase in gross profit and PBIT.

Empirical Findings and Implications

BCC DEA model used here to measures two types of efficiency one is technical and the other one is scale. For this purpose 8 steel companies are taken for 15 years with 3 sets of input & output variables. In first analysis, Gross sales and PBIT are taken as Output variables and Total interest expenses and total operating expenses are taken as input variables The CRS results shows that Bhushan steel, RINL and Bhushan power are coming out to be technically efficient in few years. . On the other hand, CRS technique can be converted into VRS technique if we lighten up the assumption, then technical efficiency is divided into technical and scale efficiency and as a result, SAIL, Tata Steel and Jindal steel came out to be technical efficient including the above 3 steel companies in so many years. This recommends that firms have to reduce their inputs cost, while maintaining the same level of output.

In second analysis, Gross sales and PBIT are taken as Output variables and total current liabilities and total debt are taken as input variables. The CRS result shows

that RINL and Bhushan power are coming out to be technically efficient in few years. On the other hand, CRS technique can be converted into VRS technique if we lighten up the assumption, then technical efficiency is divided into technical and scale efficiency and as a result, SAIL and Tata Steel came out to be technical efficient including the above 2 steel companies in few years. This recommends that if the firms can reduce its size of operation and also reduce their input costs or taken various cost cutting methods they can achieve scale efficiency.

In third analysis, Gross sales and PBIT are taken as Output variables and short term funds and long term funds are taken as input variables The CRS results shows that Bhushan steel, RINL and Bhushan power are coming out to be technically efficient in few years. On the other hand, CRS technique can be converted into VRS technique if we lighten up the assumption, then technical efficiency is divided into technical and scale efficiency and as a result, SAIL, Tata Steel and Jindal steel came out to be technical efficient including the above 3 steel companies in so many years. These companies alternatively have to either reduce their size of operations or apply cost cutting techniques and optimum fund utilisation methods to achieve scale efficiency.

Conclusion

DEA is a technique which was introduced for analysing the performance of selected firms. Here we have taken panel data of 8 companies which are listed as top steel companies in the market for performing empirical analysis. The outcome obtained from the DEA approach of this study demonstrates that during the testing period all firms attained an adequate overall level of efficiency but not in all years. This recommends that firms need to trim down their inputs cost for retaining the identical stage of production. From above findings we can conclude that the majority of big companies and small corresponding units of them are functioning at a suboptimum stage of efficiency. The result implies that DEA analysis can achieve scale efficiency either through decreasing its volume of function or have to minimised production cost and optimum fund utilisation methods. Consequently, for development of their operational performance and efficiency necessary measures have to be taken. The observed finding suggests that inefficient companies need improvement. The management must be improved by reducing total interest expenses, total operating expenses, total current liabilities and total debt and focusing more on revenue creation i.e increase in gross profit and PBIT. The analysis help us towards estimation of the target for evaluating and give explanation of the determinants of each firm's efficiency, which includes measuring the effect of economies of scale, this also involved a principally objective mathematical score. There have some shortcomings also, for this reason some additional research is required with other input and output variables. This study's results and recommendations can expectantly give benefit to the managements of inefficient companies. These findings also facilitate

them to restructure their managerial scope and business methods. They also get an idea about reconsider resource consumption in favour of getting better efficiency and enhancing performance.

Conflict of Interests

The authors declare that there are no conflict of interests that are directly or indirectly related to this research work.

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APPENDIX

Below Table-1 shows : Results for the steel companies using BCC DEA model. Here Gross sales and PBIT are taken as Output variables and short term funds and long term funds are taken as input variables.

VRS Frontier(-1:drs, 0:crs, 1:irs)

	CRS_TE	VRS_TE	NIRS_TE	SCALE	RTS
dmu:1	0.291973	0.565029	0.767792	0.516739	-1.000000
dmu:2	0.254851	0.294740	0.676173	0.864661	-1.000000
dmu:3	0.331461	0.522454	0.654384	0.634431	-1.000000
dmu:4	1.000000	1.000000	1.000000	1.000000	0.000000
dmu:5	0.159894	0.224708	1.000000	0.711561	-1.000000
dmu:6	0.436110	0.478513	0.852359	0.911387	-1.000000
dmu:7	0.564255	1.000000	0.824346	0.564255	1.000000
dmu:8	0.707205	0.707205	0.721167	1.000000	0.000000
dmu:1	0.341007	0.659625	0.774113	0.516970	-1.000000
dmu:2	0.362241	0.417940	0.678703	0.866731	-1.000000
dmu:3	0.319178	0.536040	0.553561	0.595437	-1.000000
dmu:4	0.788932	0.820107	0.835293	0.961986	-1.000000
dmu:5	0.159894	0.224708	1.000000	0.711561	-1.000000
dmu:6	0.556297	0.593801	0.900433	0.936841	-1.000000
dmu:7	0.594834	0.804924	0.597938	0.738994	1.000000
dmu:8	1.000000	1.000000	1.000000	1.000000	0.000000
dmu:1	0.362883	0.705198	0.718005	0.514583	-1.000000
dmu:2	0.614586	0.626767	0.911012	0.980565	1.000000
dmu:3	0.380581	0.650778	0.650778	0.584810	-1.000000
dmu:4	0.645381	0.680422	0.731386	0.948500	-1.000000
dmu:5	0.372662	0.443383	0.522422	0.840495	-1.000000
dmu:6	1.000000	1.000000	1.000000	1.000000	0.000000
dmu:7	0.538754	0.619098	0.721522	0.870224	1.000000
dmu:8	0.882456	0.889702	0.911952	0.991855	1.000000
dmu:1	0.494290	1.000000	1.000000	0.494290	-1.000000
dmu:2	0.607381	0.699077	0.713621	0.868833	1.000000
dmu:3	0.531628	0.964157	1.000000	0.551392	-1.000000
dmu:4	0.871518	0.945197	1.000000	0.922050	-1.000000
dmu:5	0.846456	0.890521	0.962555	0.950518	-1.000000
dmu:6	1.000000	1.000000	1.000000	1.000000	0.000000
dmu:7	0.689331	0.746071	0.916592	0.923949	1.000000
dmu:8	0.693345	0.748893	0.786940	0.925527	-1.000000
dmu:1	0.444198	0.842766	1.000000	0.527071	-1.000000
dmu:2	0.428953	0.583546	0.583546	0.735080	-1.000000
dmu:3	0.522577	0.955175	0.974175	0.547101	-1.000000
dmu:4	0.663690	0.741089	0.898347	0.895560	-1.000000
dmu:5	0.347338	0.524495	0.533107	0.662234	-1.000000
dmu:6	0.814962	0.918296	1.000000	0.887472	-1.000000
dmu:7	0.460934	0.469787	0.551422	0.981155	1.000000
dmu:8	0.475258	0.536952	0.602971	0.885104	-1.000000

dmu:1	0.533679	1.000000	1.000000	0.533679	-1.000000
dmu:2	0.548050	0.763811	0.763811	0.717520	-1.000000
dmu:3	0.497972	0.867902	0.871208	0.573765	-1.000000
dmu:4	0.612511	0.698158	0.863469	0.877325	-1.000000
dmu:5	0.323743	0.540475	0.548902	0.598996	-1.000000
dmu:6	0.606170	0.798418	0.828053	0.759214	-1.000000
dmu:7	0.467757	0.478226	0.550884	0.978108	1.000000
dmu:8	0.545372	0.615885	0.703819	0.885509	-1.000000
dmu:1	0.591571	1.000000	1.000000	0.591571	-1.000000
dmu:2	0.412428	0.692846	0.692846	0.595267	-1.000000
dmu:3	0.511935	0.855903	1.000000	0.598123	-1.000000
dmu:4	0.452004	0.524882	0.637184	0.861154	-1.000000
dmu:5	0.455014	0.749158	0.773978	0.607367	-1.000000
dmu:6	0.642351	1.000000	1.000000	0.642351	-1.000000
dmu:7	0.529945	0.623719	0.623719	0.849654	1.000000
dmu:8	0.639502	0.703424	0.777615	0.909126	-1.000000
dmu:1	0.400960	1.000000	1.000000	0.400960	-1.000000
dmu:2	0.263901	0.507205	0.538632	0.520304	-1.000000
dmu:3	0.442114	0.772171	0.772958	0.572560	-1.000000
dmu:4	0.371116	0.503121	0.543583	0.737628	-1.000000
dmu:5	0.581351	0.923666	1.000000	0.629396	-1.000000
dmu:6	0.415095	0.611772	0.712301	0.678512	-1.000000
dmu:7	0.339641	0.544601	0.544601	0.623652	-1.000000
dmu:8	0.525581	0.573540	0.667335	0.916380	-1.000000
dmu:1	0.344196	0.940001	1.000000	0.366166	-1.000000
dmu:2	0.336961	0.649590	0.649590	0.518729	-1.000000
dmu:3	0.504922	0.847949	0.847949	0.595462	-1.000000
dmu:4	0.495427	0.583273	0.586374	0.849391	-1.000000
dmu:5	0.287039	0.540604	0.605473	0.530960	-1.000000
dmu:6	0.395406	0.582243	1.000000	0.679108	-1.000000
dmu:7	0.264772	0.439903	0.439903	0.601887	1.000000
dmu:8	0.465360	0.501628	0.565033	0.927700	-1.000000
dmu:1	0.448749	0.963087	0.964056	0.465948	-1.000000
dmu:2	0.351582	0.691426	0.691426	0.508489	-1.000000
dmu:3	0.621424	1.000000	1.000000	0.621424	-1.000000
dmu:4	0.702205	0.769775	0.782222	0.912221	-1.000000
dmu:5	0.358905	0.669803	0.820079	0.535836	-1.000000
dmu:6	0.474432	0.683681	1.000000	0.693937	-1.000000
dmu:7	0.355215	0.561423	0.561423	0.632705	-1.000000
dmu:8	0.508837	0.545972	0.570415	0.931984	-1.000000
dmu:1	0.491783	1.000000	1.000000	0.491783	-1.000000
dmu:2	0.356821	0.722791	0.786379	0.493671	-1.000000
dmu:3	0.491759	1.000000	1.000000	0.491759	-1.000000
dmu:4	0.879219	1.000000	1.000000	0.879219	-1.000000
dmu:5	0.330859	0.669128	0.815368	0.494462	-1.000000
dmu:6	0.433073	0.749098	1.000000	0.578126	-1.000000
dmu:7	0.343281	0.616831	0.616831	0.556524	-1.000000

dmu:8	0.746119	0.782324	0.794479	0.953721	-1.000000
dmu:1	0.449369	0.970464	1.000000	0.463045	-1.000000
dmu:2	0.392818	0.801699	0.819933	0.489982	-1.000000
dmu:3	0.449220	0.912713	0.916189	0.492181	-1.000000
dmu:4	0.713334	0.937905	0.968398	0.760561	-1.000000
dmu:5	0.198319	0.417754	1.000000	0.474727	-1.000000
dmu:6	0.293353	0.539917	0.739748	0.543330	-1.000000
dmu:7	0.419207	0.751319	0.751319	0.557961	-1.000000
dmu:8	0.970939	1.000000	1.000000	0.970939	-1.000000
dmu:1	0.407224	1.000000	1.000000	0.407224	-1.000000
dmu:2	0.436622	0.960363	1.000000	0.454643	-1.000000
dmu:3	0.424961	1.000000	1.000000	0.424961	-1.000000
dmu:4	0.422609	0.670457	0.770012	0.630330	-1.000000
dmu:5	0.180197	0.378964	0.406953	0.475499	-1.000000
dmu:6	0.289568	0.533323	0.732776	0.542950	-1.000000
dmu:7	0.315578	0.596065	0.597790	0.529436	-1.000000
dmu:8	0.770225	0.960276	1.333333	0.802087	-1.000000
dmu:1	0.355599	0.976578	1.000000	0.364127	-1.000000
dmu:2	0.370707	0.987884	1.000000	0.375253	-1.000000
dmu:3	0.495416	1.000000	1.000000	0.495416	-1.000000
dmu:4	0.352245	0.636910	0.776381	0.553053	-1.000000
dmu:5	0.185841	0.413652	1.000000	0.449269	-1.000000
dmu:6	0.213445	0.397800	0.512896	0.536563	-1.000000
dmu:7	0.509683	0.878278	1.000000	0.580321	-1.000000
dmu:8	0.550354	0.793458	1.000000	0.693614	-1.000000
dmu:1	0.272501	0.838357	1.000000	0.325042	-1.000000
dmu:2	0.320226	0.783356	1.000000	0.408787	-1.000000
dmu:3	0.371188	0.871138	0.930283	0.426095	-1.000000
dmu:4	0.421547	0.746799	1.000000	0.564471	-1.000000
dmu:5	0.264675	0.490774	0.523396	0.539301	-1.000000
dmu:6	0.188711	0.358695	0.629144	0.526105	-1.000000
dmu:7	0.195990	0.401795	0.454364	0.487786	-1.000000
dmu:8	0.344674	0.564615	1.000000	0.610458	-1.000000

APPENDIX

Below Table-2 shows: Results for the steel companies using BCC DEA model. Here Gross sales and PBIT are taken as Output variables and Total current liabilities and total debt are taken as input variables.

VRS Frontier(-1:drs, 0:crs, 1:irs)

	CRS_TE	VRS_TE	NIRS_TE	SCALE	RTS
dmu:1	0.010588	0.318318	0.624765	0.033262	-1.000000
dmu:2	0.005689	0.043382	0.208785	0.131131	1.000000
dmu:3	0.022030	0.164792	0.509149	0.133683	-1.000000
dmu:4	0.018725	0.090625	0.252836	0.206616	1.000000

dmu:5	0.005039	0.053323	1.000000	0.094495	1.000000
dmu:6	0.020263	0.198241	0.715473	0.102212	1.000000
dmu:7	0.037725	0.085880	0.166125	0.439279	1.000000
dmu:8	0.037268	0.105051	0.530085	0.354758	1.000000
dmu:1	0.011026	0.390629	0.629550	0.028226	-1.000000
dmu:2	0.004958	0.058283	0.155797	0.085064	1.000000
dmu:3	0.036704	0.244664	0.521137	0.150018	-1.000000
dmu:4	0.014919	0.081575	0.204506	0.182883	1.000000
dmu:5	0.005039	0.053323	1.000000	0.094495	1.000000
dmu:6	0.048979	0.312790	0.587780	0.156589	1.000000
dmu:7	0.041918	0.117485	0.125340	0.356792	1.000000
dmu:8	0.054874	0.154400	0.847284	0.355403	1.000000
dmu:1	0.023605	0.503252	0.649070	0.046905	-1.000000
dmu:2	0.012357	0.093789	0.138744	0.131753	1.000000
dmu:3	0.063704	0.403836	0.461102	0.157748	-1.000000
dmu:4	0.015208	0.101614	0.232830	0.149666	1.000000
dmu:5	0.012677	0.087486	0.201342	0.144904	1.000000
dmu:6	1.000000	1.000000	1.000000	1.000000	0.000000
dmu:7	0.071149	0.187423	0.320727	0.379614	1.000000
dmu:8	1.000000	1.000000	1.000000	1.000000	0.000000
dmu:1	0.054964	0.854413	1.000000	0.064329	-1.000000
dmu:2	0.037932	0.229233	0.249045	0.165475	-1.000000
dmu:3	0.191818	0.936875	1.000000	0.204743	-1.000000
dmu:4	0.017514	0.136164	0.336701	0.128623	1.000000
dmu:5	0.021275	0.143971	0.232242	0.147771	-1.000000
dmu:6	0.098420	0.596082	0.622661	0.165111	-1.000000
dmu:7	0.065178	0.234106	0.267026	0.278412	1.000000
dmu:8	0.587192	1.000000	1.000000	0.587192	-1.000000
dmu:1	0.074579	0.704573	1.000000	0.105849	-1.000000
dmu:2	0.047756	0.293365	0.335662	0.162787	-1.000000
dmu:3	0.219802	1.000000	1.000000	0.219802	-1.000000
dmu:4	0.024899	0.142695	0.435853	0.174488	1.000000
dmu:5	0.016311	0.147848	0.235217	0.110326	-1.000000
dmu:6	0.093110	0.617463	0.727992	0.150795	-1.000000
dmu:7	0.038575	0.181662	0.195160	0.212346	1.000000
dmu:8	0.350733	1.000000	1.000000	0.350733	-1.000000
dmu:1	0.068367	0.851939	0.921227	0.080249	-1.000000
dmu:2	0.063885	0.392007	0.448500	0.162969	-1.000000
dmu:3	0.019080	0.555093	0.858701	0.034373	-1.000000
dmu:4	0.016267	0.106896	0.296260	0.152177	1.000000
dmu:5	0.017265	0.191277	0.306749	0.090263	-1.000000
dmu:6	0.044702	0.590195	0.631346	0.075741	-1.000000
dmu:7	0.020528	0.125941	0.137178	0.162999	1.000000
dmu:8	0.011637	0.076968	0.205466	0.151190	1.000000
dmu:1	0.149501	1.000000	1.000000	0.149501	-1.000000
dmu:2	0.024517	0.270753	0.270908	0.090552	-1.000000

dmu:3	0.014777	0.680463	1.000000	0.021717	-1.000000
dmu:4	0.009741	0.099800	0.185936	0.097609	1.000000
dmu:5	0.026438	0.256405	0.512710	0.103109	-1.000000
dmu:6	0.127973	1.000000	1.000000	0.127973	-1.000000
dmu:7	0.050497	0.273364	0.296072	0.184726	-1.000000
dmu:8	0.009022	0.083090	0.164150	0.108580	1.000000
dmu:1	0.034419	1.000000	1.000000	0.034419	-1.000000
dmu:2	0.018351	0.318285	0.533897	0.057655	-1.000000
dmu:3	0.010788	0.748311	1.000000	0.014416	-1.000000
dmu:4	0.008904	0.114890	0.176890	0.077498	1.000000
dmu:5	0.023482	0.271710	0.651070	0.086422	-1.000000
dmu:6	0.062764	0.892252	1.000000	0.070344	-1.000000
dmu:7	0.043585	0.267991	0.291425	0.162636	-1.000000
dmu:8	0.009515	0.102539	0.156574	0.092790	1.000000
dmu:1	0.016497	0.940207	1.000000	0.017546	-1.000000
dmu:2	0.032754	0.414998	0.523204	0.078926	-1.000000
dmu:3	0.015009	0.770313	0.955637	0.019484	-1.000000
dmu:4	0.008714	0.127014	0.127078	0.068608	-1.000000
dmu:5	0.008926	0.231443	0.312109	0.038565	-1.000000
dmu:6	0.049966	0.520845	0.784169	0.095933	-1.000000
dmu:7	0.022317	0.190957	0.235978	0.116871	-1.000000
dmu:8	0.004587	0.087599	0.095583	0.052362	1.000000
dmu:1	0.015564	0.956100	1.000000	0.016278	-1.000000
dmu:2	0.017768	0.512411	0.535231	0.034675	-1.000000
dmu:3	0.023133	0.977067	1.000000	0.023676	-1.000000
dmu:4	0.004239	0.162333	0.168007	0.026112	-1.000000
dmu:5	0.008818	0.267764	0.356796	0.032931	-1.000000
dmu:6	0.061043	0.649648	1.000000	0.093963	-1.000000
dmu:7	0.006097	0.275233	1.000000	0.022152	-1.000000
dmu:8	0.004213	0.104205	0.104246	0.040430	1.000000
dmu:1	0.027986	1.000000	1.000000	0.027986	-1.000000
dmu:2	0.017652	0.680433	0.707207	0.025942	-1.000000
dmu:3	0.038597	1.000000	1.000000	0.038597	-1.000000
dmu:4	0.004532	0.227242	0.239341	0.019941	-1.000000
dmu:5	0.011060	0.349769	0.458055	0.031619	-1.000000
dmu:6	0.033911	0.874946	1.000000	0.038758	-1.000000
dmu:7	0.006660	0.315542	0.385177	0.021106	-1.000000
dmu:8	0.004211	0.151700	0.154725	0.027756	-1.000000
dmu:1	0.015997	0.958634	0.972657	0.016688	-1.000000
dmu:2	0.015985	0.756023	0.756400	0.021143	-1.000000
dmu:3	0.021274	0.896412	1.000000	0.023732	-1.000000
dmu:4	0.004727	0.245606	0.266280	0.019248	-1.000000
dmu:5	0.018025	0.341916	1.000000	0.052717	-1.000000

dmu:6	0.022131	0.393686	0.826511	0.056214	-1.000000
dmu:7	0.005664	0.345893	1.000000	0.016375	-1.000000
dmu:8	0.005135	0.196856	0.201888	0.026086	-1.000000
dmu:1	0.014671	1.000000	1.000000	0.014671	-1.000000
dmu:2	0.016630	0.950550	0.980276	0.017495	-1.000000
dmu:3	0.077144	1.000000	1.000000	0.077144	-1.000000
dmu:4	0.003532	0.213419	0.246080	0.016548	-1.000000
dmu:5	0.027678	0.308961	1.000000	0.089585	-1.000000
dmu:6	0.021439	0.389546	0.819494	0.055036	-1.000000
dmu:7	0.006931	0.333900	0.346157	0.020758	-1.000000
dmu:8	0.004943	0.234552	0.247734	0.021075	-1.000000
dmu:1	0.015169	0.979517	0.996690	0.015487	-1.000000
dmu:2	0.016949	0.987884	1.000000	0.017157	-1.000000
dmu:3	0.066603	0.990617	1.000000	0.067234	-1.000000
dmu:4	0.004095	0.227737	0.252971	0.017980	-1.000000
dmu:5	0.019266	0.414449	0.475984	0.046486	-1.000000
dmu:6	0.006456	0.316359	1.000000	0.020408	-1.000000
dmu:7	0.006865	0.285833	0.293137	0.024018	-1.000000
dmu:8	0.010315	0.211446	0.290116	0.048785	-1.000000
dmu:1	0.012687	0.839848	1.000000	0.015106	-1.000000
dmu:2	0.015836	0.791995	1.000000	0.019996	-1.000000
dmu:3	0.042845	0.887266	0.954667	0.048289	-1.000000
dmu:4	0.004256	0.252533	1.000000	0.016853	-1.000000
dmu:5	0.013897	0.216939	0.383602	0.064061	-1.000000
dmu:6	0.006601	0.214181	1.000000	0.030818	-1.000000
dmu:7	0.006566	0.270915	0.288707	0.024238	-1.000000
dmu:8	0.006980	0.173888	1.000000	0.040143	-1.000000

APPENDIX

Below Table-3 shows: Results for the steel companies using BCC DEA model. Here Gross sales and PBIT are taken as Total Interest Expences and Total Operating Expenditure and Total current liabilities and total debt are taken as input variables.

VRS Frontier(-1:drs, 0:crs, 1:irs)

	CRS_TE	VRS_TE	NIRS_TE	SCALE	RTS
dmu:1	0.291973	0.565029	0.767792	0.516739	-1.000000
dmu:2	0.254851	0.294740	0.676173	0.864661	-1.000000
dmu:3	0.331461	0.522454	0.654384	0.634431	-1.000000
dmu:4	1.000000	1.000000	1.000000	1.000000	0.000000

dmu:5	0.159894	0.224708	1.000000	0.711561	-1.000000
dmu:6	0.436110	0.478513	0.852359	0.911387	-1.000000
dmu:7	0.564255	1.000000	0.824346	0.564255	1.000000
dmu:8	0.707205	0.707205	0.721167	1.000000	0.000000
dmu:1	0.341007	0.659625	0.774113	0.516970	-1.000000
dmu:2	0.362241	0.417940	0.678703	0.866731	-1.000000
dmu:3	0.319178	0.536040	0.553561	0.595437	-1.000000
dmu:4	0.788932	0.820107	0.835293	0.961986	-1.000000
dmu:5	0.159894	0.224708	1.000000	0.711561	-1.000000
dmu:6	0.556297	0.593801	0.900433	0.936841	-1.000000
dmu:7	0.594834	0.804924	0.597938	0.738994	1.000000
dmu:8	1.000000	1.000000	1.000000	1.000000	0.000000
dmu:1	0.362883	0.705198	0.718005	0.514583	-1.000000
dmu:2	0.614586	0.626767	0.911012	0.980565	1.000000
dmu:3	0.380581	0.650778	0.650778	0.584810	-1.000000
dmu:4	0.645381	0.680422	0.731386	0.948500	-1.000000
dmu:5	0.372662	0.443383	0.522422	0.840495	-1.000000
dmu:6	1.000000	1.000000	1.000000	1.000000	0.000000
dmu:7	0.538754	0.619098	0.721522	0.870224	1.000000
dmu:8	0.882456	0.889702	0.911952	0.991855	1.000000
dmu:1	0.494290	1.000000	1.000000	0.494290	-1.000000
dmu:2	0.607381	0.699077	0.713621	0.868833	1.000000
dmu:3	0.531628	0.964157	1.000000	0.551392	-1.000000
dmu:4	0.871518	0.945197	1.000000	0.922050	-1.000000
dmu:5	0.846456	0.890521	0.962555	0.950518	-1.000000
dmu:6	1.000000	1.000000	1.000000	1.000000	0.000000
dmu:7	0.689331	0.746071	0.916592	0.923949	1.000000
dmu:8	0.693345	0.748893	0.786940	0.925827	-1.000000
dmu:1	0.444198	0.842766	1.000000	0.527071	-1.000000
dmu:2	0.428953	0.583546	0.583546	0.735080	-1.000000
dmu:3	0.522577	0.955175	0.974175	0.547101	-1.000000
dmu:4	0.663690	0.741089	0.898347	0.895560	-1.000000
dmu:5	0.347338	0.524495	0.533107	0.662234	-1.000000
dmu:6	0.814962	0.918296	1.000000	0.887472	-1.000000
dmu:7	0.460934	0.469787	0.551422	0.981155	1.000000
dmu:8	0.475258	0.536952	0.602971	0.885104	-1.000000
dmu:1	0.533679	1.000000	1.000000	0.533679	-1.000000
dmu:2	0.548050	0.763811	0.763811	0.717520	-1.000000
dmu:3	0.497972	0.867902	0.871208	0.573765	-1.000000
dmu:4	0.612511	0.698158	0.863469	0.877325	-1.000000
dmu:5	0.323743	0.540475	0.548902	0.598996	-1.000000
dmu:6	0.606170	0.798418	0.828053	0.759214	-1.000000

dmu:7	0.467757	0.478226	0.550884	0.978108	1.000000
dmu:8	0.545372	0.615885	0.703819	0.885509	-1.000000
dmu:1	0.591571	1.000000	1.000000	0.591571	-1.000000
dmu:2	0.412428	0.692846	0.692846	0.595267	-1.000000
dmu:3	0.511935	0.855903	1.000000	0.598123	-1.000000
dmu:4	0.452004	0.524882	0.637184	0.861154	-1.000000
dmu:5	0.455014	0.749158	0.773978	0.607367	-1.000000
dmu:6	0.642351	1.000000	1.000000	0.642351	-1.000000
dmu:7	0.529945	0.623719	0.623719	0.849654	1.000000
dmu:8	0.639502	0.703424	0.777615	0.909126	-1.000000
dmu:1	0.400960	1.000000	1.000000	0.400960	-1.000000
dmu:2	0.263901	0.507205	0.538632	0.520304	-1.000000
dmu:3	0.442114	0.772171	0.772958	0.572560	-1.000000
dmu:4	0.371116	0.503121	0.543583	0.737628	-1.000000
dmu:5	0.581351	0.923666	1.000000	0.629396	-1.000000
dmu:6	0.415095	0.611772	0.712301	0.678512	-1.000000
dmu:7	0.339641	0.544601	0.544601	0.623652	-1.000000
dmu:8	0.525581	0.573540	0.667335	0.916380	-1.000000
dmu:1	0.344196	0.940001	1.000000	0.366166	-1.000000
dmu:2	0.336961	0.649590	0.649590	0.518729	-1.000000
dmu:3	0.504922	0.847949	0.847949	0.595462	-1.000000
dmu:4	0.495427	0.583273	0.586374	0.849391	-1.000000
dmu:5	0.287039	0.540604	0.605473	0.530960	-1.000000
dmu:6	0.395406	0.582243	1.000000	0.679108	-1.000000
dmu:7	0.264772	0.439903	0.439903	0.601887	1.000000
dmu:8	0.465360	0.501628	0.565033	0.927700	-1.000000
dmu:1	0.448749	0.963087	0.964056	0.465948	-1.000000
dmu:2	0.351582	0.691426	0.691426	0.508489	-1.000000
dmu:3	0.621424	1.000000	1.000000	0.621424	-1.000000
dmu:4	0.702205	0.769775	0.782222	0.912221	-1.000000
dmu:5	0.358905	0.669803	0.820079	0.535836	-1.000000
dmu:6	0.474432	0.683681	1.000000	0.693937	-1.000000
dmu:7	0.355215	0.561423	0.561423	0.632705	-1.000000
dmu:8	0.508837	0.545972	0.570415	0.931984	-1.000000
dmu:1	0.491783	1.000000	1.000000	0.491783	-1.000000
dmu:2	0.356821	0.722791	0.786379	0.493671	-1.000000
dmu:3	0.491759	1.000000	1.000000	0.491759	-1.000000
dmu:4	0.879219	1.000000	1.000000	0.879219	-1.000000
dmu:5	0.330859	0.669128	0.815368	0.494462	-1.000000
dmu:6	0.433073	0.749098	1.000000	0.578126	-1.000000

dmu:7	0.343281	0.616831	0.616831	0.556524	-1.000000
dmu:8	0.746119	0.782324	0.794479	0.953721	-1.000000
dmu:1	0.449369	0.970464	1.000000	0.463045	-1.000000
dmu:2	0.392818	0.801699	0.819933	0.489982	-1.000000
dmu:3	0.449220	0.912713	0.916189	0.492181	-1.000000
dmu:4	0.713334	0.937905	0.968398	0.760561	-1.000000
dmu:5	0.198319	0.417754	1.000000	0.474727	-1.000000
dmu:6	0.293353	0.539917	0.739748	0.543330	-1.000000
dmu:7	0.419207	0.751319	0.751319	0.557961	-1.000000
dmu:8	0.970939	1.000000	1.000000	0.970939	-1.000000
dmu:1	0.407224	1.000000	1.000000	0.407224	-1.000000
dmu:2	0.436622	0.960363	1.000000	0.454643	-1.000000
dmu:3	0.424961	1.000000	1.000000	0.424961	-1.000000
dmu:4	0.422609	0.670457	0.770012	0.630330	-1.000000
dmu:5	0.180197	0.378964	0.406953	0.475499	-1.000000
dmu:6	0.289568	0.533323	0.732776	0.542950	-1.000000
dmu:7	0.315578	0.596065	0.597790	0.529436	-1.000000
dmu:8	0.770225	0.960276	1.333333	0.802087	-1.000000
dmu:1	0.355599	0.976578	1.000000	0.364127	-1.000000
dmu:2	0.370707	0.987884	1.000000	0.375253	-1.000000
dmu:3	0.495416	1.000000	1.000000	0.495416	-1.000000
dmu:4	0.352245	0.636910	0.776381	0.553053	-1.000000
dmu:5	0.185841	0.413652	1.000000	0.449269	-1.000000
dmu:6	0.213445	0.397800	0.512896	0.536563	-1.000000
dmu:7	0.509683	0.878278	1.000000	0.580321	-1.000000
dmu:8	0.550354	0.793458	1.000000	0.693614	-1.000000
dmu:1	0.272501	0.838357	1.000000	0.325042	-1.000000
dmu:2	0.320226	0.783356	1.000000	0.408787	-1.000000
dmu:3	0.371188	0.871138	0.930283	0.426095	-1.000000
dmu:4	0.421547	0.746799	1.000000	0.564471	-1.000000
dmu:5	0.264675	0.490774	0.523396	0.539301	-1.000000
dmu:6	0.188711	0.358695	0.629144	0.526105	-1.000000
dmu:7	0.195990	0.401795	0.454364	0.487786	-1.000000
dmu:8	0.344674	0.564615	1.000000	0.610458	-1.000000

VRS Frontier: