AN EMPIRICAL EVALUATION OF OPERATIONAL EFFICIENCY OF MAJOR PORTS IN INDIA

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Submitted by

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Under the Guidance of

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DEPARTMENT OF COMMERCE

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Whose Cherished dream was to

Make me a scholar to live with

Good health and wealth forever

I kiss his feet with tears of tributes and pray

For his eternal blessing all my life

- *(Late) My Father T.M. Thangasamy*

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CERTIFICATE OF THE SUPERVISOR

This is to certify that the dissertation entitled **“AN EMPIRICAL EVALUATION OF OPERATIONAL EFFICIENCY OF MAJOR PORTS IN INDIA”** is a bonafide record of research work done by Mr**. T. RAJASEKAR** and submitted for the award of the degree of Doctor of Philosophy in Commerce of Pondicherry University. The dissertation is a record of independent research work undertaken by him under my supervision and guidance and that it has not previously formed the basis for the award of any Degree, Diploma, Associateship, Fellowship or any other similar title of this or any other University.

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DECLARATION

I hereby declare that the dissertation entitled **"AN EMPIRICAL EVALUATION OF OPERATIONAL EFFICIENCY OF MAJOR PORTS IN INDIA",** submitted by me for the award of degree of Doctor of Philosophy in Commerce is a record of research work done by me under the supervision and guidance of **Prof. MALABIKA DEO,** and that the thesis has not previously formed the basis for the award of any Degree, Diploma, Associateship or any other similar title.

Place: Puducherry **T. RAJASEKAR**

Date:

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- T. RAJASEKAR

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ABBREVIATIONS

A & P	Anderson and Peterson
BCC	Banker, Charnes and Cooper
CCR	Charnes, Cooper and Rhodes
CDI	Commodity Diversity Index
CMIE	Centre for Monitoring Indian Economy
CRS	Constant Returns to Scale
CRZ	Coastal Regulation Zone
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
DRS	Decreasing Returns to Scale
FEM	Fixed Effect Model
HDC	Haldia Dock Complex
IOC	Indian Oil Corporation
IRS	Increasing Returns to Scale
JNPT	Jawaharlal Nehru Port Trust
KDS	Kolkata Dock System
LSDV	Least Squares Dummy Variables
MMTC	Minerals & Metals Trading Corporation
MPI	Major Ports in India
NMPT	New Mangalore Port Trust
NSDP Agriculture	Net state domestic product in agriculture
NSDP Industry	Net state domestic product in industry
NSDP Services	Net state domestic product in services
NSDP	Net state domestic product

OECD	Economic Co-operation and Development
OLS	Ordinary Least Squares
OLS	Pooled Ordinary Least Square
PCA	Principal Component Analysis
PECT	Pusan East Container Terminal
RBV	Resource-Based View
REM	Random Effect Model
SCI	Shipping Corporation of India
SE	Scale Efficiency
STC	State Trading Corporation
TEU	Twenty foot Equivalent Unit
TNEB	Tamilnadu Electricity Board
VRS	Variable Returns to Scale

CHAPTER – 1

INTRODUCTION AND DESIGN OF THE STUDY

1.0 Introduction

The seaports of India have played crucial role in the development of maritime trade of the country and consequently contributed significantly for the progress of its economy. Maritime trade in India continues to be almost identical with India's overseas trade accounting almost 95 percent of total cargo by volume and 75 percent by value. In the last two decades, to be more specific, the country's economic reforms and globalization have accelerated the quantum of trade as well as directed the change towards a more diversified commodity composition of trade which has made the ports of India all the more important.

Alongside the liberalization of Indian economy, the first generation port reforms also were initiated in the mid of 1990s, in line with liberalization and globalization policies, to extend existing institutional arrangements and fundamental business processes in the port sector of India. As a result, the port sectors have witnessed profound transformation. Consequent to liberalization of port and terminal ownership, management and regulatory frameworks guiding the port operations also have undergone changes in tune with broader process of functional evolution of ports and demands of the global maritime trade.

In the studies of ports and their performance, the level of generalization have been extremely limited, because each port in the world are treated different from the other. According to the H. E. Haralambides[1], an international port expert, there is no single thing that could be adequately described by the mere word 'port' and not two patch of sea that protects fishermen from the roughness of the sea, allowing them to moor their boats and trade their wares in safety.

1.1 Maritime Trade in India

The maritime trade of India is comprised of export and import trade in various commodities i.e. bulk commodities, crude oil and other petroleum products, iron ore and coal, besides general cargo. Since the economic liberalization there is a significant increase in handling of value added goods mainly in form of containerized cargo in numerous Indian ports. This has given rise to many new dimensions in the development of the port sector in the country. Containerized trade has brought a significant redefinition of port services and demands of highly sophisticated handling and logistics service efficiencies.

The growth of Indian port sector in the past two decades registering an overall growth reckoned at about 9 – 10 percentage has been quite impressive. Which has resulted in a boost of new demands in port sector for adding more on cargo handling capacity and creation of new-dedicated berths and cargo terminals. Considering the future business potential of port sector in India, by improving efficiencies and value added services the ports can contribute substantially making country's external trade competitive in the global market.

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[1] Haralambides, H. E., Behrens, R. & Shashikumar, N. (1998). *Indian ports and transport infrastructure at the threshold of 21st Century*. Rotterdam, Erasmus University.

Basically the physical cargo volumes handled at any seaports depends on the size of the port. Hence it is a general understanding that size contributes to the volume trade and thus bigger size ports are taken to be as efficient port. The major ports of India together handled 569.90 million tonnes of cargo during the year 2010-11.

1.2 Development of Port Sector in India

India's golden age of maritime trade was the eyesore for the rest of the world and was short-lived, as it came under increased domestic, political and economic instability due to the internecine wars and feuds among princely kingdoms that ruled different parts of India as well as continuous invasions of foreign rulers. The three hundred years of British rule, starting with the establishment of the East India Company in 1600 AD witnessed both positive and negative effect of it on the Indian maritime industry. The Industrial Revolution in Europe brought about revolutionary changes in shipping and its far-reaching technological developments resulted in the establishment of modern ports of Mumbai, Kolkata and Chennai, which not only catered to colonial trade but also acted as the centers of British colonial administration. In the post-independence period, a strong undercurrent of shipping nationalism gave major strategic boost to the development of ports. It encouraged the growth of a strong national merchant fleet through policies of cargo support for Indian flagged vessels, especially to the Shipping Corporation of India (SCI). It also provided protection to coastal shipping and state canalization of exports and imports through agencies like Indian Oil Corporation (IOC), State Trading Corporation (STC) and Minerals & Metals Trading Corporation (MMTC) etc. to achieve economic self-reliance.

Presently, there are 13 Major Ports and 185 operable Minor Ports located along the 7517 km long coastline of India. The Port Trust of India under Central Government jurisdiction manages the 13 major ports and 185 operable minor ports come under the jurisdiction of the respective State Governments. Four out of the thirteen Major Ports - Calcutta, Chennai, Mormugao, and Mumbai are more than a hundred years old. The Cochin and Vishakhapatnam ports are more than fifty years old. The ports of Kandla, New Mangalore, Paradip and Tuticorin were developed after independence and Jawaharlal Nehru Port became operational in 1989. The first corporatized major Indian port, Ennore port, stated its operation in 2001. The latest addition to the major ports is the port of Port Blair during the year 2009.

1.3 Administration of Major Ports in India

According to Article 364 (2)(a) of Indian constitution "Major port" means "a port declared to be major port or under any law made by parliament or any existing law and included within the limit of such port". A port is declared as major port under section 3(8) of the Indian Ports Act 1908. According to the ports (technical) committee of India (1948), the facilities at a major port should include an all whether sheltered harbor, modern berths which can take, alongside steamers, at least 9.14 meter draft and also direct road and rail to the hinterland. Other ports fall under the category of intermediate ports and are administratively under the control of the state government.

The planning of major ports is done by the Ministry of Shipping and Transport on the basis of plans drawn by Port Trust in consultation with other organization like the Planning Commission, National Development Council, Ministry of Commerce, Finance etc. Major Port Trust Act 1963 empowers the Central Government to constitute a board of trustees for each major port. A Port Trust comprises a chairman and a deputy chairman, if necessary, appointed by the Centre, and not more than 19 other trustees in case of Bombay, Calcutta, and Madras ports, and not more than 17 for the remaining ports. Almost all major interests are represented on the Port Trusts and nominated representative of Ministry of Shipping and Transport. Port Trust which is responsible for the management of ports property, control, maintenance and operation at the harbor. It is also empowered to leavy dues on cargo, control pilot, services, conservancy, lighthouse, signal stations, regulate bars tuges etc., improve the harbor, prevent pollution and make regulations governing service conditions etc. In the present work an attempt has been made to examine the operational efficiency of Major Ports in India.

1.4 Regulatory Framework in Indian Port Sector

The nature and scope of regulatory environment in the Indian port sector have been derived from a number of existing shipping and port related laws. The port laws have been enacted to address specific areas and issues of concern to maritime governance, especially those relating to shipping and port operations, enforced through various statutory agencies under the executive authority of Central and State governments. The laws currently in force which have a bearing on port operations can be broadly grouped into the following categories. i.e. Port Laws, Shipping Laws, Port Labour Laws and Environmental related laws.

1.4.1 Port Laws

The major laws at the Central level that currently govern the port sector in India are i.e. The Indian Ports Act 1908 and the Major Port Trusts Act 1963. Some of the state governments have also established separate maritime boards under separate enactments under the authority vested on them by Indian Port Act 1908 for undertaking development and administration of State ports.

The Indian Ports Act 1908

The Indian Ports Act 1908 was enacted on the lines of Harbours Docks and Piers Act 1847 of UK and was the first-ever comprehensive Indian ports law to be enacted for governing the administration of all ports in India.

Major Port Trusts Act 1963

The enactment of the Major Port Trusts Act in 1963 marked a new milestone in the evolution of the port laws in India supplementing the Act of 1908. The Major Port Trusts Act 1963 for the first time laid down the institutional framework for creation of a separate port authorities for each major port and defined the powers and functions of such a port authority in respect of all aspects of port functioning.

1.4.2 Shipping Laws

Merchant Shipping Act 1958

The Merchant Shipping Act mainly deals with shipping regulations of the country and also has some bearing on the working of ports. The jurisdiction of the Director General of Shipping, empowered under the Merchant Shipping Act, includes conducting onboard ship inspections, pollution control and environmental safety compliance and ballast water discharge etc on overseas Indian flagged ships.

1.4.3 Indian Labour Laws

The Indian port sector traditionally was a highly labour-intensive industry because of the dominance of general and bulk cargoes handled by the ports of India. In the pre-independence period the employment of ports was totally controlled by private stevedoring companies. But in the current scenario it underwent a major change with the passing of Dock Workers Act in 1948, which came about after a protracted trade union movement among port workers.

Dock Workers (Regulation of Employment) Act 1948

Dock Workers (Regulation of Employment) Act was enacted to remove the irregularity in the working conditions faced by dock workers under private stevedoring companies. The law sought to regularize the specifications and conditions of employment of port labour, to framed standard service rules and other welfare issues of interest to port and dockworkers. The law is protective of rights of workers and is considered to be a roadblock from the standpoint of both corporatization and privatization of port.

1.4.4 Environmental Protection Act 1986

The Environmental Protection Act 1986 was enacted by Ministry of Environment and Forests administer, under this act the coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters that are influenced by tidal action (on the land side) up to 500 meters from the high tide line and the low tide line is declared as the coastal regulation zone (CRZ). The implementation CRZ rules, which is a crucial aspect of environmental regulation is under the authority of National Coastal Zone Management Authority and other state-level authorities created under the environment protection laws, which have extensive powers to review, sanction or disallow and implement various provisions of environmental laws. Ports also are expected to abide the dictums of the Act.

1.5 Economic Liberalization and Port Sector Reforms

The port related state monopoly was existent till five decades of post-independence history of India. The private sector participation in the port sector was allowed through the government policy since liberalization of Indian economy. Economic liberalization induced government to allow private sector participation in order to enhance the efficiency of ports. The main reason for allowing private sector entry into the port was that the public sector ports were failing to meet the growing demands of the port users in terms of volume and efficiency. The port sector reform were introduced in India since early nineties. As a result Indian Port Sector began to witness a new phase of transformation, reinforcement and growth. Under the reform initiatives India begun to selectively open up the sector to private sector participation and investment. The government played a major role in the development of the port assets and other facilities. The government policy of allowing private sector participation in the port sector was announced in 1996 which resulted in the setting up of India's first ever privately managed International Container Terminal at Nhava Sheva (Maharashtra), by P & O ports Australia. The port sector reform process in India need to be viewed against the backdrop of drastic changes that have taken place worldwide in terms of the trends in cargo delivery and handling by ports.

1.6 Ports and Globalization

The Globalization drive among country's economy world over, has brought tremendous increase in merchandise trade across the world, leading to what has been called the "borderless society". The manufacturing industry worldwide has been relocating across countries and production centers are shifting their bases beyond their conventional national boundaries. This has brought about important shifts in the global trade flows and has led to several international ports getting interlocked in common market for oceanic cargos. With globalization, further gearing up of the world trade particularly in sea borne trade not only has experienced growth but also has witnessed entry of several new players, who have been instrumental to rewrite the rules of the game in maritime trade. Against this backdrop, ports in many countries including in India are continuously entangled with pressing need of expanding their facilities and cargo handling productivity. The rapid growth of container traffic is forcing port authorities to develop their facilities and capacities without further delay. The need of expansion and modernization is also driven by increased deployment of large oil tankers and mega-container ships, which require deep draft facilities and sophisticated cargo equipment for cargo handling. Hence, the Port authorities are under constant pressure to improve productivity of port services and reduce handling charges for vessel operators and shippers, who themselves are operating in highly competitive market.

1.7. Research Motivations

In India maritime trade, in the past, was regarded as the economic backbone and it continues to be the same at present with its major contribution on the trade and economic growth of the country. With the emphasis on the opening of the economy in face of liberalization, the major ports in past few decades have witnessed a remarkable change. These seaports have transacted most of the export & imports of the country as well as effected transshipment of goods that were carried from Europe, Australia and some Asian countries and have exchanged and transshipped to all other Asian countries. The major ports in India are continuously witnessing significant enhancements in various domains such as infrastructures, equipments for its cargo handling purposes etc. The main advantage of major ports of India is that they enjoy suitable weather conditions i.e. temperature and wind almost throughout the year that makes them more preferred ports in the region. The motivation of the present research work is to focus on the performance of the seaport industry in India as well as to determine the guiding factor to be considered for improving the performance of the seaports. As such the better performance of Indian ports can activate the traffic performance in the whole Asian region.

1.8. Research gap

The review of literature reveals that many studies in the past, have dealt with the study of efficiency of seaports using Data Envelopment Analysis; and majority of them were confined to European Countries (Trujillo & Tovar, 2007); (Barros, 2006); (Barros & Manolis, 2004); (Cullinane et al., 2006), and few studies dealts with some Asian and Australian ports (Cullinane et al., 2005); (Lee, 2005); (Tongzon, 2005). However, none of the studies were found to have been conducted so far on efficiency analysis of seaports of India specifically the major ports in India. Some of the earlier studies like Wu, J & Lin, C, 2008, indicate that the Major Ports in India, with acceptable infrastructure and facilities, show low productivity due to lack of management skills. Some of the study observe, Indian ports illustrate inefficiency because of their under utilization capacity (Wu Yen-Chun Jim and Lin Chia-Wen., 2008, Wu Jie et al., 2009). Based on the above observations, the present research work has proposed to make an in-depth study on operational efficiency of major ports in India.

1.9. Significance of the study

Liberalization world over has contributed largely in terms of extraordinary boost of international trade of the countries. In the similar line, India's international trade also has gone substantially high (from 75,751 crore in 1991 to 28, 26,389 crore in 2011) registering around 40 fold increase in 20 years. The international trade activities mostly have been effected through searoute. Incidentally ports also have significant contribution towards substantial upsurge of trade. However the performances of all the ports are not uniform. Hence there is a need for identifying good performance and the reasons thereof, which the present research work has attempted to.

1. 10. Methodological Framework

1. 10. 1. Data

The present study is exclusively based on secondary data, which have been collected from all the major ports of India. Out of 13 major ports 12 ports were considered for the present study, as Port Blair was declared as a major port only during the year 2010, hence excluded from the data set. Since the port of Kolkata is functioning two different dock systems i.e. Kolkata dock system and Haldia dock system, the present study having the data set of 13 units from 12 Major Ports of India. The necessary data were also collected from various issues of Port Administrative Reports, Centre for Monitoring Indian Economy (CMIE) and India Stat websites. The period of study spans from 1993 to 2011. The reason behind for the selection of above study period is to have uniform data for all major ports under study. As Haldia port started operating from 1990s. It was thought appropriate to consider the period of study i.e. 1993 – 2011 so that uniform data will be available for 12 major ports of

India. Data on Total traffic, Turnaround time, Idle time, Berth throughput, Berth occupancy, Operating surplus per ton, Rate of return on turnover, Number of employees, Operating expenses were directly collected from the concern ports for the study period i.e. 1993 to 2011.

The information on Net state domestic product (NSDP), Net state domestic product in agriculture (NSDP Agriculture), Net state domestic product in industry (NSDP Industry) and Net state domestic product in services (NSDP Services) at factor cost (at current price), which were taken as external variables influencing the port performance, were collected from CMIE data base.

1.10. 2. Research Questions

Based on the thorough review of earlier studies the researcher found gap in the existing literature and tried to fill the gap as far as Indian port industry and its performance evaluation is concerned. To be more specific the research has focused on evaluation of the operational efficiency of the major ports of India.

The research gap have given the lead to the following research questions.

- How are the Indian major ports performing?
- Whether the performances of the ports are based on its magnitude?
- Whether size influences the efficiency of a port?
- What are the factors determining the port performance?
- Whether outside factors also influence port performance?

1.10. 3. Research Objectives

To answer the above questions, this study frames the research objectives in the following direction.

1. To analyze trend and growth of export, import and traffic handled by major ports in India.
2. To examine the relationship between port size and their efficiency in the context of major ports in India.
3. To find out the factors influencing the performance of the major ports in India

1.10. 4. Research Hypotheses

The following hypotheses are formulated and attempted to be tested through application of appropriate tools in the present study.

H_{01}: Size is not a determinant factor of port efficiency

H_{02}: There is no influence of outside factors on ports efficiency.

1.10. 5. Tools for analysis

Various statistical tools and econometric tools were used to analyze the data towards the desired objectives.

For the first objective, the study employed simple growth rate, compound growth rate and trend analysis to indicate the trend and growth of major ports in India.

Simple Growth Rate: Simple growth rate (SGR) gives yearly growth rate or percentage increases over the previous year. It is expressed as:

$$S.G.R = \frac{Y_t - Y_{t-1}}{Y_{t-1}} \times 100$$

In the above equation Y_t stands for value of the trade variable in the year 't' and Y_{t-1} refers to the value of the variable in the preceding year.

Compound Growth Rate: Compound growth rate is computed for over a period of time. Semi-log trend function was used in the present study. The functional form is $Y= ab^t$. After taking logarithms on both sides, the function becomes:

$$\text{Log } Y = \log a + \log b$$

And the ordinary least squares method was used to estimate the values of 'a' and 'b'. From the estimated 'b' value, the compound growth rate was computed by using the formula.

$$C.G.R = (\text{anti-log } b\text{-}1) \times 100$$

t- Test was used to test the significance.

For measuring the trend pattern of the major ports of India's trade, the measure of linear trend were used and trend indices were calculated based on method of least squares.

In case of second objective, the study used Data Envelopment Analysis (DEA) for measuring the efficiency of major ports in India. As a preliminary attempt, the study measured the efficiency through DEA – CCR (1978) and DEA – BCC (1984) models. The study also verified the utilization of capacity of major ports through DEA – Additive CRS and DEA – Additive – VRS models. The study further ranked efficient ports based on the degree of efficiency through DEA – Anderson and Peterson (1993) super efficiency model to know the degree of efficiency of the ports that are identified as efficient as efficient by the other DEA models.

i. Standard DEA – CCR and DEA – BCC Models

In the formulation of DEA model the following consideration were observed considering inputs to be $x_k = (x_{1k}, x_{2k},\dots,x_{Mk}) € R^M_+$ to produce outputs $y_k = (y_{1k}, y_{2k},\dots,y_{Nk}) € R^N_+$. The row vectors x_k and y_k form the kth rows of the data matrices X and Y, respectively, and $\lambda = (\lambda_1, \lambda_2,\dots\lambda_k) € R^K_+$ are non negative vector, which forms the linear combinations of the K firms. Finally, let e = (1,1,…,1) are the suitably dimensioned vector of unit values.

The output-oriented DEA model seeks to maximize the proportional increase in output while remaining the production possible set. An output-oriented efficiency measurement problem is written as a series of K linear programming envelopment problems, with the constraints differentiating between the DEA-CCR and DEA-BCC models, as shown in (1) – (5).

$$\max_{U,\lambda} \quad U \qquad \dots\dots\dots\dots\dots\dots (1)$$

$$\text{Subjected to} \quad Uy'_k - Y'\lambda \leq 0 \qquad \dots\dots\dots\dots\dots\dots (2)$$

$$X'\lambda - x'_k \leq 0 \qquad \dots\dots\dots\dots\dots\dots (3)$$

$$\lambda \geq 0 \text{ (DEA – CCR)} \qquad \dots\dots\dots\dots\dots\dots (4)$$

$$e\lambda' = 1 \text{ (DEA – BCC)} \qquad \dots\dots\dots\dots\dots\dots (5)$$

The combination of equations from (1) – (4) and (1) – (5), respectively from the DEA-CCR and DEA-BCC models. The output-oriented measure of technical efficiency of the k^{th} DMU, denoted by TE_k can be computed by Eq. (6).

$$TE_k = 1 / U_k \qquad \dots\dots\dots\dots\dots\dots (6)$$

The technical efficiency derived from DEA – CCR and DEA – BCC models are frequently used to obtain a measure of scale efficiency, as shown in Eq. (7) (Cooper et al, 2000).

ii. Scale Efficiency

The scale efficiency (SE) of the port have been measured by the following formula.

$$SE_k = U_{CCR\_k} / U_{BCC\_k} \qquad \text{………………. (7)}$$

Where SE_k, indicates the scale efficiency of the k^{th} DMU, while U_{CCR_k} and U_{BCC_k} are the technical efficiency measures for DMU_k derived from applying the DEA-CCR and DEA-BCC models respectively. $SE_k = 1$ indicates scale efficiency and $SE_k < 1$ denotes scale inefficiency.

iii. DEA Additive CRS and VRS models

The basic DEA models may be either Input or Output oriented. But DEA – Additive model takes the combination of both Input- Output orientation in a single model. E. q (8)

$$\begin{aligned} &\max Z = es^- + es^+ \\ &s.t. \\ &x_0 = x\lambda + s^- \\ &y_0 = y\lambda - s^+ \qquad \text{------------------ (8)} \\ &e\lambda = 1 \\ &\lambda \ge 0, s^-, s^+ \ge 0 \end{aligned}$$

iv. DEA A&P Super Efficiency Model

To rank efficient ports based on their degree of efficiency DEA – A & P super efficiency model is applied. Andersen and Petersen (1993) introduced super efficiency model, which measures the super efficient performance among the efficient units. E. q (9)

$$
\begin{aligned}
& \mathrm{Max}\ \theta - \varepsilon \left[\sum_{i-1}^{m} S_i^{-} + \sum_{r-1}^{s} S_r^{+} \right] \\
& s.t. \\
& \sum_{\substack{j-1 \\ j \neq p}}^{n} \lambda_j y_v - s_r^{+} = y_m, r = 1, \ldots, s \\
& \sum_{\substack{j-1 \\ j \neq p}}^{n} \lambda_j x_v + s_i^{-} = \theta x_{ip}, i = 1, \ldots, m \\
& \lambda_j \geq 0\ j = 1, \ldots, n \\
& S_r^{+}, S_i^{-} \geq 0\ r = 1, \ldots, s, i = 1, \ldots, m
\end{aligned}
\quad \text{----------------- (9)}
$$

For the third objective, the study attempts to find out the factors determining the port efficiency through panel data methods. Three panel data models have been used such as a) Pooled OLS regression b) Fixed effect model regression and c) Random effect model regression for measuring the determinant factors during the study period 1993 to 2011. For the determinants of port efficiency the panel data models were used. Initially 20 variables were taken for the study, and after checking out multicollinearity and autocorrelation, finally 13 variables were considered for the enquiry on determinants for port efficiency. The 13 variables considered in the analysis are total traffic, turnaround time, idle time, berth occupancy, berth throughput, operating surplus per ton, rate of return on turnover, number of employees, cargo equipments, operating expenses, net state domestic product, net state domestic product in agriculture, net state domestic product in industry and net state domestic product in services. The natural logarithm values of all variables have been taken for bringing uniformity among the variables.

i. Pooled OLS Model

A pooled ordinary least squares (*OLS*) regression model has been employed in this study to identify the determinants of efficiency. The panel consisted of data for the all Indian major ports, over the period of 1993 to 2011. The pooled ordinary least square panel regression takes the following form;

$$TOTTRAFFIC_{it} = \alpha_0 + \beta_1 TRT_{it} + \beta_2 IDLE_{it} + \beta_3 BOCC_{it} + \beta_4 BTHROUGH_{it} + \beta_5 OSPT_{it} + \beta_6 RROT_{it} + \beta_7 NOE_{it} + \beta_8 CAREQUIP_{it} + \beta_9 OPEXP_{it} + \beta_{10} NSDP_{it} + \beta_{11} NSDPAGRI_{it} + \beta_{12} NSDPINDUS_{it} + \beta_{13} NSDPSEVICE_{it} + \varepsilon_{it} \;\ldots\ldots(1)$$

Where *i* stands for *i*th individual unit (cross-section) *t* stands for *t*th time period.

The pooled OLS model assumes all the coefficients are devoid of any significant individual or temporal effect, hence remain constant across time and individuals. The dependent variables considered and their expected sign are as follows.

S. No	Variable	Description	Expected sign
1	TRT	Turnaround time	Negative
2	IDLE	Idle time of the port	Negative
3	BOCC	Berth occupancy	Positive
4	BTHROUGH	Berth throughput	Positive
5	OSPT	Operating surplus per ton	Ambiguous
6	RROT	Rate of return on turnover	Ambiguous
7	NOE	Number of employees	Ambiguous
8	CAREQUIP	Cargo equipments	Ambiguous
9	OPEXP	Operating expenses	Positive
10	NSDP	Net state domestic product	Ambiguous
11	NSDPAGRI	Net state domestic product in agriculture	Ambiguous
12	NSDPINDUS	Net state domestic product in industry	Ambiguous
13	NSDPSEVICE	Net state domestic product in services	Ambiguous

ii. Fixed Effect Model

The Fixed effects method treats the constant as group (section)-specific, i.e. it allows for different constants for each group (section). The Fixed effects is also called as the Least Squares Dummy Variables (LSDV) estimators, because it allows for different constants for each group and it includes a dummy variable for each group. The model takes the following form.

$$Y_{it} = a_{it} + \beta_1 X1_{it} + \beta_2 X2_{it} + ... + \beta_k Xk_{it} + \mu_{it} \quad ………… (2)$$

Where, the dummy variable takes different group-specific estimates for each of the constants for every different section.

iii. Random Effect Model

The Random effects method is an alternative method of estimation which handles the constants for each section as random parameters rather than fixed. Hence the variability of the constant for each section comes from the fact that:

$$a_i = a + v_i \quad \text{----------} (3)$$

Where v_i is a zero mean standard random variable.

The Random effects model therefore takes the following from:

$$Y_{it} = (\alpha + v_i) + \beta_1 X1_{it} + \beta_2 X2_{it} + ... + \beta_k Xk_{it} + \mu_{it} \quad \text{---------------} (4)$$

$$Y_{it} = \alpha + \beta_1 X1_{it} + \beta_2 X2_{it} + ... + \beta_k Xk_{it} + (v_i + \mu_{it}) \quad \text{---------------} (5)$$

iv. Hausman – Taylor Test

The Hausman test is a kind of Wald χ^2 test with k-1 degrees of freedom (where k = number of regressors). The Wald statistic is

$$W = (\beta_{FE} - \beta_{RE})' (V_{FE} - V_{RE})^{-1} (\beta_{FE} - \beta_{RE}) \quad \text{---------------} (6)$$

This test indicates the preferred model for interpretation.

1.11. Scope of the study

As the outcome of economic reforms, India has become one of the fastest growing economies in the world. The change in India's policy towards liberalization in 1991 has provided a good external environment for progressive and sustainable economic growth. Supplementing the economic reforms, port reform also took up the structural development of port sector in India. Further the reforms in terms of privatization has encouraged more competition, more entry in the field, thereby leading to work for better efficiency for survival in the field. For a developing country like India there is a need for studying the state of affair of the ports, more specifically their efficiency which contributes to enhancement of trade and in turn results in economic growth. In this context, it is imperative to measure the efficiency of major ports in India and also to identify the factors determining the port efficiency. This can help the government and policy makers in designing more effective growth policies and strategies for port sectors. The Government also would be enabled to make changes in the policies which are relevant for the ports in creating a better environment that can promote the port sector in India.

1.12. Limitations of the study

The following are the main limitation of the present study:-

i. Predominantly the work is based on secondary data, and the accuracy of the results is based on the secondary data. However the limitations of secondary data are inherent in the present thesis, hence the rightness of the results are condition to correctness of the secondary data.

ii. There may be factors other than those considered in the present study that might be contributing for the efficiency of port operations. But due to data availability constraint, the study has considered certain important factors that were conceived to affect the port efficiency.

1.13. Thesis outline

The thesis is organized into seven chapters. The first chapter presents introduction, research problem, research objectives, scope and limitation of the study along with an overview of maritime trade in India and general structure of port administration.

The second chapter critically reviews some of the available theoretical and empirical literature focusing on port performance, port efficiency relating size with efficiency and determinants of efficiency etc. Based on the existing literature attempt has been made to seek answer to the research questions focused.

The third chapter illustrates the profile of major ports and the infrastructure availability of those ports.

The fourth chapter deals with trend and growth of major ports in India, both in terms of commodity as well as container traffic.

The fifth chapter measures the efficiency of Indian major ports using Data Envelopment Analysis (DEA), and also measures the constant and variable returns to scale efficiency and super efficiency among major ports in India.

The sixth chapter attempts to figure out the factors determining the performance of major ports in India through panel regression analysis methods.

The final chapter summarizes the findings, contributions of the study and suggestions for future research work.

CHAPTER – 2

REVIEW OF LITERATURE

2. 0. Introduction

The container port plays a vital role in local economic development as it significantly contributes in form of the public infrastructure construction which in turn contributes to the trade and industries. Along with the fast development of the port industry, the operational efficiency of a container port becomes critically important. This chapter gives a review of literature relating to the subject under study. This review is divided into two sections. The first section deals with studies related to the port performance evaluation, and efficiency estimation etc. The second section deals with general studies related to ports. The exhaustic literature review in the above line helped us to find the studies that are carried out by earlier researcher in the field and also to identify the gap which becomes the basis of the present piece of research work.

2.1. Studies related to port performance

Al-Eraqi, A. S. et.al (2008)[2] measured the efficiency of Middle Eastern and East African sea ports. The main aim of this paper was to study port efficiency with the help of two stage analysis; the first stage used cross-section method and second panel data with 22 ports of Middle Eastern and East African region. The study employed DEA (CCR and BCC) for measuring the efficiency scores of the ports. The study also used window analysis to examine the port efficiency over time for the period between

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2 Al-Eraqi, A.S., Mustafa, A., Khader, A.T., & Baroos, C.P. (2008). Efficiency of Middle Eastern and East African seaports: Application of DEA using window analysis. *European Journal of Scientific Research*, 23(4), 597 – 612.

2000-2006. The window analysis revealed the fluctuation in efficiency scores among big ports and small ports. The study showed small ports are efficient while big ports were found inefficient during the study period. Finally authors concluded that ships arrival should be encouraged to increase the scale of production and thereby the port efficiency.

Coto-millan, P. et.al (2000)[3] examined the economic efficiency of Spanish ports over the period of 1985-1989. In this effort, a frontier cost function was estimated that enabled the classification of the different Spanish ports. The data used in this estimation of cost function was from a panel of 27 ports of national interest. The results indicated that most efficient ports were those which are smaller in size and managed under a more centralized regime.

Cullinane, K. et.al (2002)[4] examined the efficiency of major container terminals in Asia. The study applied a port function matrix to analyse the administrative and ownership structures of major container ports in Asia. The ports administration and ownership models were divided into four types i.e public, public/private, private/public, and private ports. The study used stochastic frontier approach to measure the efficiency of the ports. The study sample comprised 15 container ports in Asia, and the annual data were collected for the 10 year period from 1989 to 1998. The study process yielded a total of 146 observations. Through the study it was found that the port of Kaohsiung showed highest efficiency followed by Pusan, Singapore, Keelung and MTL. The ports of Kobe, Manila, Shanghai and Dalian were identified to be consistently inefficient ports in the samples. From this result it was identified

3 Coto-Millan, P. (2000). Economic efficiency in Spanish ports: Some empirical evidence. *Maritime Policy Management,* 27(2), 169-174.

4 Cullinance, K., Song, D.W., & Gray, R. (2002). A stochastic frontier model of the efficiency of major container terminals in Asia: Assessing the influence of administrative and ownership structures. *Transportation Research Part A,* 36, 743-762.

that efficiency of a container port appeared to be very closely correlated to its size, measured in terms of throughput. Through the cross sectional results, the study focused Singapore port with highest level of productive efficiency. Pusan, Kobe and Kaohsiung were second, third and fourth place respectively in terms of level of productive efficiency. The study concluded that there seemed to be no definitive link between the degree of private sector participation and the level of productive efficiency. However it appeared to support the justification for the belief that there exists a positive relationship in the productive efficiency and size.

Cullinane, K. et.al (2002)[5] examined the technical efficiency of container ports using DEA and SFA. The study used the sample comprised of world's leading top 20 container ports. The necessary data were collected from the containerization international year book. From the DEA analysis with constant returns to scale the efficiency score were found to be the lowest. On the other hand, the estimated mean technical efficiency derived by applying the stochastic frontier, under the assumption of truncated normal, exponential and gama distributions was found larger than those obtained from DEA analyses under the assumption of variable returns to scale. Spearman's ranks correlation co-efficient of the technical efficiency derived by applying alternative DEA and SFA approaches, ranged from 0.63 to 1.00, indicating that the alternative approaches yielded similar efficiency ranking. The analysis suggested that a dynamic application of these frontier techniques, utilizing panel data approaches may be more germane in ascertaining the relative efficiency levels of the international port industry.

5 Cullinane, K., Wang, T.F., Song, D.W., & Ji, P. (2002). The technical efficiency of container ports: Comparing data envelopment analysis and stochastic frontier analysis. *Transportation Research Part A,* 40, 354-374.

Cullinane, K., & Wang, T.F. (2006)[6] examined the efficiency of European container ports with cross-sectional data envelopment analysis. The study employed data envelopment analysis for measuring the efficiency of a decision making units with multiple inputs and multiple outputs. The DEA-CCR assumes constant returns to scale and the DEA-BCC allows for variable returns to scale and graphically represented by a linear convex frontier. Under this assumption a port is assumed to be minimizing the use of inputs and maximizing its outputs. The data collected for the study comprised of 69 leading container terminals with annual container throughput over 10000 TEUs distributed across 24 European countries for the year 2002. The data collected for the study reveals that a large scale of production is more likely to be associated with high efficiency scores. The study found that, in general most of the container terminal that are large in production scale were associated with higher efficiency scores. However, the study concluded that the average efficiency of container terminals located in different regions differ in efficiency level.

Rios, L.R., & Macada, A.C.G. (2006)[7] analysed the relative efficiency of container terminals of Mercosur using Data Envelopment Analysis. The objective of this paper was to analyze the relative efficiency of operations in container terminals of Mercosur in the year 2002-2004. From the study it was found that executives of the Brazilian container terminals were in need for an indicator which will be able to measure the efficiency of terminals using the main existing variables in the operation of container terminal, such as infrastructure, personnel and terminal area. In their opinion the main indicator employed in the measurement of a terminals efficiency is container

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6 Cullinane, K., & Wang, T.F. (2006). The efficiency of European container ports: A cross sectional data envelopment analysis. *International Journal of Logistics: Research and Applications,* 9(1), 19-31.

7 Rios, L.R., & Macada, A.C.G. (2009). Analyzing the relative efficiency of container terminals of Mercosur using DEA. *Maritime Economics and Logistics,* 8, 331-346.

movements per ship indicating the faster a terminal handles a ship the more efficient the terminal will be. The analysis showed that 60% of the terminals were efficient in the 3-year period. Benchmarking analysis showed that Zarate, Rio Cubatae and Teconvi were mostly used as references terminals for inefficient terminals.

Sohn, J.R., & Jung, C.M. (2009)[8] examined the relationship between size of a port and its efficiency. In this study the technical efficiency level of a port was examined through stochastic frontier analysis, and the impact of changed efficiency of a port on its container transshipment was explored through panel data analysis. The study obtained data from 16 major Asian ports. Two of the most widely used port efficiency analysis DEA and SFA were used in this study. From the analysis, it was observed that the larger Asian ports showed relatively better cargo handling efficiency. The study recorded that bigger market share in container transshipment plays a determining factor when the annual container throughput reaches 5 million twenty foot equivalent units.

Tongzon, J.L., & Heng, W. (2005)[9] analysed the container port efficiency and their competitiveness. The main objective of the study was to find out which port authorities and operators can achieve and maintain their competitive advantage. The study used stochastic frontier production function to measure the efficiency levels of selected container ports and examine the relationship between port efficiency and some port specific variables. The study obtained the data from 25 container ports. Through the study, it was found that all three inputs i.e. land, labour and capital have a positive effect on production. The efficiency result showed larger ports in terms of

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8 Sohn, J.R., & Jung, C.M. (2009). The size effect of a port on the container handling efficiency level and market share in international transshipment flow. *Maritime Policy Management,* 36(2), 117 – 129. .

9 Tongzon, J.L., & Heng, W. (2005). Port privatization, efficiency and competitiveness: Some empirical evidence from container ports. *Transportation Research Part A,* 39, 405-424.

throughput were generally more efficient than the smaller ports. From the study authors also concluded that private sector participation in the port industry is useful for improving port's operational efficiency.

Turner, H. et al. (2004)[10] analysed container port productivity in North America during 1984 to 1997. In the global scenario before 1957 the cargos were transported through break-bulk vessels and only after 1970's the cargos started to be transported through the container. The main objective of this paper was to measure the growth in productivity of seaport infrastructure in North America during the period 1987-97 and to explore the factors that influence of infrastructure productivity. The study employed Data envelopment analysis (DEA) for measuring infrastructure productivity and logit regression for examining the determinants of infrastructure productivity of seaports. The study measured top 26 seaports in US and Canadian region. The period selected was between two regulatory periods i.e. Shipping Act 1984 and Ocean Shipping Reform Act 1998. Through the study it was observed that output had grown faster than the input variables such as quay length, terminal land and container cranes. The study found railroads connections mainly contributing to port productivity. The study concluded, alike other research, that bigger ports are more efficient.

Acosta, M. et.al (2007)[11] analysed the port competitiveness in container port. The port chosen for this analysis was the port of Algeciras Bay (PAB) because of its ranking second among all Mediterranean ports as far as container traffic is concerned. The methodology applied was based on the 'extended diamond' of porter developed by Rugman and Verbeke. Porter model is a frame work that aims at identifying and

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10 Turner, H., Windle, R., & Dresner, M. (1997). North American container port productivity: 1984-1997. *Transportation Research Part E,* 40, 339-356.

11 Acosta, M., Coronado, D., & Cerban, M. (2007). Port competitiveness in container traffic from an internal point of view: The experience of the port of Algeciras Bay. *Maritime Policy Management,* 34(5), 501-520.

quantifying the main factors that determine the competitive advantage of maritime port. The model of porter's diamond includes four influential factors resource like factor conditions, demand conditions and supporting industry firm strategy, structure and rivalry. The study based on the survey used questionnaire to collect information for all ports. From the study it was found that, infrastructure constitute the most important variable on the competitiveness of the port of Algeciras Bay. The variable of superstructure is considered most significant elements in relation to maritime accessibility. The access of vessels and the handling of the cargo rated highly the technological development. The variable of internal competition was assigned the worst score by the respondents. In the form of co-operation of the institutions and companies involved in port activity contributed to reduce the level of maritime accidents. From the matrix analysis it was observed that the variables representing biggest competitive advantage are those related to transshipment services.

Desmukh, A. (2004)[12] studied the current scenario of Indian ports. This paper tried to compare the efficiency of major ports in India. It also tried to make the comparison of Indian ports with Singapore and other developing countries' ports. The study found that international cargo traffic is mainly carried through two modes of transport, by air and sea. 90% of the international cargo is transported through ships. This paper also studies the present policy for ports in India in comparison to the other counterparts.

Bassan, S. (2007)[13] undertook the seaport operation and capacity analysis. In this paper the author has elaborately discussed about the preliminary methodology for port operations. The paper followed a methodology for quantifying port operation

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12 Deshmukh, A. (2004). Indian ports- the current scenario. *Dr. Vibhooti shukla Unit in Urban Economics and Regional Development*, Working paper Series, 14.

13 Bassan, S. (2007). Evaluating seaport operation and capacity analysis - Preliminary methodology. *Maritime Policy Management,* 34(1), 3-19.

performance analogous. Through this methodology, the study suggested suitable methodology to study various dimension in the port operations. The study applied simulation analysis for measuring the seaport performance. The purpose of simulation analysis techniques was because of the ability to model the port system in detail, understanding its behavior and to estimate its performance measures. The study concluded that the final product can become a standard manual that will turn into a binding requirement for examining every port terminal quality of operation and for testing profitability of potential improvement.

Brooks, M.R. et al (2011)[14] adopted a systematic approach for evaluating port effectiveness. From the study authors wanted to understand the evaluation criteria through which users identify the port performance satisfactory and to be find out the approach by which assessment of port effectiveness is done by users. Through the online survey totally 78 samples were collected. The study used Normalized Pair-wise Estimation model to prove effectiveness of port efficiency. The study found that the evaluation criteria influencing user perception of satisfaction, competitiveness and service delivery effectiveness are different. The study also identified the attributes that have more value for port management in their efforts in developing long term strategies that may involve major changes and investments in the ports service characteristics.

Cheon, S.H. et al (2010)[15] attempted to evaluate the impact of institutional reforms on port efficiency. The study evaluated relationship of the ownership, corporate structure and total productivity of container ports. The main aim of this study was to investigate

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14 Brooks, M.R., Schelinck, T., & Pallis, A.A. (2011). A systematic approach for evaluating port effectiveness. *Maritime Policy and Management,* 38(3), 315-334.

15 Cheon, S.H., Dowall, D.E., & Song, D.W. (2010). Evaluating impacts of institutional reforms on port efficiency changes: Ownership, corporate structure, and total factor productivity changes of world container ports. *Transportation Research Part E,* 46, 546–561.

whether private sector participation improved the port efficiency or corporatization improved the port efficiency during the period 1991 and 2004. The port data included land, labour and capital for effective handling of container volumes. Based on that inputs and outputs variables of selected 98 world major ports were evaluated. It was found that all the 98 major ports improved their efficiency more than 2.4 times between 1991 and 2004. The study also revealed that the large scale port operated at the size of decreasing return to scale. The technology advancements showed a significant relationship but it was of a small impact on changes in total factor productivity. Based on the results it was interpreted that the world ports have gained their efficiency based on three primary sources i.e. improved management and optimization operation of container terminal, adjustment of production scales and technological process.

Cheon, S.H. (2009)[16] examined the impact of global terminal operators on port efficiency: using the advanced DEA analysis called "tiered data envelopment analysis". In the context of the previous studies not paying full attention to the impact of major restructuring that have taken place in past two decades shaping port efficiency and the global container industry, the author carried out the study with the objectives as (i) to estimate the impact of GTOs participation on port efficiency (ii) to understand how different institutions origin and features of GTOs can influence certain aspects of container terminal operation and port management in pursuing better efficiency (iii) to understand implications of port strategies of the recent emergence of GTOs and their performance levels. The study tested the hypothesis of how ports actual institutional arrangements with GTOs influence port management

[16] Cheon, S.H. (2009). Impact of global terminal on port efficiency : A tiered data envelopment analysis approach. *International Journal of Logistics Research and Applications,* 12(2), 85-101.

practices in the global port industry. In this study to measure the relative efficiency of ports DEA analysis based on tiered data envelopment analysis was used. TDEA was used as a tool not only to measure the relative distance of ports from production frontiers, but also to classify the sampled ports into peer groups with similar levels of efficiency. To conduct the study, a cross sectional database was constructed including information about global hub and major national gateway ports and the GTOs container production in their ports. In order to implement the TDEA model of port efficiency the top 75 ports were selected based on the container throughput. The input factors of container production were proxied by total container berth length (meters), container terminal area (s.q.meters), capacity of container cranes (tonnage) and aggregated hinterland size. The output variable was represented by container volumes handled (total TEUs) at the port level. Through the TDEA analysis it was found that the highly efficient ports groups consisted of many Asian continent ports. The study also found that, there was some positive association between crane efficiency and proportions of Asia's container production in a port. However, the higher crane efficiency was not always transformed into technical efficiency at port level. Four major regions were examined at an aggregate level that is (a) Asia, (b) Middle East and Southern Europe, (c) North Europe and North America. The study concluded that GTO's new strategies show increasing interest in reducing the level of competition they face within a port and suggested that in future the global and national gateway ports should adopt an astute approach to maintain both maritime logistics efficiency and the benefits of large terminal operators.

Choi H. R. et al (2003)[17] analysed an Enterprise Resource Planning approach for container terminal operating system. ERP enables reduction of system development time, flexibility, standardization of workflow and effective business planning capability. The purpose of this study was to explore the way to develop ERP system for container terminals in order to reduce the development time. From the study it was identified that the existing systems have problems in the view of interconnection with client companies, workflow between terminal departments, system function integration, optimal planning and verification management decision support and container service. The existing problems mainly were caused by the lack of integration of the whole information resource in container terminal, ad-hoc and poor planning capability, disconnected and incorrect data from client companies. The study suggested that the whole architecture of container terminal ERP systems be divided into five modules and advocated for standardization and improve the software quality.

Chudasama, K. M. (2009)[18] analysed the performance of Indian major ports using port ranking model. The study employed weighted score method for measuring the port efficiency. The study also compared the port performance with other ports. From the result it was found that Indian ports having better physical facilities obtained high scores and ranks. The ports of Visakhapatnam, Chennai and Mumbai obtained first three ranks in respect of operational performance. Based on overall weighted scores JNPT had a highest score among all the major ports, while Chennai and Mumbai obtained second and third ranks respectively.

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[17] Choi, H.R., Kim, H.S., & Park, B.J. (2003). An ERP approach for container terminal operating systems. *Maritime Policy Management,* 30(3), 197-210.

[18] Chudasama, K.M. (2009). Performance appraisal of Indian major ports using port ranking model. *IUP Journal of Infrastructure,* 1-15.

Cullinane, K., & Song, D.W. (1998)[19] studied the container terminal problems and panaceas in South Korea, which has achieved remarkable economic growth over the last three decades largely due to the adoption of export-oriented economic policies. Almost 99.8% of Korea's foreign trade is carried through the sea ports. The paper analysed both the extent of congestion in Korean ports and the governmental and commercial measures for solving the problems. In 1996 Korea became a member state of the organization for economic co-operation and development (OECD). In the study the authors found that Korean ports were fully dependent on the government funds. This system caused problems because of the inflexibility of the budget and the bureaucratic procedures for obtaining the funds necessary for port development and maintenance. In the present study the authors analysed the container terminal performance like Jusungdae, Shinsundae, Inchon, Uam and also related it to Korean economic performance. The analysis showed that the volume of the containers handled in korea has risen sharply since the 1970's. Now Korea have acquired fifth position in world container ports after Hong Kong, Singapore, Kaohsiung and Rotterdam. Through this analysis it was concluded that through the activities of the port sector over the past three decades have contributed to the undoubted success of this strategy, there was need to promote private investment as an important source to participate for the future expansion of port facilities. Forecasts of the future demand for Korean port capacity revolve around high growth rates in the South East Asian 'tiger' economies and especially the expansion of China's foreign trade.

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19 Cullinane, K., & Song, D.W. (1998). Container terminals in South Korea: Problems and panaceas. *Maritime Policy Management,* 25(1), 63-80.

De, P., & Ghosh, B. (2003)[20] investigated the causality between performance and traffic. In India awareness of the impact of port efficiency and infrastructure in general and foreign trade in particular, has increased in recent years. The importance of an efficient port for the growth of the port sector stems on the chain linkage between production and performance of the ports. The main purpose of this study was to analyse causality between performance and traffic of Indian ports over the period 1985-99. The authors attempted to measure the performance of Indian ports by developing a composite index with the help of principal component analysis. The performance index comprised of indicators of operational performance, asset performance and financial performance. To determine the causal relationship which best describes the deep root reality in the Indian port sector, an attempt was made to apply some econometric tests like unit root tests, co-integration tests and granger causality tests in a sequential manner to judge the nature and strength of this causality. Eight individual variables were considered in port performance index. From this study the authors found that the five ports namely Chennai, Kandla, Vishakhapatnam, Mormugao and Mumbai together contributed more than 65% of total Indian ports traffic. During the period Chennai, Kandla and Visakhapatnam were the three best performing ports. At the same time New Mangalore, Cochin and JNPT port were identified as the three worst performing ports. For majority of the ports hypothesis that performance causes traffic was validated, but no port confirmed the reverse hypothesis i.e. traffic causes performance. From the overall analysis the author concluded that to attain higher traffic, ports obviously should give highest priority to their performance by improving operational performance factors like PBWT, TRT and Asset performance indicators like BOR, and BTR. For attracting higher traffic

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[20] De, P., & Ghosh, B. (2003). Causality between performance and traffic: An investigation with Indian ports. *Maritime Policy Management,* 30(1), 5-27.

policy towards performance augmenting facilities should be given priority as higher efficiency is induced by higher traffic. When a port performs better by improving its operational and asset performance then its likely to get higher traffic. The paper suggested for an urgent implementation of a comprehensive policy which will strongly influence the port performance and will be consistent with the globalization programme.

Ducruct, C. et al (2009)[21] measured the commodity variety and seaport performance. The study analysed the commodity diversity index (CDI) and the Gini-coefficient of thirty commodities in metric tons for virtually every port in Europe between 1997 and 2006. The study found that the ports are embedded not only with the global chains, but also in urban and regional spatial structures that both fix and constrain their evolution. It was therefore the task before the interested parties to ensure that a strong dependence on few commodities should not harm too much not only port activities but also local economies depending on the port.

Sophia, E. (2003)[22] examined corporative legislative frame work for port inefficiencies. The study was conducted to analyse the following queries like what is perceived as the cause of port inefficiency. The paper argued that ministerial intervention may lead to sub optimal performance which may not be the fundamental cause of the problem. The study indicated that corporatization model in existence were driven under ideological/political consideration. The model initially introduced by the greiner coalition government was that of a government owned companies. The study concluded that if Australian ports are to operate with freedom from political

21 Ducruet, C., Hans, R.A., Koster, & Beek, D.V. (2009). Commodity variety and seaport performance. *Regional Studies,* 1, 1-20.

22 Sophia, E. (2003). Corporatization: A legislative framework for port inefficiencies. *Maritime Policy Management,* 30(3), 211-219.

interference and have opportunity to maximize commercial objectives, then in the first instance the fundamental cause of the problem must be addressed. The legislation which was created a business model ostensibly as a market focused entity in reality was an ideological and political artifact, which had indirectly affected the port performance.

Giri, D. V. et al (1992)[23] analysed productivity efficiency of Paradip port trust, which had showed good efficiency in recent years. The necessary data were collected during May-June 1991 from secondary sources. The study was divided into two major periods. There were two contrasting trends observed in the years 1980-81 to 1985-86 and 1986-87 to 1989-90. The study attempted to identify the causative factors of these two trends. From the results it was observed that there was a significant improvement in the port's productive efficiency during the second period i.e. 1986-87 to 1989-90 while compare the first period i.e. 1980-81 to 1985-86. The study concluded that productivity of port improved when the management adopted a cooperative labour relation orientation, which in turn led to efficiency.

Goodman, A.C. (1984)[24] studied the port planning and financing for bulk cargo ships. The study was conducted in the context of North American ports. Simple economic model were employed to analyse the North American sea ports and their capital improvements relative to bulk cargo. From the study it was found that North American ports of Baltimore and Norfolk had adopted requisite policy alternatives which could lead to ships in the coal hinterland of 50 miles or more. The study suggested that North American sea ports facilities system has to be improved.

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23 Giri, D.V., Patro, G.C., & Parida, S.C. (1992). Improving productive efficiency: Lessons from a port's experience. *Indian Journal of Industrial Relations,* 28(2), 169-178.

24 Goodman, A.C. (1984). Port planning and financing for bulk cargo ships: Theory and a North American example. *Journal of Transport Economics and Policy,* 18(3), 237-252.

Ha, M. (2003)[25] compared the service quality at major container ports in Korea. The paper sought to identify the major factors of service quality in container ports and make a comparative evaluation of the top container ports in terms of service qualities. The study considered 157 samples through personal interview and questionnaire surveys and used analysis of variance and Duncan test techniques to probe whether there are significant differences in the perceptions of service quality factors at individual container ports. From the study it was found that Singapore is at the top in all service sections followed by long beach, Hong Kong, New York, Seattle and Rotterdam white Bussan Kwan Yang and Shanghai rank lowest in the respondent's opinion. The study also found that there was no significant differences in the opinion between ship operators and logistic mangers. The specific reference to Korea and North East Asia the study indicated that it Bussan and Kwan Yang are to improve their competitive position in the container trades of northeast Asia they need to upgrade the service qualities in various service categories.

Koh, Y. (2001)[26] examined the optimal investment priority in the container port. The recent day transport system problems have become more complicated than ever before. The main objective of this paper was to develop realistic and relevant investment planning models for inland container transport system with the usefulness and pragmatism of an heuristic algorithm. The model attempted to identify the optimum inland container transport system by way of matching mathematically a frame work for dynamic programming with mechanism of linear programming. The objective function of this study consisted of the total system costs associated with

25 Ha, M. (2003). A comparison of service quality at major container ports: Implications for Korean ports. *Journal of Transportation Geography,* 11, 131-137.

26 Yong- Ki, K. (2001). Optimal investment priority in container port development. *Maritime Policy Management,* 28(2), 109-123.

container port development. The total system costs was divided into three categories (a) construction costs (b) transportation costs (c) cost relating to the infrastructure. The model was applied to the Korean inland container transport systems to determine the optimal size and priority of container port development. The author evaluated the top five optimal alternatives. Consideration of the top five optimal alternatives showed that Kwangyang port should be given priority for new container port development over the ports being planned.

Kia, et al (2002)[27] analysed port capacity using computer simulation model. The use of computer simulation is a standard approach for evaluating design of complex cargo handling facilities. It attempted to investigate the positive impact of ship-to-tail direct loading on the capacity of container terminal. From the study the authors found that real time operations factors such as train delays, cancellation, truck delays have a direct impact of the performance of container terminal. On the basis of results from the simulation model, the study concluded that the presence of distribution centers in the chain of transport moves the method of terminal operations, create more space for container stacking, reduce congestion within terminal and reduces ships time at port there by increases berth availability.

Lam, J., & Yap, W. (2008)[28] analysed the competition for transshipment containers among major ports in Southeast Asia using the slot capacity analysis. Container ports in Southeast Asian handled an estimated 44.9 million TEU in 2004, half of which consisted of transshipment containers. The main objectives of this paper was to throw greater light to the container port competition dynamics in Southeast Asia for

27 Kia, M., Shayan, E & Ghotb, F. (2002). Investigation of port capacity under a new approach by computer simulation. *Computers and Industrial Engineering,* 42, 533-540.

28 Lam, J.S.L., & Yap, W.Y. (2008). Competition for transshipment containers by Major ports in South East Asia: Slot capacity analysis. *Maritime Policy Management,* 35(1), 89-101.

transshipment cargo by confining the entire focus to their relationships with port Klang. The study focused on the developments in annualized slot capacity deployed by container shipping services that called at these ports on the trade routes served. This research method of analyzing annualized slot capacity can reveal the connectivity of the ports in a systematic and quantifiable manner. This is useful for assessing the competitiveness of the ports as well as the developments of competition between the ports. The competition for transshipment containers was mainly effected between Singapore and the ports of Tanhung Pelepas and port Klang rather than between port klang and tanjung pelepas. The analysis showed that competition from port Klang and Tanjung Pelepas had a negative impact on Singapore transshipment performance in the study period. As a whole, good connectivity in terms of shipping network is essential for transshipment ports. The study also focused on the interrelationship between mainline services and the availability of feeder service at the port.

Lin, L.C., & Tseng, C.C. (2007)[29] analysed operational performance evaluation of major container ports in the Asia pacific region. The study selected top six container ports in the Asian pacific region. The objectives of the study was to measure the efficiency values and to identify ports that are relatively efficient or inefficient. Next to identify the factors that determine efficiency of ports and to explore the influence of various inputs and output variables on the operational efficiency of the ports. The study applied five models of data envelopment analysis to acquire a variety of complementary information about the operational efficiency of major container ports in the Asia pacific region. The two basic models of DEA, CCR and BCC were used to

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29 Lin, L.C., & Tseng, C.C. (2007). Operational performance evaluation of major container ports in the Asia-Pacific region. *Maritime Policy Management,* 34(6), 535-551.

provide the efficiency values for appraisal of port operational performance. The A&P model was used to make further distinctions among the efficient DMUs since they all had efficient values of 1 in the CCR and BCC models. Slack variables analysis addressed the utilization rate of input and output variables. The study also conducted the sensitivity analysis to identify which variables make greater contribution to the efficiency. The study found out that the ports of Pusan, Kaohsiung, Yokohama and Kobe were relatively inefficient as a result of inappropriate application of input resources. From the analysis of results as revealed by the CCR model, Hong Kong, Shanghai and Singapore were relatively efficient ports all through the period of study. Hong Kong was the second best ports in terms of efficiency. The study including the ports of China was not significantly different from the ranking in the first phase. The ports of Hong Kong, Singapore and Keelung were identified as the top five in both rankings. From the study the authors identified the trends in ports efficiency and established a return to scale for each port. When the new ports with better performance were included into the model, the efficiency values of existing ports reduced. Hence the authors suggested that the management of each ports should strive for complete and detailed data collection with regard to its operations and conduct an annual detailed analysis. This will not only help management to respond to the ever increasing pressure of worldwide competition, but also serve as a basis for objective decision making with respect to ongoing improvement in operational efficiency.

Loo, B., & Hook, B. (2002) [30]analysed the interplay of international, national and local factors in shipping container port development in Hong Kong port. The port Hong Kong has maintained it's top position as the world's busiest container port. The

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[30] Loo, B., & Hook, B. (2002). Interplay of international, national and local factors in shaping container port development: A case study of Hong Kong. *Transport Reviews,* 2, 219-245.

study opined that the political and other consideration has equal importantance in the port operations along with the medium and long term distance container freight mainly carried through the railways not road and inland river trade. The study suggests that the Hong Kong government should take quicker action to strengthen the railway infrastructure to enlarge the china's container freight.

Liu, C. (2008)[31] evaluated the operational efficiency of major ports in the Asia-pacific region. The study took a sample of ten ports in the Asia-pacific region. It used three revised DEA models namely CCR model, BCC model and 3-stage DEA model. In the first stage conventional DEA model of Charnes et. al (CCR, 1978) and Banker, et. al (BCC, 1984) was applied to measure the preliminary efficiency score for each DMU using input and output quantity data. While evaluating a port's operational efficiency, it was mainly container cargo handled; cargo handling capacity and the number of ships called were used as the productivity indicators. The efficiency estimated by 3-stage DEA procedure was highest, while CCR efficiency was lowest. It was also noted that the efficiencies in the study based on CCR model, BCC model were somewhat lower than the 3-stage model, this may be because the model like CCR and BCC have not included the environmental factors, managerial factors and statistical noises in account.

Medda, F., & Carbonaro, G. (2007)[32] examined the growth of container seaborne traffic in the Mediterranean basin. The new trends in containerization shipping activities in the Mediterranean region has boosted up the socio-economic developments of the region as a whole. The objective of the study was to examine the

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31 Liu, C. (2008). Evaluating the operational efficiency of major ports in the Asia-Pacific region using data envelopment analysis. *Applied Economics,* 40, 1737-1743.

32 Medda, F., & Carbonaro, G. (2007). Growth of container seaborne traffic in the Mediterranean basin: Outlook and policy implications for port development. *Transport Reviews,* 5, 573-587.

underlying reasons for the development of seaborne container traffic and to pay specific attention to the recent evolution of ports, specifically transshipment ports. Study covers the data from 1998 to 2005 in the Mediterranean container ports. The analysis revealed that growth of Gioia Tauro and Valancia, Algeciras ports were found to be above average, while the ports like Laspezia and Alexandria, Marseilles were below average. The ports of Gioia Tauro and Valancia are now respectively first and third biggest ports in southern Europe. Both ports since 2000 have been the fastest growing ports in the basin with 50-60% increasing in tonnage handled. Of late in east-west axis, Mediterranean is increasingly becoming an 'Asian Gateway' for traffic to and from European destination. North-south traffic, the demand segment exchanges between European countries and countries on southern eastern of Mediterranean. Finally the study concluded that the process of political and economic modernization and the removal of trade barriers, as envisaged in the Barcelona process would increase the Intra-Mediterranean transportation demand substantially and there by more production.

McCalla, R. et al (2005)[33] analysed the global trends in containerization in the Caribbean region. The study explored the data in Caribbean basin between the 1994 and 2002. The study examined in three issues like container service network, actual pattern of container port activity and the traffic developments. The study showed that in each of the year top ports have handled approximately 80% of the containers in the Caribbean basin. From the study it was found that in Caribbean networks, the smaller carriers are playing major role, and it catered to a particular kinds of traffic and destinations. The study also highlighted traffic of most important ports in the North

[33] Mccalla, R., Slack, B., & Comtois, C. (2005). The Caribbean basin: Adjusting to global trends in containerization. *Maritime Policy Management,* 32(3), 245-261.

and Western part of the basin has grown at slower rates than the ports in the south and east. The growth of transshipments was found to be driving the most important development of port traffic.

Mitra, K. et al (2006)[34] measured the performance of the major Indian ports. This analysis revealed that the performance of Indian ports is still poor when compared with other ports in the same region such as port of Colombo and port of Singapore. In this study, the authors compared the performance of major ports of India with respect to the criteria that would enable them to achieve excellence in port's performance. The study concluded that JNPT is ranked first among major ports in India followed by Visakhapatnam, Haldia, Mumbai, Mormugao, and Kolkata. The study stated that operational performance of the old ports, such as Kolkata, Mumbai, Cochin, Chennai was poor as well as few new ports like New Mangalore, Tuticorin etc.

Paradali, A., & Michalopolos, V. (2008)[35] examined the position of container handling ports of Piraeus with benchmark analysis. The benchmark scores were given to the ports which includes supply-demand technical performance of each port. The model determines leader port on the basis of the criterion of the maximum number of best scores. The port data were converted in the tools and benchmark score, best score were found, and the degree of competitiveness were found. Through the analysis it was found that more than one port achieved best scores either in features or quality criteria. The port of Gioia Tauro was identified as the leader port in the Mediterranean, as it showed the highest percent of best scores and also PCD (13.09). The port position could be clearly understood by analyzing through operational basis

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34 Mitra, K., Chowdhury, S., & Chowdhury, P. (2006). An analytical hierarchy process approach in ranking the ports: A case study of major ports of India. *Marine Engineering Institute,* 87.

35 Paradali, A., & Michalopoulos, V. (2008). Determining the position of container handling ports, using the benchmarking analysis: The case of the Port Piraeus. *Maritime Policy Management,* 35(3), 271-284.

and strategic basis. The ports were evaluated in terms of some of the quality criteria variables like rail connection, cargo control statistics, accounting, advertisement and administration. The study identified port of Piraeus registered good scores in terms of all variables except railway network.

Mathew E.H. (2009)[36] analysed the effect of block with storage yard layout on maritime container terminal performance. The paper investigated how the width of storage blocks in container terminals yard and affect the terminal performance. The simulation model was used for analysis which can identify the block width that strikes the optimal balance between variety of different scenarios. The study considered 20 world's busiest ports during 2007. From the analysis it was found that (Gross Crane Rate) GCR is higher to block width and optimal block width ranges from 6 to 12 rows depending on size shape and throughput of the terminal. Secondly the optimal block width decreases when more equipment deployed. From the overall analysis it was found that the performance improves as the shape of the terminal becomes more like a square. This experiment provided a direct connection between block and long run performance at a seaport container terminal.

Ray, A. (2005)[37] studied port performance of Jawaharlal Nehru Port Trust. JNPT was established with the goal of creating a world- class port in India. Indeed, it clearly enjoyed an edge over other Indian ports with respect to both infrastructure and performance even in the pre-reforms period. This paper discussed the key reforms at JNPT, their formulation and implementation. It was clear from the study that the

[36] Mathew E. H. (2009). Effect block width and storage yard layout on marine container terminal performance. *Transportation Research Part E,* 45, 591-610.

[37] Ray, A. (2005). Managing port reforms in India: A case study of JNPT Mumbai. *Background Paper Prepared for the World Development Report.*

reform process was well designed and optimally sequenced with active participation of a wide range of factors.

Sau, S.N. (1990)[38] analysed economies of Calcutta-Haldia port complex. The study used secondary data from 1960-1987. The study showed sluggish growth in the economy of eastern region. The port of Calcutta-Haldia showed initially good growth but later the performance declined during the period 1970-85 as the total traffic handled went down from 10.8% to 9.8%. The study attempted to shows that economic factors are significant enough to explain the trends of traffic of Calcutta-Haldia port as well as the falling share of the port in total seaborne traffic of major ports in recent years.

Sanchez, R.J. et al (2003)[39] measured the port efficiency and international trade. The main objectives of this paper was to measures the port efficiency of Latin American ports and to estimate a model of waterborne transport costs. The primary data was collected from 41 ports terminals mainly handling general containerized cargoes for the year 1999. In order to incorporate different port efficiency measures, the study used principal component analysis (PCA) and regression models. From the study it was found that more efficient ports are clearly associated with lower freight costs after controlling some variables like distance, type of product, linear services and insurance cost. The study also found explanatory variables those were statistically significant were the monthly linear services, distance and goods value per ton.

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38 Sau, S.N. (1990). Economics of Calcutta - Haldia port complex. *Economic and Political weekly,* 25(18), 1015-1026.

39 Sanchez, R.J., Hoffmann, J., Micco, A., Pizzolitto, G., Sgut, M., & Wilmsmeier, G. (2003). Port efficiency and international trade: Port efficiency as a determinant of maritime transport costs. *Maritime Economics and Logistics,* 5, 199-218.

Shabayek, A.A., & Yeung, W.W. (2000)[40] analysed container terminal performance in Hong Kong using the queuing model. The growth of container handling industry and their impact on Hong Kong economy has aroused considerable attention in recent decades. Within the period the growth of container handling industry has led Hong Kong to become one of the world's busiest port. In this study the authors developed a queuing model for measuring the performance of Hong Kong container terminal. In the model three essential parameters i.e. inter-arrival time distribution, service time distribution and number of parallel identical servers were considered. The study found that the container handling rate has been improved to become 80 and 90 TEU.s/hr. the number of serves has also increased to 20 and 22, while the container handling rate is still 70 TEU.s/hr. Finally the authors concluded that the combinations of forecasting (trends and seasonal index) and queuing theory have proved to be useful in estimating the limit of container handling capacity of the container terminals.

Talley, W.K. (2008)[41] examined the container port efficiency and output measures. The output of container ports generally are measured by its TEU throughput; the number of carrier interchanged one to another. It was found that TEU throughput per units of TEU time in pots, short run time do not imply a decrease in the ports technical efficiency. The study also identified that output measures are consistent with measurement utilized by container port mangers for investigating reduction in technical efficiency at their ports, ship loading and unloading service rates. The TEU time in port can be obtained from RFID sensors attached to containers.

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[40] Shabayek, A. A., & Yeung, W.W. (2000). A queuing model analysis of the performance of the Hong Kong container terminals. *Transportation Planning and Technology,* 23, 323-351.

[41] Talley, W. K. (2008). Container port efficiency and output measures. *A paper presented at the annual conference of the international association of maritime economists,* Dalian Maritime University, Dalian, China.

Tongzon, J. (1995)[42] attempted to identify the determinants of performance and efficiency. The study model sought to specifically and empirically test the underlying factors influencing port performance and efficiency. The study employed data from 23 sample ports during the year 1991 and applied regression and Ordinary Least Squares (OLS) model to test the efficiency of ports. The results indicated that port performance is influenced by several factors some of which are beyond the control of port authorities such as level of economic activity, geographical location and frequency of ship calls. It also found that terminal efficiency is a vital component of any water front aimed at improving the best port performance and efficiency. The authors concluded that the dominant contribution of crane productivity to terminal efficiency justifies the need to put more emphasis on enhancements of crane productivity.

Turner, H. (2000)[43] examined the impact of maritime container terminal leasing policy of seaport performance. The paper compared container terminal utilization and container vessel time in the system. The study examined the seaport performance as opposed to terminal performance, using stochastic simulation, which is considered a valuable tool for comparing the impact of policy alternatives. The study applied the base case model of the port of Seattle, with 1996 data. The base models validity was then evaluated by comparing its output to actual annual data. The study found that, all the terminals experience a significant reduction in time in queue at 0.05 levels. The largest time saving occur at terminals 37 and 18. In the utilization of terminal aspects, terminal 30 is nearly inactive. The effect of this policy change is elimination of two

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[42] Tongzon, J.L. (1995). Determinants of port performance and efficiency. *Transportation Research Part A,* 29A(3), 245-252.

[43] Turner, H.S. (2000). Evaluating seaport policy alternatives: A simulation study of terminal leasing policy and system performance. *Maritime Policy Management,* 27(3), 283-301.

terminals and near elimination of a third, maintaining throughput intact. The study concluded that, the current effort adds support, shows both a possible negative effect on seaport efficiency resulting from dedicated terminal leases and the interdependence of carriers serving a seaport.

Valentine, V. F., & Gray, R. (2000)[44] attempted to measure the port efficiency, by using DEA-CCR model. The data was collected from 21 container ports among top 100 container ports. The study result shows that port of Klang and Charleston had high efficiency score among the container ports. The study further reported that DEA model ability to handle multiple inputs and outputs combined with the ability to weights for a meaningful analysis.

Vacca, I. et al (2007)[45] analysed optimization of container terminals: status, trends and perspective. The objective of the study was to minimize ships turnaround time and terminal performance of shipping companies. From the study it was revealed that congestion and traffic issues would be more and more pertinent in years to come, especially due to the percentage increase of the volume of container traffic. The authors observed that the service demand characterized in concentration of loading and unloading operations and high utilization of possible interaction between the terminal and the other market players that directly affect in the decision making process. In particular the assumption that arrival time can be negotiated with final transporters; the terminal could effect in gain in efficiency by having more control on congestion and traffic issues.

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44 Valentine, V.F., & Gray, R. (2000). The measurement of port efficiency using data envelopment analysis. *Special Interest Group on Maritime Transport and Ports a member of the WCTR Society, International Workshop,* Genoa.

45 Vacca, I., Bierlaire, M., & Salani, M. Optimization at container terminals: Status, trends and perspective. *Report submitted to Transport and Mobility Laboratory,* Switzerland.

Albert, W. et al (2008)[46] analysed the growth potential of container shipping on the Yangtze river. Despite the rapid economic growth in the Yangtze River delta area, the river itself was lagging behind as measured by the ratio of container volume in respect of the total freight volume. The research aim of the study was the assessment of the growth and development of an inland water way system. To that effect, the study used the transport model of Borg. It focused on the physical operations of ships and ports. The paper introduced a five-layer model that identified the existing or potential restrictions to container shipping. The study provided estimates of container flows for the years 2006 and 2010 based on port throughput and shipping connections. Through this study researcher identified that there will be an almost negligible cost difference in the container transportation. The study also found logistic position of Wuhan was better than that of Nanjing. Nanjing being so close to shanghai it's efficiency gains of shorter and frequent services from upstream ports to the hub did not materialize as much, compared with Wuhan.

Wu, J. et al (2009)[47] analysed the performance of Asian ports using cross-evaluation DEA. The main objective of the port performance was to minimize the use of inputs and maximize outputs. The study adopted conventional application of DEA to undertake an efficiency analysis of Asian container ports. A ports sample included 28 container ports from 12 countries in Asia and compared them under the traditional and newly proposed methods. The study found that on the average efficiency China is best, followed by Japan and Korea showing good performance especially by Shekou port of China, which has shown the efficiency score 0.93388 and was ranked in the

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[46] Albert, W., Veenstra, M., & Ludema, M. (2008). The growth potential of container shipping on the Yangtze River. *Maritime Policy Management,* 35(6), 535-549.

[47] Wu, J., Yan, H., & Liu, J. (2009). Groups in DEA based cross - evaluation: An application to Asian container ports. *Maritime Policy Management,* 36(6), 545-558.

first place among the 28 container ports. The study showed Chinese mainland ports are significantly better than those of other countries i.e. Japan and Korea. The study concluded that, ports in different countries behave differently in the aspect of container port performance.

Wu, J., & Gosh, M. (2010)[48] analysed container port efficiency in emerging and more advanced countries. This study adopted the output oriented CCR and BCC models to evaluate the efficiency of container ports collecting data from containerization international year book. The study covered 21 countries divided into two groups i.e. advanced markets (G7, USA, France, Italy, Canada, Germany, Japan and UK) and emerging markets (i.e. Brazil, Russia, India, China, Bangladesh, Egypt, Indonesia, Iran, Korea, Mexico, Pakistan, Philippines, Turkey and Vietnam). The results indicated that operations at Bangladesh maritime freight port are more efficient than that of China. During the period Bangladesh had highest container port efficiency. The study concluded that the port of Shanghai in China, Chittagong in Bangladesh and Santos in Brazil had maximum efficiency operation levels in 2005. These ports also had the highest self assessment and peer assessment efficiency values. The outcome of the study suggested that ports (except China, Brazil, Bangladesh) need to upgrade their facilities and capacity urgently to come out of the bottlenecks, as trade volume expands.

Wu, J., & Lin, C. (2008)[49] analysed the national port competitiveness implications for India. The main objective of this paper was of two fold; first one was to evaluate the current status of Indian ports competitiveness with counterparts in emerging and

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48 Wu, J., & Gosh, M. (2010). Container port efficiency in emerging and more advanced markets. *Transportation Research Part E,* 46, 1030–1042.

49 Wu, J., & Lin, C. (2008). National port competitiveness: Implications for India. *Management Decisions,* 46(10), 1482 – 1507.

advanced countries. Second one was to analyze the advantage and disadvantages of Indian port operations and make recommendations. The study used DEA methods for measuring the efficiency of the ports. The necessary data were collected from the IMF balance of payments data from the year 2000 and 2005. The result of this analysis shows the ports of Shanghai in China, Chittagong in Bangladesh had a better efficiency level during the study period. The study also showed India's efficiency scores unsatisfactory with the country ranking 6th among the ports under CCR model and 10th under BCC model. The study suggested that India need to be aware of the potential weakness and should make best use of its competitiveness advantages over its counterparts. The author pointed out that the status of logistics industry in India is weak due to poor infrastructure such as road linkages, ports and complex regulatory structures. The authors also indicated the lack of electricity as one of the causes for India's poor infrastructure. From the study it was recommended that India should improve its road/IT infrastructure, and specifically major ports need to be linked with highways to expenditure the movement of cargo.

Yap, W.Y. et al (2006)[50] examined the developments of the container ports in East Asia. The container ports like Hong Kong, Bussan and Kaohsiung have dominated container handling in East Asia as well as the overall container trade. In this region China and Hong Kong together account for the largest proportion and were in some of the top ports in the world. Of the top ten ports in the world five were in East Asia and of the top ten ports in East Asia five were in China. The main aim of the study highlights the competition dynamics between container ports in East Asia. By analyzing the extent and degree of port competition between the major transshipment

[50] Yap, W.Y., Lam, J., & Nottebottom, T. (2006). Developments of the container ports in East Asia. *Transport Reviews,* 26(2), 167-188.

and gateway ports from the container shipping perspective, the paper addressed the potential impact of trade developments in china on container shipping services deployed in the region including future trends that are likely to have a significant impact on the development of container port competition. The author used slot capacity analysis to measure the competition between the container ports. The competition of container port traffic for the top three ports in East Asia showed that apart from relying gateway traffic, these ports handled significant amount of transshipment containers. Through the analysis the authors found Hong Kong had more slot capacity connected to Taiwan and Kaohsiung. The strong economic growth in East Asia in the earlier decades helped traditional hub ports such as Hong Kong, Pusan and Kaohsiung to register high values of container throughput. The East Asia ports continuously strive to remain as the regional gateway and transshipment centers and to retain their top positions in the league of container ports in the world. The study also found, apart from the four largest global terminal operators in the world, other terminal operators like Modern terminal ltd, Dubai ports, and China merchants also show the good performance and trying to expand their presence in the region. Because of the container development china's economic potential has enhanced, which had relied to a great extent on the China's continued efforts to upgrade and invest in new port development to ensure its growth momentum to be maintained. Finally the study concluded that both ports generate positive effects on each other's container throughput. The container throughput handled by region and trade route, financial data, operational data shows their general economic impact.

Yaragal, & Nagaraj. (2007)[51] analyzed the performance of Major ports in India using appraisal index method. The performance of the port were assessed based on multiple parameters. This study compared not only different ports based on the performance, but also suggested corrective measures, identifying weak areas and strengthening of key parameters.

Yeo, G. et al (2008)[52] evaluated the port competitiveness in Korea and China ports. To analyze the port competitiveness the necessary primary data were collected with the face to face and telephone interview during the period October and November 2003. A total of 75 from Korea and 24 from China were selected as respondents. Factor analysis was employed for analysis. From the study it was observed that the professionals and skilled labour force in port and sophistication level of port proved to be important factors. The results indicated that key factors of port competitiveness are hardware and labour towards software technology. Apart from the above, most competitive ports rely on efficiency hinterland logistics system. The study also indicated that port competitiveness requires more infrastructures combined with high level of operational management. Through the study authors concluded that port of Korea and China require not only increased port investment but also high quality port service and technology focused port operations.

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51 Yaragal, & Nagaraj. (2007). Performance of major ports using performance appraisal index. *IE(I) Journal- MR,* 8 – 10.

52 Yeo, G., Roe, M., & Dinwoodie, J. (2008). Evaluating the competitiveness of container ports in Korea and China. *Transportation Research Part A,* 42, 910–921.

2.2. General studies related to Ports / Containers

Azevedo, S.G., & Ferreira, J. (2008)[53] examined the competitiveness of the port Sines with the help of RBV (Resource Based View). The study adopted case study methodology by the help of data from strategic planning and from statistical reports . This paper analysed the main resources and capabilities of the port of sines focusing on its principal characteristics in an effort to understand the factors that justify its success and international competitiveness and concluded that the port has capability to attain superior performance and competitive advantage.

Bichou, K., & Gray, R. (2004)[54] analysed the logistic supply chain management approach to port performance. The work measured the port performance and efficiency. The study used action research paradigm for measuring the performance of port efficiency and supply chain management. The necessary primary data was collected through the structured questionnaires from the three panelists i.e. ports panel, institution panel, and consultation panel. A total of 73 sample were collected from almost 60 international ports. From the study it was found that there was lack of familiarity as regards to logistics and supply chain concepts. Institutional panel showed that there was a need to expand and develop co-ordination arrangement between the members of international shipping and logistics to reduce the distribution costs at the same time to increase the efficiency of logistic system. Finally consultant panel indicated that port mangers were not familiar with logistics and supply chain concepts and they don't have clear and detailed description. Overall the logistic supply chain management was suggested for the ports that can be of great benefit.

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53 Azevedo, S.G., & Ferreira, J. (2008). Competitiveness of the Port of Sines: The RBV contribution. *Dept of Management and Economics, University of Beira Interior, Working Paper Series.*

54 Bichou, K., & Gray, R. (2004). A logistics and supply chain management approach to port performance measurement. *Maritime Policy Management,* 31(1), 47-67.

Cullinane, K., & Song, D.W. (2002)[55] analysed the port privatization policy and practice in UK ports. The paper investigated the theoretical and practical claims and validity of privatization model. Port privatization was initiated in the UK ports, and its effects were more pronounced than anywhere else in the world. UK had a large number of ports which played a pivotal role in the national economy. In this study the authors found that, geographical location and deregulation seem to have a greater influence on efficiency. The results suggested that port privatization policy should be implemented. The study concluded that close cooperation between port and the national economic planning department is essential, to make the entire port system flexible enough to permit modifications in response to changing business environment.

Dragovic, B. et al (2006)[56] attempted for ship-berth link performance evaluation. The efficiency of operations and processes on the ship-berth link was analysed through the basic operating parameters such as berth utilization. The study used simulation and analytical approach to measure the ship-berth link performance. The data used for this study were actual ships arrival at the Pusan East Container Terminal (PECT) for the six month period from 6 sep 2004 to 27 feb 2005. The study measured performance using simulation model employing the GPSS/H linking ship berth to performance of PECT. The study provided good results in predicting the actual ship berth link operation system of PECT. Finally the model addressed the issue such as the performance criteria and the model parameters to propose an operational method that reduces average cost per ship served and increase the terminal efficiency.

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55 Cullinane, K., & Song, D.W. (2002). Port privatization policy and practice. *Transport Reviews,* 22(1), 55 – 75.

56 Dragovic, B., Park, N.K., & Radmilovic, Z. (2006). Ship - berth link performance evaluation: Simulation and analytical approaches. *Maritime Policy Management,* 33(3), 281-299.

Gilman, S., & Williams, G.F. (1976)[57] analysed the economies of multiport Itineraries for large container ships in UK. The study mainly attempted to distinguish between the types of routes and decision process involved in establishing route patterns and competitive patterns of UK ports. The authors pointed out that west coast ports like Liverpool and Bristol were well located for inland distribution and very well suited for ships serving the UK. In terms of geographical aspects the ports like Southampton, Thames, Flexstoue and Immingham are well located for the south and south-east coast routes. The study also found that Southampton has a favored position as a port, which could respond quickly and economically to the needs of new facilities for shipping.

Khadaroo, A.J., & Seetanah, B. (2007)[58] analysed the contribution of disaggregated components of transport capital in the form of road, port and air capital to economic performance, with the help of time series data from 1950 to 2000, where the public stock of the country is generated and disaggregated into relevant components. From the study it was found that all three components of transport capital have a positive effect on the economic development, but air capital (0.012) does not have significant effect. The study also showed that non transport capital with an output elasticity of 0.23 was found to be more productive than transport capital. Overall the study identified transport capital as an contributor for the Mauritian economic growth. It was also found that the private capital was most instrumental in accounting for the growth of the Mauritian economy.

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57 Gilman, S., & Williams, G.F. (1976). The economics of multi - port itineraries for large container ships. *Journal of Transport Economics and Policy,* 10(2), 137-149.

58 Khadaroo, A.J., & Seetanah, B. (2007). Assessing the contribution of land, sea and air transport capital to the economic performance of the small island state of Mauritius. *Applied Economics Letters,* 14, 1151-1155.

Knovitz, J.W. (1994)[59] analysed Crises of Atlantic Port Cities, for the period of 1880 to 1920", taking into consideration the relationship between space, labor, and public policy. The paper also analysed the industrialization of shipping and the spatial growth of ports, ports labor and space. Port cities were already struggling with problems when world war brought new challenges. Finally author concluded that after a generation of postponed investment, port cities on the North Atlantic were more than ready to address the deleterious consequences of industrial port development by undertaking the task of transforming social and environmental conditions in waterfront districts.

Lee, L.H. et al (2006)[60] analysed the multi commodity network flow model for Asia's container ports. The study mainly focused on the container flow in intra-Asia and also measured the transpacific and Europe for east shipping routes. The data used were from 1999 to 2002, collected from PC-TAS, International Trade Centre. The study showed that Hong Kong port has highest throughput compared to other Asian ports. The study also indicated that quality and land cost links plays a pivotal role. It further observed that neighboring ports have helped to improve the service and costs; which has significant impact on Singapore port container throughput. The authors suggested that there is a need to improve or revise the ports economic parameters such as freight costs, lead time and capacity limits.

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[59] Konvitz, J.W. (1994). The Crises of Atlantic port cities. *Comparative Studies in Society and History,* 36(2), 293- 318.

[60] Lee, L.H., Chew, E.P., & Lee, S. (2006). Multi commodity network flow model for Asia's container ports. *Maritime Policy Management,* 33(4), 387-402.

Pallies, A., & Syriopoulos, T. (2006)[61] studied financial performance of Greek ports. The work examined the financial statements and accounts of the twelve major Greek ports. The authors indicated that certain rigidities still exist which affect the performance and further suggested for steps towards modernization and restructuring are essential.

Song, D. et al (2005)[62] attempted to measure the cost efficiency of the global container shipping network. The objective of this paper was to develop a reliable model that assigns world trade volumes to the container shipping network, so as to examine the cost efficiency and trade pattern of the shipping network. The study adopted a heuristic method to find an efficient, local optimal solution. The model predicted the cost efficiency and movement pattern of the container shipping network. The study suggested to minimize the total shipping cost by reducing container movement and by efficiently using shipping service capacity. The movement patterns of shipping network showed, the ten biggest shipping lines were having above average performance. This showed that the running cost per slot is lower among the biggest companies owing to the deployment of larger vessels. This result suggested that the current container shipping network is, to some extent, already working optimally. Finally the study concluded that the heuristic model is able to reproduce all incomes, costs and container movement pattern for the industry as well as for shipping line ports.

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61 Pallis, A., & Syriopoulos, T. (2006). An empirical evaluation of Greek ports financial performance. *Paper Presented at European Economics and Finance Society, "European Labour Markets, Trade & Financial Flows and Economic Growth.* (pp. 18-21). Heraklion, Crete, Greece.

62 Song, W., Zhang, J., Carter, J., Field, J., Marshall, J., Polak, J., Schumacher, K., Sinha, R., & Woods, J. (2005). On cost - efficiency of the global container shipping network. *Maritime Policy Management,* 32(1), 15-30.

Yip, T.L. (2008)[63] examined port traffic risk in Hong Kong waters. The study investigated port traffic issues by discussing historic accidents in Hong Kong port. During the year 2001-05, overall 2012 accidents and 94 deaths were reported in this port. In this study negative binominal regression model was used to test the port traffic risks. Through the study it was found that port traffic risks are in certain pattern and collision accidents are the most popular incidents when port traffic is heavy. The results also reported that marine collision accounts for over two-thirds of all accidents within Hong Kong waters. Through the study the author suggested that policy strategies should be provided for passenger ships in order to strengthen traffic safety.

Zohil, J., & Prijon, M. (1999)[64] studied the relationship between the diversion distance and the transshipment volumes, as well as the relationship to the total container traffic volume. The study investigated interdependence of the parameters. The transshipment volumes of all the ports showed that there was an impact of diversion distance as well as connection to the total traffic throughput. The study suggested for an assessment variable of TRANSTEU (Estimated number of 000 twenty-foot equivalent units transshipped) as a function of time engaged and the container traffic throughput if transshipment is avoided.

2.3. Summary

On the background of above literature review, the present study attempts to analyze the operational performance of major ports in India. The earlier studies demonstrated the linkage or otherwise between the size with the performance of ports.

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63 Yip, T.L. (2008). Port traffic risks- A study of accidents in Hong Kong waters. *Transportation Research Part E,* 44, 921- 931.

64 Zohil, J., & Prijon, M. (1999). The MED rule: The interdependence of container throughput and transshipment volumes in the Mediterranean ports. *Maritime Policy Management,* 26(2), 175-193.

The studies like Cullinane et al (2002), Tongzon and Heng (2005), Wang and Cullinane (2006), Veldman and Vrookmen (2007), Lemarchand and Joly (2009), Sohn and Jung (2009) argue that larger ports have positive effect on their efficiency level. In contrast some of the studies like, (Al-Eraqi et al. (2008) Cullinane et al (2006), Coto-millan (2000)) report that smaller ports are efficient compared to the bigger ports.

Many a studies used advanced techniques for performance analysis. Studies like Cheon San Hym (2009), Lin and Tseng (2007), Liu (2008), Valentine and Gray (2000) analysed container terminal performance with the help of sophisticated Data Envelopment Analysis tool with BCC, CCR and Tiered DEA models. The scale efficiency and technical efficiency were measured for the container terminal performance in different regions.

Few studies like Cullinane and Song (2002) analysed ports in terms of port privatization and efficiency. Dragovic et.al (2006) analysed ship-berth link performance evaluation using simulation and other analytical approach. Lee et al. (2006) analysed the multi commodity network flow model for Asia's container ports.

It was noticed from the review of literature that majority of the studies have used analytical tools like Data Envelopment Analysis, Stochastic Frontier Analysis and Simulation Analysis for measuring the efficiency of ports in different region. However the most frequently used analytical tool was DEA. Hence it was decided to use the DEA analysis for the present study also. A careful observation on the variables those have been considered separately or in conjugation by various earlier studies were variables like land, labour and equipment in various connotation. The earlier literature of researches carried out on various ports helped in generating a possible list of variables like turnaround time, pre-berthing time, idle time, output per ship per day, berth occupancy, berth throughput, operating surplus per ton, rate of return on turnover, number of berths, berth length, number of employees, cargo equipment, transport equipment, total equipment, operating expenses, net state domestic product, net state domestic product in agriculture, net state domestic product in industry and net state domestic product in services. The present study also tried to take these variables subject to the test of collinearity. Hence all the 19 variables as possible factors influencing efficiency were taken initially and finally 13 variables were taken after checking the multi collinearity. As far as output variable is considered most of the study considered port performance in terms of total traffic. Hence our output variable was taken as the total traffic.

From the review of relevant literature it was observed that very few studies have aimed at examining the operational performance of ports. Quite a number of earlier studies have attempted to relate performance of ports to its size. But most of the studies pertained to ports of other parts of the world. However studies were very scanty as far as Indian ports are concerned. Few studies have focused on the aspects such as performance appraisal, casual effect and growth of port sectors in India. And no study was found measuring the port efficiency with sophisticated model to probe into the intricate performance parameters as far as India is concerned. In the light of the above observations this study has attempted to analyze the operational efficiency of major ports in India.

CHAPTER – 3

PROFILE OF MAJOR PORTS IN INDIA

3.0. Introduction

A mere glance at the globe representing our earth shows that more than seventy percent of the surface area of our planet is covered with water in the form of oceans; the land occupies only about thirty percent. More significant is the fact that the water bodies form extensive and a continuous stretch spread over thousands of square kilometers joining the major continental margins over the entire globe. Another still interesting fact that would immediately be noticed by a keen observer is that most of the well known cities of the world in different continents are located close to the coastal areas or water fronts of these water bodies. The water transport medium is considered as the cheapest, the safest and the best transport medium available to man as a natural gift.

It is but natural that man developed along these coastal areas, devices and structures of great engineering significance for meeting his needs of short and long-distance means of travel on water surface. The boats, the ships and the containers are few classic mediums invented, improved upon and used extensively over the water bodies from early times to the present day. Associated with these transporting devices came the need of developing leaving and arrival points located on the shore to enable loading/unloading of cargo and embarking/disembarking of the passengers besides providing safe sheltering points of refuge for the boats and ships. These places came to be known as docks, harbours and ports and gradually developed into the most important locations of trade, commerce, travel and a host of other activities.

3.1. Profile of Indian Major Ports

India is outlined by sea from 3 sides with an extensive 7517 km long coastline. It is a natural peninsula, strategically located on the crucial East – West trade route of the world which links Europe and Far East. India has 13 Major Ports and 185 Minor or Intermediate ports. The Port Trust of India under Central Government jurisdiction manages the 13 major ports and 185 minor operable ports are managed under the jurisdiction of the respective State Governments. The post independent economic planning has bought about most of the major ports. Four out of the twelve Major Ports - Calcutta, Chennai, Mormugao, and Mumbai are more than a hundred years old. The Cochin and Vishakhapatnam ports are more than fifty years old. The ports of Kandla, New Mangalore, Paradip and Tuticorin were developed after independence. Jawaharlal Nehru Port became operational in 1989. Additions to the Major Ports in form of first corporatized major Indian port, was Ennore port, which stared its operation in 2001. The latest 13th Major Port of India is port of Port Blair which has been given the major port status in the year 1st June 2010.

Chennai Port

Chennai port formerly known as Madras Port, is the second largest port in India and the largest port in Bay of Bengal. Chennai ports is third oldest port among the major ports in India and the maritime trade was started here from 1639 on the sea shore. Chennai ports is an artificial port with wet docks. It is due of the existence of the port that the city of Chennai became to be known as the Gateway of South India. The port with 3 docks, 24 berths and draft ranging from 12 to 16.5 m (39 to 54.1 ft) has become hub port for containers, cars and project cargo in the East Coast of India. Chennai ports is currently ranked the 86th largest container ports in the world and is going to expand in the coming years with the capacity going up to 140 million tonnes per year. It is transformed into a main line port having direct connectivity to more than 50 ports around the world. Chennai port situated on a flat coastal plain known as Eastern Coastal Plains on the east coast of Indian peninsula known as the Coromondel Coast in the Bay of Bengal. The region surrounding the port falls under Seismic Zone II indicating a moderate risk of earthquake.

The port is handling a variety of cargo including Iron ore, Coal, Granite, Fertilizers, Petroleum products, Containers, Automobiles and several other types of general cargos. The port has current depth of 17 m (56 ft) and is capable of handling fourth generation vessels up to 1, 50, 000 Dead Weight Tonns. It is going through an expansion and will have a depth of 18-22 m (59-72 ft), a continuous quay length of 2 km and back-up area of around 100 hectare.

Situated in the Coromandel Coast in the south – east of India, the port has more than 100 years of tradition. Strategically located and well connected with major parts of the world, it is today the hub port in the Indian subcontinent. Committed to efficiency through innovation, the four corner stones of the port that are poised to see much growth in the years to come are (i) continuous modernization, (ii) efficiency services at minimum cost, (iii) simple and intergraded procedures and (iv) user-friendly approaches.

Cochin Port

Cochin port is a major ports on the Arabian Sea – Indian Ocean sea-route and is one of the largest ports in India. The port lies on two islands in the Lake of Kochi: Willingdon Island and Vallarpadam towards the Fort Kochi. The International Container Transshipment Terminal (ICTT), part of the Cochin port, is the largest container transshipment facility in India. The port is governed by the Cochin Port Trust, a government of India establishment. The port was established in the year 1926. Cochin Shipyard, the largest shipbuilding as well as maintenance facility in India and Single Point Mooring facility of the Kochi Refineries, an offshore crude carried mooring facility and the Kochi Marina.

The port of Cochin is located on the Wellington Island at 9 degree 58' north latitude and 76 degree 14' east longitude on the south-west coast of India. It lies about 930 km south of Mumbai and 320 km north of Kanyakumari. The entrance to the port is through the Cochin Gut between the peninsular headland Vypeen and Fort Cochin. The port limits extend up to the entire backwaters and the connecting creeks and channels. The approach channel up to the Cochin Gut is about 10 km long with a designed width of 200m and maintained dredged depth of 13.8M. From the Gut the channel divides into Mattancherry channel and Ernakulam Channel, leading to west and east of Wellingdon Island, respectively.

The port was formed naturally due to the great floods of Periyar in 1341 AD, which choked the Muziris Port, one of the greatest ports in ancient world. Ever since Cochin became one of the major ports with extensive trading relations Romans, Greeks and Arabs. The port further attracted European colonialists like Portuguese, Dutch and finally British who extended their supremacy over Kochi Kingdom and the port city of Fort Kochi. A port with 16 berths and draft of 38 ft is maintained in the Ernakulam channel along with the facilities, which enables the port to bring in larger vessels. In the Mattancheery channel a draft of 30 ft is maintained. The port provides round-the-clock pilot age to ships subject to certain restrictions on the size and draft. There is a efficient network of railways, roads, waterways and airways, connecting the Cochin port with the hinterland centers spread over the states of Kerala, Tamilnadu an Karnataka.

Ennore Port

The Ennore port is situated on the Coromandal coast, about 24 km north of the Chennai port along the coastline. It is the 12^{th} major port and the first corporatized major port in India. The Ennore port was originally conceived as a satellite port of the Chennai port, primarily to handle thermal coal to meet the requirement of Tamilnadu Electricity Board (TNEB). The preview was expanded taking into account subsequent developments such as the plan of the Government of Tamilnadu to encompass (i) An 1880 MW LNG power project in association with a private consortium (ii) A large Petrochem park (iii) A naphtha cracker plant.

Ennore port, designed as Asia's energy port, is the first corporatized port in India and has only 86 employees. Envisaged being a satellite port to decongest and improve the environmental quality at the bustling Chennai Port, Ennore port is evolving itself into a full-fledged port with the capacity to handle a wide range of products. Ennore port lies on the northeastern corner of the state of Tamilnadu on a flat coastal plain known as the Eastern Coastal Plains. It is located on the east coast of the Indian peninsula known as Coromandel Coast in the Bay of Bengal and is situated 2.6 km north of the Ennore creek. Being coastal and situated on the thermal equator zone, the port experiences minimal variations in seasonal temperature ranging from a maximum of 38 – 42 °C in summer to a minimum 18-20 °C winter. The Ennore Container Terminal (ECT) known as the Bay of Bengal Gateway Terminal.

Jawaharlal Nehru Port Trust (JNPT)

Jawaharlal Nehru Port Trust (JNPT) lies at the latitude of 18 degrees 57 minutes north and longitude of 72 degrees 57 minutes east. It provides round the clock pilotage to all ocean-going vessels calling the port. Since February 1998, It has launched night sailing of long Panamax container vessels up to 270 MLOA and 12 M draft on a regular basis.

Jawaharlal Nehru Port Trust also known as Nhava Sheva, is the largest container port in India. The port is located south of Mumbai in Maharashtra, on the Arabian Sea and is accessed via Thane Creek. The port lies near Navi Mumbai on the Konkan mainland across from the island city of Mumbai. The port is spread over 10 km (2500 acres), and was developed to relieve pressure on Mumbai Port. The port started its operations in the year 1989. It is one of the largest ports in the world. The port is autonomous corporation wholly owned by the Government of India. The port having Container Terminal operated by the port management has a quay length of 680 metres with 3 berths. The port having 12 berths to facilitate the cargo handling operations. The major commodities like Textiles, Sporting goods, Carpets, Textile Machinery, Boneless meat, Chemicals and Pharmaceuticals has been exported from the port. The import commodities like Chemicals, Machinery, Plastics, Electrical machinery, Vegetable oil and Aluminium goods were traded to the ports. The port handles cargo traffic mostly originating from or destined for Maharashtra, Madhya Pradesh, Gujarat, Karnataka as well as most of North India.

Kandla Port

Kandla Port is also known as New Kandla in Kutch district of Gujarat state in western India. The port is located on the Gulf of Kutch, and is one of the major ports on west coast of India situated some 256 nautical mile southeast of the Port of Karachi in Pakistan and over 430 nautical miles northwest of the Port of Mumbai. The Kandla port is situated in the Kandla Creek. It is 90 km from the mouth of the Gulf of Kachchh. It is a protected natural harbor. It lies in 23° 01’ N and latitude and 70° 13’ E longitude. The Kandla port has 10 berths, 6 oil jetties, 1 maintenance jetty, 1 dry dock and small jetties which can accommodate from large to small vessels. Near all these terminal and jetties there are storage cargo facilities for petroleum. The port was established in the year 1931 and the port of Kandla Special Economic Zone was the first special economic zone to be established in India and in Asia which was established in the year 1965. The port of Kandla SEZ is the biggest multiple product SEZ in the country. It covers over 310 hectares. The port of Kandla is India’s hub for exporting grains and importing oil and one of the highest earning in the country. The major commodities imported the port of Kandla are Petroleum, Chemicals, Iron, Salt, Textiles and Grain.

Kolkata Port

The Kolkata Port is India’s only riverine port with two dock system; (i) Kolkata Dock System (KDS) at Kolkata with the oil wharves at Baj Baj and (ii) to a deep-water dock system at Haldia Dock Complex (HDC) at Haldia for sea borne trade. It has the most sophisticated port facilities with extensive storage facility for diverse cargo. With a modern computerized container terminal the port offers a very customer-friendly approach.

Kolkata Dock System

KDS is situated at latitude of 22° 32’ 53” north and longitude of 88° 18’ 5” east. It comprises the impounded dock systems at Kidderpore dock (KPD), and Netaji Subhas dock (NSD), in Kolkata, Petroleum wharves at Baj Baj, and anchorages at Saugor, Diamond Harbour and Sandheads. KDS is situated on the left bank of the river Hoogly. The pilotage statin is at Gasper/Saugor Roads and the total pilotage distance to KDS is 145 kilometers. The Kolkata Dock System is situated on the left bank of the Hooghly River about 203 km upstream from the sea. The port is having 33 berths, apart from this the port having around 80 major riverine jetties and many minor jetties, and a large number of ship breaking berths.

Haldia Dock Complex

HDC is situated 60 km from the pilotage station at latitude of 22° 02’ north and longitude of 88° 06’ east. Its features include;

Impounded dock system with 12 berths, three oil jetties in the river, three barge jetties in the river for handling oil carried by barges and Haldia anchorage for LASH vessels.

Mormugao Port

The Mormugao port, one of the oldest ports on the west coast of India, with a fine natural harbor, has been relentlessly serving the nation in its economic development for over a century. It was declared a major port on 2nd December 1963. The port is ISPS Code compliant. In 1997, the meter gauge railway of the port linking to the South Central Railway was converted to broad gauge, and by this, the port is now accessible from any part of the country.

Mumbai Port

Port of Mumbai has long been the principal gateway of India. Over the years it has played a dominant role in developing the country's trade and commerce. Its rise to eminence was largely due to its strategic location, situated almost midway along the west coast of India and is gifted with a natural harbor providing ample shelter for shipping throughout the year. There are three enclosed wet docks namely Indira, Prince's and Victoria docks. For handling crude and petroleum product there are four jetties at Jawahar Dweep – an island in the Mumbai harbor. Chemical and products also handled at Pir Pau. The port, during its long chequered history of over 130 years, has been called upon to handle all types of cargo handling up to, approximately, one-sixth of the total sea borne trade of the country.

Paradip Port

Paradip port is an artificial, deep-water port on the East Coast of India in Jagatsinghpur or Odisha. It is situated at confluence of the Mahanadi River and the Bay of Bengal. It is situated 210 nautical miles south of Kolkata and 260 nautical miles north of Visakhapatnam. The port is administered by the Paradip Port Trust, an autonomous corporation wholly owned by the Government of India. Paradip is one of the major ports of India and is the main outlet and inlet of the sea-borne trade of the eastern part of the country spread over states of Orissa, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Bihar and West Bengal. The natural resources and industrial products of this widespread hinterland are immense and the value of the ore trade of the country passing through this port of paradip is considerably much higher than many other major ports. Paradip port has 15 berths with a minimum draft of 13 meters. It can accommodate vessels up to 70, 000 Dead Weight Tonns. The fully automated coal handling plant can handle up to 20 million tons of coal imports per annum. As of 2010, the approach channel was being dredged to increase depth to at least 18.7 meters to enable the port to handle capesize vessels. A western dock with 6 additional berths is planned to be completed by 2014. The port operates an autonomous railway system, with its own railway station. The rail system connects to the Eastern Railways network of the Indian Railways over a 10 km route. NH 5A is a four-lane national highway connecting the port to Haridaspur near Cuttack, and to the rest of India's highway network.

New Mangalore Port Trust (NMPT)

The New Mangalore Port Trust, the only major port of Karnataka was declared as the 9th major port on 4th May 1974 and was formally inaugurated by the Indian Prime Minister smt. Indira Gandhi on 11th January 1975. The provisions of the Major Port Trust Act, 1963 were applied to NMP with effect from 1st April 1980. Since then the port has been functioning as a catalyst for the economic development of this region and catering the needs of the shippers. The New Managalore port has 13 berths with 3528 meters quay length. The major commodities exported through the port are Iron ore, POL products, Granite stones and Containerized cargo. The major imports of the port are Crude and POL products, LPG, Wood pulp, Timber logs, Finished fertilizers, Liquid ammonia, Phosphoric acid and other liquid chemicals.

Tuticorin Port

The Tuticorin port is an artificial deep-sea harbor formed with rubble mound type parallel break waters projecting into the sea for about 4 km. the length of north breakwater is 4098.66 m, south breakwater is 3873.37 m, and the distance between the breakwaters is 1275 m. The port was designed and executed entirely through indigenous efforts. The harbor basin extends to about 400 hectares of protected water area and is served by an approach channel of 2400 meters length and 183 meters width. Tuticorin has been a centre for maritime trade and pearl fishery for more than a century. The natural harbor with a rich hinterland activated the development of the port initially with wooden piers and iron screw pile pier and connections to the railway. It was declared as a minor anchorage port in 1868. Since then there have been various developments over the years.

To cope with the increasing trade, the government of India on 11^{th} July 1974 sanctioned the construction of an all-weather port of Tuticorin. Thus the newly constructed Tuticorin port was declared as the 10^{th} major port on 1^{st} April 1979. The erstwhile Tuticorin minor port and the newly constructed Tuticorin major port were merged and the Tuticorin Port Trust was constituted under the Major ports Act, 1963.

Visakhapatnam Port

The port of Visakhapatnam, the gateway to the east coast of India, plays a crucial role as the middle point distribution base for the southern, eastern, central and northern states of India. Described as the 'brightest jewel' of all Indian major ports for its outstanding performance and productivity, the port serves as a catalyst in spurning domestic and international trade. The port Visakhapatnam situated in latitude 17-41° 34', and longitude 83-17° 45' on the stretch of the eastern seaboard of India, known historically as the "Circars". The town is located to the north of entrance channel of the Visakhapatnam port, on a sandy foreshore over a mile in width, which originally divided the sea from the swampy hinterland. Since 1933, the swamp had been dredged to form the sheltered harbor of the Visakhapatnam port.

3.2. Summary

The present chapter discussed the profile of major ports of India. In geographical location the above major ports are classified into East coast ports and West coast ports of India. There are 7 major ports such as Kolkata dock system, Haldia dock system, Paradip, Visakhapatnam, Chennai, Tuticorin, Ennore and Port Blair located in the east coast area and 6 major ports such as Cochin, New Mangalore, Mormugao, Mumbai, JNPT and Kandla were located in the west coast port area. This chapter also briefly presented the location and facilities available in the major ports in the current scenario. It gives an excellent managerial outlook for the major ports of India in the logistics sectors. Overall this profile chapter gives a detailed outlook of the major ports of India that constitute the entire gamut of Major Ports of India which are constituted by separate Act and come under the supervision of Port Trust of India more specifically port trusts constituted in successive years which do not come under the preview of the respective state governments.

CHAPTER – 4

TRADE TRANSACTED BY MAJOR PORTS IN INDIA

4.0. Introduction

This chapter gives an overview of trade carried out predominantly by Major Ports of India. The trade transacted in forms of import, export and transshipment trade, the trend over the study period, the categorization of commodities traded are the spot lights of this chapter.

This chapter specifically highlights the growth rate of export and import, changes of export and import and also discusses about the share of traffic handling among major ports in India. The chapter also throws light on the commodity wise traffic performance and container traffic for overall major ports in India.

An analysis of growth of foreign trade assumes importance for more than one reason. It is by means of growth, one can understand the annual changes in trade as well as trends in foreign trade over a period of time. Secondly, from the growth, one can also understand the fluctuations or inconsistency in trade pattern. Lastly, once the magnitude of growth and instability are understood, the underlying factors fostering growth and the causes of instability could be clearly traced. Accordingly, in this chapter an attempt has been made to analyze the trend and growth of trade transacted by major ports in India.

4.1. Role of Exports in Economic Growth:

Export sector is considered to be a propulsive sector as it can disseminate the impulses of growth into other supporting sectors of the economy. There is, however, a controversy over the issue whether exports pull up growth or growth determines the level of exports. The notable among the studies which established positive relationship are Ahmet, O., (2007), Raju, S., and Kurien, J., (2005), Ahmad, J., and Harnhirun, S., (1996), Attri, V.N., (1996), Ratirom (1985) Riedal (1984) and Vanek, J., (1971).

The resource structure and the stage of economic growth predominantly determine the place exports occupies in a country's economy. In the early stages of economic growth, the share of exports is supposed to be very low and may be over powered by imports. But in the later stages exports picksup and pulls up other sectors of economy. In this context, it is pertinent to distinguish the pattern of trade i.e. in terms of commodity wise exports from the major ports of India (Singh, D.R, 1985).[65]

4.2. Role of Imports in Economic Growth:

Imports ensure a sure and unequivocal growth for all economies. Imports provide the much needed technology and capital goods, which the economy is incapable of producing at the initial stages of economic growth. Such an economy may also need to import machinery and equipment needed to expand the production capacity of the economy. Such imports are called developmental imports (Singh, D. R, 1985)[66]. The quantum of imports required for the development of any economy is conditioned by various factors such as 1) Import content of investment 2) Techniques of production 3) Volume of exports earnings and 4) Extent of foreign exchange reserves and expected flow of foreign exchange from different sources.

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[65] Singh, D.R. "Pattern of foreign trade and planning in India" New Delhi, Deep and deep publishing, 1985

[66] Op.cit

4.3. Analysis

4.3.1. Export, Import and Transshipment trade of Major Ports in India

Major port trust of India trade data in terms of export, import and transshipment are presented in Table 4.1. It also shows the changes in export, import, transshipment and trade balance in terms of tones, over the period of 19 years from 1993 to 2011.

Table – 4.1

Total exports, Total imports and Trade balance of Major Ports of India

(Figures in '000 tonnes)

	Total Exports	Changes in %	Total Imports	Changes in %	Trans shipment	Changes in %	Trade Balance
1993	67267	-2.97	95877	12.99	3431	0.38	-28610
1994	76606	13.88	96673	0.83	5981	74.32	-20067
1995	81391	6.25	109684	13.46	6187	3.44	-28293
1996	85416	4.95	120265	9.65	9657	56.09	-34849
1997	87247	2.14	128273	6.66	11737	21.54	-41026
1998	94764	8.62	142168	10.83	14727	25.47	-47404
1999	86229	-9.01	150780	6.06	14711	-0.11	-64551
2000	87651	1.65	163432	8.39	20840	41.66	-75781
2001	102486	16.93	160486	-1.80	18133	-12.99	-58000
2002	110445	7.77	160634	0.09	16500	-9.01	-50189
2003	130355	18.03	168038	4.61	15136	-8.27	-37683
2004	146595	12.46	181150	7.80	17054	12.67	-34555
2005	166094	13.30	200800	10.85	16852	-1.18	-34706
2006	173198	4.28	227971	13.53	22398	32.91	-54773
2007	185594	7.16	250395	9.84	27793	24.09	-64801
2008	208755	12.48	277321	10.75	33238	19.59	-68566
2009	210995	1.07	287676	3.73	31862	-4.14	-76681
2010	212124	0.54	322736	12.19	26230	-17.68	-110612
2011	213532	0.66	329724	2.17	26663	1.65	-116192
Mean SD CV	129803.55 54170.81 41.73%		182946.80 75774.29 41.42%		17127.40 8965.29 52.34%		
Linear Growth rate		9.19 * (14.75)		12.71 * (15.19)		1.40 * (9.55)	
CAGR in %		7.30 *		7.10 *		10.10 *	

Note: Figures in the parentheses represents t-value
*- Significant at 1% level

It could be seen from the table, that the total exports of major ports in India grew from 67267 ('000 tonnes) to 213532 ('000 tonnes) between 1993 and 2011. There were wide fluctuations in the annual growth of exports. Other than negative growth of exports for the year 1993 and 1999, major ports in India depict an overall positive change in export front during the period under study. The maximum growth was registered in the year 2003. Of 19 years of study only 6 years registered double digit growth over the previous year. However the linear growth rate registered was 9.19% during the period. The growth rate was also statistically significant at one percent probability level as could be seen from the computed t-value 14.75. The compound annual growth rate of exports during the period was 7.30. The imports during the same period had risen from 95877 ('000 tonnes) to 329724 ('000 tonnes) during the study period. The imports showed negative growth only in the year 2001. Annual imports were also subjected to considerable fluctuations ranging from a low of -1.8 percent in 2001 to a high of 13.53 percent in 2006. There was an average linear annual growth rate of 12.71 percent and the growth rate was statistically significant at one percent probability with a computed t-value of 15.19. The compound growth of imports during the period was 7.10. Interestingly the compound growth rate of import was lower than that of export which is an positive feature of the better trade performance of the ports of India contributing towards the economic welfare. The transshipment trade during the period 1993 to 2011 has increased from 3431 ('000 tonnes) to 26663 ('000 tonnes). The linear growth rate shows an average of 1.40 percent during the period, with 't' value 9.55 which was statistically significant at one percent level. Over the years transshipment trade has shown substantial fluctuation. It could also be seen from the table that trade balance had all along been negative during the whole period indicating that the magnitudes of imports were always greater than the export.

4.3.2. Trend analysis of Exports, Imports and Transshipment trade of MPI

Exports are the major focus of India's trade policy. The export sector is a core sector in the economic growth of the country and is important for addressing macroeconomic concerns. The incentives offered by the export promotion package is comparable to that of any other country. The focus remains on inducing the foreign investors to set up export oriented units in India. India offers a production base for foreign markets around the world for sourcing components and products manufactured at a low cost. India's strategic location, between Middle East and South East Asia, presents itself as a country with immense business opportunities. Its neighbors include Pakistan, China, Nepal, Sri Lanka and Bangladesh. The countries labor advantage adds to this. India has vast reserves of technical and scientific manpower, backed by engineering and management institutes of excellence. From the following table it shows the trends of Exports, Imports and Transshipment trade Indian Major Ports during the period 1992-2011.

Table – 4.2

Trend analysis for Total Exports, Total Imports and Transshipment Trade

	Total Exports	Trend Indices	Trend Values ■	Total Imports	Trend Indices	Trend Values ✸	Total Trans shipment	Trend Indices	Trend Values ♦
1993	67267	100.00	50271.54	95877	100.00	73663.08	3431	100.00	5231.44
1994	76606	113.88	59462.09	96673	100.83	86379.36	5981	174.32	6633.38
1995	81391	121.00	68652.64	109684	114.40	99095.64	6187	180.33	8035.33
1996	85416	126.98	77843.19	120265	125.44	111811.92	9657	281.46	9437.27
1997	87247	129.70	87033.75	128273	133.79	124528.20	11737	342.09	10839.22
1998	94764	140.88	96224.30	142168	148.28	137244.48	14727	429.23	12241.17
1999	86229	128.19	105414.85	150780	157.26	149960.76	14711	428.77	13643.11
2000	87651	130.30	114605.40	163432	170.46	162677.04	20840	607.40	15045.06
2001	102486	152.36	123795.95	160486	167.39	175393.32	18133	528.50	16447.00
2002	110445	164.19	132986.50	160634	167.54	188109.60	16500	480.91	17848.95
2003	130355	193.79	142177.05	168038	175.26	200825.88	15136	441.15	19250.90
2004	146595	217.93	151367.60	181150	188.94	213542.16	17054	497.06	20652.84
2005	166094	246.92	160558.15	200800	209.44	226258.44	16852	491.17	22054.79
2006	173198	257.48	169748.70	227971	237.77	238974.72	22398	652.81	23456.73
2007	185594	275.91	178939.26	250395	261.16	251691.00	27793	810.06	24858.68
2008	208755	310.34	188129.81	277321	289.25	264407.28	33238	968.76	26260.63
2009	210995	313.67	197320.36	287676	300.05	277123.56	31862	928.65	27662.57
2010	212124	315.35	206510.91	322736	336.61	289839.84	26230	764.50	29064.52
2011	213532	317.44	215701.46	329724	343.90	302556.12	26663	777.12	30466.46

■ Yc = 46326.75 + 8787.037.1(X) origin of X= 1993
✸ Yc = 65386.58 + 12374.76 (X) origin of X= 1993
♦ Yc = 3753.07 + 1407.824 (X) origin of X= 1993

Table 4.2 exhibits the trend analysis of export and import in Major ports of India. The trend has been established on the basis of the base year of 1993, which is the initial year for this study period. The export trend percentage increased from 100 in 1993 to 317.44 in 2011. During this period export trend values increased from 50271.54 to 215701.46. Import trend percentage increased from 100 to 343.90 during the study period. In the same period import trend values increased from 73663.08 to 302556.12. Trend percentage in the transshipment trade increased to 772.18 during the study period. The same period trend value has increased from 5231.44 to 30466.46. Exports showed a consistently increasing trend except in 1999 when the exports came down compared to the previous years. Imports also showed consistent increasing trend over the period of time, except in the year 2001 where it come down and after that it managed to increase for rest of the years. When a linear growth rate trend was fitted to the export, import and transshipment data it was observed that all the coefficients were positive and were 8787.037 for export, 12374.76 for import and 1407.824 for transshipment. It shows growth rate in import was substantially high as compared to export. Another interesting feature observed was that as far as export concerned for 11 out of 19 years actual export was more than the trend value, and 12 out 19 years of study the trend value was lower than the actual for imports, 9 out of 19 years the actual transshipment was more than the trend value. During the study period transshipment trade shows fluctuating trend. However, overall exports, imports and transshipment trade show an increasing trend during the study period.

4.3.3. Growth and Instability of Major Ports in India

In economic theory, there is a sample literature on the relationship between growth and instability. In other words, growth and instability are positively associated. Higher growth rate is generally associated with higher degree of instability and vice-versa. There is also another school of thought that expresses a contrary opinion. According to this school of thought, with increased growth, the instability would decline. The problem prevails in every branch of knowledge where the issues of growth and instability are involved. In this section an attempt is made to examine the relationship between growth and instability using the major ports data in terms of tonnes. As mentioned already, in the present study, growth is defined in terms of semi-log function, $Y = ab^t$ or $\log Y = \log a + t \log b$ and the growth rate is computed using the equation (anti-log of b-1) X 100. The growth rate computed for the whole years was divided into four phases, the reason behind dividing the whole period was to identify whether the growth rates were consistent or otherwise. For this the whole period was divided into four phases the growth rates were computed. The growth rate of the breakup periods is given in table 4.3.

Table – 4.3

Compound Growth rate of Major Ports of India

Period	**Exports** (Percentage)	**Imports** (Percentage)	**Transshipment** (Percentage)
1993 to 1997	6.72	7.55	36.00
1998 to 2002	3.10	3.90	2.88
2003 to 2007	9.23	10.49	16.41
2008 to 2011	0.76	4.42	-7.08
Overall	7.30	7.10	10.10

Compound growth rate of export, import and transshipment trade in major ports in India in the truncated period is presented in this table. The whole period has been divided into four division to identify precisely the growth and its consistency during the whole period. The compound growth rate of export was 6.72 percent during the first phase 1993 to 1997; and during this phase import growth was 7.55 percent. In the subsequent period, CGR of exports showed less growth rate compared with imports i.e. 3.10 percent for exports and 3.90 percent for imports during the second phase 1998 - 2002. In the third phase 2003 to 2007, exports growth went up to 9.23 percent whereas the import growth was 10.49 percent. The last phase export growth dipped down to 0.76 percent where as import growth was 4.42 percent during 2008 to 2011. The overall compound growth rate shows exports growths are slightly better than imports. From the table it can also be identified that the variation of growths of exports, imports and transshipment was similar during the study period, i.e. during the second phase all the above said growths declined more or less on similar percentages, whereas the third phase increased almost at the same rate and again it come down during the last phase of the study period. Mostly the growths in export have been over shadowed by the growth in import all the years.

The compound growth of transshipment trade had shown fluctuating trend during four phases. In the first phase CGR of transshipment during the year 1993 – 1997 was 36.00 percent. Whereas, CGR of transshipment trade declined to 2.88 percent during second phase. Third phase again the CGR of transshipment increased to 16.41 percent during 2003 – 2007. The last phase the CGR of transshipment trade showed negative growth i.e. -7.08 percent. The overall observation that can be noted from the table is transshipment trade is showing better performance than export, import transacted. The negative transshipment trade observed in the last phase i.e. from 2008 – 2011 might be because of the global set back in trade during this period as a whole.

4.3.4. Commodity wise traffic growth of Major Ports in India

During the nineteen years of study, the overall cargo traffic volumes (at 561.09 million tonnes in 2010) handled by Indian major ports has seen an impressive growth at a compounded growth rate of 7.30 percent. The commodity traffic volumes handled at all major ports has growth more than three times from 166.57 million tonnes in 1993 to 569.90 million tonnes in 2011. The major ports in the country (including the corporatized Ennore port) accounted for 75 per cent value and 90 percent volume of the total sea borne cargo movement in the country. The commodity-wise growth performance of major port traffic, in fact, has mainly come from growth in the container cargo traffic. Table 4.4 presents commodity wise traffic performance of Indian major ports during 1993 – 2010.

Table – 4.4

Commodity wise traffic growth of Major Ports in India ('000 tones)

	POL	Coal	Iron ore	Fertilizer raw material	Fertilizer finished	Other liquid cargo	Food grains	Vegetable oils	Iron & steel	Other ores	Sugar	Cement	Newsprint	Other cargo
1993	73610 (6.21)	23910 (7.66)	29830 (-7.07)	3797 (-4.16)	3582 (13.79)	4163 (-2.14)	2321 (86.28)	223 (-42.67)	3313 (76.22)	1247 (19.44)	277 (-43.47)	278 (51.09)	197 (103)	10315 (11.47)
1994	76922 (4.50)	26427 (10.53)	34128 (14.41)	3187 (-16.07)	4256 (18.82)	3597 (-13.60)	1440 (-37.96)	372 (66.82)	3764 (13.61)	1594 (27.83)	261 (-5.78)	365 (31.29)	277 (40.61)	9931 (-3.72)
1995	82151 (6.80)	30309 (14.69)	34917 (2.31)	4107 (28.87)	4388 (3.10)	4877 (35.59)	877 (-39.10)	631 (69.62)	4890 (29.91)	1675 (5.08)	2105 (706)	172 (-52.88)	266 (-3.97)	10204 (2.75)
1996	91065 (10.85)	31326 (3.36)	34517 (-1.15)	3836 (-6.60)	5779 (31.70)	5311 (8.90)	2862 (226.3)	1509 (139.1)	3966 (-18.90)	1625 (-2.99)	643 (-69.45)	57 (-66.86)	286 (7.52)	14609 (43.17)
1997	98080 (7.70)	34872 (11.32)	33047 (-4.26)	3833 (-0.08)	3346 (-42.10)	6144 (15.68)	3256 (13.77)	1707 (13.12)	3909 (-1.44)	1741 (7.14)	728 (13.22)	47 (-17.54)	290 (1.40)	15544 (6.40)
1998	104004 (6.04)	41831 (19.96)	40732 (23.25)	7963 (107.7)	4850 (44.95)	2157 (-64.89)	3021 (-7.22)	1907 (11.72)	4193 (7.27)	1712 (-1.67)	418 (-42.58)	126 (168)	248 (-14.48)	15035 (-3.27)
1999	107444 (3.31)	42762 (2.23)	34288 (-15.82)	8105 (1.78)	4664 (-3.84)	2963 (37.37)	3571 (18.21)	2999 (57.26)	3463 (-17.41)	1453 (-15.13)	515 (23.21)	502 (298)	86 (-65.32)	15019 (-0.11)
2000	116704 (8.62)	42492 (-0.63)	36090 (5.26)	6408 (-20.94)	5541 (18.80)	4155 (40.23)	2719 (-23.86)	4406 (46.92)	4317 (24.66)	1405 (-3.30)	714 (38.64)	996 (98.41)	68 (-20.93)	16119 (7.32)
2001	108347 (-7.16)	53361 (25.58)	40460 (12.11)	9076 (41.64)	3028 (-45.35)	4870 (17.21)	1989 (-26.85)	3860 (-12.39)	4208 (-2.52)	1838 (30.82)	197 (-72.41)	1393 (39.86)	115 (69.12)	13707 (-14.96)

2002	103175 (-4.77)	50066 (-6.17)	45756 (13.09)	10469 (15.35)	3492 (15.32)	3747 (-23.06)	3856 (93.87)	3438 (-10.93)	3666 (-12.88)	2138 (16.32)	764 (287)	1386 (-0.50)	4 (-96.52)	18392 (34.18)
2003	109630 (6.26)	52076 (4.01)	50555 (10.49)	10286 (-1.75)	2881 (-17.50)	4062 (8.41)	8514 (120.8)	3318 (-3.49)	4549 (24.09)	2457 (14.92)	1030 (34.82)	897 (-35.28)	0 (0.0)	16976 (-7.70)
2004	122163 (11.43)	53538 (2.81)	58810 (16.33)	8973 (-12.76)	2857 (-0.83)	3777 (-7.02)	6831 (-19.77)	3777 (13.83)	5365 (17.94)	2587 (5.29)	719 (-30.19)	494 (-44.93)	24 (100)	21277 (25.34)
2005	126442 (3.50)	59694 (11.50)	76195 (29.56)	10215 (13.84)	3846 (34.62)	5906 (56.37)	3812 (-44.20)	3681 (-2.54)	6701 (24.90)	3154 (21.92)	1515 (110)	734 (48.58)	0 (0.0)	24877 (16.92)
2006	142087 (12.37)	67941 (13.82)	79171 (3.91)	10297 (0.80)	6624 (72.23)	6046 (2.37)	2092 (-45.12)	3858 (4.81)	8535 (27.37)	3033 (-3.84)	895 (-40.92)	1074 (46.32)	0 (0.0)	27676 (11.25)
2007	154339 (8.62)	71125 (4.69)	80585 (1.79)	10799 (4.88)	7928 (19.69)	6272 (3.74)	5005 (139.2)	3552 (-7.93)	8854 (3.74)	3469 (14.38)	795 (-11.17)	978 (-8.94)	0 (0.0)	36438 (31.66)
2008	168751 (9.34)	77515 (8.98)	91796 (13.91)	10373 (-3.94)	10612 (33.85)	8514 (35.75)	2202 (-56.0)	3821 (7.57)	7839 (-11.46)	4041 (16.49)	1325 (66.67)	1026 (4.91)	0 (0.0)	37924 (4.08)
2009	176138 (4.38)	81744 (5.46)	94036 (2.44)	10240 (-1.28)	12153 (14.52)	7737 (-9.13)	1792 (-18.62)	4782 (25.15)	6336 (-19.17)	4040 (-0.02)	1746 (31.77)	1149 (11.99)	0 (0.0)	33833 (-10.79)
2010	175190 (-0.54)	87033 (6.47)	100744 (7.13)	6758 (-34.00)	10939 (-9.99)	15738 (103.4)	1826 (1.90)	5562 (16.31)	8363 (31.99)	4563 (12.95)	3618 (107)	1769 (53.96)	101 (100)	53374 (57.76)
2011	180188 (2.85)	72734 (-16.43)	87537 (-13.11)	7603 (12.50)	12384 (13.21)	15438 (-1.91)	1800 (-1.42)	5441 (-2.18)	8107 (-3.06)	4842 (6.11)	1794 (-50.41)	1701 (-3.84)	0 (0.0)	56304 (5.49)
Average	121917	52671	57010	7701	5955	6077	3146	3097	5491	2558	1055	797	103	23555
%	42.92	18.54	20.07	2.71	2.10	2.14	1.11	1.00	1.93	0.90	0.37	0.28	0.04	8.29

Table 4.4 provides the growth of commodities traffic of Major Ports in India during 1993 – 2011. The commodities that have been traded through major ports are Petrol, Oil and Natural gas (POL), Goal, Iron ore, Fertilizer, Food grains, Vegetables, Iron and Steel, Sugar, Cement, News print, Liquid cargo and other cargoes. Among all commodities the maximum traded commodities Petroleum and Oil products (POL) had highest growth of 12.37 percent in 2006 and the lowest growth of -7.16 percent in 2001. During the study period the volume of POL increased from 73610 ('000) tones to 180188 ('000 tones). Commodity POL had registered positive growth throughout the study periods except in 2001, 2002 and 2010, with an average growth of 42.92 percent during the study period. The percentage of growth of Coal was the highest at 25.58 (2001) percent and registered the lowest of -16.43 (2011) percent, during the study period. Commodity coal showed the positive growth except in the year 2002 and 2011. The volume of coal increased during the study period from 23910 ('000 tones) to 72734 ('000 tones). The commodity Iron ore got increased from 29830 ('000 tones) in 1993 to 37537 ('000 tones) in 2011. The growth was highest 29.56 percent in 2005 and the lowest -15.82 percent in 1999. Fertilizer both raw and finished showed highest growth of 107.07 percent in 1998 and next 72.23 percent in 2006 and the lowest of -42.10 percent in 1997. The commodities fertilizer raw and fertilizer finished had shown fluctuating trend during the study period. Other liquid cargo volume have increased from 4163 ('000 tones) to 15438 ('000 tones) during the study period 1993 – 2011, It had registered the highest growth of 56.37 percent in 2005 and the lowest growth of -64.89 percent in 1998. Other liquid cargo had registered the highest growth of 103.4 percent in 2010 and the lowest of -64.89 percent in 1998. Food grain had its highest growth of 226.3 percent in 1996 and the lowest growth was -44.25 percent in 2005. During this period the volume of food grains showed a fluctuating trend. The commodity vegetable oil has increased from 223 (‘000 tones) to 5441 (‘000 tones) during the period 1993 – 2011. This commodity had registered the highest growth of 69.62 in 1995. The commodities of Iron & Steel and other ores had registered the highest growth of 76.22 percent, 30.82 percent during the period of 1993 and 2001 respectively and the lowest growth of -19.17 percent in 2009, -15.13 percent in 1999 for both the commodities. The same study period the volume of the commodities has increased from 3313 (‘000 tones) to 8107 (‘000 tones) and 1247 (‘000 tones) to 4842 (‘000 tones) respectively. The commodity of sugar had increased from 277 (‘000 tones) to 1794 (‘000 tones) during the study period 1993 – 2011. It had registered the highest growth of 66.67 percent in 2008 and the lowest of -72.41 percent in 2001. Commodity of cement had registered the highest growth of 98. 41 percent in 2000 and the lowest growth were -66.86 in 1996. The commodity of newsprint was not traded uniformly during the study periods, and the growth was not stable. The commodities in the form of other cargo had registered the highest growth of 57.76 in the year 2010 and the lowest growth was -14.96 in the year 2001.

The above table also reveals that on an average that among all the commodities the commodity of POL traded highest i.e. 121917 (‘000 tones) out of 23556 (000’ tons) sharing 42.92 percent of the total and took the first position, followed by Iron with 20.07 percent share with the volume of 55010 (‘000 tones). The commodity of coal shared 18.54 percent and took a third place among the overall commodities. Other cargo, fertilizer raw material, other liquid cargo and fertilizer finished goods occupied the fourth, fifth, sixth and seventh places respectively sharing of 8.29, 2.71, 2.14 and 2.10 percentages of the total.

4.3.5. Cargo Traffic Handled at Major Ports in India

The recent statistics published by the Indian Ports Association (IPA) showed that sea cargo, till the first quarter of the current fiscal, is growing remarkably. Traffic handled at the Major Ports during April – June 2011, was around 5.22 percent compared to 1.92 percent during the corresponding period of last year. The Major Ports like Ennore (37 percent), Tuticorin (18.02 percent), Visakhapatnam (18.57 percent) and Kolkata (13.03 percent) have shown the tremendous growth during this period. These ports had shown marginal cargo growth during the corresponding period of last year. According to the IPA Managing Director, "Indian ports are capable of handling the prospective surge in sea cargo volumes in the days to come. So far, we have enough cargo handling capacity at major ports to meet the growing demands of the trade. As such, there is no major bottleneck at the major ports in respect sea cargo. However, there are continuous efforts being made at the port as well as government level for augmenting the draught level at ports, rapid mechanization, and seamless connectivity between port, rail and road" (Ratan Kr Paul, Cargo Talk, 2011)[67]. Table 4.5 presents the overall of cargo traffic handled by major ports in India over years along with their share percentages during 1993 – 2010.

[67] Ratan Kr Paul (2011). Cargo traffic from Indian ports: Need for speed in capacity building. Cargo Talk, XI (9), 16-25.

Table – 4.5

Cargo Traffic Handled at Major Ports in India (from 1993 to 2010) 000' dwts

	Chennai	Cochin	Ennore	Haldia	Jawaharlal Nehru	Kandla	Kolkatta	Morm ugao	Mumbai	New Mangalore	Paradip	Tuticorin	Vishakh apatnam	Total
1993	25330 (15.21)	7978 (4.79)	-	13180 (7.91)	3007 (1.81)	22909 (13.75)	5157 (3.10)	16314 (9.79)	29024 (17.42)	7088 (4.26)	7607 (4.57)	6215 (3.73)	22766 (13.67)	166575 (100)
1994	26542 (14.81)	7619 (4.25)	-	13327 (7.43)	3388 (1.89)	24500 (13.67)	5169 (2.88)	18717 (10.44)	30745 (17.15)	8631 (4.81)	8327 (4.65)	6700 (3.74)	25595 (14.28)	179260 (100)
1995	29463 (14.94)	8631 (4.38)	-	14731 (7.47)	5008 (2.54)	26502 (13.43)	5804 (2.94)	18881 (9.57)	32047 (16.25)	8005 (4.06)	10121 (5.13)	8040 (4.08)	30029 (15.22)	197262 (100)
1996	30720 (14.27)	11503 (5.34)	-	15391 (7.15)	6873 (3.19)	30338 (14.09)	6124 (2.84)	18095 (8.40)	34048 (15.81)	8884 (4.13)	11259 (5.23)	9286 (4.31)	32817 (15.24)	215338 (100)
1997	31848 (14.01)	11742 (5.17)	-	17101 (7.52)	8069 (3.55)	33730 (14.84)	6023 (2.65)	17312 (7.62)	33727 (14.84)	12453 (5.48)	11580 (5.10)	9174 (4.04)	34498 (15.18)	227257 (100)
1998	35531 (14.12)	12324 (4.90)	-	20205 (8.03)	8895 (3.53)	38901 (15.46)	7952 (3.16)	21182 (8.42)	32097 (12.75)	15282 (6.07)	13302 (5.29)	9974 (3.96)	36014 (14.31)	251659 (100)
1999	35201 (13.98)	12665 (5.03)	-	20224 (8.03)	11723 (4.66)	40637 (16.14)	9163 (3.64)	18020 (7.16)	30970 (12.30)	14206 (5.64)	13108 (5.21)	10150 (4.03)	35653 (14.16)	251720 (100)
2000	37443 (13.77)	12797 (4.71)	-	20713 (7.62)	14976 (5.51)	46303 (17.03)	10313 (3.79)	18226 (6.70)	30412 (11.18)	17601 (6.47)	13636 (5.01)	9993 (3.67)	39510 (14.53)	271923 (100)
2001	41220 (14.66)	13117 (4.67)	-	22842 (8.13)	18575 (6.61)	36741 (13.07)	7158 (2.55)	19628 (6.98)	27063 (9.63)	17891 (6.36)	19901 (7.08)	12284 (4.37)	44685 (15.90)	281105 (100)

2002	36115 (12.56)	12057 (4.19)	3401 (1.18)	25029 (8.70)	22521 (7.83)	37728 (13.12)	5374 (1.87)	22928 (7.97)	26433 (9.19)	17501 (6.09)	21131 (7.35)	13017 (4.53)	44344 (15.42)	287579 (100)
2003	33686 (10.74)	13001 (4.15)	8485 (2.71)	28603 (9.12)	26844 (8.56)	40633 (12.96)	7201 (2.30)	23649 (7.54)	26796 (8.55)	21430 (6.84)	23901 (7.62)	13294 (4.24)	46006 (14.67)	313529 (100)
2004	36710 (10.65)	13572 (3.94)	9277 (2.69)	32567 (9.45)	31190 (9.05)	41523 (12.04)	8693 (2.52)	27874 (8.08)	29995 (8.70)	26673 (7.74)	25311 (7.34)	13678 (3.97)	47736 (13.84)	344799 (100)
2005	43806 (11.42)	14095 (3.67)	9480 (2.47)	36212 (9.44)	32809 (8.55)	41551 (10.83)	9945 (2.59)	30659 (7.99)	35125 (9.16)	33891 (8.83)	30104 (7.85)	15811 (4.12)	50147 (13.07)	383635 (100)
2006	47248 (11.15)	13887 (3.28)	9168 (2.16)	42337 (10.00)	37836 (8.93)	45907 (10.84)	10806 (2.55)	31688 (7.48)	44190 (10.43)	34451 (8.13)	33109 (7.82)	17139 (4.05)	55801 (13.17)	423567 (100)
2007	53414 (11.52)	15257 (3.29)	10714 (2.31)	42454 (9.15)	44815 (9.66)	52982 (11.42)	12596 (2.72)	34241 (7.38)	52364 (11.29)	32042 (6.91)	38517 (8.30)	18001 (3.88)	56385 (12.16)	463782 (100)
2008	57154 (11.01)	15810 (3.04)	11563 (2.23)	43588 (8.39)	55838 (10.75)	64920 (12.50)	13741 (2.65)	35128 (6.76)	57038 (10.98	36019 (6.94)	42438 (8.17)	21480 (4.14)	64597 (12.44)	519314 (100)
2009	57491 (10.84)	15228 (2.87)	11500 (2.17)	41791 (7.88)	57291 (10.80)	72225 (13.61)	12428 (2.34)	41681 (7.86)	51876 (9.78)	36691 (6.92)	46412 (8.75)	22011 (4.15)	63908 (12.05)	530533 (100)
2010	61057 (10.88)	17429 (3.11)	10703 (1.91)	33378 (5.95)	60763 (10.83)	79500 (14.17)	13045 (2.32)	48847 (8.71)	54541 (9.72)	35528 (6.33)	57011 (10.16)	23787 (4.24)	65501 (11.67)	561090 (100)
2011	61460 (10.78)	17873 (3.14)	11009 (1.93)	34892 (6.12)	64299 (11.28)	81880 (14.37)	12540 (2.20)	50022 (8.78)	54585 (9.58)	31550 (5.54)	56030 (9.83)	25727 (4.51)	68041 (11.94)	569908 (100)
Total	**781439**	**246585**	**95300**	**518565**	**514720**	**859410**	**169232**	**513092**	**713076**	**415817**	**482805**	**265761**	**864033**	**6439835**
Avg	**12.70**	**4.10**	**1.15**	**8.08**	**6.82**	**13.54**	**2.72**	**8.09**	**11.83**	**6.19**	**6.87**	**4.09**	**13.84**	**100.00**

Note: Figures in the brackets are represents share percentage in relation to overall major port trade.
Ennore ports started its operation in 2002 only.

The total traffic including exports, imports and transshipment cargo stands 64, 39, 835 ‘000 Dead-weight tons (DWTs). From this table it is clearly seen that huge amount of cargo is carried through Major Ports in India. A cursory glance at the performance of the individual ports of India shows that invariably the traffic of goods carried through all major ports from 1993 to 2011 had increased substantially and have shown constant increase.

Taking average traffic handled by respective ports, from 1993 – 2011 as per table 4.5, the major ports of India can be put into three categories.

1. Above average ports
2. Average ports
3. Below average ports

The above average ports in handling traffic were Chennai, Haldia, Kandla, JNPT, Mormugao, Mumbai, Vishakapatnam and these ports were able to handle cargo traffic of more than 5,00,000 ‘000 (Dead-Weight Tons) DWTs. During this period these ports handled the cargo traffic more than the average traffic. The ports like New Mangalore, Paradip were able to handle average cargo traffic i.e. between 4, 00, 000 to 5, 00, 000 lakh ‘000 DWTs. While the ports are like Cochin, Ennore, Kolkata, Tuticorin were able to handle cargo traffic of less than 4 lakh ‘000 DWTs.

From Table 4.5 Vishakhapatnam port was found to be placed first among all major ports in India. During the period it registered consistent increase from 22766 ‘000 tons in 1993 to 68041 ‘000 tons in 2011. Similarly, Kandla port was placed second in terms of cargo traffic handling, during the period which increased from 22909 ‘000 tons in 1993 to 81880 ‘000 tons in 2011. The port of Chennai handled the cargo trade totaling 781439 ‘000 tonns during the period and took the third position among major ports in India. During the study period the cargo traffic handled by Chennai port increased from 25330 ‘000 tonns in 1993 to 61460 ‘000 tonns in 2011. The port of Kolkata and Ennore showed least cargo trade performance during the study period. The port of Ennore started its operation only in the year 2002 this might be the reason for having low trade performance. The port of Kolkata has transacted the cargo traffic to a tune of 5157 ‘000 tonns in 1993 which has gone up to 12540 ‘000 tonns in 2011. This was the least performing port in terms of cargo traffic handling during the study period.

The proportion of average traffic handled to the total traffic during the period of study places Vishakhapatnam, Kandla, Chennai, Mumbai and Mormugao in first five positions. The locational advantage, modernized cargo handling facilities may be the reasons for attracting more traffic.

4.3.6. Container Traffic Performance of Indian Major Ports

Containerization is the technique or practice of stowing freight in reusable containers of uniform size and shape for transportation. The freight may sometimes be oddly shaped and may be in different quantities. But when stowed and shipped in containers, it can be handled as a single piece thus making it a lot easier to transport. This reduces the time and costs involved. Containers are not a modern invention. There are records of containers being used in pre-railway tramways of England, Silesia and America as early in 1830s for the transportation of ores, limestone, and coal. These containers were like the ones seen today. But they were much smaller and most had a capacity of 5 – 10 tons. The maritime containers that we see today originated in the second half of 1950. They were the brainchild of Malcom Mclean, a North Carolina truck operator, considered to be the father of containerization, who diversified into shipping in 1955 with the purchase of Pan Atlantic Steamship Company and Waterman Steamship Company. He hit upon the idea of using containers for transportation of goods years back while watching goods being hoisted onto ships from trucks at the dockside. Richard F. Gibney, a journalist was responsible for coining the term “Twenty Foot Equivalent Unit (TEU). He started his career in journalism in 1960s at Shipbuilding & Shipping Record in UK, compiling tables of ships ordered and completed. In 1969, while compiling vessel statistics, he was faced with the problem of accounting for different sizes and dimensions of containers used by different lines. Notable among them were Matson’s 24’ and Sealand’s 35’ containers. So he coined TEU as a measure of comparison. The terms stuck and the rest is history.

Containerization was first introduced in the united states in 1956 and it was initially confined to countries like the Canada, UK., and Japan which faced acute shortage of port labour. Later it was extended to their trading partners in the developing countries. The big ships are now so designed as to carry commodities in containers of the standard size. It reduces handling costs, enables quicker loading-unloading facilitating speedier turnaround of ships, makes intermodal transport feasible, protects the contents from damage or deterioration, and therefore reduces claim liabilities. In India the first container ship was received at Cochin in 1973. Port performance also can be measured through the container traffic growth.

Table 4.6

Container Traffic Performance of Major Ports in India (‘000 tones)

	Chennai	Cochin	Haldia	JNPT	Kandla	Kolkata	Mormugao	Mumbai	New Managalore	Paradip	Tuticorin	Visakhapatnam
1993	1487	431	95	1712	359	1009	7	3132	15	0	277	85
1994	1606 (8.00)	426 (-1.16)	87 (-8.42)	2077 (21.32)	730 (103.34)	1399 (38.65)	10 (42.86)	5413 (72.83)	15 (0.0)	0 (0.0)	405 (46.21)	81 (-4.71)
1995	2019 (25.72)	700 (64.32)	83 (-4.60)	2929 (41.02)	798 (9.32)	1761 (25.88)	13 (30.00)	6268 (15.80)	8 (-46.67)	0 (0.0)	653 (61.23)	126 (55.56)
1996	2308 (14.31)	796 (13.71)	51 (-38.55)	4069 (38.92)	961 (20.43)	1814 (3.01)	19 (46.15)	6748 (7.66)	0 (-100)	0 (0.0)	758 (16.08)	94 (-25.40)
1997	2564 (11.09)	967 (21.48)	118 (131.37)	5078 (24.80)	1179 (22.68)	1951 (7.55)	34 (78.95)	7632 (13.10)	0 (0.0)	0 (0.0)	901 (18.87)	166 (76.60)
1998	3002 (17.08)	876 (-9.41)	383 (224.58)	6050 (19.14)	1299 (10.18)	2122 (8.76)	30 (-11.76)	8097 (6.09)	0 (0.0)	0 (0.0)	1115 (23.75)	146 (-12.05)
1999	2942 (-2.00)	977 (11.53)	427 (11.49)	8029 (32.71)	915 (-29.56)	1971 (-7.12)	37 (23.33)	7098 (-12.34)	0 (0.0)	1 (0.0)	1213 (8.79)	172 (17.81)
2000	3977 (35.18)	1247 (27.64)	434 (1.64)	10679 (33.01)	1134 (23.93)	2117 (7.41)	50 (35.14)	6157 (-13.26)	0 (0.0)	0 (-100)	1633 (34.62)	262 (52.33)
2001	5769 (45.06)	1790 (43.54)	806 (85.71)	14277 (33.69)	1287 (13.49)	2011 (-5.01)	44 (-12.00)	4363 (-29.14)	20 (0.0)	7 (0.0)	1570 (-3.86)	278 (6.11)
2002	5857 (1.53)	1899 (6.09)	1522 (88.83)	18484 (29.47)	1752 (36.13)	1410 (-29.89)	58 (31.82)	3684 (-15.56)	37 (85.00)	7 (0.0)	2199 (40.06)	320 (15.11)

2003	7218 (23.24)	2070 (9.00)	1850 (21.55)	22864 (23.70)	2225 (27.00)	1498 (6.24)	90 (55.17)	3143 (-14.69)	84 (127.03)	33 (371.43)	2301 (4.64)	296 (-7.50)
2004	8628 (19.53)	2125 (2.66)	2275 (22.97)	27785 (21.52)	2404 (8.04)	1746 (16.56)	103 (14.44)	2816 (-10.40)	96 (14.29)	60 (81.82)	2687 (16.78)	277 (-6.42)
2005	9864 (14.33)	2315 (8.94)	2029 (-10.81)	28747 (3.46)	2754 (14.56)	2357 (34.99)	117 (13.59)	2571 (-8.70)	136 (41.67)	31 (-48.33)	3205 (19.28)	635 (129.24)
2006	11756 (19.18)	2539 (9.68)	1711 (-15.67)	33777 (17.50)	2311 (-16.09)	3234 (37.21)	105 (-10.26)	1957 (-23.88)	149 (9.56)	45 (45.16)	3428 (6.96)	630 (-0.79)
2007	14166 (20.50)	2949 (16.15)	1918 (12.10)	40810 (20.82)	2778 (20.21)	4003 (23.78)	127 (20.95)	1580 (-19.26)	265 (77.85)	31 (-31.11)	4011 (17.01)	799 (26.83)
2008	18049 (27.41)	3239 (9.83)	2242 (16.89)	51923 (27.23)	2639 (-5.00)	5139 (28.38)	135 (6.30)	1632 (3.29)	319 (20.38)	54 (74.19)	5630 (40.36)	1133 (41.80)
2009	20581 (14.03)	3521 (8.71)	2373 (5.84)	50602 (-2.54)	2143 (-18.79)	5483 (6.69)	147 (8.89)	1291 (-20.89)	404 (26.65)	31 (-42.59)	5482 (-2.63)	1362 (20.21)
2010	23477 (14.07)	3928 (11.56)	2010 (-15.30)	53095 (4.93)	2436 (13.67)	6646 (21.21)	192 (30.61)	606 (-53.06)	475 (17.57)	44 (41.94)	6599 (20.38)	1678 (23.20)
2011	29421 (25.32)	4419 (12.50)	2764 (37.51)	56426 (6.27)	2586 (6.16)	6221 (-6.39)	182 (-5.21)	652 (7.59)	568 (19.58)	61 (38.64)	8169 (23.79)	2571 (53.22)
Average	9194.26	1958.63	1219.89	23127.00	1720.53	2836.42	78.95	3938.95	136.37	21.32	2749.26	584.79

Note: Figures in the brackets represent growth in relation to previous year.

Ennore port does not handled container trade during the study period

Table 4.6 presents the container traffic of major ports in India during the period of study. The port of Chennai had registered the highest growth of 45.06 percent in 2001 and the lowest growth was -2.00 percent in 1999. During the study period Chennai ports showed positive growth for all the years except in the year 1999. The volume of container traffic in Chennai port has increased from 1487 (‘000 tones) to 29421 (‘000 tones) during the period 1993 to 2011, followed by Cochin port which registered the highest growth of 64.32 percent in 1995 and the lowest growth of -9.41 percent in 1998. The Cochin port also registered positive growth rate of all the years except in the year 1994 and 1998. During the study period the volume of container traffic increased from 431 (‘000 tones) to 4419 (‘000 tones). Haldia dock showed highest growth of 224.58 percent in 1998 and the lowest growth of -38.55 percent in 1996. During the study period the Haldia dock showed fluctuating growth of container traffic. Haldia dock container traffic volume has increased from 95 (‘000 tones) to 2764 (‘000 tones) during the study period. Jawaharlal Nehru Port Trust showed high volume of container traffic during the study period. The container traffic volume have increased from 1712 (‘000 tones) to 56426 (‘000 tones). JNPT had registered the highest growth of 41.02 percent in 1995 and the lowest growth was -2.54 percent in 2009. Kandla port registered the highest growth of 103.34 percent in 1994 and the lowest growth of -29.56 percent in 1999. During the study period container growth showed fluctuating trend. The port of Kolkata showed highest growth of 37.21 percent in 2006 and the lowest growth was -29.89 percent in 2002. The Mormugao port had less volume of container traffic for all the years. The port had registered highest growth of 78.95 percent in 1997 and the lowest growth was -12.00 percent in the year 2001. The Port of Mumbai had registered high volume of container traffic for the first eight years, but later the growth had declining trend. The port of Mumbai had registered highest growth of 72.83 percent in the year 1994 and the lowest growth was -53.06 percent in the year 2010. The New Mangalore port container traffic was megre during the study period. Container traffic in Paradip port was very low, even the volume have not crossed 61 ('000 tones) during the whole period of study. It was the lowest average container traffic among all the major ports in India. Tuticorin port trust container traffic was found increasing convincingly in every year. The port had registered highest growth of container traffic (61.23 percent) in 1995 and the lowest growth of container traffic (-3.86) in the year 2001. The volume of container traffic has increased from 277 ('000 tones) in 1993 to 8169 ('000 tones) in 2011. The port of Visakhapatnam had registered the highest growth of 129.24 percent in the year 2005 and the lowest growth was -25.40 percent in 1996. The volume of the container traffic have increased from 85 ('000 tones) to 2571 ('000 tones) during the period 1993-2011.

The above table also reveals that the average volume of container traffic and the positions of various ports in handling container traffic. From the table it was evident that Jawaharlal Nehru Port Trust effected the highest average container traffic of 23127 ('000 tones) and was placed in first position among the major ports in India, followed by Chennai port trust with the average volume of container traffic of 9194 ('000 tones). The Mumbai port trust initially registered good growth of container traffic but later the volume declined. Even then the port managed to get a third position among the major ports (average 3938.95 '000 tonns). The container traffic performance placed Kolkata, Tuticorin, Cochin and Kandla 4th, 5th, 6th and 7th position respectively with reasonably good performance among the major ports. The Haldia dock showed average container traffic of 1219 ('000 tones) with the 8th position. The ports of Visakhapatnam, New Mangalore, Mormugao and Paradip had transacted below 500 (‘000 tones) of average container traffic and were placed in the last three positions respectively. The port of Ennore did not trade any container traffic during all the study years.

4.3.7. Performance Indicators of Major Ports in India

Port performance indicators are simply measures of various aspects of the ports operation. A good indicator should indicate the performance in most simple terms and also should be easy to calculate and simple to understand. It should provide insight to port management with regard to operations of key areas, which can be used, first, to compare performance with a target and second, to observe the trend in performance levels. The indicators should also be capable of being used as input for negotiations on port congestion surcharges, port development, port tariff considerations and investment decisions.

4.3.7.1. Average turnaround time of Major Ports in India

The ship turnaround time is the duration of the vessel's stay in port and is calculated from the time of arrival to the time of departure. Traditionally expressed in days, it is now common to express turnaround time in hours. The port authority normally compile statistics that would provide monthly and annual average turn-round time. The average turnaround time per ship is determined by dividing the total hours by the total number of ships calling at the port. In its basic form, ship turnaround time does not mean much, as the length of stay of a vessel is influenced by (a) the volume of cargo, (b) the facilities made available and (c) the composition of the cargo itself. Thus it becomes necessary for the port to break the basic ship turn-round time down for tankers, bulk carriers, container vessels and general cargo vessels, and even subdividing these into domestic trade, regional trade and ocean going vessels.

Table – 4.7

Average Turn-around Time of Major Ports in India (In days)

	Chennai	Cochin	Haldia	JNPT	Kandla	Kolkata	Mormugao	Mumbai	New Mangalore	Paradip	Tuticorin	Visakha-patnam	Ennore
1993	7.1	5.5	6.7	7.7	8.6	10.4	7.2	8.6	6.4	6	5.5	7.3	-
1994	7.2	4.5	5.7	4.3	7.4	9.5	6.2	8.8	5.4	5.7	5.8	6	-
1995	8	4	7.2	5.2	9.7	9.5	6.9	9.3	5.8	5.6	5.4	5.7	-
1996	8.2	4.2	6.8	9	14.9	9.1	6.3	10.1	5.2	6.3	6	7.8	-
1997	8.3	3.9	6	6	9	7.7	6.3	7.7	4.4	4.9	5.1	5.6	-
1998	7.1	4	5.3	4.5	9	7.5	6.3	8.4	4.1	5.1	5	6.1	-
1999	7.5	3.6	4.7	2	8.6	6.6	4.8	7	3.7	4.1	4.9	5.3	-
2000	6.4	3.2	5.2	1.7	6.2	6.6	4.3	5.6	3.8	3.9	6.4	4.8	-
2001	5.8	3.1	4	2.5	4.7	5.5	4.3	5.2	2.9	4.2	4.1	3.7	-
2002	5.3	2.4	4	2.3	6.5	4.7	2	5.5	2.7	4	4.1	3.5	3.6
2003	3.7	2.2	3	2.3	5.9	4.5	3.9	5.1	1.9	3.4	3.6	3.7	2.2
2004	4.6	2.2	2.9	2	5.1	4.3	4.5	4.1	2.4	3.4	2.6	3.3	1.9
2005	3.9	2.3	3	1.8	4.6	4.2	4.3	4.2	3	3.4	2.7	3.2	1.7
2006	3.3	2.1	4	2	4.4	4.1	4.1	4.1	3	3.6	2.8	3.8	2.2
2007	3.4	2.2	4	1.7	5.5	3.9	4.5	4.6	3.1	3.5	3.7	3.6	1.9
2008	4.6	2	4.3	1.9	5.1	4.9	4	4.4	3.2	5.5	3.8	3.9	2.0
2009	4.2	2.1	4.2	2	5.2	4.6	3.6	5	3	4.8	3.7	3.9	2.4
2010	4	2.1	5	2	5	5.5	5.6	4.6	3.1	9	4	4.8	2.4
2011	4.4	2.2	4.5	2.7	5.9	5.4	6.5	4.5	2.7	7.7	4.1	5.8	2.8
Average	**5.63**	**3.04**	**4.76**	**3.35**	**6.91**	**6.24**	**5.03**	**6.15**	**3.67**	**4.95**	**4.38**	**4.83**	**2.31**

Table 4.7 presents the performance indicators of Major Ports in India, in terms of average turnaround time. From the table it is observed that Chennai Port having the highest turnaround time of 8.3 in 1997 and the lowest of 3.3 in the year 2005. On an average the port registered the turnaround time 5.63 days, followed by Cochin port with highest turnaround time in 5.5 days in the year 1993 and the lowest turnaround time of 2 days in 2008. On an average the port registered turnaround time of 3.04 days during the study period. The Haldia port experienced the highest turnaround time of 6.8 in 1996 and the lowest turnaround time of 2.9 days in the year 2004, with an average of 4.76 days. Jawaharlal Nehru Port Trust showed highest turnaround time of 7.7 days in 1993 and the lowest turnaround time of 1.7 days in 2000 and 2007 respectively. The average turnaround time was 3.35 days. Kandla port had an average of 6.91 days turnaround time with the highest turnaround time of 14.9 days in 1996 and the lowest of 4.4 in the year 2006. The Kolkata port's highest and lowest turnaround time ranged between 10.4 to 3.9 in 2007 averaging 6.24 days. Mormugao port recorded highest turnaround time of 7.2 days in 1993 and the lowest was 2 days in the year 2002. The Mumbai port's highest turnaround time was 10.1 lowest was 4.1 days. New Mangalore port recorded average turnaround time 3.67 days. The Paradip port showed the highest turnaround time of 6.3 days in the year 1996 and the lowest of 3.4 days in the year 2004, 2005 and 2006. The port of Tuticorin showed the highest turnaround time of 6.4 days in the year 2000 and the lowest of 2.6 days in the year 2004. The port of Visakhapatnam had average turnaround time of 4.83 days with turnaround time ranging between 7.3 to 3.2 days. Ennore port stated its operation in 2002, from the study period the port shows highest turnaround time of 3.06 days in 2002 and the lowest turnaround time of 1.7 days in 2005. On an average port registered the turnaround time of 2.31 during the study period.

On the basis of the average turnaround time among Major ports in India, the port of Cochin performed well during the study period i.e. 3.04 days, followed by JNPT 3.35 days. The table depicts an interesting observation i.e. initially all the major ports of India's turnaround time were high but in subsequent years invariably all the ports could reduce the turnaround time. That means the duration of vessels stay in the port has been reduced compared to the previous years, which is a good sign as far as the overall performance of Indian port is concerned. In terms of turnaround time Kandla port was the worst followed by Mumbai, Chennai and Mormugao.

4.3.7.2. Average Pre-berthing time of Major Ports in India

A major problem with the Indian ports is pre berthing detention. It is the waiting time for a ship before it gains entry to a berth in a port. Berth allocation constitutes an integral part of marine services. When vessels call at anchorage, the marine department of each port allots berths for cargo handling operations. The allocations primarily depend upon the availability of vacant berths, equipment support available in the port and the type of cargo handled. Pre-berthing time is nothing but time spent on waiting by a vessel before it is allotted a berth in the port for loading / unloading the cargo or containers.

Table – 4.8

Average Pre-berthing time of Major Ports in India (In Days)

	Chennai	Cochin	Haldia	JNPT	Kandla	Kolkata	Mormugao	Mumbai	New Mangalore	Paradip	Tuticorin	Visakh-apatnam	Ennore
1993	2.1	1	2	2.3	3.5	0.8	1.1	2.3	1.4	1.5	1.6	1.8	-
1994	1.9	1	1.6	0.8	3	1	0.8	2.4	1.9	1.4	2	1.3	-
1995	2.7	0.9	2	1.8	4.9	0.9	0.7	3.4	2.2	1.5	1.9	1.1	-
1996	3.5	1.2	2.6	2.2	9.6	1.4	2.8	4.2	1.7	2.4	2.3	2.4	-
1997	4.1	1.1	2.2	2.1	6.6	1	2.2	4.6	1.5	1.6	1.6	1.6	-
1998	3	1.1	2	1.7	5.1	1.1	2.1	2.9	1.1	1.7	1.6	2	-
1999	3.6	0.9	1.3	1.3	3.3	1	1.4	2.1	0.9	1.2	1.6	1.6	-
2000	2.8	0.9	1.6	1.6	3	1	1.1	1.4	1.1	1.1	3	1.4	-
2001	2.4	0.7	0.9	0.9	1.5	0.6	1.3	1.3	0.8	1.4	1.4	0.8	-
2002	2	0.6	0.9	0.9	3.1	0.6	1.8	1.3	0.8	1.2	1.6	0.8	0.4
2003	1.1	0.5	0.9	0.8	2.2	0.5	1.9	1.1	0.2	0.8	1.4	0.8	0.08
2004	2.3	0.4	1	0.8	2	0.5	2.6	0.9	0.6	0.7	0.7	0.8	0.07
2005	0.9	0.5	1.4	0.7	1.7	0.4	2.4	0.8	0.8	0.8	0.5	0.8	0.07
2006	0.7	0.6	2.2	0.9	1.6	0.4	2.1	1	0.8	1	0.7	1	0.2
2007	0.6	0.6	2	0.6	2.7	0.4	2.5	1.2	0.6	1.1	1.2	0.9	0.1
2008	1.6	0.6	2.9	0.8	2.6	0.5	2.2	1	0.6	3	1.2	1.1	0.3
2009	1.4	0.7	3.4	1	2.6	0.6	1.9	1.3	0.6	2.3	1.1	1.3	0.27
2010	1.3	0.8	4.5	1	2.6	0.9	3.7	1.3	0.8	6.3	1.4	1.9	0.37
2011	0.04	0.19	1.15	0.57	1.51	0.14	0.59	0.32	0.03	0.10	0.39	0.10	0.37
Average	**2.00**	**0.75**	**1.92**	**1.20**	**3.32**	**0.72**	**1.85**	**1.83**	**0.97**	**1.64**	**1.43**	**1.24**	**0.22**

Table 4.8 portrays the average pre-berthing time of Indian major ports. A glance at the pre-berthing time at different major ports over years show that Chennai ports had the highest pre-berthing time of 4.1 in 1997 and the lowest of 0.04 days in 2011. The port of Cochin had the highest pre-berthing time of 1.2 in the year 1996 and the lowest of 0.19 days in 2011. Haldia port showed a highest pre-berthing time of 4.5 days in the year 2010 and the lowest of 0.9 days in the year 2001, 2002 and 2003. JNPT had the maximum of 2.3 pre-berthing time days in the year 1993 and the lowest was 0.57 days in the year 2011. Kandla port had recorded the maximum pre-berthing time of 9.6 days in the year 1996 and the lowest of 1.5 days in the year 2011. Kolkata port had the highest pre-berthing time 1.4 in the year 1996 and the lowest of 0.14 days in the year 2011. Marmugao port shows the maximum pre-berthing time 2.8 days in the year 1996 and the lowest of 0.59 in the year 2011. Mumbai port registered the maximum pre-berthing of 4.6 days and the lowest pre-berthing of 0.32. New Mangalore had the highest pre-berthing time 2.2 days in 1995 and the lowest time was 0.03 in the year 2011. The port of Pardip had highest pre-berthing time of 6.3 days in the year 2010 and the lowest time was 0.1 in the year 2011. Tuticorin port shows the highest pre-berthing time of 1.9 in 1995 and the lowest time were 0.39 in the year 2011. The port Visakhapatnam shows the highest pre-berthing time of 2.4 in the year 1996 and the lowest of 0.1 days from 1993 to 2011. The Ennore port shows the maximum pre-berthing time of 0.4 days in the year 2002 and the lowest of 0.1 days during 2007. In the year 2011 almost all the major ports recorded the least pre berthing time. It shows an improved performance of all the ports in 2011 where in the pre berthing time for all the major ports was minimized.

Average Pre-berthing time shows the vessels / ships waiting time for getting the berth into the port for cargo handling. It can be seen from the table that almost all the ports have reduced the pre-berthing time during 2011. Reasons may be modernization and increased infrastructure facilities the ports have acquired which has enabled then to performed faster than the earlier years. From this table it can be seen that Kolkata port pre-berthing time has reduced from 0.8 to 0.14 during the study period. The port performed the best, as on an average it showed less than 1 day pre-berthing time i.e 0.72 days. The Cochin port also performed quite efficiently in terms that during the study period it showed 0.78 days of pre berthing time. The Mangalore port also had reduced its pre-berthing waiting time to 0.97 days during the study period. Rest of the ports had acquired the pre-berthing time more than 1 day.

4.4. Summary:

In this chapter an attempt was made to analyze the trend and growth of Major Ports in India in terms of tones. An analysis of Export, Import and Transshipment trade of Major Ports in India clearly indicated that the growth rate of exports was less than imports during the study period. During the study period export linear growth rate shows an average of 9.19 percent, at the same time average linear annual growth rate of Imports was 12.71 percent. These growths were statistically significant at 1% level. The commodity of POL registered the highest growth among all the 14 commodities and shared a major portion of the total with 42.92 percent alone of the overall commodities thus was placed in first position, followed by Iron ore having 20.07 percent of total trade with the volume of 57010 (‘000 tones). The commodity of coal shared 18.54 percent and took the third place among the overall commodities. Further when it was attempted to analyse the total cargo handled and share percentage of respective ports out of overall cargo handled by major ports of India it was found that ports of Vishakhapatnam, Kandla, Chennai, Mumbai and Mormugao occupied the first five positions respectively. The locational advantage, modernized cargo handling facilities and industrialization might have been the reasons for attracting more traffic. The export trend percentage had gone up from 100 in 1993 to 317.44 in 2011. Whereas Import trend percentage reached 343.90 in the year 2011 and the trend percentage of transshipment trade went up to 777.12 during this study period with the base year 1993. From this analysis it was observed that in terms of performance of container traffic. Jawaharlal Nehru Port Trust had the average container traffic of 23127 ('000 tones) with the first position among the major ports in India, followed by Chennai port trust registering average volume of container traffic of 9194 ('000 tones). The Mumbai port trust registered reasonably good growth of container traffic but in later years the volume has declined. Even then the port could manage to get the third position among the major ports. Traditional performance Indicators in form of average turnaround time and pre-berthing time when employed to evaluate the performance of major ports of India it was observed that Port of Cochin performed best during the study period with 3.04 days of turnaround time, followed by JNPT having 3.35 days turnaround time. It indicated that the duration of vessels stay in the port has declined as compared to the previous years. The reason may be of port modernization and increased infrastructure facilities available in recent times. Kolkata port ranked high in terms of average Pre-berthing time performance among the major ports in India. On an average the port showed less than 1 day pre-berthing time (0.72 days). The Cochin port also performed reasonably well during the study period with 0.75 days of pre berthing time. New Mangalore port also had less than one day pre-berthing waiting time with an average 0.97 days during the study period. Rest of the ports had average pre-berthing waiting time more than 1 day. It shows that the vessels waiting time for getting berth in the port have been managed well by most of the ports in India and have reduced as compared to the previous years because of infrastructure facilities which have facilitated cargo handling and thereby reduced the time considerably.

CHAPTER – 5

MEASURING THE OPERATIONAL EFFICIENCY OF INDIAN MAJOR PORTS

5.0. Introduction

Many a earlier studies have evaluated operational performance of ports and predominantly the size of the port has been related to the better performance. This chapter examines the relationship between size of the port and its efficiency indirectly to validate or refute the general understanding "Bigger ports perform better". In the same line an attempt has been made to check whether the performance is conditioned to size or not, as far as Indian major ports are concerned. The hypothesis tested here is that the size is not a determining factor of port/terminal performance. The relationship between the size and the efficiency level of the port is examined through Data Envelopment Analysis (DEA), which is considered a more effective model for evaluating efficiency in terms of decision making unit for port performance (Wang T.F. et al, 2003).

Since majority of the goods traded are transported through seaports, seaborne transport services have drawn the attention and concern of almost every regions in the universe. Seaborne trade, except for those countries who are totally bound by land from all the sides, contribute strength to the economic development of any country. Seaborne trade is the backbone of development for many countries (Cullinane et al 2002), as this contribute almost 77 percent of the total volume of world trade, and a mere 16 percent of tradable goods moves overland, 6.7 percent through pipeline trade and only 0.3 percent are traded over through air (Lloyd's MIU, 2007). Within these seaborne trade, majority of the goods are being transported in the form of containerization as well as bulk cargo (Galhena, 2008). Hence the performance of ports, more specifically the volume of container traffic can indicate how the seaborne trade is being transacted through the ports, and this calls for an assessment of the performance of seaports. The measurement of efficiency with the help of sophisticated analytical techniques can help the authorities to identify the area that needs attention, so that in the face of increased competition, corrective steps can be taken for improved efficiency, to face the competition with strength.

The fundamental concept of measuring the efficiency is the ratio of total outputs divided by total inputs. Charnes et al (1978) were the first to introduce the Data Envelopment Analysis, as a multi-factor productivity module, for measuring the relative efficiencies of decision making units (DMUs). This model measures the constant return to scale efficiencies but not on the variable return to scale efficiency. To overcome the limitations of Charnes et al, Banker et al (1984) brought out a new concept of BCC model which measures the variable return to scale efficiency of DMUs.

In many a performance evaluation studies, Data envelopment analysis (DEA) has been applied to measure the relative efficiency of DMUs. Roll and Hayuth (1993) were the first who used the Data envelopment analysis in their study on the port sector. Martinez-Budria et al (1999) evaluated the Spanish port performance. Tongzon (2001) assessed the performance of 16 terminals in various countries. Itoh (2002) examined Japanese port performance and Turner et al (2004) enquired on the North-American terminal performance with the help of DEA analysis. Barros and Athanassiou (2004) also analysed the efficiency of two Greek and four Portuguese ports with the help of same tool. The literature review clearly indicate that majority of research on port efficiency had adopted DEA techniques for their analysis.

For the DEA analysis the output of container ports have been commonly measured by its Twenty foot Equivalent Units, the number of TEUs that passed through the port from one transport carrier to another. Generally the container ports with greater TEU throughput are considered to be more productive than ports with less TEU throughput. TEU throughput has also been used in Data Envelopment Analysis (DEA) and stochastic frontier analysis models for investigating the relative technical efficiency among container ports (Cullinane, 2002; Cullinane and Song, 2006), where technical efficiency is defined as the maximum efficiency obtainable in the use of a given level of resources.

5.1. DEA technique

Data Envelopment Analysis (DEA) was developed by Charnes et al in the year 1978. The DEA is essentially a linear programming technique that converts multiple inputs and multiple outputs into measurement of efficiency. It is classified as a non-parametric test because it allows the analysis of input-output relationships without using identical pre-defined production function for the organizations. This analytical technique has been used even to measure the relative efficiency of both nonprofit organization such as schools, hospitals and profit seeking organizations i.e. banks and restaurant (Athanassopoulos and Curram, 1996). Siems (1992) have indicated that the measurement of efficient unit has been carried out in most of the cases between weighted sum of outputs and weighted sum of inputs. Marinho (2003) affirms that DEA technique set score for each DMU that represents units' relative performance. Normally, these scores are fixed either from 0 to 1 or from 0% to 100%. The efficient unit acquires the value equal to 1 or 100%. Macedo and Souza (2003) indicated some other characteristics of the DEA method like using inputs and outputs in their physical values and calculate the efficiency ratios based on real data. The DEA analysis have been used as an supplement to central tendency and cost benefit analysis. It considers the possibility that efficient units not only represent deviations but also possibly act as benchmarks to be taken for measurement by other units.

After considering suitability of DEA technique which has the capability to give robust result, it seemed most viable and appropriate to adopt the same for port performance analysis. In addition to its non-parametric nature this technique has been found to be most suitable, as it does not require an explicit priori determination of relationships between input and output variables. The model DEA also has the advantage of being an efficiency evaluation model based on mathematical calculations. Wang et al (2003) suggested that DEA as the most effective model for evaluating efficiency in terms of decision making units for port operational performance. DEA application can be input-oriented and output-oriented. Input-oriented DEA minimizes the input so that the desired level of output is achieved. Output- oriented DEA maximize the output while the inputs is kept as constant. Both input and output oriented model seek maximum efficiency, minimizing inputs or maximizing outputs. In the era of globalization many container ports often need to review their capacity in order to make sure that they can provide better services to port users and maintain their competitive edge. Based on these perspectives, this study has used output-oriented DEA models to evaluate the efficiency of port operations.

In terms of model orientation, the input – oriented data envelopment analysis is closely related to operational and managerial issues, while the output-oriented model is closely associated with planning and strategies (Cullinane et al., 2005). With the adoption of economic liberalization and port sector reforms, many ports are expected to frequently review their capacity in order to ensure that they can provide satisfactory services to port users and maintain their competitive edge. Based on these perspectives, this study used output-oriented DEA – CCR and output-oriented DEA-BCC to evaluate the efficiency of major ports in India.

5. 2. DEA Models

5. 2. 1. Standard DEA – CCR and DEA – BCC Models

Formally the model pre supposes, if inputs be $x_k = (x_{1k}, x_{2k}, \ldots, x_{Mk}) € R^M_+$ to produce outputs $y_k = (y_{1k}, y_{2k}, \ldots, y_{Nk}) € R^N_+$. The row vectors x_k and y_k form the k^{th} rows of the data matrices X and Y, respectively. Let $\lambda = (\lambda_1, \lambda_2, \ldots \lambda_k) € R^K_+$ be non negative vector, which forms the linear combinations of the K firms. Finally, let e = (1,1,…,1) be a suitably dimensioned vector of unity values.

The output-oriented DEA model seeks to maximize the proportional increase in output while maintaining the input set constant. An output-oriented efficiency measurement problem can be written as a series of K linear programming envelopment problems, with the constraints differentiating between the DEA-CCR and DEA-BCC models, as shown in (1) – (5).

$$\max_{U,\lambda} \quad U \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Subjected to

$$Uy'_k - Y'\lambda \leq 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$X'\lambda - x'_k \leq 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\lambda \geq 0 \text{ (DEA – CCR)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$e\lambda' = 1 \text{ (DEA – BCC)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

The combination of equations from (1) – (4) and (1) – (5), respectively, from the DEA-CCR and DEA-BCC models. The output-oriented measure of technical efficiency of the k^{th} DMU, denoted by TE_k, can be computed by Eq. (6).

$$TE_k = 1 / U_k \qquad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The technical efficiency derived from DEA – CCR and DEA – BCC models are frequently used to obtain a measure of scale efficiency, as shown in Eq. (7) (Cooper et al, 2000).

5. 2. 2. Scale Efficiency

For measuring the scale efficiency (SE) of the ports the following formula have been used.

$$SE_k = U_{CCR\_k} / U_{BCC\_k} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where SE_k, indicates the scale efficiency of the k^{th} DMU, while U_{CCR_k} and U_{BCC_k} are the technical efficiency measures for DMU_k derived from applying the DEA-CCR and DEA-BCC models respectively. $SE_k = 1$ indicates scale efficiency and $SE_k < 1$ indicates scale inefficiency.

Scale inefficiency can be due to either increasing or decreasing returns to scale which can be determined by inspecting the sum of weights, eλ', under the specification of the CCR model. To identify the nature of returns to scale, first the CRS score is compared with VRS scores. For a given port, if the VRS score equals the CRS score, the port is said to be at a state where, law of constant return to scale prevails. Whereas increasing returns to scale and decreasing returns to scale prevail when the sum is greater than, or less than one respectively.

5. 2. 3. DEA Additive CRS and VRS models

The basic DEA models may be either Input or Output oriented. But DEA – Additive model takes the combination of both Input- Output orientation in a single model. E. q (8)

$$\begin{aligned} &\max Z = es^{-} + es^{+} \\ &s.t. \\ &x_0 = x\lambda + s^{-} \\ &y_0 = y\lambda - s^{+} \\ &e\lambda = 1 \\ &\lambda \geq 0, s^{-}, s^{+} \geq 0 \end{aligned} \qquad \text{--------------- (8)}$$

5. 2. 4. DEA A&P Super Efficiency Model

The Standard DEA – CCR and BCC models dichotomize ports into inefficient and efficient ones. However, it is not possible to differentiate the degree of efficiency of the efficient ports i.e. differentiating based on efficiency score the most efficient and efficiency downs the ladder. Since all efficient ports receive the same efficient score of one. The score one may be obtained by multiple number of ports, and it may not be possible to identify which one is more efficient and to what extent, as compared to other ports. To overcome this limitation, Andersen and Petersen (1993) introduced super efficiency model, which measures the super efficient performance among the efficient units. E. q (9)

$$
\begin{aligned}
& \operatorname{Max}\ \theta - \varepsilon \left[\sum_{i-1}^{m} S_i^{-} + \sum_{r-1}^{s} S_r^{+} \right] \\
& s.t. \\
& \sum_{\substack{j-1 \\ j \neq p}}^{n} \lambda_j y_v - s_r^{+} = y_{m,} r = 1, \ldots, s \\
& \sum_{\substack{j-1 \\ j \neq p}}^{n} \lambda_j x_v + s_i^{-} = \theta x_{ip,} i = 1, \ldots, m \qquad \text{------------------ (9)} \\
& \lambda_j \geq 0\ j = 1, \ldots, n \\
& S_r^{+}, S_i^{-} \geq 0\ r = 1, \ldots, s, i = 1, \ldots, m
\end{aligned}
$$

In this study, a composite list of input and output variable have been considered on the basis of the relevant literature listed in table below. After taking into consideration the availability of data and the correlation among the variables, finally the above inputs and outputs to be used in the various DEA models have been selected.

5. 3. Compilation of Input and Output Variables

Variables	Contents	Relevant Literature
Input Variable	No of Berth	Rios and Macada (2006), Liu (2008)
	Berth Length	Al-Eraqi A. Salem (2008), Cullinane K et. al (2006), Cullinane and Wang (2006),
	No of Equipments	Al-Eraqi A. Salem (2008), Rios and Macada (2006), Wu and Lin (2008), Cullinane and Wang (2006), Liu (2008)
	No of Employees	Roll and Hayuth (1993), Rios and Macada (2006),
Output Variable	Container Throughput (TEU)	Valentine and Gray, Wu and Lin (2008), Cullinane K et. al (2006), Cullinane and Wang (2006),
	Total Traffic	Coto-Millan et. al. (2000), Valentine and Gray, Al-Eraqi A. Salem (2008), Liu (2008)

While evaluating the operational efficiency of ports, container throughput (TEU), total cargo handling and the number of berths were used as the productivity parameters and were selected to measure port efficiency. On the other hand, port infrastructure, equipments (such as wharves, granes, straddle) land, manpower are all resource inputs that contribute to the port's productivity. The equipments have become particularly important, because the loading and unloading function are carried out with the help of equipments. For this reason the ports berth length and number of berths also impart an important influence on the measurement of a port's efficiency.

5. 3. 1. Pearson Correlation results

	Total traffic	Container throughput	No of berths	Berth length	No of equipment s	No of employees
Total traffic	1.000					
Container throughput	0.286	1.000				
No of berths	0.197	0.008	1.000			
Berth length	0.334	-0.024	0.926	1.000		
No of equipments	0.086	0.535	0.482	0.474	1.000	
No of employees	0.094	-0.070	0.837	0.795	0.532	1.000

In order to further confirm whether the selection of input and output variables is able to fully explain the effect on port efficiency, the input and output variables were subject to conform to 'isotonicity' i.e. as inputs increase, outputs should not decrease. This was verified using correlation among the variables, so that output variables that are not positively correlated should be eliminated from the list of table variables specified to be studied. According to Jenkins and Anderson (2003) the variable those show the correlation below 0.6, indicate that there is no need for variable elimination. The variables selected for this study have justified their selection in terms of explaining port efficiency as no where the correlation was more than 0.6.

5. 4. Analysis

5. 4. 1. Summary Statistics of the variables

	Output		***Input***			
	Total Traffic	*Container Throughput*	*No of Berths*	*Berth Length*	*No of Equipment*	*No of Employees*
Mean	27826908	293.77	17.21	3656.12	37.61	6118.07
Median	25462500	111.00	14.00	3464.00	28.00	3961.50
Maximum	81880000	4271.00	49.00	7653.00	201.00	26614.00
Minimum	3007000	0.00	3.00	858.00	-8.00	1476.00
Std. Dev.	17027515	664.71	11.04	1858.05	32.06	5338.04
CV	6.12	2.26	0.64	0.51	0.85	0.87
Skewness	0.72	4.29	1.37	0.55	1.13	1.99
Kurtosis	2.88	22.54	4.33	2.40	4.81	7.01
Jarque-Bera	20.05	4327.59	88.12	14.77	79.43	302.85
Probability	0.00	0.00	0.00	0.00	0.00	0.00
Reliability	19718250	1067.75	11.50	1698.75	71.50	6284.50
Sum	6340000000	66980.00	3925.00	833594.70	8575.00	1394920.00
Obser	228	228	228	228	228	228

Thus the variable those were included for the performance analysis of all the Major ports in India during 1993-2011 are for Output – Total traffic, Container throughput and for Input – Number of berths, Berth length, Number of equipments and Number of employees. The required secondary data for this analysis was collected individually from all the Port Trusts and some of the information have been collected from the Centre for Monitoring Indian Economy (CMIE) database as well as from annual report of the respective ports, India stat website etc. The summary statistics presented in table 5.4.1 depict that the variables like Total traffic and

Number of employees had a highest mean value during the whole study period, also this table showed positive mean value for all the input and output variables. The coefficient of variation were found to be reasonably low indicating that the variations were not abnormal. The variables were found to be positively skewed but except container throughput rest of the variables were not heavily skewed. It should be noted that all the variables qualify under reliability test to be included in the measurement of efficiency of major ports in India.

Table – 5. 4. 2. Standard DEA - CCR

	Chennai	Cochin	Haldia	JNPT	Kandla	Kolkata	Mormugao	Mumbai	NMPT	Paradip	Tuticorin	Vizag	Ennore
1993	0.736	0.514	0.719	1.000	1.000	0.326	1.000	1.000	0.502	1.000	1.000	0.568	0.000
1994	0.685	0.522	0.680	1.000	1.000	0.326	1.000	1.000	0.553	1.000	1.000	0.572	0.000
1995	0.637	0.591	0.615	1.000	1.000	0.297	1.000	0.980	0.494	1.000	1.000	0.573	0.000
1996	0.619	0.500	0.620	1.000	1.000	0.260	1.000	0.910	0.560	1.000	1.000	0.612	0.000
1997	0.707	0.546	0.608	1.000	1.000	0.227	1.000	0.859	0.737	1.000	1.000	0.614	0.000
1998	0.690	0.378	0.623	1.000	1.000	0.229	1.000	0.828	0.831	1.000	1.000	0.555	0.000
1999	0.552	0.341	0.633	1.000	1.000	0.219	1.000	0.672	0.783	1.000	1.000	0.594	0.000
2000	0.520	0.292	0.559	1.000	1.000	0.189	1.000	0.485	0.933	1.000	1.000	0.582	0.000
2001	0.600	0.326	0.654	1.000	1.000	0.117	1.000	0.299	0.951	1.000	1.000	0.747	0.000
2002	0.461	0.307	0.606	1.000	1.000	0.073	1.000	0.227	0.933	0.776	1.000	0.662	1.000
2003	0.400	0.383	0.653	1.000	1.000	0.079	1.000	0.181	1.000	0.753	1.000	0.637	1.000
2004	0.401	0.984	0.672	1.000	1.000	0.098	1.000	0.215	1.000	0.657	1.000	0.591	1.000
2005	0.445	0.877	0.664	1.000	1.000	0.109	1.000	0.233	1.000	0.676	1.000	0.546	1.000
2006	0.480	0.265	0.792	1.000	1.000	0.118	1.000	0.320	1.000	0.724	1.000	0.613	1.000
2007	0.998	0.502	0.782	1.000	1.000	0.413	1.000	0.347	1.000	0.833	1.000	0.599	1.000
2008	0.666	0.294	0.644	1.000	1.000	0.316	1.000	0.302	1.000	0.786	1.000	0.602	1.000
2009	0.702	0.308	0.575	1.000	1.000	0.332	1.000	0.270	1.000	0.796	1.000	0.542	1.000
2010	0.621	0.283	0.413	1.000	1.000	0.346	1.000	0.242	1.000	0.865	1.000	0.499	1.000
2011	0.725	0.036	0.423	1.000	1.000	0.327	1.000	0.296	0.918	0.832	1.000	0.517	1.000
Average	***0.613***	***0.434***	***0.628***	***1.000***	***1.000***	***0.232***	***1.000***	***0.509***	***0.852***	***0.879***	***1.000***	***0.591***	***1.000***
Rank	***9***	***12***	***8***	***1***	***1***	***13***	***1***	***11***	***7***	***6***	***1***	***10***	***1***

Note: Ennore Port started its operation in the year 2002.

With a view to acquire information to identify the relative efficient and inefficient ports in India during 1993-2011, study adopted different DEA models. Table – 5.4.2 presents the results of the DEA- CCR model and its ranking for major ports in India. The DEA – CCR model has measured the technical efficiency of the ports under study. From results portrayed in the table it was observed that the port of JNPT, Kandla, Mormugao, Tuticorin, and Ennore were seen to have operational efficiency throughout the study period. The port of Chennai, Cochin, Haldia, Kolkata and Visakhapatnam were found to be inefficient all through the years. Mumbai port depicted efficiency in the first two years which slipped down to inefficiency in later years. The port of New Mangalore showed efficiency only during 2003 – 2010, and for rest of the years it was observed as inefficient unit, whereas Paradip port which showed efficiency during first nine years, later it was found to be inefficient. From the analysis of the results presented in the table it was inferred that 5 major ports i.e. 38.46% showed efficiency, while rest of the 8 major ports i.e. 61.54% were found to be technically inefficient during the study period.

The efficiency scores for the sample under study based on the Standard DEA – CCR shows, five ports like JNPT (1.000), Kandla (1.000), Mormugao (1.000), Tuticorin (1.000) and Ennore (1.000) have occupied the first five positions among the Major Ports in India and identified as efficient ports, followed by Paradip port in fifth position with an average of 0.879. The other ports like Haldia, Chennai, Visakhapatnam, Mumbai, Cochin and Kolkata acquired the position from eighth to thirteen respectively. Cochin & Kolkata ports remained at the lowest position in the ranking list.

Table – 5. 4. 3. Standard DEA – BCC

	Chennai	Cochin	Haldia	JNPT	Kandla	Kolkata	Mormugao	Mumbai	NMPT	Paradip	Tuticorin	Vizag	Ennore
1993	1.000	0.606	1.000	1.000	1.000	0.334	1.000	1.000	0.853	1.000	1.000	0.942	0.000
1994	1.000	0.614	1.000	1.000	1.000	0.338	1.000	1.000	0.969	1.000	1.000	0.987	0.000
1995	1.000	0.676	0.649	1.000	1.000	0.313	1.000	1.000	0.605	1.000	1.000	1.000	0.000
1996	1.000	0.599	0.636	1.000	1.000	0.291	1.000	1.000	0.663	1.000	1.000	1.000	0.000
1997	0.990	0.651	0.630	1.000	1.000	0.269	1.000	1.000	1.000	1.000	1.000	1.000	0.000
1998	1.000	0.436	0.635	1.000	1.000	0.306	1.000	1.000	1.000	1.000	1.000	0.926	0.000
1999	1.000	0.418	0.654	1.000	1.000	0.317	1.000	1.000	1.000	1.000	1.000	0.877	0.000
2000	1.000	0.361	0.578	1.000	1.000	0.324	1.000	0.952	1.000	1.000	1.000	0.853	0.000
2001	1.000	0.389	0.712	1.000	1.000	0.227	1.000	0.758	1.000	1.000	1.000	1.000	0.000
2002	0.917	0.346	0.715	1.000	1.000	0.151	1.000	0.672	1.000	0.792	1.000	1.000	1.000
2003	0.821	0.422	0.762	1.000	1.000	0.179	1.000	0.626	1.000	0.773	1.000	1.000	1.000
2004	0.849	1.000	0.830	1.000	1.000	0.200	1.000	0.669	1.000	0.729	1.000	1.000	1.000
2005	0.959	1.000	0.915	1.000	1.000	0.220	1.000	0.756	1.000	0.852	1.000	1.000	1.000
2006	0.945	0.325	0.983	1.000	1.000	0.217	1.000	1.000	1.000	0.880	1.000	1.000	1.000
2007	1.000	0.528	0.884	1.000	1.000	0.437	1.000	0.964	1.000	0.834	1.000	1.000	1.000
2008	0.915	0.326	0.693	1.000	1.000	0.325	1.000	0.879	1.000	0.789	1.000	0.995	1.000
2009	0.852	0.319	0.637	1.000	1.000	0.338	1.000	0.718	1.000	0.797	1.000	0.885	1.000
2010	0.834	0.303	0.471	1.000	1.000	0.356	1.000	0.686	1.000	0.870	1.000	0.824	1.000
2011	0.824	0.330	0.477	1.000	1.000	0.338	1.000	0.667	1.000	0.857	1.000	0.832	1.000
Average	***0.942***	***0.508***	***0.730***	***1.000***	***1.000***	***0.288***	***1.000***	***0.860***	***0.952***	***0.904***	***1.000***	***0.954***	***1.000***
Rank	***8***	***12***	***11***	***1***	***1***	***13***	***1***	***10***	***7***	***9***	***1***	***6***	***1***

Note: Ennore Port started its operation in the year 2002.

Table - 5.4.3 presents the results of the DEA-BCC model and the ranks of Major Ports in India during 1993-2011. The DEA – BCC model measures pure technical efficiency. From this table it was observed that the port operations of JNPT, Kandla, Mormugao, Tuticorin and Ennore were again rated of being efficient throughout the period of time. The port of Kolkata showed pure technical inefficiency throughout the period of time. The other ports like Chennai, Cochin, Haldia, Mumbai, New Mangalore, Paradip and Visakhapatnam showed fluctuating performance during the study period. Comparing the results of (DEA-CCR) and (DEA-BCC), the efficiency values obtained under the DEA-BCC model were higher than those yielded by the DEA-CCR model. The reason is that the DEA-CCR model measures the constant return to scale while the DEA-BCC measures variable return to scale. From the table it was also noted that 38.46% of the ports i.e. five ports showed efficiency and rest 61.54% of the ports i.e. eight ports showed inefficiency during the study period. The inefficient ports had acquired the average efficiency scores less than 1 during the study period. This indicated that these container ports have lot of room to improve their technical efficiencies as they are indicated technical inefficient as per the table. To improve their efficiency either the ports need to reduce their input to a reasonable level or expand their output to profitable level. But for improving the efficiency of container ports, increasing changeable outputs may be more appropriate than reducing the given inputs. These ports also need to adopt hub strategy i.e. adopting strategy where all kind of container traffic can be transacted, to increase the container throughputs and cargo traffic of these ports. Also it is necessary to seek cooperation strategies between ports and improve their transport infrastructure to link with the hinterland.

Efficiency ranking under DEA-BCC showed JNPT, Kandla, Mormugao, Tuticorin and Ennore acquired top positions with efficient port operations, which was followed by Visakhapatnam, New Managalore and Chennai with 6th ranks to 8th ranks during the study period. Other ports like Paradip, Mumbai, Haldia, Cochin and Kolkata were ranked as the bottom five port as per their efficiency level.

Table. 5. 4. 4. Scale Efficiency Measurement of Major Ports in India

	Chennai	Cochin	Haldia	JNPT	Kandla	Kolkata	Mormugao	Mumbai	NMPT	Paradip	Tuticorin	Vizag	Ennore
1993	0.736	0.848	0.719	1.000	1.000	0.976	1.000	1.000	0.589	1.000	1.000	0.603	0.000
1994	0.685	0.850	0.680	1.000	1.000	0.964	1.000	1.000	0.571	1.000	1.000	0.580	0.000
1995	0.637	0.874	0.948	1.000	1.000	0.949	1.000	0.980	0.817	1.000	1.000	0.573	0.000
1996	0.619	0.835	0.975	1.000	1.000	0.893	1.000	0.910	0.845	1.000	1.000	0.612	0.000
1997	0.714	0.839	0.965	1.000	1.000	0.844	1.000	0.859	0.737	1.000	1.000	0.614	0.000
1998	0.690	0.867	0.981	1.000	1.000	0.748	1.000	0.828	0.831	1.000	1.000	0.599	0.000
1999	0.552	0.816	0.968	1.000	1.000	0.691	1.000	0.672	0.783	1.000	1.000	0.677	0.000
2000	0.520	0.809	0.967	1.000	1.000	0.583	1.000	0.509	0.933	1.000	1.000	0.682	0.000
2001	0.600	0.838	0.919	1.000	1.000	0.515	1.000	0.394	0.951	1.000	1.000	0.747	0.000
2002	0.503	0.887	0.848	1.000	1.000	0.483	1.000	0.338	0.933	0.980	1.000	0.662	1.000
2003	0.487	0.908	0.857	1.000	1.000	0.441	1.000	0.289	1.000	0.974	1.000	0.637	1.000
2004	0.472	0.984	0.810	1.000	1.000	0.490	1.000	0.321	1.000	0.901	1.000	0.591	1.000
2005	0.464	0.877	0.726	1.000	1.000	0.495	1.000	0.308	1.000	0.793	1.000	0.546	1.000
2006	0.508	0.815	0.806	1.000	1.000	0.544	1.000	0.320	1.000	0.823	1.000	0.613	1.000
2007	0.998	0.951	0.885	1.000	1.000	0.945	1.000	0.360	1.000	0.999	1.000	0.599	1.000
2008	0.728	0.902	0.929	1.000	1.000	0.972	1.000	0.344	1.000	0.996	1.000	0.605	1.000
2009	0.824	0.966	0.903	1.000	1.000	0.982	1.000	0.376	1.000	0.999	1.000	0.612	1.000
2010	0.745	0.934	0.877	1.000	1.000	0.972	1.000	0.353	1.000	0.994	1.000	0.606	1.000
2011	0.880	0.109	0.887	1.000	1.000	0.967	1.000	0.444	0.918	0.971	1.000	0.621	1.000
Average	***0.651***	***0.837***	***0.876***	***1.000***	***1.000***	***0.761***	***1.000***	***0.558***	***0.890***	***0.970***	***1.000***	***0.620***	***1.000***
Rank	***11***	***9***	***8***	***1***	***1***	***10***	***1***	***13***	***7***	***6***	***1***	***12***	***1***

Note: Ennore Port started its operation in the year 2002.

Table – 5.4.4 revealed the Scale Efficiency of Major Ports and their ranks during the study period i.e. from 1993 to 2011. From this table it was observed that the port operations of JNPT, Kandla, Mormugao, Tuticorin and Ennore were again rated being scale efficient throughout the period of time. The other ports like Chennai, Cochin, Haldia, Kolkata and Visakhapatnam were found to be scale inefficient during all the years. The port of Mumbai was found to be efficient during first two years, later it was observed as an inefficient unit. The New Mangalore port was also found to be efficient during 2003-2010, and for rest of the years found to be inefficient. The Paradip port was observed as efficient port during 1993-2001 and for rest of the years it was found to be an inefficient port. From the results it was inferred that the ports like Chennai, Cochin, Haldia, Kolkata, Mumbai, NMPT, Paradip and Visakhapatnam were found to be inefficient in terms of their utilization of resources. Hence these ports need to concentrate on their utilization performance. To improve the scale efficiency these ports need to adopt modernized facilities and need to improve infrastructure facilities to speed up the cargo movement.

DEA-Scale Efficiency ranking put JNPT, Kandla, Mormugao, Tuticorin and Ennore in top five positions with efficient port operations, followed by Paradip, New Mangalore, Haldia and Cochin respectively. Ports like Kolkata, Chennai, Visakhapatnam, and Mumbai were ranked at the bottom 4 among the major ports of India.

Table. 5. 4. 5. Relative Efficiency analysis of Major Ports in India

1993	*DEA - BCC*	*SE*	*Reasons for Inefficiency*	*Return to Scale*	*1994*	*DEA - BCC*	*SE*	*Reasons for Inefficiency*	*Returns to Scale*
Chennai	1.000	0.736	Scale Inefficient	Increasing	Chennai	1.000	0.685	Scale Inefficient	Increasing
Cochin	0.606	0.848	Pure Technical Inefficient	Increasing	Cochin	0.614	0.850	Pure Technical Inefficient	Increasing
Haldia	1.000	0.719	Scale Inefficient	Decreasing	Haldia	1.000	0.680	Scale Inefficient	Decreasing
JNPT	1.000	1.000	*****	Constant	JNPT	1.000	1.000	*****	Constant
Kandla	1.000	1.000	*****	Constant	Kandla	1.000	1.000	*****	Constant
Kolkata	0.334	0.976	Pure Technical Inefficient	Increasing	Kolkata	0.338	0.964	Pure Technical Inefficient	Increasing
Mormugao	1.000	1.000	*****	Constant	Mormugao	1.000	1.000	*****	Constant
Mumbai	1.000	1.000	*****	Constant	Mumbai	1.000	1.000	*****	Constant
New Mangalore	0.853	0.589	Scale Inefficient	Decreasing	New Mangalore	0.969	0.571	Scale Inefficient	Decreasing
Paradip	1.000	1.000	*****	Constant	Paradip	1.000	1.000	*****	Constant
Tuticorin	1.000	1.000	*****	Constant	Tuticorin	1.000	1.000	*****	Constant
Visakhapatnam	0.942	0.603	Scale Inefficient	Increasing	Visakhapatnam	0.987	0.580	Scale Inefficient	Increasing
1995	*DEA - BCC*	*SE*	*Reasons for Inefficiency*	*Return to Scale*	*1996*	*DEA - BCC*	*SE*	*Reasons for Inefficiency*	*Return to Scale*
Chennai	1.000	0.637	Scale Inefficient	Increasing	Chennai	1.000	0.619	Scale Inefficient	Increasing
Cochin	0.676	0.874	Pure Technical Inefficient	Increasing	Cochin	0.599	0.835	Pure Technical Inefficient	Increasing
Haldia	0.649	0.948	Pure Technical Inefficient	Increasing	Haldia	0.636	0.975	Pure Technical Inefficient	Decreasing
JNPT	1.000	1.000	*****	Constant	JNPT	1.000	1.000	*****	Constant
Kandla	1.000	1.000	*****	Constant	Kandla	1.000	1.000	*****	Constant
Kolkata	0.313	0.949	Pure Technical Inefficient	Increasing	Kolkata	0.291	0.893	Pure Technical Inefficient	Increasing
Mormugao	1.000	1.000	*****	Constant	Mormugao	1.000	1.000	*****	Constant
Mumbai	1.000	0.980	Scale Inefficient	Increasing	Mumbai	1.000	0.910	Scale Inefficient	Increasing
New Mangalore	0.605	0.817	Pure Technical Inefficient	Decreasing	New Mangalore	0.663	0.845	Pure Technical Inefficient	Decreasing
Paradip	1.000	1.000	*****	Constant	Paradip	1.000	1.000	*****	Constant
Tuticorin	1.000	1.000	*****	Constant	Tuticorin	1.000	1.000	*****	Constant
Visakhapatnam	1.000	0.573	Scale Inefficient	Increasing	Visakhapatnam	1.000	0.612	Scale Inefficient	Increasing

1997	*DEA - BCC*	*SE*	*Reasons for Inefficiency*	*Return to Scale*	*1998*	*DEA - BCC*	*SE*	*Reasons for Inefficiency*	*Return to Scale*
Chennai	0.990	0.714	Scale Inefficient	Increasing	Chennai	1.000	0.690	Scale Inefficient	Increasing
Cochin	0.651	0.839	Pure Technical Inefficient	Increasing	Cochin	0.436	0.867	Pure Technical Inefficient	Increasing
Haldia	0.630	0.965	Pure Technical Inefficient	Decreasing	Haldia	0.635	0.981	Pure Technical Inefficient	Decreasing
JNPT	1.000	1.000	*****	Constant	JNPT	1.000	1.000	*****	Constant
Kandla	1.000	1.000	*****	Constant	Kandla	1.000	1.000	*****	Constant
Kolkata	0.269	0.844	Pure Technical Inefficient	Increasing	Kolkata	0.306	0.748	Pure Technical Inefficient	Increasing
Mormugao	1.000	1.000	*****	Constant	Mormugao	1.000	1.000	*****	Constant
Mumbai	1.000	0.859	Scale Inefficient	Increasing	Mumbai	1.000	0.828	Scale Inefficient	Increasing
New Mangalore	1.000	0.737	Scale Inefficient	Decreasing	New Mangalore	1.000	0.831	Scale Inefficient	Decreasing
Paradip	1.000	1.000	*****	Constant	Paradip	1.000	1.000	*****	Constant
Tuticorin	1.000	1.000	*****	Constant	Tuticorin	1.000	1.000	*****	Constant
Visakhapatnam	1.000	0.614	Scale Inefficient	Increasing	Visakhapatnam	0.926	0.599	Scale Inefficient	Increasing

1999	*DEA - BCC*	*SE*	*Reasons for Inefficiency*	*Return to Scale*	*2000*	*DEA - BCC*	*SE*	*Reasons for Inefficiency*	*Return to Scale*
Chennai	1.000	0.552	Scale Inefficient	Increasing	Chennai	1.000	0.520	Scale Inefficient	Increasing
Cochin	0.418	0.816	Pure Technical Inefficient	Increasing	Cochin	0.361	0.809	Pure Technical Inefficient	Increasing
Haldia	0.654	0.968	Pure Technical Inefficient	Decreasing	Haldia	0.578	0.967	Pure Technical Inefficient	Decreasing
JNPT	1.000	1.000	*****	Constant	JNPT	1.000	1.000	*****	Constant
Kandla	1.000	1.000	*****	Constant	Kandla	1.000	1.000	*****	Constant
Kolkata	0.317	0.691	Pure Technical Inefficient	Increasing	Kolkata	0.324	0.583	Pure Technical Inefficient	Increasing
Mormugao	1.000	1.000	*****	Constant	Mormugao	1.000	1.000	*****	Constant
Mumbai	1.000	0.672	Scale Inefficient	Increasing	Mumbai	0.952	0.509	Scale Inefficient	Increasing
New Mangalore	1.000	0.783	Scale Inefficient	Decreasing	New Mangalore	1.000	0.933	Scale Inefficient	Decreasing
Paradip	1.000	1.000	*****	Constant	Paradip	1.000	1.000	*****	Constant
Tuticorin	1.000	1.000	*****	Constant	Tuticorin	1.000	1.000	*****	Constant
Visakhapatnam	0.877	0.677	Scale Inefficient	Increasing	Visakhapatnam	0.853	0.682	Scale Inefficient	Increasing

2001	***DEA - BCC***	***SE***	***Reasons for Inefficiency***	***Return to Scale***	***2002***	***DEA - BCC***	***SE***	***Reasons for Inefficiency***	***Return to Scale***
Chennai	1.000	0.600	Scale Inefficient	Increasing	Chennai	0.917	0.503	Scale Inefficient	Increasing
Cochin	0.389	0.838	Pure Technical Inefficient	Increasing	Cochin	0.346	0.887	Pure Technical Inefficient	Increasing
Haldia	0.712	0.919	Pure Technical Inefficient	Increasing	Haldia	0.715	0.848	Pure Technical Inefficient	Increasing
JNPT	1.000	1.000	*****	Constant	JNPT	1.000	1.000	*****	Constant
Kandla	1.000	1.000	*****	Constant	Kandla	1.000	1.000	*****	Constant
Kolkata	0.227	0.515	Pure Technical Inefficient	Increasing	Kolkata	0.151	0.483	Pure Technical Inefficient	Increasing
Mormugao	1.000	1.000	*****	Constant	Mormugao	1.000	1.000	*****	Constant
Mumbai	0.758	0.394	Scale Inefficient	Increasing	Mumbai	0.672	0.338	Scale Inefficient	Increasing
New Mangalore	1.000	0.951	Scale Inefficient	Decreasing	New Mangalore	1.000	0.933	Scale Inefficient	Decreasing
Paradip	1.000	1.000	*****	Constant	Paradip	0.792	0.980	Pure Technical Inefficient	Decreasing
Tuticorin	1.000	1.000	*****	Constant	Tuticorin	1.000	1.000	*****	Constant
Visakhapatnam	1.000	0.747	Scale Inefficient	Increasing	Visakhapatnam	1.000	0.662	Scale Inefficient	Increasing
					Ennore	1.000	1.000	*****	Constant

2003	***DEA - BCC***	***SE***	***Reasons for Inefficiency***	***Return to Scale***	***2004***	***DEA - BCC***	***SE***	***Reasons for Inefficiency***	***Return to Scale***
Chennai	0.821	0.487	Scale Inefficient	Increasing	Chennai	0.849	0.472	Scale Inefficient	Increasing
Cochin	0.422	0.908	Pure Technical Inefficient	Increasing	Cochin	1.000	0.984	Scale Inefficient	Decreasing
Haldia	0.762	0.857	Pure Technical Inefficient	Increasing	Haldia	0.830	0.810	Scale Inefficient	Increasing
JNPT	1.000	1.000	*****	Constant	JNPT	1.000	1.000	*****	Constant
Kandla	1.000	1.000	*****	Constant	Kandla	1.000	1.000	*****	Constant
Kolkata	0.179	0.441	Pure Technical Inefficient	Increasing	Kolkata	0.200	0.490	Pure Technical Inefficient	Increasing
Mormugao	1.000	1.000	*****	Constant	Mormugao	1.000	1.000	*****	Constant
Mumbai	0.626	0.289	Scale Inefficient	Increasing	Mumbai	0.669	0.321	Scale Inefficient	Increasing
New Mangalore	1.000	1.000	*****	Constant	New Mangalore	1.000	1.000	*****	Constant
Paradip	0.773	0.974	Pure Technical Inefficient	Increasing	Paradip	0.729	0.901	Pure Technical Inefficient	Increasing
Tuticorin	1.000	1.000	*****	Constant	Tuticorin	1.000	1.000	*****	Constant
Visakhapatnam	1.000	0.637	Scale Inefficient	Increasing	Visakhapatnam	1.000	0.591	Scale Inefficient	Increasing
Ennore	1.000	1.000	*****	Constant	Ennore	1.000	1.000	*****	Constant

2005	***DEA - BCC***	***SE***	***Reasons for Inefficiency***	***Return to Scale***	***2006***	***DEA - BCC***	***SE***	***Reasons for Inefficiency***	***Return to Scale***
Chennai	0.959	0.464	Scale Inefficient	Increasing	Chennai	0.945	0.508	Scale Inefficient	Increasing
Cochin	1.000	0.877	Scale Inefficient	Decreasing	Cochin	0.325	0.815	Pure Technical Inefficient	Increasing
Haldia	0.915	0.726	Scale Inefficient	Increasing	Haldia	0.983	0.806	Scale Inefficient	Increasing
JNPT	1.000	1.000	*****	Constant	JNPT	1.000	1.000	*****	Constant
Kandla	1.000	1.000	*****	Constant	Kandla	1.000	1.000	*****	Constant
Kolkata	0.220	0.495	Pure Technical Inefficient	Increasing	Kolkata	0.217	0.544	Pure Technical Inefficient	Increasing
Mormugao	1.000	1.000	*****	Constant	Mormugao	1.000	1.000	*****	Constant
Mumbai	0.756	0.308	Scale Inefficient	Increasing	Mumbai	1.000	0.320	Scale Inefficient	Increasing
New Mangalore	1.000	1.000	*****	Constant	New Mangalore	1.000	1.000	*****	Constant
Paradip	0.852	0.793	Scale Inefficient	Increasing	Paradip	0.880	0.823	Scale Inefficient	Increasing
Tuticorin	1.000	1.000	*****	Constant	Tuticorin	1.000	1.000	*****	Constant
Visakhapatnam	1.000	0.546	Scale Inefficient	Increasing	Visakhapatnam	1.000	0.613	Scale Inefficient	Increasing
Ennore	1.000	1.000	*****	Constant	Ennore	1.000	1.000	*****	Constant
2007	***DEA - BCC***	***SE***	***Reasons for Inefficiency***	***Return to Scale***	***2008***	***DEA - BCC***	***SE***	***Reasons for Inefficiency***	***Return to Scale***
Chennai	1.000	0.998	Scale Inefficient	Increasing	Chennai	0.915	0.728	Scale Inefficient	Increasing
Cochin	0.528	0.951	Pure Technical Inefficient	Increasing	Cochin	0.326	0.902	Pure Technical Inefficient	Increasing
Haldia	0.884	0.885	Pure Technical Inefficient	Increasing	Haldia	0.693	0.929	Pure Technical Inefficient	Increasing
JNPT	1.000	1.000	*****	Constant	JNPT	1.000	1.000	*****	Constant
Kandla	1.000	1.000	*****	Constant	Kandla	1.000	1.000	*****	Constant
Kolkata	0.437	0.945	Pure Technical Inefficient	Increasing	Kolkata	0.325	0.972	Pure Technical Inefficient	Increasing
Mormugao	1.000	1.000	*****	Constant	Mormugao	1.000	1.000	*****	Constant
Mumbai	0.964	0.360	Scale Inefficient	Increasing	Mumbai	0.879	0.344	Scale Inefficient	Increasing
New Mangalore	1.000	1.000	*****	Constant	New Mangalore	1.000	1.000	*****	Constant
Paradip	0.834	0.999	Pure Technical Inefficient	Increasing	Paradip	0.789	0.996	Pure Technical Inefficient	Decreasing
Tuticorin	1.000	1.000	*****	Constant	Tuticorin	1.000	1.000	*****	Constant
Visakhapatnam	1.000	0.599	Scale Inefficient	Increasing	Visakhapatnam	0.995	0.605	Scale Inefficient	Increasing
Ennore	1.000	1.000	*****	Constant	Ennore	1.000	1.000	*****	Constant

2009	DEA - BCC	SE	Reasons for Inefficiency	Return to Scale	2010	DEA - BCC	SE	Reasons for Inefficiency	Return to Scale
Chennai	0.852	0.824	Scale Inefficient	Increasing	Chennai	0.834	0.745	Scale Inefficient	Increasing
Cochin	0.319	0.966	Pure Technical Inefficient	Increasing	Cochin	0.303	0.934	Pure Technical Inefficient	Increasing
Haldia	0.637	0.903	Pure Technical Inefficient	Increasing	Haldia	0.471	0.877	Pure Technical Inefficient	Increasing
JNPT	1.000	1.000	*****	Constant	JNPT	1.000	1.000	*****	Constant
Kandla	1.000	1.000	*****	Constant	Kandla	1.000	1.000	*****	Constant
Kolkata	0.338	0.982	Pure Technical Inefficient	Decreasing	Kolkata	0.356	0.972	Pure Technical Inefficient	Decreasing
Mormugao	1.000	1.000	*****	Constant	Mormugao	1.000	1.000	*****	Constant
Mumbai	0.718	0.376	Scale Inefficient	Increasing	Mumbai	0.686	0.353	Scale Inefficient	Increasing
New Mangalore	1.000	1.000	*****	Constant	New Mangalore	1.000	1.000	*****	Constant
Paradip	0.797	0.999	Pure Technical Inefficient	Decreasing	Paradip	0.870	0.994	Pure Technical Inefficient	Decreasing
Tuticorin	1.000	1.000	*****	Constant	Tuticorin	1.000	1.000	*****	Constant
Visakhapatnam	0.885	0.612	Scale Inefficient	Increasing	Visakhapatnam	0.824	0.606	Scale Inefficient	Increasing
Ennore	1.000	1.000	*****	Constant	Ennore	1.000	1.000	*****	Constant

2011	DEA - BCC	SE	Reasons for Inefficiency	Return to Scale
Chennai	0.824	0.880	Pure Technical Inefficient	Increasing
Cochin	0.330	0.109	Scale Inefficient	Increasing
Haldia	0.477	0.887	Pure Technical Inefficient	Increasing
JNPT	1.000	1.000	*****	Constant
Kandla	1.000	1.000	*****	Constant
Kolkata	0.338	0.967	Pure Technical Inefficient	Decreasing
Mormugao	1.000	1.000	*****	Constant
Mumbai	0.667	0.444	Scale Inefficient	Increasing
New Mangalore	1.000	0.918	Scale Inefficient	Decreasing
Paradip	0.857	0.971	Pure Technical Inefficient	Decreasing
Tuticorin	1.000	1.000	*****	Constant
Visakhapatnam	0.832	0.621	Scale Inefficient	Increasing
Ennore	1.000	1.000	*****	Constant

Note: - ***** - represents efficient unit.

Table - 5.4.6. Summary of Relative Efficiency Analysis of Major Ports in India

	Chennai		Cochin		Haldia		JNPT	Kandla	Kolkata		Mormugao	Mumbai		NMPT		Paradip		Tuticorin	Vizag		Ennore	SIE	PTIE	EFF
1993	SIE	↑	PTIE	↑	SIE	↓	EFF	EFF	PTIE	↑	EFF	EFF	-	SIE	↓	EFF	-	EFF	SIE	↑	NOP	**4**	**2**	**6**
1994	SIE	↑	PTIE	↑	SIE	↓	EFF	EFF	PTIE	↑	EFF	EFF	-	SIE	↓	EFF	-	EFF	SIE	↑	NOP	**4**	**2**	**6**
1995	SIE	↑	PTIE	↑	PTIE	↑	EFF	EFF	PTIE	↑	EFF	SIE	↑	PTIE	↓	EFF	-	EFF	SIE	↑	NOP	**3**	**4**	**5**
1996	SIE	↑	PTIE	↑	PTIE	↓	EFF	EFF	PTIE	↑	EFF	SIE	↑	PTIE	↓	EFF	-	EFF	SIE	↑	NOP	**3**	**4**	**5**
1997	SIE	↑	PTIE	↑	PTIE	↓	EFF	EFF	PTIE	↑	EFF	SIE	↑	SIE	↓	EFF	-	EFF	SIE	↑	NOP	**4**	**3**	**5**
1998	SIE	↑	PTIE	↑	PTIE	↓	EFF	EFF	PTIE	↑	EFF	SIE	↑	SIE	↓	EFF	-	EFF	SIE	↑	NOP	**4**	**3**	**5**
1999	SIE	↑	PTIE	↑	PTIE	↓	EFF	EFF	PTIE	↑	EFF	SIE	↑	SIE	↓	EFF	-	EFF	SIE	↑	NOP	**4**	**3**	**5**
2000	SIE	↑	PTIE	↑	PTIE	↓	EFF	EFF	PTIE	↑	EFF	SIE	↑	SIE	↓	EFF	-	EFF	SIE	↑	NOP	**4**	**3**	**5**
2001	SIE	↑	PTIE	↑	PTIE	↑	EFF	EFF	PTIE	↑	EFF	SIE	↑	SIE	↓	EFF	-	EFF	SIE	↑	NOP	**4**	**3**	**5**
2002	SIE	↑	PTIE	↑	PTIE	↑	EFF	EFF	PTIE	↑	EFF	SIE	↑	SIE	↓	PTIE	↓	EFF	SIE	↑	EFF	**4**	**4**	**5**
2003	SIE	↑	PTIE	↑	PTIE	↑	EFF	EFF	PTIE	↑	EFF	SIE	↑	EFF	-	PTIE	↑	EFF	SIE	↑	EFF	**3**	**4**	**6**
2004	SIE	↑	SIE	↓	SIE	↑	EFF	EFF	PTIE	↑	EFF	SIE	↑	EFF	-	PTIE	↑	EFF	SIE	↑	EFF	**5**	**2**	**6**
2005	SIE	↑	SIE	↓	SIE	↑	EFF	EFF	PTIE	↑	EFF	SIE	↑	EFF	-	SIE	↑	EFF	SIE	↑	EFF	**6**	**1**	**6**
2006	SIE	↑	PTIE	↑	SIE	↑	EFF	EFF	PTIE	↑	EFF	SIE	↑	EFF	-	SIE	↑	EFF	SIE	↑	EFF	**5**	**2**	**6**
2007	SIE	↑	PTIE	↑	PTIE	↑	EFF	EFF	PTIE	↑	EFF	SIE	↑	EFF	-	PTIE	↑	EFF	SIE	↑	EFF	**3**	**4**	**6**
2008	SIE	↑	PTIE	↑	PTIE	↑	EFF	EFF	PTIE	↑	EFF	SIE	↑	EFF	-	PTIE	↑	EFF	SIE	↑	EFF	**3**	**4**	**6**
2009	SIE	↑	PTIE	↑	PTIE	↑	EFF	EFF	PTIE	↓	EFF	SIE	↑	EFF	-	PTIE	↓	EFF	SIE	↑	EFF	**3**	**4**	**6**
2010	SIE	↑	PTIE	↑	PTIE	↑	EFF	EFF	PTIE	↓	EFF	SIE	↑	EFF	-	PTIE	↓	EFF	SIE	↑	EFF	**3**	**4**	**6**
2011	PTIE	↑	SIE	↑	PTIE	↑	EFF	EFF	PTIE	↓	EFF	SIE	↑	SIE	↓	PTIE	↓	EFF	SIE	↑	EFF	**4**	**4**	**5**

SIE – Scale inefficient, PTIE – Pure technical inefficient, EFF – Efficient, NOP – Not in operation, ↑ - Increasing return to scale, ↓ - Decreasing returns to scale

Table – 5.4.5 & 5.4.6 presents the relative efficiency and summary of relative efficiency of major ports of India, during 1993 to 2011. This table estimates the efficient unit as well as inefficient unit and the reasons of inefficiency thereof. The score report shows that JNPT, Kandla, Mormugao, Tuticorin and Ennore were more efficient as compared to the rest of the major ports of India. The ports of Chennai and Visakhapatnam were observed to be scale inefficient throughout the period of study. This shows that these ports need to improve their utilization of resources through modernization of the ports. The ports like Kolkata, Cochin and Haldia were observed to be pure technical inefficient in most of the years. This suggests that these ports are technologically behind, while compared to other ports. Thus the technological up gradation should be under taken to make them efficient.

From the summary table it is revealed that on an average 3 to 4 ports had operated as scale inefficient but on the whole the scale inefficiency has declined during the study period. During the initial period only 2 ports operated as pure technical inefficient and it increased to 4 ports in later years indicating that more ports are failing due to lack of technical upgradation. Thus for Indian ports to become efficient more stress should be given for technical upgradation. . From the table it can be stated that initially 5 ports operated as efficient ports among major ports in India, and in the later stage the number of efficient ports increased to 6. Overall on an average 31.32% of ports were found scale inefficient, 25.04% of ports operated as pure technical inefficient, rest 43.63% of the ports were efficient during the study period.

The study further investigated the status of returns to scale of the ports through DEA scores. From the efficiency measurement, on an average 44.13% showed increasing return to scale (IRS), 11.73% ports exhibited decreasing return to scale (DRS), while the rest 44.13% ports reported constant return to scale (CRS). Those ports that experienced increasing return to scale in their operations, for them any increase in inputs is expected to result in more than proportional increase in outputs. Hence the ports that operate with IRS can achieve significant efficiency gains by increasing their scale of operations. The scale could be altered via expansion or internal growth and building alliances amongst shipping organizations. For ports which are operating at decreasing return to scale, a further increase in inputs would only results in a smaller proportional increase of outputs. The ports those experience DRS should reduce their scale of operations via giving up some of the ports assets through concession & leaseholds and outsource operational functions to other specialized entities. This will allow efficient handling of transit of containers as well as help promote intra-port competition between multiple service providers within the port which can lead to higher efficiency gains.

Table. 5. 4. 7. DEA – Additive – Constant Returns to Scale Efficiency

	Chennai	Cochin	Haldia	JNPT	Kandla	Kolkata	Mormugao	Mumbai	NMPT	Paradip	Tuticorin	Vizag	Ennore
1993	0.618	0.505	0.510	1.000	1.000	0.218	1.000	1.000	0.388	1.000	1.000	0.448	0.000
1994	0.583	0.494	0.397	1.000	1.000	0.123	1.000	1.000	0.365	1.000	1.000	0.374	0.000
1995	0.562	0.539	0.413	1.000	1.000	0.136	1.000	0.849	0.343	1.000	1.000	0.367	0.000
1996	0.534	0.471	0.463	1.000	1.000	0.123	1.000	0.750	0.410	1.000	1.000	0.519	0.000
1997	0.554	0.529	0.322	1.000	1.000	0.112	1.000	0.752	0.628	1.000	1.000	0.391	0.000
1998	0.531	0.320	0.366	1.000	1.000	0.125	1.000	0.732	0.748	1.000	1.000	0.336	0.000
1999	0.484	0.311	0.397	1.000	1.000	0.149	1.000	0.517	0.598	1.000	1.000	0.448	0.000
2000	0.409	0.268	0.296	1.000	1.000	0.141	1.000	0.302	0.669	1.000	1.000	0.308	0.000
2001	0.464	0.310	0.340	1.000	1.000	0.112	1.000	0.284	0.827	1.000	1.000	0.183	0.000
2002	0.287	0.267	0.348	1.000	1.000	0.070	1.000	0.206	0.811	0.500	1.000	0.229	1.000
2003	0.349	0.317	0.349	1.000	1.000	0.072	1.000	0.156	1.000	0.383	1.000	0.228	1.000
2004	0.353	0.458	0.352	1.000	1.000	0.077	1.000	0.197	1.000	0.322	1.000	0.153	1.000
2005	0.388	0.458	0.373	1.000	1.000	0.091	1.000	0.221	1.000	0.341	1.000	0.180	1.000
2006	0.452	0.243	0.369	1.000	1.000	0.100	1.000	0.297	1.000	0.293	1.000	0.180	1.000
2007	0.975	0.361	0.494	1.000	1.000	0.216	1.000	0.321	1.000	0.539	1.000	0.201	1.000
2008	0.541	0.268	0.358	1.000	1.000	0.211	1.000	0.207	1.000	0.358	1.000	0.223	1.000
2009	0.509	0.257	0.317	1.000	1.000	0.184	1.000	0.196	1.000	0.326	1.000	0.202	1.000
2010	0.467	0.250	0.220	1.000	1.000	0.174	1.000	0.135	1.000	0.693	1.000	0.177	1.000
2011	0.487	0.259	0.239	1.000	1.000	0.162	1.000	0.212	0.865	0.659	1.000	0.211	1.000
Average	***0.502***	***0.362***	***0.364***	***1.000***	***1.000***	***0.137***	***1.000***	***0.439***	***0.771***	***0.706***	***1.000***	***0.282***	***1.000***
Rank	***8***	***11***	***10***	***1***	***1***	***13***	***1***	***9***	***6***	***7***	***1***	***12***	***1***

Note: Ennore Port started its operation in the year 2002.

Table 5.4.7 places the result of efficiency analysis based on additive model. The efficiency scores of Additive model are evaluated under constant return to scale and the ranks of all the major ports under study are presented in the table. The Additive DEA model is a combination of input and output orientation while Standard DEA is either input-oriented or output-oriented discretely. From the table it is revealed that JNPT, Kandla, Mormugao, Tuticorin and Ennore were found to be efficient ports during the period under study. The other major ports like Chennai, Cochin, Haldia, Kolkata and Visakhapatnam were found to be inefficient throughout the period of time. The Mumbai port was efficient for the first two years, afterwards its slipped to inefficiency. The New Mangalore port showed efficiency during 2003 – 2010, and for rest of the period it was found to be inefficient. The port of Paradip showed efficiency during first nine years, later it was observed as an inefficient unit.

From the above table it was observed that the ports like JNPT, Kandla, Mormugao, Tuticorin and Ennore were found to be technical efficient compared to other Major Ports of India. This indicates that these ports are technologically performing well in all their logistics activities. The other ports like Chennai, Cochin, Haldia, Kolkata, Mumbai and Visakhapatnam were found to be technical inefficient. Hence these ports must concentrate on technological and infrastructural development to become efficient units.

In overall ranking under additive model JNPT, Kandla, Mormugao, Tuticorin and Ennore shared top five positions, followed by New Mangalore Port, Paradip, Chennai, Mumbai, Haldia, Cochin, Visakhapatnam and Kolkata taking the 6^{th} to 13^{th} position among the major ports in India.

Table. 5. 4. 8. DEA – Additive – Variable Returns to Scale Efficiencies

	Chennai	Cochin	Haldia	JNPT	Kandla	Kolkata	Mormugao	Mumbai	NMPT	Paradip	Tuticorin	Vizag	Ennore
1993	1.000	0.483	1.000	1.000	1.000	0.255	1.000	1.000	0.768	1.000	1.000	0.462	0.000
1994	1.000	0.494	1.000	1.000	1.000	0.243	1.000	1.000	0.872	1.000	1.000	0.381	0.000
1995	1.000	0.623	0.434	1.000	1.000	0.252	1.000	1.000	0.450	1.000	1.000	1.000	0.000
1996	1.000	0.446	0.465	1.000	1.000	0.245	1.000	1.000	0.400	1.000	1.000	1.000	0.000
1997	0.922	0.546	0.287	1.000	1.000	0.240	1.000	1.000	1.000	1.000	1.000	1.000	0.000
1998	1.000	0.347	0.356	1.000	1.000	0.279	1.000	1.000	1.000	1.000	1.000	0.785	0.000
1999	1.000	0.312	0.392	1.000	1.000	0.231	1.000	1.000	1.000	1.000	1.000	0.492	0.000
2000	1.000	0.273	0.288	1.000	1.000	0.206	1.000	0.456	1.000	1.000	1.000	0.789	0.000
2001	1.000	0.284	0.501	1.000	1.000	0.146	1.000	0.582	1.000	1.000	1.000	1.000	0.000
2002	0.844	0.258	0.479	1.000	1.000	0.088	1.000	0.590	1.000	0.200	1.000	1.000	1.000
2003	0.751	0.310	0.508	1.000	1.000	0.083	1.000	0.159	1.000	0.220	1.000	1.000	1.000
2004	0.816	1.000	0.629	1.000	1.000	0.084	1.000	0.405	1.000	0.320	1.000	1.000	1.000
2005	0.919	1.000	0.712	1.000	1.000	0.100	1.000	0.711	1.000	0.160	1.000	1.000	1.000
2006	0.905	0.245	0.736	1.000	1.000	0.110	1.000	1.000	1.000	0.807	1.000	1.000	1.000
2007	1.000	0.367	0.651	1.000	1.000	0.269	1.000	0.940	1.000	0.514	1.000	1.000	1.000
2008	0.633	0.270	0.547	1.000	1.000	0.246	1.000	0.466	1.000	0.655	1.000	0.987	1.000
2009	0.638	0.264	0.223	1.000	1.000	0.229	1.000	0.474	1.000	0.569	1.000	0.494	1.000
2010	0.634	0.254	0.179	1.000	1.000	0.227	1.000	0.447	1.000	0.674	1.000	0.490	1.000
2011	0.638	0.267	0.198	1.000	1.000	0.215	1.000	0.562	1.000	0.711	1.000	0.506	1.000
Average	***0.879***	***0.423***	***0.504***	***1.000***	***1.000***	***0.197***	***1.000***	***0.726***	***0.921***	***0.728***	***1.000***	***0.810***	***1.000***
Rank	***7***	***12***	***11***	***1***	***1***	***13***	***1***	***10***	***6***	***9***	***1***	***8***	***1***

Note: Ennore Port started its operation in the year 2002.

Table 5.4.8 shows the DEA-Additive Variable Return to Scale model and ranks all the Major Ports in India as per their efficiency in utilization of resources during 1993-2011. The port operations of JNPT, Kandla, Mormugao, Tuticorin and Ennore were rated as being efficient all through. Whereas New Mangalore port was found to be efficient during 1997 – 2010, and for rest of the period it was observed as inefficient. The ports like Chennai, Haldia, Mumbai, Paradip and Visakhapatnam showed fluctuating efficiency over the period of time. The other ports like Cochin and Kolkata were observed as a inefficient in terms of port operations throughout the period of time. The DEA-Additive model measures the performance of utilization of resources in the ports. From this analysis it was observed that the ports like JNPT, Kandla, Mormugao, Tuticorin and Ennore were found to be utilizing their resources satisfactorily. The other ports like Chennai, Cochin, Haldia, Kolkata, Mumbai, New Mangalore, Paradip and Visakhapatnam were found to be inefficient in utilization of their resources. This result suggest that these ports must concentrate to improve the utilization capacity to become efficient units.

Ranking under DEA-Additive VRS shows JNPT, Kandla, Mormugao, Tuticorin and Ennore taking first five positions among all the major ports in India, whereas New Mangalore, Chennai and Visakhapatnam positioning at sixth, seventh and eighth respectively. The other ports like Paradip, Mumbai, Haldia, Cochin and Kolkata occupied the last six places among the ports under study.

Table. 5. 4. 9. DEA – A & P Super Efficiency Model

	Chennai	Cochin	Haldia	JNPT	Kandla	Kolkata	Mormugao	Mumbai	NMPT	Paradip	Tuticorin	Vizag	Ennore
1993	0.736	0.514	0.719	6.446	1.481	0.326	1.727	1.062	0.502	3.730	2.901	0.568	0.000
1994	0.685	0.522	0.680	5.190	1.424	0.326	1.838	1.072	0.553	3.559	3.179	0.572	0.000
1995	0.637	0.591	0.615	6.063	1.291	0.297	1.406	0.980	0.494	4.288	4.370	0.573	0.000
1996	0.619	0.500	0.620	7.043	1.505	0.260	1.580	0.910	0.560	4.356	3.393	0.612	0.000
1997	0.707	0.546	0.608	6.945	1.761	0.227	1.229	0.859	0.737	4.682	2.555	0.614	0.000
1998	0.690	0.378	0.623	7.824	1.757	0.229	1.488	0.828	0.831	3.768	1.911	0.555	0.000
1999	0.552	0.341	0.633	10.000	2.260	0.219	1.233	0.672	0.783	4.364	1.882	0.594	0.000
2000	0.520	0.292	0.559	10.000	2.159	0.189	1.020	0.485	0.933	4.489	2.152	0.582	0.000
2001	0.600	0.326	0.654	10.000	1.535	0.117	1.734	0.299	0.951	5.070	2.182	0.747	0.000
2002	0.461	0.307	0.606	10.000	1.444	0.073	2.141	0.227	0.933	0.776	2.124	0.662	10.000
2003	0.400	0.383	0.653	10.000	1.408	0.079	2.433	0.181	1.044	0.753	1.731	0.637	10.000
2004	0.401	0.984	0.672	10.000	1.124	0.098	2.889	0.215	1.192	0.657	1.727	0.591	10.000
2005	0.445	0.877	0.664	10.000	1.146	0.109	2.199	0.233	1.711	0.676	1.916	0.546	10.000
2006	0.480	0.265	0.792	8.399	1.199	0.118	2.244	0.320	1.673	0.724	1.805	0.613	10.000
2007	0.998	0.502	0.782	8.833	1.211	0.413	2.708	0.347	1.176	0.833	1.634	0.599	9.366
2008	0.666	0.294	0.644	10.000	1.300	0.316	2.133	0.302	1.430	0.786	1.407	0.602	5.832
2009	0.702	0.308	0.575	10.000	1.333	0.332	2.418	0.270	1.221	0.796	1.420	0.542	5.370
2010	0.621	0.283	0.413	10.000	1.341	0.346	2.777	0.242	1.023	0.865	1.183	0.499	3.543
2011	0.725	0.326	0.423	10.000	1.405	0.327	2.961	0.296	0.918	0.832	1.179	0.517	3.343
Average	***0.613***	***0.449***	***0.628***	***8.776***	***1.478***	***0.232***	***2.008***	***0.516***	***0.982***	***2.421***	***2.140***	***0.591***	***7.745***
Rank				***1***	***5***		***4***				***3***		***2***

Note: Ennore Port started its operation in the year 2002.

The Table – 5.4.8 presents DEA- A & P Super efficiency model of Major Ports in India during 1993-2011. Super efficiency ranking method developed by Anderson and Peterson (1993) is the most widespread ranking method and hence was followed by many of the researchers for evaluating higher efficiency. The larger the value of the super efficiency measure, the higher an observation is ranked among the efficient units. Super-efficiency measures can be calculated for both inefficient and efficient observations. In the case of inefficient observations the values of the efficiency measure do not change, while efficient observations may obtain higher values. From the table it was observed that JNPT had highest efficiency all though with the average value of 8.776 and thus acquired first position among the Major Ports of India, followed by Ennore port showing higher efficiency over the period of time with average value of 7.745 placed at the second place. The port of Tuticorin was also among the super efficient ports and this port was ranked third with an average value of 2.140. Mormugao port was fourth among super efficient ports with average of 2.008. The port of Kandla was the last one among super efficient unit with an average of 1.478 taking the fifth position. The other ports like Chennai, Cochin, Haldia, Kolkata, Mumbai, New Mangalore, Paradip and Visakhapatnam were observed as inefficient units, but they are not ranked as per the degree of efficiency or otherwise because the DEA – A&P super efficiency do not measure the inefficient unit.

5. 5. Summary

In the globalized world with fierce competition, port performance is of major importance for evaluating the port competitiveness. This chapter analysed the relative efficiency of Major Ports in India during the study period 1993 – 2011. The Data Envelopment Analysis technique was used extensively to measure the relative efficiency of ports. In the present analysis the selection of input and output variable were adopted, taking in to consideration the variables closely related to the ports efficiency like number of berths, berth length, number of equipments, number of employees, container throughput and total cargo. The results of this analysis revealed that JNPT, Kandla, Mormugao, Turicorin and Ennore were found efficient ports during the study period under Standard DEA - CCR & BCC. A close look at the efficiency scores revealed that both bigger ports (JNPT, Mormugao, Kandla) as well as smaller ports (Ennore, Tuticorin) showed efficiency. From the results it was inferred that size was not a distinguishable factor in determining the efficiency of ports.

The analysis revealed that 44.13% of the ports were exhibiting increasing returns to scale. The results suggest that these ports need to increase their scale of operations via expansion or internal growth and building alliances amongst shipping organization. About 11.73% of ports exhibited decreasing returns to scale. These ports can decrease their scale of operations by giving up some of the terminal assets and operational functions to other specialized private entities so that overall efficiency score can improve.

CHAPTER – 6

DETERMINANTS OF THE PERFORMANCE OF THE MAJOR PORTS OF INDIA

6. 0. Introduction

In the earlier analysis the performance of the major ports was undertaken by measuring the efficiency scores under different models and it was observed that the ports like JNPT, Mormugao, Kandla, Tuticorin and Ennore showed efficient operations. The study also found that there is no relationship between size and its efficiency. As a corollary to previous analysis it was necessary to identify what are the determining factors behind the efficient port operations. The inputs for the Data Envelopment Analysis (DEA) was confined by the land, labour and equipments exist in the ports. But there may be some other factors acting as determinants of port efficiency, which may be outside as well as inside the ports. Thus this chapter attempts to address this issue and tries to identify the factors determining port performance of major ports in India with its limited scope.

In India, awareness towards the factors determining the port efficiency, its infrastructure and its trade has increased in recent years. The importance of determinants of factors for port performance is the linkage between growth, performance of individual ports and overseas transportation leading to exports as well as imports since the liberalization initiated in 1991(Indian Port Report). The effect of poor port performance reflects on its countries economic development. Port efficiency varies widely from country to country and, specifically from region to region. It is well known that some of the Asian countries (Singapore, Hong Kong) are having the most efficient ports in the world, while some of the most inefficient ports are located in Africa (Ethiopia, Nigeria, Malawi) or South America (Colombia, Venezuela, Ecuador) (Wu, J., & Lin, C, 2008, Wu, et al., 2009). It seems geographical location also plays a determinant factor of ports efficiency. The port becomes inefficient because of lack of integrated services, outdated work practices or the obsolete facilities. These can be stopping the country's economic growth even in the borderless world. Because of increasing number of inefficient ports the governments all over the world were forced to deregulate the port operating system. (Estache A Carbajo J 1997 and Bollard A Picford M 1998). Many governments have begun to deregulate economic activities and decentralize decision making system, with the objective of increasing financial viability and productive efficiency of the ports. Towards this direction, governments across the world are presently reformulating regulation the way of control, and are managing ports with the general principle of reducing direct intervention and, introducing where ever feasible, the use of the private sector for typical port operations. According to Thomas and Monie (2000), ports and terminals must measure their performance. The measurement of ports or terminal efficiency and its determinant is of particular importance because they are vital for the economy of the country and for the success and welfare of its industries and citizens.

Number of studies (Tongzon and Heng 2005, Tongzon 1995) have pointed out container handling efficiency is a major factor affecting the volume of total throughput of a port. To test the relationship between the independent factors both inside and outside the port with traffic volume, a panel-data model was attempted for evaluating the performance of the Indian major ports. While taking the variables for finding out factors determining the port efficiency some of the important points were kept under consideration i.e. variables like port location (Veldman and Vrookman 2007, Zohil and Prijon 1999, Tongzon 1995) the volume of export/import or total traffic (Veldman and Vrookmen 2007, Zohil and Prijon, 1999) the number of equipments obtainable for the ports (Gouvernal, et al., 2005) feeder service costs (Veldman and Vrookmen, 2003) and cargo handling costs at port (Tongzon, 1995) as well as the state wise net domestic product and its categorization.

The forgoing analysis addresses the issue of determinant of ports efficiency in the context of Indian major ports. There are some studies which have tried to understand the relationship between a transport costs, infrastructural development and port efficiency (Clark et al. 2004, Sanchez et al. 2003). But no study has touched upon the factors determining port efficiency through the consideration of important variables inside and outside the ports. In this analysis part an attempt has been made to find out the factors determining port efficiency in the aspects of factors inside and outside the ports.

Along with deregulating and liberalizing the economy. India also thought about taking some steps leading to deregulation of its port sector. Indian ports generally are characterized by the existence of obsolete and poorly maintained equipment, hierarchical and bureaucratic management structures, weak coordination between the port trusts and users of the ports. In addition, considering the country's entry into the second stage reform, present direction of analysis may help to assess the potential benefits of moving towards a deregularized port sector under a liberal trading region when more than 75% of the country's foreign trade passes through seaports. For instance, on the basis of the determinant identified efforts can be taken by the port authorities to stimulates traffic, and then the benefits of performance augmenting factors might contribute not only in redistribution of existing traffic but also for attracting new merchants. For these obvious reasons, an inspection should be made on the factors affecting the performance of the Indian ports sector.

6. 1. Data, Model and Estimation Technique

6. 1. 1. Basic Specification of the model

To measures the factor determining the port efficiency basic panel data used the following formula

$$Y_{it} = f\{\alpha_{it} + \beta X_{it} + \varepsilon_{it}\} \quad \text{-----------} (1)$$

i = 12 Major Port of India, t = 19 years (1993 to 2011)

Where,

Y_{it} is the Volume of Total Traffic in the selected Ports

X it is the Independent variables that are considered such as Turnaround time, Idle time, Berth occupancy, Berth throughput, Operating surplus per ton, Rate of return on turnover, Number of employees, Cargo equipments, Operating expenses, Net state domestic product, Net state domestic product in agriculture, Net state domestic product in industry, Net state domestic product in services.

α is the intercept and β is parameters to be estimated

ε error term.

The natural log function has been used for making the data normal.

6. 2. Econometric Model

The structure of the available dataset allowed the use of panel data methodology for the present empirical research. This type of analysis can control firm heterogeneity, and reduce collinearity among the variables that are contemplated (Arellano and Bover, 1995). This technique enables to eliminate the potential biases in the resulting estimates due to correlation between unobservable individual effects and the explanatory variables included in the model. Hsiao (2003) and Klevmarken (1989) list several benefits of panel data. These include:

1. Panel data give more informative data, more variability, less collinearity among the variables, more degrees of freedom and more efficiency.
2. Panel data are better able to study the dynamics of adjustment. Cross- sectional distributions that look relatively stable hide a multitude of changes.
3. Panel data are better able to identify and measure effects that are simply not detectable in pure cross-section or pure time-series data.
4. It reduces the identification problems.
5. Controlling for individual heterogeneity. Panel data suggests that individuals, firms, states or countries are heterogeneous. Time-series and cross-section studies not controlling this heterogeneity run the risk of obtaining biased results.

Panel data are of two types; balanced panel data which has equal number of observations for each individual (cross-section), as well as unbalanced panel data not having equal number of observations for each individual. Panel data models in macroeconomic have become popular since last decades. The idea of a panel data set is that a cross-section of observational units, typically individuals or economic entities, are selected and a response or explanatory variables are observed for each unit. So panel data set contains observations on multiple phenomena observed over multiple time periods. Panel data sets generally include chronological blocks or cross-sections of data, within each of which resides a time series. The port data under study holds the above mentioned characteristics, which gives a lead to panel data analysis of the performance of major ports of India.

Primary reason for making a panel data analysis is that it offers opportunity for controlling unobserved individual and/ or time specific heterogeneity, which may be correlated with the included explanatory variables. Both time series and cross-section when combined, enhances the quality and quantity of data in ways that would be impossible using only one of these two dimensions (Gujarati, 2003). As per Klevmoarken (1989), Hsiao (2003, 2005), Woolridge (2002), Baltagi (2005), Greene (2005), etc., benefits for using panel data, are multifarious, as it increases the precision of parameter estimates, allows to sort out model temporal effects without aggregation bias, gives more informative data, less collinearity among variables, more efficiency, etc. As per Hausman and Taylor (1981) combining time-series and cross-sectional data, individual-specific unobservable effects (may be correlated with other explanatory variables) can be controlled.

The earlier researchers using panel data analysis reveal that, Hsiao (2004) used the panel data models with slope heterogeneity under various testing. The study suggested for simulation equation random coefficient model as it is the most recent development for common framework. Frees et al. (2001) studied the illustration of panel data models that can be applied to different functional areas and their features. They also pointed out that the data could provide opportunity to enhance the model specification. Greene (2001) specifies the selection of random and fixed effects with the panel data. This study suggested that the estimation of fixed effects model is quite feasible even in panel with large number of groups. According to Baltagi (2005) panel data problem may arise when designing surveys which include design, data collection problem and cross section dependence.

In the present part of the analysis Pooled Ordinary Least Square (OLS), Fixed Effect Model (FEM) and Random Effect Model (REM) have been used for estimating the determining factor for port performance of major ports in India. A balanced panel data set is used which has equal number of observations for each individual (cross-section) and for best model selection, for best model testing, Hausman specification test are used (see Breusch and Pagan, 1979, Gujarati, 2003, Hsiao, 2003 etc).

In constant coefficient model all intercepts and coefficients are assumed to be same (i.e. there is neither significant of ports nor significant of time effects), in this way space and time dimensions of the pooled data are disregarded, data is pooled and an ordinary least squares (OLS) regression model is run. So these models are with highly restricted assumptions.

Different variations with reference to cross-section or time series are applied to the fixed effects models here. The fixed effects model has constant slopes but intercepts differ according to the cross-sectional (group) unit. For i classes $i - 1$ dummy variables are used to designate the particular unit, this model is sometimes called the LSDV model. Another fixed effects panel model where the slope coefficients are constant, but the intercept varies over individual / unit as well as time. FEM with differential intercepts and slopes can also be applied on data, but inclusion of lot of variables and dummies may give such result, for which interpretation is cumbersome. Because many dummies may cause the problem of multicollinearity. There is also a fixed effects panel model in which both intercepts and slopes might vary according to unit and time. This model specifies i-1 unit dummies, t-1 time dummies, the variables under consideration and the interactions between them. If all of these are statistically significant, there is no reason to pool (Gujarati, 2003).

In the random effects model the intercept is assumed to be a random outcome variable, whereas the random outcome is a function of a mean value plus a random error. Two way of random effects model is used for estimation purpose.

According to Swamy (1971) the random effect model is

$$y_{it} = \beta_i' x_{it} + \varepsilon_{it}, \ t = 1 \ldots, T(i), \ i = i, \ldots, N$$

$$\beta_i = \beta + v_i$$

Where $E[v] = 0$ and $Var[v_i] = \Omega$

The model is generalized, group wise heteroscedastic model.

Hausman specification test is used to select the best model from Fixed Effect and Random Effect Model.

6. 2. 1. Pooled OLS Model

While using the assumption that all coefficients are constant across time and individuals, it is assumed that there is neither significant individual nor significant temporal effects, and all the data were pooled and an ordinary least squares (*OLS*) regression model was employed. The panel consists of data for the all Indian major ports, over the period of 1993 to 2011. The pooled ordinary least square panel regression takes the following form;

$$TOTTRAFFIC_{it} = \alpha_0 + \beta_1 TRT_{it} + \beta_2 IDLE_{it} + \beta_3 BOCC_{it} + \beta_4 BTHROUGH_{it} + \beta_5 OSPT_{it} + \beta_6 RROT_{it} + \beta_7 NOE_{it} + \beta_8 CAREQUIP_{it} + \beta_9 OPEXP_{it} + \beta_{10} NSDP_{it} + \beta_{11} NSDPAGRI_{it} + \beta_{12} NSDPINDUS_{it} + \beta_{13} NSDPSEVICE_{it} + \varepsilon_{it} \quad \ldots\ldots(2)$$

Where *i* stands for *i*th individual unit (cross-section) *t* stands for *t*th time period. The below table shows the final list of variables for determinants of port efficiency and its expected signs.

The selected variables used for the panel data models have been listed below table with description and expected sign. The variables like turnaround time and idle time sign are expected to be negative, because it is obvious that if turnaround time and idle time reduces it will be indicative of higher traffic. The variables like berth occupancy, berth throughput, operating expenses are expected to having the positive relationship because the increase in the above variables are expected to be associated with higher traffic. Operating surplus may or may not lead to higher traffic, similar is the case with rate of return on turnover. A higher number of employees some time lead to higher activity, otherwise also is equally possible. Hence the expected sign is unpredictable. A large number of cargo equipment may lead to higher cargo traffic handling but sometime large number of equipments leads to higher congestion, less movement, less flexibility thus less activity. Hence the sign is unpredictable. The net domestic product from state and sector wise may have undefined sign as it is not definite what way they affect the container traffic. Thus the variables having ambiguous expected signs have to be seen after fitting into the estimated model and they can be interpreted according to the results of the model.

S. No	**Variable**	**Description**	**Expected sign**
1	TRT	Turnaround time	Negative
2	IDLE	Idle time of the port	Negative
3	BOCC	Berth occupancy	Positive
4	BTHROUGH	Berth throughput	Positive
5	OSPT	Operating surplus per ton	Ambiguous
6	RROT	Rate of return on turnover	Ambiguous
7	NOE	Number of employees	Ambiguous
8	CAREQUIP	Cargo equipments	Ambiguous
9	OPEXP	Operating expenses	Positive
10	NSDP	Net state domestic product	Ambiguous
11	NSDPAGRI	Net state domestic product in agriculture	Ambiguous
12	NSDPINDUS	Net state domestic product in industry	Ambiguous
13	NSDPSEVICE	Net state domestic product in services	Ambiguous

6. 2. 2. Fixed Effect Model

The Fixed effects method treats the constant as group (section)-specific, i.e. it allows for different constants for each group (section). The Fixed effect is also called as the Least Squares Dummy Variables (LSDV) estimators, because it allows for different constants for each group and it includes a dummy variable for each group. The model takes the following form.

$$Y_{it} = a_{it} + \beta_1 X1_{it} + \beta_2 X2_{it} + ... + \beta_k Xk_{it} + \mu_{it} \text{ .... (3)}$$

Where, the dummy variable takes different group-specific estimates for each of the constants for every different section.

6. 2. 3. Random Effect Model

The Random effects method is an alternative method of estimation which handles the constants for each section as random parameters rather than fixed. Hence the variability of the constant for each section comes from the fact that:

$$a_i = a + v_i \text{ ---------- (4)}$$

Where v_i is a zero mean standard random variable.

The Random effects model therefore takes the following from:

$$Y_{it} = (\alpha + v_i) + \beta_1 X1_{it} + \beta_2 X2_{it} + ... + \beta_k Xk_{it} + \mu_{it} \text{ --------------- (5)}$$

$$Y_{it} = \alpha + \beta_1 X1_{it} + \beta_2 X2_{it} + ... + \beta_k Xk_{it} + (v_i + \mu_{it}) \text{ --------------- (6)}$$

6. 2. 4. Model Specification Test

The fixed effects and random effects can be the taken in the same model, having different assumptions about Cov (β_i, X_{it}). There are also different tests available for fixed and random effect models. The most popular test that can be used F-test and Hausman –

Taylor (1978) to check whether fixed or random effect model should be considered better for interpreting the results.

Fixed Effects Hypothesis Testing

To check which model is better, a formal test for two models can be used. Pooled regression model is used as the baseline for the comparison. The significance test can be performed with an F test resembling the structure of the F test for R^2 change.

$$F_{\text{groups effects}} = \frac{\left(R^2_{fix} - R^2_{pooled}\right) / (N-1)}{\left(1 - R^2_{LSDV}\right) / (NT - N - K)} \quad \text{-------------- (7)}$$

Here T is the total number of temporal observations, N is the number of groups or cross-sections, and k is the number of regressors in the model. If a significant improvements is found in the R^2, then there is a statistically significant group effect.

Hausman – Taylor Test

The most commonly used specification test is Hausman specification test, which tests the null hypothesis that the coefficients estimated by the efficient random effects estimator are the same as the ones estimated by the consistent fixed effects estimator. If they are insignificant, then it is safe to use random effects and if P – value is significant it is better to use fixed effects. The Hausman test is a kind of Wald χ^2 test with k-1 degrees of freedom (where k = number of regressors) on the different matrix between variance-covariance of the LSDV with that of the Random Effect Model. The Wald statistic is

$$W = (\beta_{FE} - \beta_{RE})'(V_{FE} - V_{RE})^{-1}(\beta_{FE} - \beta_{RE}) \quad \text{-------------- (8)}$$

6. 3. Results and Discussion

6. 3. 1. Summary statistics of the sample

	Mean	SD	Max	Min	Skewness	Kurtosis	N
TOTTRAFFIC	16.929	0.693	18.221	14.915	-0.413	2.418	228
TRT	1.513	0.413	2.701	0.531	-0.190	2.817	228
IDLE	3.349	0.438	4.091	1.960	-0.853	3.710	228
BOCCU	4.187	0.2090	4.582	3.371	-0.797	3.904	228
BTHROUGH	14.270	0.805	15.936	11.990	-0.675	3.531	228
OSPT	3.540	0.905	5.171	0.000	-1.486	7.094	228
RROT	-1.087	0.538	0.000	-3.483	-1.428	6.743	228
NOE	8.433	0.727	10.189	7.297	0.506	2.470	228
CAREQUIP	3.110	1.221	5.303	0.000	-0.914	3.220	228
OPEXP	21.230	0.762	22.771	19.028	-0.369	2.778	228
NSDP	13.835	1.180	16.100	9.704	-0.996	4.414	228
NSDPAGRI	2.843	0.490	3.701	1.173	-0.840	3.792	228
NSDPINDUS	3.470	0.254	4.077	2.951	0.160	2.432	228
NSDPSERVICE	4.009	0.146	4.276	3.605	-0.349	2.382	228

The dependent and explanatory variables included in the model are: Total traffic (TOTTRAFFIC), Turnaround time (TRT), Idle time (IDLE), Berth occupancy (BOCCU), Berth throughput (BTHROUGH), Operating surplus per ton (OSPT), Rate of return on turnover (RROT), Number of employees (NOE), Cargo equipments (CAREQUIP), Operating expenses (OPEXP), Net state domestic product (NSDP), Net state domestic product in agriculture (NSDPAGRI), Net state domestic product in industry (NSDPINDUS), Net state domestic product in services (NSDPSERVICE), included in the correlation matrix.

Table 6.3.1 presents the summary statistics of the determinant variables considered for evaluating the performance of Indian major ports for the overall period during 1993 to 2011. The dependent variable is the total traffic flows from sample ports considered in the study. The nature of the panel data taken is strongly balanced in the sense that during 1993 to 2011 for 12 major ports of India (i.e. 13 units because Kolkata port is operating as Kolkata and Haldia dock system and the present study have not considered port of Port Blair due to lack of data availability, because the port got status of major port in the year 2010) and 13 independent variables were taken. The summary statistics presented in table 6.3.1 depict that the variables like Operating expenses, Total traffic and Berth throughput had a highest mean value during the study period. On the other hand Rate of return on turnover shows negative mean value. From the standard deviation, the variables like Cargo equipment and Net state domestic product showed high deviation from the average and the entire set of variables shows positive deviation from the average during the study period. The highest mean value were observed among the variables like Operating expenses, Total traffic, Berth throughput and Net state domestic product. From this table it can also be noted that all the variables except Net state domestic in industry are negatively skewed during the study period. From the results it is observed that the standard deviation are not abnormally high and majority of the variables are skewed negatively. The above data average value falls between the maximum and minimum observation and deviation is more in positive direction from the average value. It shows the reliability of the data for the above analysis.

6.3. 2. Correlation matrix of the model variables

	TOT TRAFFIC	***TRT***	***IDLE***	***BOCCU***	***BTHR OUGH***	***OSPT***	***RROT***	***NOE***	***CAR EQUIP***	***OPEXP***	***NSDP***	***NSDP AGRI***	***NSDP INDUS***	***NSDP SERVICE***
TOTTRAFFIC	1.0000													
TRT	-0.1159	1.0000												
IDLE	-0.3911	0.4988	1.0000											
BOCCU	0.2756	0.4058	-0.0146	1.0000										
BTHROUGH	0.6665	-0.1993	-0.4504	0.3850	1.0000									
OSPT	0.0033	-0.1045	-0.1333	0.0433	0.0383	1.0000								
RROT	0.1166	-0.1058	-0.1719	0.1781	0.2454	0.2245	1.0000							
NOE	0.1235	0.4646	0.4085	0.0348	-0.4263	-0.1711	-0.3504	1.0000						
CAREQUIP	0.1033	0.0723	0.0076	-0.0514	-0.3655	0.1260	-0.0652	0.4422	1.0000					
OPEXP	0.6140	-0.1745	-0.2456	-0.0233	0.0885	0.1121	-0.1606	0.3956	0.4049	1.0000				
NSDP	0.3871	-0.3058	-0.3244	-0.1474	-0.1631	0.2032	0.0949	0.0301	0.5244	0.5894	1.0000			
NSDPAGRI	-0.3724	0.3132	0.4014	-0.0858	-0.4599	0.1896	0.1059	0.1905	0.1306	-0.2081	-0.0079	1.0000		
NSDPINDUS	0.3646	0.1990	-0.3639	0.3692	0.5719	-0.1310	0.0911	-0.2232	-0.2662	-0.1798	-0.2306	-0.5686	1.0000	
NSDPSERVICE	0.2105	-0.5926	-0.2233	-0.2747	0.0071	-0.0752	-0.1414	-0.0501	0.2759	0.4443	0.4295	-0.5559	-0.1752	1.0000

The dependent and explanatory variables included in the model are: Total traffic (TOTTRAFFIC), Turnaround time (TRT), Idle time (IDLE), Berth occupancy (BOCCU), Berth throughput (BTHROUGH), Operating surplus per ton (OSPT), Rate of return on turnover (RROT), Number of employees (NOE), Cargo equipments (CAREQUIP), Operating expenses (OPEXP), Net state domestic product (NSDP), Net state domestic product in agriculture (NSDPAGRI), Net state domestic product in industry (NSDPINDUS), Net state domestic product in services (NSDPSERVICE), included in the correlation matrix.

The correlation matrix of dependent and explanatory variables is presented in the table 6.3.2 and is used to examine the possible degree of collinerarity among variables. As it is observed from the above table, the correlation coefficients are not large enough to cause collinearity among the variables and these coefficients are statistically significant at the usual level of significance hence they qualify to be considered as independent variables influencing the port performance in terms of total traffic.. The dependent variable TOTTRAFFIC is highly as well as positively correlated with BTHROUGH, OPEXP, NSDPINDUS and BOCCU. The dependent variable is correlated negatively with TRT and IDLE variables. From the correlation coefficient matrix table, it was observed that independent variable are not highly correlated with other explanatory variables. The existence of high correlation independent variables have been removed through initial stage of correlation test because high correlation among independent variables will lead multicollinearity problem.

6.3.3. Determinants of Port Efficiency: panel data estimation based on pooled OLS

Determinants of Port Efficiency (A Panel Data Approach)
Dependent Variable: Total Traffic, estimation period 1993 to 2011

Explanatory Variable	Co-efficient	Std Error	t-statistic	P-value
Cons	-6.8565	1.1619	-5.90	0.000 ***
TRT	-0.0760	0.0573	-1.33	0.186
IDLE	-0.1005	0.0436	-2.30	0.022 **
BOCCU	0.1556	0.0744	2.09	0.038 **
BTHROUGH	0.7753	0.0275	28.22	0.000 ***
OSPT	-0.0425	0.1463	-2.91	0.004 **
RROT	0.0529	0.2564	2.06	0.040 **
NOE	0.4859	0.0306	15.86	0.000 ***
CAREQUIP	-0.0452	0.0142	-3.18	0.002 **
OPEXP	0.0986	0.0320	3.08	0.002 **
NSDP	0.3110	0.0179	17.42	0.000 ***
NSDPAGRI	0.1463	0.0565	2.59	0.010 **
NSDPINDUS	0.5148	0.1063	4.84	0.000 ***
NSDPSERVICE	0.2010	0.1746	1.15	0.251
Prob>F	0.0000 (250.91)			
R^2	0.9384			
Adjusted R^2	0.9347			

** - denotes 5% level of significance, *** - denotes 1% level of significance.

Table 6.3.3 estimates the pooled OLS regression for the study period. The robustness of parameter coefficient is used to explain the relationship between Total traffic and the selected independent variables. The growth rates of Berth throughput, Number of employees, Net state domestic product and Net state domestic product in industry were found strongly and positively influencing the dependent variable in pooled OLS model. On the other hand idle time and cargo equipments have strong negative effect on the growth rates of total traffic. The outcome of the model shows that one percentage increase in Berth throughput leads to a rise in the growth of total traffic by 0.77 percentage points. Similarly, one percentage change in the growth of net state domestic product in industry leads to change in the growth of total traffic by 0.51 percentage points. The results of the regression also points out that one percentage change in number of employee's leads to 0.48 percentage change in total traffic.

The table also shows that a one percentage reduction in the growth of idle time (i.e. non working time of the port) leads to rise in the growth of total traffic by 0.07 percentage, and, one percent decrease in the growth of cargo equipments leads to 0.04 percent increase in the growth of total traffic. From this pooled OLS results it can be inferred that the independent variable like berth occupancy, berth throughput, rate of return on turnover, number of employees, operating expenses, net state domestic product, net state domestic product in industry, net state domestic product in services are positively contributing towards growth of total traffic. At the same time the other variables like idle time, operating surplus per ton and cargo equipments shows negative influence on the total traffic.

6.3.4. *Determinants of Port Efficiency: Panel data estimation based on Fixed Effect Model (FEM)*

Determinants of Port Efficiency (A Panel Data Approach) Dependent Variable: Total Traffic, estimation period 1993 to 2011				
Explanatory Variable	Co-efficient	Std Error	t-statistic	P-value
Cons	-2.7794	1.3134	-2.12	0.036 **
TRT	-0.7653	0.4303	-1.78	0.077 *
IDLE	-0.2116	0.6945	-3.05	0.003 **
BOCCU	0.0210	0.0695	0.30	0.763
BTHROUGH	0.8689	0.4363	19.91	0.000 ***
OSPT	0.0229	0.0117	1.96	0.051
RROT	0.0507	0.0180	2.82	0.005 **
NOE	0.2200	0.0769	2.86	0.005 **
CAREQUIP	-0.0725	0.0164	-4.41	0.000 ***
OPEXP	0.2618	0.0551	4.75	0.000 ***
NSDP	0.0510	0.0534	0.96	0.340
NSDPAGRI	0.0120	0.0477	0.25	0.801
NSDPINDUS	-0.1067	0.1149	-0.09	0.926
NSDPSERVICE	-0.0884	0.1368	-0.65	0.519
Prob>F	0.000 (27.14)			
R^2	0.7808			

*, ** and ***- denotes 10%, 5% and 1% level of significance.

The Fixed Effect Model is designed to control for omitted variables that differ across individuals but are constant over time. This is equivalent to generating dummy variables for each individual-cases and including them in a standard linear regression to control for these fixed individual-effects. The estimation of Fixed Effect model results have been presented in the table 6.3.4. The growth rates of Berth throughput, Rate of return on turnover, Number of employees, Operating expenses were found strongly and positively influencing the dependent variable in pooled OLS model. On the other hand turnaround time, idle time and cargo equipments depicted strong negative effect on growth of total traffic. The result of the model shows that one percentage increase in Berth throughput leads to raise in the growth of total traffic by

0.86 percentage points. In the same line, one percentage change in the growth of operating expenses leads to change in the growth of total traffic by 0.26 percentage points. The results of the regression also points out that one percentage change in number of employee's leads to 0.22 percentage change in total traffic.

This table also reveal that one percentage decrease in turnaround time leads to increase 0.76 percentage total traffic growth. However one percentage decrease in the idle time (i.e. non working time of the port) leads to increase 0.21 percent growth of total traffic. In the similar fashion one percentage decrease in the cargo equipments leads to increase 0.07 percentage growth of total traffic.

From the Fixed Effect Model regression results, it can be inferred that the factors like berth throughput, number of employees and operating expenses are the strong determining factor for port efficiency i.e. total traffic, which have a effect such that any percentage increase in this variables leads to higher traffic. The other variables like turnaround time, idle time and cargo equipments are the factors of determining the port efficiency in an inverse fashion i.e. any decrease in these variables leads to higher traffic. The variables like berth occupancy, operating surplus per ton, net state domestic product, net state domestic product in agriculture, net state domestic product in industry and net state domestic product in services were found to be insignificant in the said model. From the results it may noted that none of the variables were different on their effect on total traffic. All the variables were found associated with expected sign.

6.3.5. *Determinants of Port Efficiency: Panel data estimation based on Random Effect Model (REM)*

Determinants of Port Efficiency (A Panel Data Approach)
Dependent Variable: Total Traffic, estimation period 1993 to 2011

Explanatory Variable	Co-efficient	Std Error	t-statistic	P-value
Cons	-6.8565	1.1619	-5.90	0.000 ***
TRT	-0.7598	0.5726	-1.33	0.185
IDLE	-0.1005	0.0436	-2.30	0.021 **
BOCCU	0.1556	0.0744	2.09	0.037 **
BTHROUGH	0.7753	0.0275	28.22	0.000 ***
OSPT	-0.0425	0.0146	-2.19	0.004 **
RROT	0.0529	0.0256	2.06	0.039 **
NOE	0.4858	0.3064	15.86	0.000 ***
CAREQUIP	-0.4522	0.0142	-3.18	0.001 **
OPEXP	0.0986	0.0320	3.08	0.002 **
NSDP	0.3110	0.0179	17.42	0.000 ***
NSDPAGRI	0.1463	0.0565	2.59	0.010 **
NSDPINDUS	0.5148	0.1063	4.84	0.000 ***
NSDPSERVICE	0.2010	0.1746	1.15	0.250
Prob>Chi2	0.0000			
R2	0.9384			

*, ** and ***- denotes 10%, 5% and 1% level of significance.

The Random Effect Model is used if there are reasons to believe that some omitted variables may be constant over time but vary between cases, and others may be fixed between cases but vary over time. Table 6.3.5 estimates the Random Effect Model regression for the determinants of total traffic of major ports of India during the period. The result reveals that the growth of Berth throughput, Berth occupancy, Number of employees, Operating expenses, Net state domestic product and Net state domestic product in industry are strongly and positively influential on port efficiency. On the other hand idle time and cargo equipments have strong negative effect on the total traffic as the coefficients are significant. In the random effect regression result only turnaround time was the only variable found insignificant though negatively correlated. The variable of net state domestic product in service found insignificant but positively correlated.

6.3.6. *Hausman Specification Test*

Variables	Coefficient		Difference	S.E.
	Fixed (b)	Random (B)	(b-B)	
TRT	-0.7653	-0.7598	-0.0055	
IDLE	-0.2116	0.1005	-0.3121	0.0194
BOCCU	0.0210	-0.1556	0.1766	
BTHROUGH	0.8689	0.7753	0.0937	0.0339
OSPT	0.0229	-0.0425	0.0655	
RROT	0.0507	0.0529	-0.0022	
NOE	0.2200	0.4858	-0.2658	0.0705
CAREQUIP	0.0725	-0.4522	0.5246	0.0082
OPEXP	0.2618	0.0986	0.1632	0.4485
NSDP	0.0510	0.3110	-0.2600	0.5030
NSDPAGRI	0.0120	0.1463	-0.1343	0.4041
NSDPINDUS	-0.1067	0.5148	-0.6216	0.0437
NSDPSERVICE	-0.0884	0.2010	-0.2894	
Prob>Chi2	0.000 (154.14)			

Hausman (1978) had provided a test for discriminating between the fixed effects and the random effects estimators. The test is based on comparing the difference between the two estimators of the coefficient vectors, where the random effects estimators of the coefficient consistent under the null hypothesis and inconsistent under the alternative hypothesis. The fixed effects estimator is consistent under both the null hypothesis. If the null hypothesis is true then the difference between the estimators should be close to zero. The calculation of test statistics (distributed chi-square) requires the computation of the covariance matrix of $\beta_1 - \beta_2$. Where β_1 is the fixed effects estimator and β_2 is the random effects. The robustness of parameter coefficients are used to explain the relationship between total traffic and the selected independent variables. Since the results of pooled OLS regression and Random effects model confirm the robustness with fixed effect model. The Random effect model is rejected in the analysis based Hausman specification test (1978). Which indicates that the result is better expressive is fixed effect model and interpretation based on the said model should be preferred to fixed effect model.

6.4. Summary

In this chapter attempt was made to investigate the factors determining the efficiency of Indian Major Ports during the study period 1993 – 2011. In this part of analysis the three panel data models i.e. a) Pooled OLS regression b) Fixed effect model and c) Random effect model regression were used. For identifying the determinants of ports efficiency, total traffic was considered as dependent variable and the independent variables like turnaround time, idle time, berth occupancy, berth throughput, operating surplus per ton, rate of return on turnover, number of employees, operating expenses, net state domestic product, net state domestic product in agriculture, net state domestic product in industry and net state domestic product in services were considered based on the correlation matrix analysis. From the above analysis it was found that Berth throughput, Number of employees and Operating expenses showed a positive influence under all the models. The variables like idle time and cargo equipments showed negative coefficient indicating a reverse influence of them on the dependent variable improving the port efficiency. Hausman test was applied to choose the appropriate model. It strongly supported the Fixed Effect model.

The hypothesis tested in this study is outside factors also equally affect the port performance. From the analysis it was seen that, the variables those have shown significant effect on the efficiency of ports were all inside factors like Berth throughput, Number of employees, Operating expenses, idle time and Cargo equipments. Thus it can be concluded that both factors inside and outside affect efficiency of a port as they have significant relationship. But conspicuous factors are mostly inside factors, because the variable inside the ports were having significant coefficient, thus indicating more influence than outside factors where the regression coefficients were not significant. This result was the outcome of fixed effect model. Hausman test suggested the fixed effect model application for better interpretation of result.

The overall inference from the result is that the efficient port operations depends heavily on independent variables like Berth throughput, Number of employees and Operative expenses as these variables are having significant positive influence on the port efficiency. This shows that every increase in these variables have positive effect on the growth of total traffic. The variables like Idle time and Cargo equipments available in the ports were found negatively and strongly effecting port efficiency. This shows that any percentage decreases in the above variables will lead to increase the growth of total traffic. The result indicate that the port efficiency is effected by the above variables, and the port management should give more importance to these variables for getting better efficiency and also to overcome operational inefficiency if exists.

CHAPTER – 7

SUMMARY AND CONCLUSION

7.0. Introduction

Ports are the conduit through which the overseas trade of a country gets transacted. Without the existence of ports the import, export of a country cannot be smoothly effected as the water route is considered to be the cheapest route for effecting the foreign trade. Thus the contribution of ports on the economic welfare of a country cannot be under estimated. In addition, it is imperative that the ports should be efficient in handling the cargo moving in or out of the country with minimum loss of time. Evidences are ample worldwide that the countries with efficient ports prosper more in terms of their foreign trade, which contributes largely for the prosperity of the country's economy.

India had a chequred history of prosperous maritime trade. It's ports had played a significant role in making India prosperous, India at present has 13 major ports and 187 operable minor ports located along 7517 km long coast line surrounded by sea from 3 sides. The 13 major ports are regulated and controlled by central government through the Port Trust of India.

The seaports of India have played historical role in the development of maritime trade and economy of India. In Indian context, maritime trade continues to be interpreted almost identical with India's overseas trade, as it accounts for 95 percent of total cargo by volume and 75 percent by value. In the last two decades, in the wake of the country's economic reforms and globalization, the international trade have surged up significantly and also have accelerated the process of change towards a more diversified commodity composition of trade.

It is a common understanding that bigger ports perform better. In the present state of affair there is a need to understand whether this believe is tenable or not i.e. whether size has something to do with performance of ports. Keeping this is mind the whole thesis have been built up and also an effort has been made to find what factor influence the performance of a port.

Some of the earlier studies argued that larger ports had a positive effect on its efficiency such as Cullinane et al (2002), Tongzon and Heng (2005), Wang and Cullinane (2006), Veldman and Vrookmen (2007), Lemarchand and Joly (2009), Sohn and Jung (2009) some other studies reported that smaller ports are efficient while compared to bigger size ports i.e. Al-Eraqi et al. (2008) Cullinane et al (2006), Coto-millan (2000). Some of the studies like Cheon San Hym (2009), Lin and Tseng (2007), Liu (2008), Valentine and Gray (2000) analysed container terminal performance using through Data Envelopment Analysis with BCC, CCR and Tiered DEA models. They have measured the scale efficiency and technical efficiency of ports in different regions. Based on the observation from the earlier researches the present study has made an attempt to analyse the operational efficiency of Indian major ports. The procedure of the study has developed in the logical sequence detailed below.

7.1. Research Questions

The earlier studies on Ports and their performance provided the insight for the present piece of work. The review of literature triggered the following research question which became the object of the enquiry in the present research work.

- How are the Indian major ports performing?
- Whether the performances of the ports are based on its magnitude?
- Whether size influences the efficiency of a port?
- What are the factors determining the port performance?
- Whether outside factors also influence port performance?

To answer the above questions, this study has framed the research objectives in the following lines.

7.2. Research Objectives

The literature review and research questions, paved the way for framing the objectives of the present research work. To be precise the research enquiry has been carried out in this thesis with the following objectives.

1. To analyze trade growth of export, import and traffic handled by major ports in India.
2. To examine the relationship between port size and efficiency of major ports in India.
3. To find out the factors influencing the performance of major ports in India

7.3. Data

The present study is exclusively based on secondary data. The data have been collected from all the major ports of India except Port Blair. The sample excluded the port of Port Blair as there were no sufficient data to justify its inclusion in the present research work because the port was declared as a major port only during 2010; the necessary data were collected from various issues of Port Administrative Report, Centre for Monitoring Indian Economy (CMIE) and India stat websites. The study used annual data collected during 1993 to 2011. Data on Total traffic, Turnaround time, Idle time, Berth throughput, Berth occupancy, Operating surplus per ton, Rate of return on turnover, Number of employees, Operating expenses were directly collected from the concerned ports for the entire study period spanning from 1993 to 2011.

The information regarding Net state domestic product (NSDP), Net state domestic product in agriculture (NSDP Agriculture), Net state domestic product in industry (NSDP Industry) and Net state domestic product in services (NSDP Services) at factor cost (at constant price) were collected from Centre for Monitoring Indian Economy (CMIE) and India stat data base from 1993 – 2011.

7.4. Tools used for the study

Various statistical and econometric tools were used to make the efficiency evaluation and the performance analysis of major ports in India. For the first objective, the study employed simple growth rate, compound growth rate and trend analysis. For carrying out the investigation for the second objective i.e. measuring the efficiency of major ports in India, the study used Data Envelopment Analysis (DEA). As the preliminary steps the study measured the efficiency through DEA – CCR

(1978) and DEA – BCC (1984) models. The study also verified the utilization capacity of major ports through DEA – Additive CRS and DEA – Additive – VRS models. The study further investigated the super efficient ports through DEA – Anderson and Peterson (1993) super efficiency model. For the third objective, the study attempted to identify the factors determining the port performance through panel data methods. A total of three panel data models such as a) Pooled OLS regression b) Fixed effect model regression and c) Random effect model regression were used for identifying the determinant for factors port performance during the study period 1993 to 2011.

7.5. Major Findings

The study found the imperative rejoin on performance evaluation of ports through appropriate models, which are listed below in the sequence of the objectives set for the study.

7.5.1. Trend and growth of major ports in India

i. Trend and growth of exports, imports and transshipment trade table shows total exports of major ports in India grew from 67267 (‘000 tonnes) to 213532 (‘000 tonnes) between 1993 and 2011. There were wide fluctuations in the annual growth of exports; the linear growth rate was at an average of 9.19 percent during the period. The imports during the same period had escalated from 95877 (‘000 tonnes) to 329724 (‘000 tonnes) between 1993 and 2011, and the growth rate of import was 12.71 percent. It could also be observed that trade balance had all along been negative during the whole period indicating that imports were of higher magnitude than the export. But the compound growth rate in export exhibited better performance than import.

ii. To study the stability of growth of import and export or otherwise the data were analysed on four phases and it was observed that the compound growth rate of major ports of India's exports showed less growth than imports during all the four phases, but the variation in both imports and exports were in similar direction.

iii. Commodity wise performance of export and import through major ports in India, shows that POL had the highest share among all the 14 commodities accounting 42.92% of the total commodity traded with a volume of 121, 917, 000 tons, followed by Iron ore registering the 20.07 percent with the volume of 55010 ('000 tones). The commodity of coal shared 18.54 percent during the study period. These three commodities are responsible for the more than 80% of the commodity traded by major ports of India.

iv. Cargo traffic performance of individual major ports of India showed Vishakhapatnam, Kandla, Chennai, Mumbai and Mormugao taking first five positions during the study period. The reasons attributable to these performances may be their locational advantage; modernized cargo handling facilities that attracts more traffic to these ports.

v. The export had increased from 100 in 1993 to 317.44 in terms of trend indices registering more than 300% growth by the year 2011 at the same time import trend indices had gone up to 343.90 with 1993 as the base year registering similar growth. Trend index in the transshipment trade went up to 772.18 with the base year 1993 during the study period. The growth in transshipment was significantly higher than export and import. However, overall exports, imports and transshipment trade showed an increasing trend all through the study period.

vi. Container traffic performance of major ports showed Jawaharlal Nehru Port Trust registering the average container traffic of 23127 ('000 tones) taking the first position, followed by Chennai port trust with the average volume of container traffic of 9194 ('000 tones) at second position. The Mumbai port trust registered reasonably good growth in container traffic initially but later on the volume showed a declining trend. Still, the port managed to take a third position among the major ports of India. In container traffic performance the ports like Paradip and Mormugao were at the bottom.

vii. In terms of Performance of average turnaround time the port of Cochin performed best among all the other ports under study with 3.04 days of turnaround time, followed by JNPT with 3.35 days turnaround time. It was observed that oflate all the ports have reduced their turnaround time, which were relatively high during initial period of study. This is a positive indication of better performance of all the ports in terms of reduced number of days of stay of vessels in the port.

viii. With regard to performance of ports in terms of pre-berthing waiting time the port of Kolkata had an average pre berthing time of 0.72 days which had reduced from 0.8 to 0.14 during the study period. The Cochin port had shown an average of 0.78 days of pre berthing time. The port of New Mangalore showed 0.97 days pre berthing time during the study period. In this respect port of Kolkata had the top position followed by port of Cochin. It was observed that almost all the ports had reduced their pre-berthing time during 2012. The reason may be the effect of present drive of modernization and increased infrastructure facilities that has effected in port operations improving the recent years with faster handling of vessels.

7.5.2. Measuring the efficiency of major ports in India

i. The technical efficiency of the ports were measured through Data Envelopment Analysis models. The standard DEA – CCR model that measures the technical efficiency of the Decision Making Units (DMUs) was employed in this study for efficiency evaluation of major ports of India. From the analysis it was observed that the port of JNPT, Kandla, Mormugao, Tuticorin, and Ennore were proved to be efficient ports with score 1 in terms of port operations throughout the study period. Through the analysis it was found that 5 out of 12 major ports (13 units) i.e. 38.46% showed efficiency, while rest of the 8 out of 12 major ports i.e. 61.54% were found to be technical inefficient. Lack or delay in upgradation, modernization might be rendering the ports to become technical inefficient. This may be attributed to inefficient or indifferent attitude of management or bottlenecks in implementing and adopting modern applications in port operation.

ii. The result of standard DEA –BCC analysis showed port operations of JNPT, Kandla, Mormugao, Tuticorin and Ennore again being rated as efficient over the whole period of study. While rest of the ports showed inefficiency in pure technical ground. The ports who secured less than 1 score were categorized as inefficient. In this score Visakhapatnam, New Mangalore, Chennai, Paradip, Mumbai, Haldia, Cochin and Kolkata acquiring the average efficiency scores less than 1 during the study period were identified as inefficient ports. This results indicates that the inefficient container ports have room to improve their efficiency by upgradation.

iii. The relative efficiency analysis not only estimates the efficient unit as well as inefficient unit it also assess the reason of inefficiency. From this analysis it was found that JNPT, Kandla, Mormugao, Tuticorin and Ennore were observed to be efficient among all the major ports of India. While other ports like Chennai and Visakhapatnam were observed as scale inefficient throughout the period of study. The ports like Kolkata, Cochin and Haldia were observed as pure technical inefficient in most of the years. The ports with scale inefficiency need to utilize the capacity to fuller extent, on the other hand technical inefficient ports need to upgrade the technology.

iv. Under the efficiency analysis of DEA – Additive CRS model JNPT, Kandla, Mormugao, Tuticorin and Ennore were found to be technical efficient compared to other Major Ports of India. The other ports like Chennai, Cochin, Haldia, Kolkata, Mumbai and Visakhapatnam were found to be technical inefficient.

v. The DEA-Additive VRS model measures the performance in terms of utilization of resources in the ports. From this analysis it was observed that the ports of JNPT, Kandla, Mormugao, Tuticorin and Ennore were found to be utilizing their resources satisfactorily, whereas other ports like Chennai, Cochin, Haldia, Kolkata, Mumbai, New Mangalore, Paradip and Visakhapatnam were shown with inefficiency in utilization of its resources.

vi. DEA super efficiency model ranks the efficient ports in order of efficiency which is not indicated under DEA – CCR, DEA – BCC and DEA – Additive models where all efficient units get the same score 1. Through DEA super efficiency model the overall analysis of efficient ports reveal that JNPT had highest efficiency all though with the average value of 8.776 and acquired first position among the Major Ports of India followed by Ennore port with next best efficiency score of 7.745. The port of Tuticorin was found to be third among super efficient port major ports of India with an average value of 2.140. Mormugao port rated as super efficient units with average of 2.008 and the port of Kandla found to be super efficient unit with an average of 1.478. The other ports like Chennai, Cochin, Haldia, Kolkata, Mumbai, New Mangalore, Paradip and Visakhapatnam was observed as inefficient units and were not considered for ranking as the DEA – A&P super efficiency do not take the inefficient units into ranking.

7.5.3. Determinants of efficiency in major ports of India

i. Based on various studies (Cullinane et al (2002), Tongzon and Heng (2005), Wang and Cullinane (2006), Veldman and Vrookmen (2007), Lemarchand and Joly (2009), Sohn and Jung (2009) Al-Eraqi et al. (2008) Cullinane et al (2006), Coto-millan (2000, Cheon San Hym (2009), Lin and Tseng (2007), Liu (2008), Valentine and Gray (2000), 19 variables i.e. turnaround time, pre-berthing time, idle time, output per ship per day, berth occupancy, berth throughput, operating surplus per ton, rate of return on turnover, number of berths, berth length, number of employees, cargo equipments, transport equipments, total equipments, operating expenses, net state domestic product, net state domestic product in agriculture, net state domestic product in industry and net state domestic product in services were considered as possible factors influencing the efficiency or performance of port. The performance of port was taken as the dependent variable and the independent variables considered after testing the multicollinearity problem were turnaround time, idle time, berth occupancy, berth throughput, operating surplus per ton, rate of return on turnover, number of employees, cargo equipments, operating expenses, net state domestic product, net state domestic product in agriculture, net state domestic product in industry and net state domestic product in services. A Pooled OLS regression for panel data was considered appropriate to study the performance over time and across the ports. The estimated result from pooled OLS regression for the selected period and the robustness of parameter coefficient are used to indicate and explain the relationship between Total traffic and the selected independent variables. From the pooled OLS results it was observed that the independent variable like berth occupancy, berth throughput, rate of return on turnover, number of employees, operating expenses, net state domestic product, net state domestic product in industry, net state domestic product in services were positively contributing to enhance the total traffic. At same time the other variables like idle time, operating surplus per ton and cargo equipments were found negatively contributing to the total traffic.

ii. From the Fixed Effect Model regression results, it can be inferred that the factors like berth throughput, number of employees and operating expenses affect in positive direction, the port efficiency (i.e. total traffic) i.e. increase in these variable leads to higher traffic. The variables like turnaround time, idle time and cargo equipments were identified as the factors affecting negatively the port efficiency i.e. any decreases in quantum of these variable leads to higher traffic.

iii. The Random Effect Model regression for the selected period revealed that the growth rates of Berth throughput, Berth occupancy, Number of employees, Operating expenses, Net state domestic product and Net state domestic product in industry strongly and positively influence the port efficiency. On the other hand idle time and cargo equipments have strong negative effect on the performance of port in terms of total traffic.

iv. Hausman provides a test for discriminating between the fixed effects and the random effects estimators and choosing the right model to interpret the data. The Random effect model was rejected in the analysis based Hausman specification test (1978). Hence the interpretation of fixed effect model results were considered appropriate for identifying the determinant factors.

v. Thus factors influencing port efficiency were identified to be variables like berth throughput, number of employees and operating expenses which were found with significant coefficient with positive sign. Whereas the other variables turnaround time, idle time and cargo equipments showed negative significant effect on port efficiency. Hence the port authorities should pay appropriate attention to above said variables for achieving better performance.

7.6. Policy implications

India's port sector is generally considered to be less attractive in comparison to other countries, because of their relatively low productivity, inefficient process and procedures. The findings of the present piece of research work are consistent with previous research done by several researchers regarding the ports performance and the determinants of port performance. Therefore, it is critical to strengthen the container handling operations of the major ports of India and make them more efficient and smooth flowing. This study makes several recommendations for future action.

1. First, in terms of internal port operations, the study indicated that most of the major ports of India are inefficient both in technical & scale operations. The port management need to think on the long-term plan for equipment improvements in terms of modernization and technological upgradation to boost up efforts to upgrade the infrastructure facilities in the major ports so that it can operate in full scale, which may help in making the ports to achieve better efficiency score. The ports identified as technical inefficient should focus their efforts for technological upgradation.

2. The ports would be able to utilize their capacity to the fullest extent only when the supporting infrastructures are adequate (Water, 1999). Hence the Government must think of facilitating the same by supplementing the ports with better connectivity and infrastructural development which can contribute to the efficiency of the ports in a bigger way. Those ports which are identified scale inefficient should pay attention in this line.

3. To improve competitive growth in terms of cargo volume or container volume, the ports need to have their own adequate infrastructure facilities as per the requirement. The existing infrastructures are found not sufficient in the present level to meet the new demands and growth of the country's foreign trade. That is the reason higher percentages of ports are found inefficient some way or other.

4. The variables like Berth throughput, Number of employees and Operative expenses have been found positively and significantly contributing for port efficiency, and the variables like Idle time, Cargo equipments available and Turnaround time in the ports contribute negatively on the port efficiency. Hence the port management must give more importance to these variables for improving the efficiency level of the organizational unit.

7.7. Conclusion

As the competition among the world ports has become increasingly fierce, every port is striving to improve its productivity and lower its operational costs. Using a range of Data Envelopment Analysis and Econometric analysis models, the present study has evaluated the operational efficiency of Indian major ports during 1993 to 2011.

The empirical investigation first attempted to analyze the trend and growth of trades transacted by Ports in India. An analysis of Export, Import and Transshipment trade of Major Ports in India and their trend analysis clearly indicated that the growth rate of exports was less than imports during the study period. The commodity of POL had the highest share of trade among all the 14 commodities, followed by Iron ore and coal respectively. These three commodities comprise 80% of the total commodity traded by all major ports during the study period. Trade wise analysis places Vishakhapatnam, Kandla, Chennai, Mumbai and Mormugao in top five positions. The locational advantage, modernized cargo handling facilities and Industrialization may be the reasons for these ports transacting more cargo. In terms of performance on container traffic Jawaharlal Nehru Port Trust registered the average trade of 23127 ('000 tones) followed by Chennai port trust registering the average volume of container traffic of 9194 ('000 tones). The lowest in the container traffic performance was Paradip port.

Apart from the above parameters indicating general performance generally the apparent operational performance analysis of ports is done by observing certain physical indicators such as average turnaround time, average pre-berthing time etc. In terms of these indicators performance of Ennore port was the best as it had the least turnaround time. But it's operations started only from 2002 and it was one of the most sophisticated port, hence it was obvious that turnaround time was the least. Among rest of the ports Cochin port performed the best followed by JNPT and New Mangalore port successively. The worst performance among them was Kandla as the average turnaround time was the highest. However it was noticed that all the ports have shown reduction in turnaround time in successive years. The effort to reduce the time is seen in the performance of each individual port.

As per pre-berthing time Kolkata had performed best and Kandla was the worst. But all the ports also had reduced their pre-berthing time in recent times.

All these performances have been analyzed in terms of standalone indicator which does not give a composite view on the efficiency of the port. As a busiest port may have more turnaround time or pre-berthing time and port having less traffic may take less turnaround time and pre-berthing time. Just by observing one indicator one may not be able to give a overall judgment on the performance. Hence the performance analysis was done with sophisticated analytical techniques like Data Envelopment Analysis.

The Data Envelopment Analysis technique is widely used to measure the relative efficiency of ports. The selection of input and output variable were done taking in to consideration the variables closely related to the ports efficiency like number of berths, berth length, number of equipments, number of employees, container throughput and total cargo. The results of this analysis revealed that JNPT, Kandla, Mormugao, Turicorin and Ennore were found efficient ports during the study period under Standard DEA - CCR & BCC, DEA-Additive - CRS & VRS methods. The study also found that JNPT, Ennore, Tuticorin, Mormugao and Kandla earned higher efficiency scores and ranked at top 1 to 5 respectively. The study revealed that both bigger ports (JNPT, Mormugao, Kandla) as well as smaller ports (Ennore, Tuticorin) showed efficiency. So, it was inferred that size is not a determinant factor of port efficiency contrary to the general perception that “bigger perform better”. The study also observed that 44.13% of the ports were exhibiting increasing returns to scale. These ports should increase their scale of operations via expansion or internal growth and building alliances amongst shipping organization. About 11.73% of ports exhibited decreasing returns to scale. These ports can decrease their scale of operations by giving up some of the terminal assets and operational functions to other specialized private entities via concession and leaseholds. This will allow efficient handling of activities as well as promote intra-port competition between multiple service providers within a port, which can lead to higher efficiency gains.

For identifying the determinants of ports efficiency, total traffic was considered the dependent variable and variables like turnaround time, idle time, berth occupancy, berth throughput, operating surplus per ton, rate of return on turnover, number of employees, operating expenses, net state domestic product, net state domestic product in agriculture, net state domestic product in industry and net state domestic product in services were taken as independent variables which were selected based on the correlation matrix analysis. From the analysis it was seen that fixed effect model (which is supported by Hausman, 1978), was the most appropriate model in the present analysis and the variables like Berth throughput, Number of employees, Operating expenses, idle time and Cargo equipments were identified as the important factors influencing port efficiency. It can be concluded that there mostly the inside factor influence the port efficiency and the effect of outside factors were not very significant as the coefficients of inside variables were significant when compared with outside variables.

Several factors affect ports operational efficiency, including utilization of capacity, cargo equipments available in the port, berth throughput and so on. However, it is quite difficult to accommodate all the data variables, and it was therefore imperative to adjust the combination of input and output variables which can be taken into consideration for the analysis as it was an overall analysis of all major ports. The management of each major port should therefore make a thorough analysis of their performance with the detailed data periodically so that they can upgrade their facilities which may have visible impact on the performance time to time. This will not only help management to respond to every increased operational pressure due to increased level of activity, but also serve as a basis for objective decision-making with respect to ongoing improvement in operational efficiency.

7.8. Scope for future work

Data Envelopment Analysis (DEA) is a tool for measuring the efficiency of decision making units. The main purpose of the study was to analyze the operational efficiency of major ports of India. The future study may attempt the efficiency evaluation of minor ports and also the studies can attempt to make comparison of major ports and minor ports.

The present study measured the factors determining for port efficiency among major ports in India through panel data. There exist still a scope to attempt on causality between port performance variables and port efficiency.

Future work can also be attempted to measure casual relationship between cargo-specific performance and total traffic of each port. The reason being, most of the Indian ports were designed predominantly to handle specific categories of cargo at the time of inception, which is no more the reality at present. Might be as the other types of cargo traffic are required to be handled by these ports, and they are not adequately equipped for it they are not able to handle efficiently. Thus cargo specific performance evaluation also can be attempted to.

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