Study of Principal Operational Performance Indicators of Various Indian Ports for Imported Steam Coal

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Abstract

India be ing t he largest importer of s team a nd it a ccounts f or 54% of t hermal energy i n the c ountry. The limitations of domestic production and supply have seen tremendous increase in imports of steam coal from Indonesia, South Africa and Australia. Understanding various bottlenecks and high costs which are incurring due t o p ort c ongestion, p oor i nfrastructure a nd po or por t pe rformance, t here w as a ne ed t o study por t performance indicators for st eam co al. F rom t he literature survey, t hough number o f studies w ere made to measure port performance indicators in general, but no specific research was made scientifically for specific bulk car goes like s team co al. Therefore e ight p ort performance i ndicators w ere t aken b ased o n U NCTAD guidelines and eleven east coast ports of India which handle steam coal were considered for study.

The data for of these port performance indicators was collected and Principal Component Analysis was done to reduce the eight variables.

From the research study it was found that port draft and berthing time efficiency played major role to reduce berthing time efficiency and ocean freight costs.

Keywords: port performance indicators, Coal and IFSPA

1. Introduction

In India the power sector has installed capacity of 1,73,26 Megawatts as of as March, 2011 as per Ministry of coal (Report of working of Coal and Lignite, 2006). Out this the thermal power's share is 64% of the total installed capacity. The coal fired thermal plants contribute to 54% of India's electricity capacity. The hydro power accounts for 22 % and na tural g as for 10 %. The s hare o f n uclear is 2.8 % a nd that of r enewable i s 10.6%.

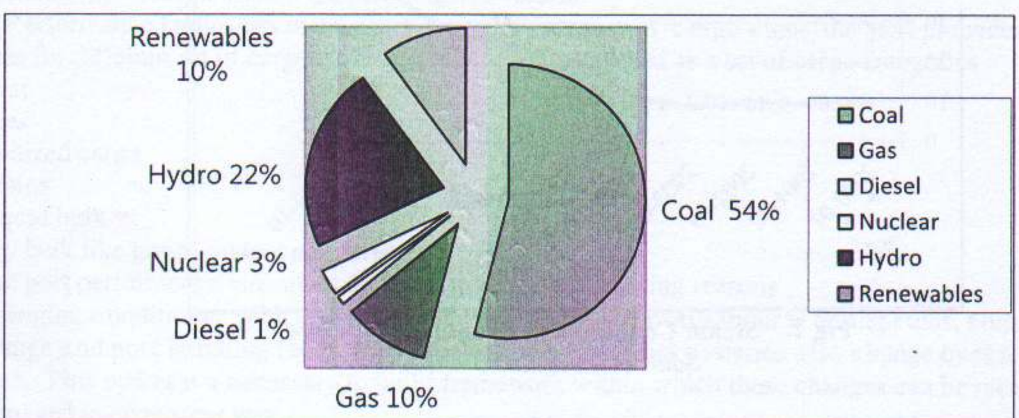


Fig 1. India's Power Sources
Source: Planning Commission

The above percentages do undergo a change when it is transformed in terms of energy generation for Hydro and renewable. Keeping in view the capacity factor which is less for Hydro power and renewable energy in the share in electricity generation would be 14% and 2.4% respectively. This clearly shows India is very much dependent on Coal fired thermal Power for its future requirement.

The Ministry of Shipping as stated (report of working group for Port sector for the 12th five year plan, 2011) that at the end of 12th five year plan India would import 336 million tonnes of steam Coal which would account for 25% of its total requirement which would be 842 million tonnes.

To calculate the productivity at ports as stated by UNCTAD (port performance indicators, 1976) there are various reasons to calculate various Port performance indicators. The UNCTAD has brought forward the need to calculate two kinds of Port Performance Indicators

1. Financial port performance Indicators
2. Operational Port Performance Indicators.

1.1 Need for study

India over period of time is increasingly depending on imported steam coal for its power requirements. Keeping in view the increasing demand and prices of steam coal for its thermal power requirements, it is high time it brings down the costs of handling and shipping at various Indian ports. Due to the high costs of handling, there would be great impact on trade in regard to increase in inflation due to high costs of fuel. In the 12th five year plan [4] the ministry of shipping has envisaged the need for investment for increasing port infrastructure in Indian Ports. Hence there is need to identify key areas where the coal ports and berths need the investment for better infrastructure and identify bottlenecks that lead to congestion, thereby high costs.
The Indian Power consumers mainly consist of agricultural sector and domestic sector which account for 21% and 25% in the year 2008-09 as per Planning commission (Annual report on working state power utilities and electricity departments, 2011). Thus cutting down costs of steam coal handling would lead lower power tariffs and thus farmers and consumers would benefit at the end.

2. Review of Research Work

There has been tremendous increase in India's steam coal imports as per figures from www.indiastat.com. From Figure 2 the steam coal imports have steadily risen from 12.03 million tons in 2004-05 to 44.28 million tons in 2009-10. This trend brings forth the need of imported steam coal for India power Sector.

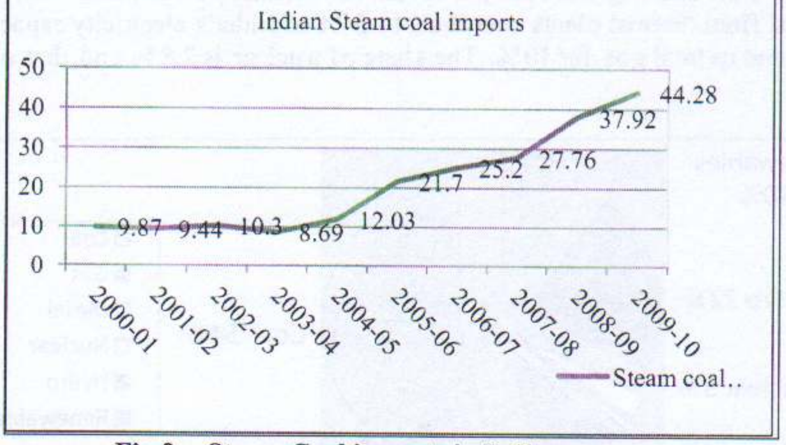


Fig 2. Steam Coal imports in India
Source: Indiastat.com

The import of steam coal has been increasing due to rapid growth in power sector and the inferior quality of domestic coal. Also the Power plant operators in coastal regions of southern Indian and western India preferred imported coal due to rail transportation challenges faced due to congested rail network. Also the coal imported has higher GCV of around 4,750 to 6800 Kcal/Kg compared to Domestic coal with GCV at around 3,755Kcal/Kg.

In the report by Ministry of Shipping (Report of working group for Port sector, 2011) Steam Coal demand was assessed as shown below:

Table 1. Future Coal Demand and Coal availability scenario in Million tonnes

	2012-13	2013-14	2014-15	2015-16	2016-17
Steam Coal requirement	515	572	650	737	842
Indigenous Coal supply	416	436	471	521	550
Coal to be imported by Thermal power station designed on imported coal	32	40	47	49	50
Shortage	67	96	132	167	242
Coal to be imported for Thermal power stations designed on indigenous coal	45	64	88	111	161

From the above table at the end of twelfth five year plan the Thermal power stations designed on Indigenous coal would be importing 161 million tonnes and Thermal power stations designed on imported steam coal would be importing 50 million tonnes. Thus the total Imports of Steam coal would be 211 million tonnes.

Thus at the end of 12th five year plan, 25% of the Coal demand would be met by imports. These imports would be routed through various existing Indian ports along east and west coast of India.

2.1 Research Work Examined

As discussed by UNCTAD (Port Performance Indicators, 1976), the Port performance Indicators have been brought forward and the following guidelines and importance of Port performance indicators were discussed.

There are various reasons for a need to calculate performance Indicators:

1. The Data can be used for improving port performance.
2. These can provide an appropriate basis for future.
3. Port performance Indicators are measures of various aspects of Port's operation. To fulfil the purpose, these indicators are easy to calculate and simplified to understand. They provide insight to the management of port in the operation of key areas. These can be used to compare the performance with a benchmark and also to observe trend in performance levels. These indicators can also be used for negotiations on port congestion surcharges, port development, port tariff considerations and port development.
4. The key purpose for collecting information to maintain performance indicators is to provide an ideal management information system for planning and control.
5. These Performance Indicators must exist for each category of cargo since the port provides different facilities for different set of cargoes. The following are suggested as a set of cargo categories
   a. Coal
   b. Ores
   c. Unitized cargo
   d. Grains
   e. Liquid bulk
   f. Dry bulk like grain, cement and fertilizers
6. The port performance indicators are attractive due to following reasons
   a. Changing conditions: With the development of trade the port labour working rules, shipping lines change and port handling technology changes. The priorities assigned also change over a period of time. This makes it a necessary to build framework within which these changes can be measured and managed in consistent way.
   b. Scarcity of management personnel: In developing countries the scarcity of trained and qualified middle management is a common feature. By developing the performance standards, by establishment

of reporting systems and standardising of methods for collection and analysis of information can minimize the problems created by this deficiency.

   c. Scarcity of capital resources: Port development is one among many strategic investments in a developing country. There is an opportunity cost involved in capital invested as it is obtained at the expense of other areas. In order o justify investments in these areas need justification. These performance indicators necessitate adequate information for development of long range plans.

7. Control of an operation is possible only if there is a feedback of performance. Feedback involves the measuring of an actual output and comparing it with desired output to determine what course of action to take.
8. Control is the compliment of planning and neither element is useful without the other. The main step in control is the measurement of of deviation from goals and standards that have been set during the planning activity. Thus the selection and the maintenance of Indicators is a necessary step for ports to obtain effective control. A set of indicators will allow management to make improvised utilization of resources by highlighting problem areas and thereby improve service to port users and reduce unit costs. There would be additional benefits which could be derived from the proper use of indicators
   a. Highlighting the start and the cause of a congestion period.
   b. The negotiation of a reduction in a port congestion surcharge as a result of monitoring and documenting port performance.
   c. The timely adjustment of port tariffs.
   d. The provision of a sound information base for port planning and justification for capital development.

Performance indicators were classified as:
1. Financial Port Performance Indicators.
2. Operational Port Performance Indicators.

The Financial Port Performance Indicators would deal with revenues generated from its operations and services.

Various Financial Indicators to be calculated are:
1. Total Tonnage worked
2. Berth occupancy Revenue per ton of cargo.
3. Cargo handling revenue per tonne of cargo.
4. Labour expenditure per ton of cargo
5. Capital equipment expenditure per ton of cargo.
6. Total contribution
7. Contribution per tonne of cargo.
8. Revenue produced from a service.
9. Cost of the service.

The report by I-maritime research and consulting division (India Port report, 2003), has brought forward need for ports, has discussed about berth occupancy, waiting time, service time, seasonal variations, cost considerations for every port investment and port planning. Special focus has been given for bulk cargoes like ores, coal, bauxite, phosphates, fertilizers and grains. The characteristics of these terminals, handling equipment performance specifications, types of various ship unloading equipments, storage of these bulk cargo and standby facilities have been discussed.

Geoffrey Poitras, Jose Tongzon and Hongyu Li have made study to make international comparisons of port efficiency. They have stated that available studies have not provided sufficient answer for calculating comparative port efficiency. They have used Data Envelopment Analysis and have ranked five Australian and Eighteen international container ports. They found this analysis easy as the calculations were nonparametric and do not require knowledge of prior weights for inputs and outputs.

The relative efficiency of container ports was done in South Korea by Hokey Min. The author has proposed a Hybrid Data Envelopment Analysis model by using real examples of major container terminals in South

Korea. The data analysis and TFP approach was done to measure the efficiency of Chinese container terminals by Bing-Lian Liu, Wai-Lin-Liu and Cheng-Ping Cheng.

There were studies in regard to scenario analysis for supply chain integration in container by Jasmine Siu lee lam and Eddy Van de Voorde. The authors have conducted their research for Indian Shipping scenario for container shipping.

Sushila Muniswamy and Gurcharan Singh did Data Envelopment Analysis to bench mark and evaluate the operating performance of 69 major Asian container ports and generate efficiency ranking. A regression model for vessel turnaround time for container vessels was calculated by Kasyapi Mokhtar and Dr. Muhhannad Zaly Shah (2006). Two ports in Port Kelang- West port and East port, data was collected to show that vessel turnaround time is highly correlated with crane allocation.

Studies with regard to logistics and supply chain management approach, to port performance measurement was discussed by Khalid Bichou and Richard Gray (2004). This approach could be beneficial to port efficiency by directing port strategy towards relevant value added logistics services.

The functional analysis of Port Performance as strategic tool for strengthening port's competitive and economics model was brought forward by Diego Teurelincx, (2000). The methodology discussed was to provide an efficient tool for analysis of functional strengths and weaknesses in ports. The traffic analysis and bottleneck assessment stages were discussed.

The sensitive performance measures in container port were identified by Jie Wu, Hongyan and John liu (2010). The results indicate that the number of berths and capital deployed are the most sensitive measures impacting performance of container ports. The analysis also reveals that container ports located in different continents behave differently.

A study on efficiency of iron ore and coal ports using Data envelopment analysis method was made by Gabriel figueiredo, De Oliveira and Pierre Cariou (2011). The paper shows that main source of inefficiency in bulk terminals is related to scale. The authors recommend that national efficiency can be achieved either through a limited number of large ports or by combining smaller ports with complimentary characteristics.

A great deal of significant studies were made in measuring port efficiency as a determinant of Maritime cost by Ricardo J. Sanchez, Jan Hoffman, Alejandro Micco, Georgina V. Pizzilitto, Martin Sgut and Wilmsmier (2003). The authors have calculated operational performance indicators for nine Latin American Countries and have done Principal Component Analysis. The conclusions are relevant for the policy makers which show that port performance indicators are relevant for determining port's competitiveness. The authors could collect data only containerized cargo and could not collect for bulk cargoes.

UNCTAD (Port development, 1985) has brought forward on ways of measuring and valuating port performance and Productivity. The author has detailed the process and guidelines for calculating various possible Performance Indicators at various ports and various categories of cargo.

The importance of Operational Performance indicators and Asset performance indicators were brought forward by Kek Choo Chung. The author has identified and defined various operational performance indicators, their importance and need.

One of the most significant contributions to the research studies for Indian port sector made by Prabir De (2009). The author has made studies related to port performance indicators and labour endowment in determining port traffic. Also has detailed about port productivity growth in Indian ports with their significance in globalization scenario. The author also has made studies related to technological change in terms of its power and ability to improve the productivity of labour at port in Indian Scenario. Also there has been an attempt to measure the concentration and competition in Indian port sector which would be beneficial for national economies, consumers and exporting/importing industries.

2.2 *Research gap*

We understand that India would importing 211 million tons at the end of 12th five year plan. Ports and Port infrastructure are of major concern for these imports due to high costs incurred. From the above literature survey we can find there is a huge research gap in regard to port and shipping studies. The Port Performance Indicators were calculated as a whole for all the commodities together but research work in regard to particular class of commodity like coal was not present. Also a lot of studies were done in regard to containers for which the data was easily accessible and the authors Richardo J. Sanchez, Jan Hoffman, Alejandro Micco and Georgina V. Pizzilitto, Martin Sgut, and Gordon Wilmsmier (2003), have mentioned the scope for studies in bulk cargoes like coal and iron ore.

The report by Ministry of Shipping (2011) have discussed some Port Performance Indicators in regard to Major ports without taking cargo class in to consideration. The authors have also brought forward absence of appropriate performance Indicators for bulk cargoes like iron ore, coal and fertilizers. Hence there is need for study in Port Performance Indicators for imported steam coal.

3. Objectives of the study

3.1 *To study principal Operational Port Performance Indicators for coal handling along east coast of India*

The primary data was collected for one year from April 2010 till March 2011. The ship file and productivity file records maintained by port authority for all import shipments along east coast ports were collected and operational Performance Indicators were calculated. The operational performance Indicators as suggested by UNCTAD (1976) were taken into consideration. The Operational Port Performance Indicators considered were shown below:

S no	Operational performance Indicator	Description	Units
1	Waiting time	The time a ship has to wait at anchorage before getting entry into berth	Hours/ship
2	Pilotage time	The time taken from to move the vessel from anchorage till berthing of ship at port	Hours/ship
3	Service Time	The total time the ship has spent at the berth.	Hours/ship
4	Tons per ship hour at berth	The total tonnage handled towards ship berthing time.	Tonnes/hour
5	Effective working time at berth	The time effectively used for discharging of cargo at port	days
6	Average tonnage per ship	The average cargo carried by the ships at the port	Tonnes/ship
7	Average draft per ship	The vertical length of ship immersed in the water	meters
8	Ships arrival rate	The number ships arriving over a period of time	Ships/month

The performance indicators in regard to labour were not considered keeping in view that the focus was on to improve port infrastructure. All ports are not guided by any uniform labour laws and these indicators were not required for our objectives.

All the handling equipment, port location, port infrastructure, weather conditions and port topography was considered to be same for study. Factors related to environmental pollution and labour issues were not taken into consideration. All the time calculations other than documentation delays by the importer were considered to be in Port account.

4. Research design

4.1 *Data collection*

The Port Authority personnel and Shipping surveyors were requested to share their documents related to shipments. The Ship file and ship Data card documents were accessed and various operational performance indicators were calculated for each shipment. This method was obtained to gather accurate information from the facts recorded for every vessel which arrives to the port.

4.2 *Sampling Frame*

For the second objective the primary data was collected from all eleven ports which were handling steam coal along the East Coast of India were considered for study. The ship data card and ship files for all shipments pertaining to steam coal shipments from April 2010 till March 2011 were obtained. The average values of the Operational Port performance Indicators were calculated Port wise.

4.3 *Tools for Analysis*

The main idea of research was to form, from an existing set of Operational Performance Indicators a new set of reduced Indicators which would contain as much variability of the original data as possible. This could reduce the data which would be easy to handle and use it for further decision making purpose. For this Principal Component Analysis (PCA) was selected. SPSS version 19 software was used for analysis.

4.4 *Analysis of Operational Port performance Indicators*

The objective of the study was to find the principal Operational Port Performance Indicators for steam coal handling and shipping operations. Average values of eight operational Performance Indicators for eleven ports were calculated. The purpose was to form, from the existing set of Performance Indicators a new set of Indicators which are few in number as possible that contain as much variability of the original data as possible. These new Indicators would represent some sort of index of certain property that is measured by the original Indicators. For this the Principal Component Analysis was chosen.

4.5 *Principal Component Analysis*

Values of Eight Port Performance Indicators were calculated for eleven ports as per Table 2 below.

Table 2. Values of Port Performance Indicators

Port	Waiting time in days	Pilotage time in Hours	Service time in days	Tonnes per ship at berth in tonnes/ hour	Effective working time at berth in days	Average tonnage in '000 tonnes /ship	Average draft per ship in metres	Ships arrival rate in ships/ month
Haldia	5.95	7.80	2.77	395	2.21	20.30	9.15	4.33
Paradip	18.15	6.60	5.18	470	3.65	43.70	12.35	3.25
Gangavaram	0.60	5.20	2.85	1288	2.64	81.60	13.60	4.92
Vishakapatnam	4.22	6.30	6.25	485	4.31	45.40	12.18	4.75
Kakinada	6.30	7.50	3.83	605	3.10	44.30	10.60	4.25
Krishnapatnam	2.08	5.75	3.45	810	3.13	59.50	12.70	6.91
Ennore	0	4.95	3.41	760	3.08	54.90	12.40	2.30
Chennai	1.68	6.85	4.35	560	3.75	47.60	11.30	7.91
Karaikal	0	5.50	2.43	840	2.06	53.70	11.20	4.83
Chidambaranar	1.75	7.60	5.73	425	5.05	48.70	11.60	6.25
Cochin	0.90	9.60	1.87	445	1.34	20.00	8.30	0.16

Here the total variance of the data is considered for the analysis. The data was collected from all the ports along the east coast. Since the data was collected from the entire population was collected there is no need to test any hypothesis. The values of Kaiser-Meyer-Olkin and Barlett's Test of Spericity were just calculated. The values were found to be Kaiser-Meyer-Olkin, Value= 0.595.

Barlett's test of Spericity
Approximate Chi-Square = 86.194
Df =28
Sg =0.000

To number of factors here were determined based on E igen v alues. In this approach, only Performance Indicators (factors) with eigen values greater than 1.0 were retained. The other indicators (factors) were not included in the model. An eigen value represents the amount of variance associated with factor. Performance Indicators (factors) less than 1.0 a re no longer better a single variable, because, due to standardization, each variable has a variance of 1.0.

Table. 3 Extraction of Components

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.786	47.326	47.326	3.786	47.326	47.326	3.698	46.220	46.220
2	2.571	32.138	79.464	2.571	32.138	79.464	2.660	33.244	79.464
3	.964	12.046	91.510						
4	.415	5.184	96.695						
5	.216	2.704	99.399						
6	.029	.361	99.760						
7	.014	.176	99.937						
8	.005	.063	100.000						

Fig 3. Screen Plot for the Principal component Analysis

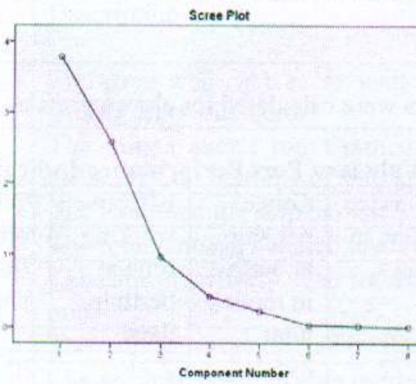


Table 4. Extraction Method: Principal Component Analysis

Component Matrix

	Component	
	1	2
average draft per ship	.961	.082
average tonnage per ship	.944	-.261
pilotage time	-.872	.217
ships arrival rate	.602	.298
service time	.349	.910
effective working time at berth	.495	.817
tonnes per ship hour at berth	.685	-.693
waiting time	-.112	.621

2 components extracted

The PCA analysis reduced the eight variables into two components were extracted taking Eigen values greater than 1. The two components account for 79% of the total variance. Using the varimax rotation, an orthogonal rotation of the factor tends to maximize the variance of squared factor loadings of a factor on all variables. Thus it minimizes the number of factors, which have large factor loadings on the given factor.

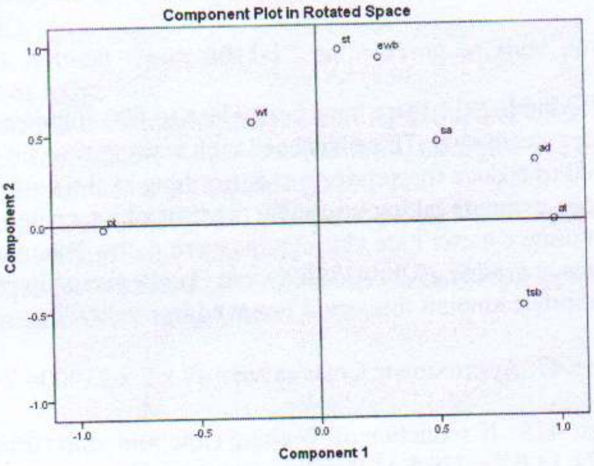
Table 5. Rotation Method: Varimax with Kaiser Normalization.

Rotated Component Matrix[a]

	Component	
	1	2
average tonnage per ship	**.979**	.003
average draft per ship	**.903**	.338
pilotage time	-.898	-.026
tonnes per ship hour at berth	.846	-.482
ships arrival rate	.499	.449
service time	.090	**.970**
effective working time at berth	.257	**.920**
waiting time	-.276	.568

[a] Rotation converged in 3 iterations.

Fig 4. Component Plot in Rotated Space



From the rotated component matrix two components extracted are:

Component 1 Ship draft Index	Average tonnage per ship (0.979) Average Draft per ship (0.903)
Component 2 Berthing time Efficiency	Service Time (0.970) Effective working time at Berth (0.920)

5. Conclusions and Recommendations

From the Principal component analysis, we arrive at two components:

1. Ship draft Index
2. Berthing time efficiency.

The two were the major components identified from statistical analysis. By improving the draft,

1. The size of vessel can be increased.
2. Parcel sizes could be larger thereby less number ships required.
3. The freight rates would less and cost per ton of coal would be reduced.

By improving berthing time efficiency

1. The ship turnaround time would be reduced.

2. Effective utilization of unloading equipment.
3. Decrease in waiting time of the ships.

5.1 *Shipping draft Index*

The draft at the port plays a critical role for the coal Imports. The approximate maximum drafts of various ships size are:

1. Handymax= 10.5 metres.
2. Panamax= 12.5 metres.
3. Capesize= 20 metres.

At present only two ports Krishnapatnam and Gangavaram have sufficient draft for handling capsize vessels. If the coal ports along the east through dredging upgrade for 20 m draft the all the coal imports could be carried by Capesize ships. The capsize have freight advantage of US$ 5 over Panamax and US$ 8 over Handymax considering imports from Indonesia and South Africa. Understanding from report [3] from Planning commission, at the India would be importing 211 million tons at the end of 2017. Then the total reduction in costs for this tonnage in terms of Ocean freight would be:

Total cost saved if cargo is carried by Capesize over Panamax = 211 X 5 = 1055 million US$ per Year.

Total costs saved if cargo is carried by Capesize over handymax = 211X 8 = 1688 million US$ per Year.

5.2 *Berthing time efficiency*

In the in the period April 2010 till March 2011 there have been close to 600 shipments have been done along all the ports in east coast of India for steam coal. There has been high waiting time up to 18 days and also high Ship turnover time. There is a need to reduce the service or the berthing at the port. Even though we cannot exactly quantity the loss but still can estimate taking into view the time charter rates for the Ships of various sizes. Considering at the present time charter rate during this period the Panamax ship rates at around 14,000US$/day, Capesize ship rates at around 19,000US$/day and Handy max ship rates at around 9000 US$ per day we can calculate the approximate amount that could be saved every day.

Number of Shipments by Capesize= 47: Approximate Costs saved= 47 x 2 x 21000= 2 million US$.

Number of shipments by Panamax: 425: If reduction of Waiting time and ship turnover by two days, then Approximate Costs saved= 425 x 2x 14,000= US $ 11.9 million per year.

Number of Shipments by Handymax = 126: Approximate Costs saved= 126 x 2 x 9000=US$ 2.2 million per year.

Total costs saved= US$ 2 +11.9+2.2=16.1 million US$.

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