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The Relative Efficiency between the Container Terminals Operated in Jawaharlal Nehru Port Trust–Navi Mumbai

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ABSTRACT

The Indian container market is flourishing every year with the huge investments from Indian and global operators targeting for higher handling capacities throughout the terminals at Indian ports. Jawaharlal Nehru Port Trust (JNPT) is one of the top 10 ports in the continent of Asia and ranked as the 33rd place among the top 100 ports has been taken up for an analysis. The four terminals installed in JNPT have a lion a share of more than 52 % out of the total container traffic handled at Indian ports. Eventually, the relative operational and productivity efficiency between the four container terminals operated in JNPT has been taken up the study. The methodology of Data Envelopment Analysis (DEA) and the Malmquist Productivity Index (MPI) analysis which is the most powerful tool is adopted for assessing the physical efficiency of the four terminals.

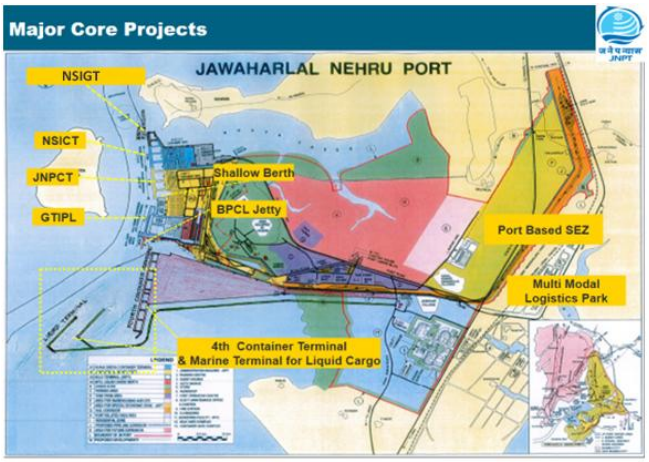
1. Introduction

Generally, the cargo meant for shipment is classified as bulk and break-bulk. Break-Bulk cargo is transported individually, often on a pallet or in a crate whereas in the case of bulk cargo such as petroleum/crude oil, grain, coal, iron ore or gravel which are either in liquid or in granules are transported unpacked. The method of handling break-bulk cargo through container has been effective from 1950 in some of the international ports. Initially, the regular container service commenced in 1961 between the ports located in US East Coast, Caribbean, Central, and South America. In the case of economically strong and stable countries, the transportation of break-bulk cargo has switched over containerization in to whereas the global average of handling break-bulk cargo through containers is at the range of 70 %. In the international sea transportation, the load transport through containers has achieved importance in the past 60 years. The handling of break-bulk through containers is accounted to be more efficient, cheaper and faster. Due to rapid increase in containerization there is tough competition between some of the seaport container terminals which is quite encouraging.

The world container throughput for the year 2017 was 752 million TEUs, which has increased by 2.1% in 2017 through 250 container terminals situated all over the world according to the analysis of the recent UNCTAD report. Despite the existence of 250 container terminals, 60% of the container traffic has been handled only by 40 terminals. The container traffic handled on the continent of Asia was more than 480 million TEUs in 2017 which has increased by 2.1% in 2017 according to the Review of Maritime Transport 2018. The combined throughput at the world's leading 20 container terminals together handled an estimated 336.6 million TEUs, accounting for 45% of the world's total. JNPT, being one of the top 10 ports in the continent of Asia and ranked as the 33rd place among the top 100 ports is taken up for the study.

JNPT was commissioned as a Major Port in the year 1989 and brought within the purview of Major Port Trusts Act in 1963. Out of the 12 berths situated in JNPT, two berths had been exclusively earmarked for container handling operation since the date of initial operation. Apart from the operation of container handling by the Port Authority, by way of Build Operate and Transfer (BOT) agreement the Port Authority entrusted the container handling to the private bodies for 30 years at different stages through amendments effected to the statutory provisions in the MPT Act 1963. The geographical location of the four terminals taken up for the study isin the diagram below:

Figure-1
JNPT Layout



Source: JNPT Administration Report 2017-18

The Indian container market flourishes every year with huge investments from Indian and global operators in building large capacities across the Indian coast to serve the nation. Every operator is trying their best to establish India as a leader on the logistic map of the world. The study report on Indian Infrastructure reveals that there had been a constant growth in the gateways ports coinciding with transshipment hub at the rate of 11 % and 10 % in the installed capacity and traffic handled respectively in the last few years which is attributable due to the efforts rendered by the private payers duly supported by the Government.

The above report further shows that in the year 2017-18 the installed capacity of the container terminals in India was 21 million TEUs against which the actual containers handled was 15.37 million TEUs with the growth rate of 12 % .On Indian coast, all these years, the west coast plays a dominant role with higher capacities in the Maharashtra and Gujarat regions, the west coast predominantly captures two-thirds of the country's container business.

2. Literature Review

Several studies on port efficiency have been carried globally in the past irrespective of the fact that the port concerned is classified as a hub port or otherwise, among which the studies relating to Small and Medium Ports(SMP) are far and few. In so far as, the Indian Ports are concerned, they fall under latter category in which the JNPT which is at the rank of 30 globally has been taken for study on relative efficiency. The DEA method which was used in respect of hub ports in the aforesaid study has been utilized for the purpose of this study on relative efficiency in respect of JNPT ports.

The term DEA method has been defined to be a nonparametric method due to the fact that there is no requirement of assumptions regarding the shape or the parameters of the underlying production function for evaluating the efficiency of a Decision-Making Units (DMU), which is structured directly from the sample data by applying a linear or non-linear programming method. The CCR and BCC models are the most widely applied DEA models. However, this model can only examine the relative efficiency of targets.

The Malmquist productivity index (MPI) was first presented by Malmquist (1953) and subsequently expanded by Fare et al. (1994) as a DEA-based MPI that measures productivity efficiency change over time. Nowadays, more and more researchers are using DEA-Malmquist both to estimate efficiency and to evaluate changes in efficiency over time. Li et al. (2013) proposed the three-stage DEA model to evaluate wide-ranging efficiency, pure technical efficiency, and scale efficiency. Fu et al. (2009) applied the DEA- based Malmquist productivity index to measure the operating efficiencies of 10 leading container ports in China from 2001 to 2006.

To have an easier perspective and understanding the details of such studies, they are tabulated below which will be an eye opener for undertaking similar study in respective of container terminals in Indian ports with specific reference to JNPT.

Table-1
Non-parametric method of analysing the relative efficiency of container ports and terminals

Authors	Model	Sample and Region	Inputs	Outputs
Cullinane, Wang Song& Ji (2006)	DEA-CCR;DEA-BCC	30 container ports	Terminal length;Terminal area;Quay cranes;Yard gantry cranes;Straddle carries	Container throughput
Guimaraes et al. (2014)	DEA-CCR;DEA-BCC	15 Brazilian container terminals	Total Energy;Non-renewable energy;Sewage emission;Office supplies consumption;Total emissions & Water consumption per worker	Container throughput
Hai-Bo and HeZhong (2009)	SFA	13 port companies in China	Net permanent asset;Total employees	Main business revenue
Hung et al. (2010)	DEA-CCR;DEA-BCC;DEA with bootstrap method	31 container ports in Asia- Pacific	Terminal area; STS container; Gantry cranes (No); Berths (No);Total Quay length	Container throughput
Jiang and Li (2009)	DEA-CCR; DEA-BCC	12 container ports in Asia	Import/Export by customs;GDP by regions;Berth Length;Crane number	Container throughput
Li et al. (2013)	DEA;SFA	42 Coastal ports in China	Terminal length Handling equipment (bridge, mobile & beam cranes); Number of employees	Container throughput
Lim, Bae & Lee (2011)	Additive non-oriented DEA RAM	26 Asian container terminals	Quay length;Total area;Gantry Cranes	Container throughput
Sanchez and Millan (2012)	Malmquist index	46 ports in Spain	Number of employees;Intermediate Consumption ;Capital	Liquid bulk; Solid bulk; and general cargo;
Tongzon (2001)	DEA-CCR;Additive DEA	4 Australian and 12 other international container ports	Number of cranes;Number of container berths;Number of tugs;Terminal area;Delay time;Labor (units)	Container throughput;Number of ship calls
Wanke (2013)	Network-DEA centralized efficiency	27 Brazilian ports	Number of berths;Warehousing area;Yard area;Container frequency (shipments)	Container throughput
Wilms Meier and al. (2013)	Malmquist index	40 ports in Central and South America	Terminal area;Ship-to-shore crane capacity equivalent;Number of employees	Container throughput

Source: Computed

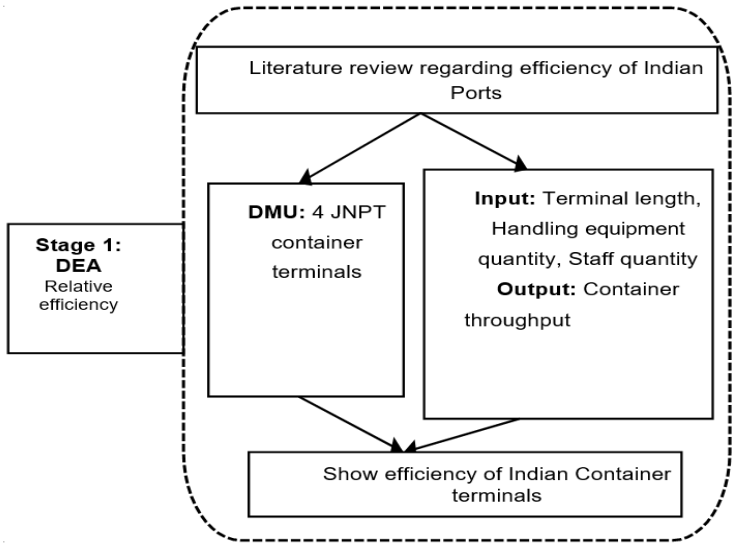
3. Methodology

The core framework of this analysis is shown in Figure 2, the DEA method is employed to measure the relative efficiency of 4 container terminals between 2015-16 and 2017-18 using input variables (terminal length, installed capacity, handling equipment quantity, and staff strength) and output variable container throughput. In the next stage, Malmquist Productivity Indexes (MPIs) are applied to examine productivity and efficiency change in selected container terminals. The results indicate that a higher shareholding ratio of state-owned shipping lines can lead to more efficient terminal productivity change.

(i) DEA- Malmquist - Empirical Analysis

In recent years, there have been a number of studies investigating port efficiency, many of which used DEA for analyse port industries (Cullinane and Wang, 2006).

Figure-2
Core framework of an analysis



Source: Computed

The Malmquist productivity index (MPI) was first presented by Malmquist (1953) and subsequently expanded by Fare et al. (1994) as a DEA-based MPI that measures productivity efficiency change over time. The index can be divided into two parts, one measuring changes in technical efficiency and the other changes in the technology changes. For the purposes of this paper and taking account of the accessible resources, DEA-Malmquist is used as the preferred analysis method.

(ii) Malmquist Productivity Application

The comparative analysis on relative efficiency in respect of two terminals indicated at Sl.No.4 and 1 of Table 2 in respect of NSIGT and JNPTwhere the efficiency has shown constant growth. According to which the growth in respect of Nhava Sheva (India) Gateway Terminal (NSIGT) and Jawaharlal Nehru Port Container Terminal (JNPCT) are at the level of 33 percent and 8.6 percent respectively (base year 2015-16), whereas in respect of the two other terminals at Sl.No.2 and 3 in respect of NSICT and GTI depicts the decline in the growth rate at 42.6 percent and 8.5 percent, respectively. The average value of the all the terminals' Malmquist productivity indices (MPI) was 0.933, representing a 6.7 percent decline over 2015-16.

Table-2
Malmquist Productivity Results

Terminal Operator	DMU	DMU_No	MPI	TECI	TCI
(1)JNPT	JNPT	DMU_1	1.086	1.035	1.049
(2)DP World	NSICT	DMU_2	0.574	0.547	1.049
(3)AP Moller	GTI	DMU_3	0.915	0.825	1.11
(4)DP World	NSIGT	DMU_4	1.33	0.998	1.334
Mean value	0.933	0.826	1.13		

Source: Computed

The mean value of the Technical Efficiency Change Index (TECI) was 0.826 between 2015 and 2018. The efficiency change indices of JNPT terminal were greater in 2018 than in

2015, and all other terminals showed a value of less than 1. It is noted that the efficiency of NSICT decreased by almost 45 percent compared with 2015. The mean value of the Technical Change Index (TCI) was 1.13 between 2015 and 2018, and during this period, NSIGT ports' technical change was higher than the other terminals and increased by 33.4 percent.

An analysis of the four container terminal operators of JNPT elucidating the infrastructure and other facilities existed at each terminal could be classified in the forthcoming narration.

Table-3
Snapshot of JNPT Container Terminals

PARTICULARS	JNPCT	NSICT	GTI	NSIGT
Commencement of Operation	1989	1999	2006	2016
Quay Length (Meter)	680	600	712	330
Installed Capacity(Mill.TEU)	1.5	1.2	1.8	0.8
Drafts (Meter)	14	14	14	15.45
Max.LOA (Mtrs)	370	370.	370	370
Backup-Area in Hectares (CY)	61.49	25.84	47.24	25
Railway Siding Track For ICD	04	02	03	Nil
Reefer Plugs (Nos.)	576	772	880	336
RMQC (Nos.)	9	8	10	4
RTGC (NOS.)	27	29	46	12
Tractors, Trailers	148	90	139	40
Staff Strength	600	300	350	150

Source: JNPT Administration Report 2017-18

JNPT is the largest container terminal in India. It has handled 4.83 million TEUs in 2017-18 which is 52% of the country's seaborne container trade. With the progressive outlook for expansion to handle 10 million TEU per annum in the target year 2023, the JNPT developed a new container terminal through M/S Bharat Mumbai Container Terminal Private Limited (BMCT) a Subsidiary of PSA International. JNPT's flexibility of the new technology and the enhancement of port infrastructure intensified the operations across its container terminal to record one of the highest throughputs in India.

JNPT has four container terminals such as JNPCT, NSICT, GTI and NSIGT. Among the four container terminals, the JNPCT owned and operated by the Port Authorities has handled more than 30% of the total container throughput of the port. The other three container terminals leased out on BOT basis to private operators, the NSICT, a subsidiary of DP World was commissioned in the year 2000 on Royalty basis handled only 13 % of the container throughput, a decrease in throughput, compared to the last three years. The decrease is attributable due to the reason that the DP world ventured a new terminal in July 2016 named as NSIGT on Revenue sharing basis. However, the reason behind DP world taking over the second terminal NSIGT was that the method of Revenue Sharing was more beneficial for them, compared to the former terminal commissioned on a Royalty basis. In the case of Royalty the quantum payable to the Port Authority is against the 'Minimum Guaranteed Throughput' which will be increasing every year as agreed to at the initial stage of agreement whereas in the case of Revenue Sharing, the percentage of share fixed at the initial stage will be constant until the agreement is in force. This has resulted in decreasing the volume of traffic handled in the former terminal which gets diverted to the second terminal operated by them in the different banner. As a result, the quantum of traffic handled in the second terminal has shown an increase of 48% within three years. The two terminals of DP World functioning under different administration are contributing the throughput of 13% each in 2017-18.

The other terminal taken up for the study is Gateway Terminals India (GTI) which is a joint venture with CONCOR under BOT on Revenue sharing basis started functioning in the year 2006. This terminal has a significant contribution of having handled more than 2 million TEUs individually, which is the highest throughput in Indian Ports and also contributed more than 42 % share in the total traffic handled in JNPT.

(iii). DEA Application Results

The relative efficiency of 4 container terminals between 2015-16 and 2017-18 was estimated using DEA based on input variables (terminal length, handling equipment quantity, and staff strength) and output variable container throughput. The results are shown in Table 4.

Table-4
Efficiency scores of each DMU

DMU	2015-16				2016-17				2017-18			
	CCR	BCC	SE	RTS	CCR	BCC	SE	RTS	CCR	BCC	SE	RTS
DMU1(JNPT)	1.00	1.00	1.00	CRS	1.00	1.00	1.00	CRS	1.00	1.00	1.00	CRS
DMU2(NSICT)	0.67	0.86	0.78	IRS	0.51	0.69	0.74	IRS	0.40	0.55	0.72	IRS
DMU3(GTI)	1.00	1.00	1.00	CRS	1.00	1.00	1.00	CRS	1.00	1.00	1.00	CRS
DMU4(NSIGT)	0.33	1.00	0.33	IRS	0.75	1.00	0.75	IRS	0.98	1.00	0.98	IRS

Source: Computed

Between 2015-16 and 2017-18, the CCR, BCC, and SE (scale efficiency) index of JNPCT and GTI were all valued at 1. Compared with other two container terminals of JNPT, these two terminals have a reasonable usage of input in terms of number of gantry cranes and quay length. In addition, GTI partnered with the CONCOR, the Ministry of Railways to open lines from JNPT up to Ludhiana via Diva, Vasai road, Vadodara, Ratlam, Kota, Bayana, Mathura junction, Tughlakabad and Delhi. The operator of GTI provides facility for container handling comparatively at lower costs and also offers integrated transport chains right from the place of origin and up to the point of destination due to their financial, technical, managerial and strategic capability. In view of the fact that the operator concerned is in possession of 63 ports and 154 inland service locations across the globe

Amongst the four terminals at JNPT, GTI has the longest jetty with a quay length of 712 meters and operates with a channel depth of 13.1 meters and it accounts for about 45 % of the total container handled at JNPT and crossed the 2 million TEUs in a year by which it stands first among all other terminals in India.

In so far as other three terminals are concerned , one of the terminal named as Jawaharlal Nehru Port Container Terminal (JNPCT)which is owned and controlled by the JNPT management have migrated its Terminal Operating Systems (TOS) to SPARCS N4 platform developed by Navis – a Global leader in developing Terminal Operating Systems have presence for almost three decades. The other two terminals have been leased out private sector on BOT basis which are functioning under the control of DP World. As per the comparative analysis made supra, the performance of NSIGT commissioned in 2016 is more attractive, at the users point of view, than other terminal viz., NSICT established in 1999 though NSICT had given stiff competition to JNPCT and had succeeded in diverting a considerable amount of traffic from the latter since 2000. NSICT's traffic continued to grow for the rest of 2000 while that of JNPCT continued to fall, reflecting clear signs of traffic diversion in favor of the former. By overstretching its capacity, NSICT left its customers dissatisfied. For instance, NSICT norms were rather strict with regard to last moment cargo loading, which the shipping lines often failed to meet due to logistic problems. JNPCT is much more flexible in this regard. The change in JNPCT's set-up and functioning, along with efficient marketing strategies, succeeded in attracting some of these customers to JNPCT. During 2017- 2018, GTI successfully tapped the extra business potential of the Maersk Sealand Shipping Line and allowed them to set up their new equipment and conduct "private yard management" within JNPCT. The estimated traffic potential in this context was 2.5 million TEUs per year on a regular basis.

4. Conclusion and Future Work

The presentation evaluates the operational and productivity efficiency of four container terminals in JNPT and also quantifies the factors that influence productivity according to which the JNPCT and NSIGT are classified as most efficient in terms of productivity and while GTI stands best in terms of throughput. It will be worth considering that such type of study in respect of other areas such as handling break bulk and dry bulk cargo could be undertaken to pave way for increasing the productivity in Indian ports at optimum level.

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