A Benchmarking of Major Seaports of India

Sandip Solanki, Krishna Murthy Inumula

Abstract:This research study uses annual time series data 1999-2017 on selected physical performance indicators vessel traffic, average pre-berthing waiting time, average turn round time (ATRT), percentage of idle time at berth to time at working berth (PIBTW) and average output per ship berth day (AOPBD) of major ports in India. These selected physical performance indicators analysed by the method of principal component factor analysis which had given equal weights to the indicators thereby ranked the ports based on the overall score. Result found that JNPT port occupies the first position with a total score of 966 awarded rank 1, followed by Ennore port second rank with a score of 789 and Kandla port occupying with rank three with a total score of 712, Kolkata, Haldia and Tuticorin ports showed poor performance and are ranked 13, 12 and 11th positions respectively.

Key Words: Port Ranking, Physical Performance Indicator, Benchmarking and Factor Analysis
JEL Code: F14, L92, P17

I. INTRODUCTION:

India has a rich history of internal and external trade through ports. Indian ports play a significant role in transforming Indian economy to a new level at par with the developed economy. The majority of industries in India & around the world are located in the coastal belts, in the vicinity of major ports. India handled the tune of 561.39 MT cargo during April –January 2018 and currently 578.86 MT of cargo during April-January 2019, through its 13 major ports, representing a growth of 3.11 per cent. In the era of the globalization, Indian ports saw a good competition among the neighbouring ports that helped more efficient import and export business contributing to national development in creating new import and export zones in the country. As seaports handle the majority of international merchandise trade, ports act as a hub for the shipping of goods between the nations and existence of developed ports help in the movement of inbound and outbound cargo between trading nations. Geographic concentrations of ports occur in all major trading regions and their solidity is strictly connected to the economic well-being of their neighbourhoods and the foreign provinces where they are connected by shipping services (Pettit & Beresford, 2008). An efficient seaport infrastructure provides comparative advantages to the nation in the global market. Therefore, the systematic appraisal of seaport efficiency can reveal their relative positions in the competitive environment. The paper has been organized into five sections. The first section gives an introduction and provides some necessary information about the background of the study. The second section assesses the literature.

Data sources and methodology have been presented in the third session. The results have been described in the fourth section. The final and fifth section concludes with conclusions and some policy implications of the study.

II. LITERATURE REVIEW:

There is no study on physical performance indicators covering the time series 1999-2017 with particular reference to India. Some literature reviewed as below;

Jose L. Tongzon & Ganesalingam (1994) compared the performance and efficiency of the ASEAN ports by their (similar) external foils. The results inveterated that the ASEAN ports have realized advanced stages of competence in the use of cranes, berths and storage areas, with the Singapore port being the highest player. However, they are usually less effective in terms of appropriateness, labor, and use of tugs. The rates in ASEAN ports are also significantly more than those of their (similar) foreign counterparts. Rajasekar, Ashraf, & Deo (2014) highlighted that JNPT seaport rated the excellent competent port amongst designated key ports in India. Jim Wu & Lin (2008) found that the efficacy worth of the vessel seaport in India is second only to the US port of Los Angeles among the ports surveyed in the developed countries. Prabir De (2002) studied further growth in the seaport is highly dependent on how quickly new machinery and better facilities can accommodate it. Coto-Millan, Banos-Pino, & Rodriguez-Alvarez (2000) analysed annual data for the 27 Spanish ports from 1985 to 1989, highlighted that comparatively bigger seaports are economically additional incompetent. De (2006) reviewed that ports in India are becoming more wealth concentrated in the post reform period, and except one, the rest of all Indian ports showed statistically substantial variations in TFP's overall productivity factor in the last quarter of a century. The study also found that, contrary to popular belief, the post-reform economic climate still has no significant influence on the routine of Indian ports in terms of the most popular performance degree, the TFP.

Jose Tongzon, (2001) used Data Envelopment Analysis (DEA) to provide competence measurements for four Australian and twelve other global vessel ports. Research has shown that the ports of Melbourne, Rotterdam, Yokohama and Osaka are the greatest incompetent ports, based on continuous and adjustable returns to scale norms, largely due to the massive loose in their vessel berths. J. Wu, Yan, & Liu (2010) results indicated that the number of berths and the capital deployed are the most sensitive measures impacting performance of most container ports.

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The study analysed 77 global container ports. Cuadrado, Frasquet, & Cervera (2004) found that the selection of a port made by clients–freight companies and export and import companies–is not based solely on location; the different port services offered and the quality of service are highly relevant. Woo, Pettit, & Beresford (2011) presented that seaport productivity is multilayered, it is not just restricted to inside procedures, but also connected to external facility features such as facility superiority, etc.

Cheon (2007) examined that port efficiency is formed not only by the strength of interplanetary rivalry, but also by the aptitude of port specialists to device groundbreaking official practices in the context of a internationalized, modest world trade arrangement.

Valentine & Gray (2001) studied that the simple structure is the most efficient form of organizational structure, whilst ownership structure does not appear to have any significant influences upon efficiency. Organizational restructuring of an inefficient port must not been seen in its own right to be the panacea, but must go hand-in-hand with new financing and investment. Pantouvakis & Dimas (2010) found that ISO-certified seaports are financially extra competent than their non-certified players. De & Ghosh (2003) found that the fundamental affiliation amongst port result and port traffic flow using Indian data. The use of the co-integration investigation resulted in performance being preceded by traffic in most ports in India. Estrada, Jenatabadi, & Chin (2017) found that the marginal level of seaport efficiency is centered on how the human capital factor can be adapted to these new changes. Park & De (2014) found that alternate DEA is a possibly prevailing method to the assessment of the general competence of ports. Atul Deshmukh (2002) found that only the JNPT seaport has exposed some optimistic competence related to other key seaports in India. Prakash Gaur, Shivani Pundir, & Tarun Sharma (2010) tried to probe on how ports in developing countries like India should increase their capacity from operative size to likely size and to complete size. The study found that if Indian seaports grow at a very high development speed, they may face size limitations. It means adding capacity without improving the efficiency of the system would result in underutilizing the potential capacity of the system. The study suggested that institutional cooperation could be used as a strategic tool to improve efficiency and, at the same time, options such as public private participation should be tested by the government to improve competition and, subsequently, the efficiency of ports.

Dwarakish & Salim (2015) studied the role played by ports in the development of a nation. Gaur et al., (2011) argued that, although major programs and actions are launched to upsurge the size of seaports, there is a lack of immediate need to increase the efficiency of port operations. J. Wu, Yan, & Liu (2009) extended the Doyle and Green model by considering the DMU groups to determine the final cross-efficiency. A new approach based on the cross-efficiency assessment method is being developed and applied to the efficiency analysis of 28 container ports in 12 Asian countries. Feng, Mangan, & Lalwani (2012) suggested that Western European seaports has to develop administration provision, decrease seaport rates, spread seaport possession and advance seaport connectivity, while Eastern Asian seaports require to advance levies facilities, increase vicinity facilities, upsurge logistic demand, inspire intermodals and set up' dry ports.' SangHyun Cheon (2007) observed that ports across the world have improved in their productivity due to three main reasons. These three are: (a) improvement in management in capital inputs, (b) production scale adjustments, and (c) technological progress. The study also found that large-scale ports need to be more efficient, as they have adopted in the above-mentioned points. The study also notes that port efficiencies also depend on the ability of port establishments to device ground-breaking formal practices in a global competitive environment. KM Chudasama (2009) presented that the physical facilities of ports make a significant contribution to the largely result of the seaport. The size of freight held, one of the functioning factors, meaningfully affected the outcome of seaport.

III. DATA & METHODS

A. Data and Scope

This research study uses annual time series data 1999-2017 on selected physical performance indicators vessel traffic, average pre-berthing waiting time, normal turn round period, proportion of indolent period at berth to time at working berth and average productivity per ship berth daytime of major Indian seaports. The data is extracted from Indiasta.com web portal from the source of Ministry of Shipping, Road Transport & Highways Government of India. The expansion of the seaport segment is significant for the growth of sea trade in existing globalized world. In the first four decades of post-independence, India's shipment and seaport segment saw intense development on the inventiveness of deliberate progress and lively administration provision. Over two thirds of seaport shipment handling capacity and more than half of India's national transport weight have been recognized in the first four periods of freedom.

India lacks of inter-port and intra-port competition that has led to significant increases in productivity in other countries due to unfortunate interior connectivity and a rule management that protects local seaports from economic weights. In this context, the present study identifies five physical performance indicators on the basis of which the major ports of India are benchmarked by giving them ranks based on the best performance.

B. Research Methods

Descriptive research design is used in this study, simple arithmetic measures like descriptive statistics mean and standard deviation describe the average values of data variables and their deviation from the average value. The compounded annual growth rate (CAGR) is a useful measure of growth over the study period it gives the growth rate of physical indicators over the period of time.

Correlation matrix is used to measure the linear relationship between physical performance indicators of major ports, the correlation coefficient (r) value determines the magnitude and direction of correlation, if the value of r lies between 0.75 and 1 expect high optimistic association, between 0.5 and 0.75 modest optimistic association and 0 to 0.5 low positive correlation. If the value of r lies between -1 and -0.75 expect high negative correlation, between -0.75 and -0.5 moderate adverse association and - 0.5 to 0 low negative correlation.

A comprehensive study by Nardo, M.,et al. (2005). Tools for Composite Indicators Building used in this study as a reference. Principal component based factor analysis to weigh the performance indicators in port ranking, the detail methodology is as follows. Principal component analysis (PCA) based factor analysis is a method of data reduction technique in which the number of factors extracted are lesser than the variables in such a way that the first factor represent highest likely difference followed by the next highest and so on such that all likely difference in the variables or pointers represented by the least likely quantity of factors. After verifying the correlation structure of the variables the next step is to determine the number of factors to be selected based on value of Eigen value or higher proportion of explained variance methods. The standard practice is to choose factors that: (i) have associated eigenvalues larger than one; (ii) cumulatively contribute to the explanation of the overall variance by more than 60%. The next step is to rotate the factors (usually varimax method of rotation) so that the variance extracted will be distributed proportionately to the selected factors. The final step concerns the structure of the mass of the background of the factor loadings after rotation, given that the square of the factor loadings represents the percentage of the total unit alteration of the pointer clarified by the aspect. The approach taken by Nicoletti G., Scarpetta S., Boylaud O. (2000) is the grouping of sub-indicators with the highest loading factors in the composite indicator.

The factor weights are obtained by dividing the square of the factor loadings by the explained variance of that factor (Eigen value), the proportion of factor variance is obtained by dividing the explained variance by the total variance. The final weights are obtained as a sum product of proportion of factor variance and factor weights. The original variables are transformed in to standardized variables by a suitable transformation then multiplied with the final weights as a sum product to get the total score for each decision making unit (in this study the major ports of India) higher the total score better the rank in terms of physical performance indicators.

IV. RESULTS & DISCUSSIONS

Trend of Data Variables

PORT	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	AVG
Kolkata	922	687	644	677	687	730	734	891	1012	1057	1301	1301	1203	1216	1241	1314	1442	1306	1020
Haldia	1258	1405	1529	1659	1832	2086	2348	2300	2335	2399	2166	2189	1982	1943	1970	1907	2026	2087	1968
Paradip	712	886	890	887	961	1052	1187	1355	1513	1536	1531	1487	1328	1274	1443	1400	1521	1580	1252
Visakhapatnam	1654	1648	1580	1622	1677	1805	2071	2052	2346	2347	2406	2469	2432	2041	1970	1942	2018	1944	2001
Ennore	-	-	71	154	166	171	173	201	213	250	273	293	385	475	689	779	813	801	369
Chennai	1797	1765	1598	1593	1656	1669	1857	2059	2053	2078	2122	2181	2043	1928	1804	1790	1733	1600	1852
Tuticorin	1071	1205	1400	1426	1479	1435	1548	1509	1576	1524	1414	1402	1376	1292	1095	1380	1588	1662	1410
Cochin	973	969	979	945	912	821	959	907	806	757	872	819	833	875	995	997	1169	1216	934
Mangalore	749	734	763	832	876	1057	1080	1015	1144	1184	1186	1097	1136	1072	1062	1022	1243	1417	1038
Mormugao	505	559	597	626	677	694	642	699	748	805	895	853	785	475	398	519	605	760	656
J.N.P.T	1338	1654	1883	1766	2105	2064	2395	2775	3119	2981	3049	3100	2929	2588	2526	2642	2780	2720	2467
Mumbai	2233	1921	1796	1629	1800	1883	2053	2087	2066	1931	2046	2092	2017	1908	2262	1959	2027	1994	1984
Kandla	1855	1452	1672	1813	1823	1940	2124	2318	2598	2517	2776	2692	2714	2764	2304	2216	2513	2568	2259
TOTAL	15067	14885	15402	15629	16651	17378	19171	20168	21529	21366	22047	21975	21163	19851	19759	19877	21488	21655	

Figure 1 Vessel Traffic at Major Ports (1999-2017)

Vessel Traffic (VT): one of the port throughput measures represents the number of vessels sailed over time mostly affected by the demand for cargo, cargo volumes and physical capacity of the port. The traffic in terms of the number of vessels (excluding container) handled by the major ports considered in the study (Figure 1) have increased from 15067 to 21655 during the period 1999-00 to 2016-17 registering a compound growth rate of 2.24%. The major ports of India experienced consistently increasing trend in vessels traffic throughout the period.

The JNPT tops the list with highest vessels traffic increased from 1338 in 1999-00 to 2720 in 2016-17, with an average container vessels traffic of 2467 with average growth rate of 12.73% during the study period, followed by Kandla Port Trust whose average vessels traffic during the period was 2259 with an average growth rate of 11.72%, Visakhapatnam port occupies third place with an average vessels traffic 2001 with an typical progression degree of 10.44%. The lowest number of vessels traded was at Ennore Port with an average vessels traffic of 369 with an average growth rate of 1.82%.

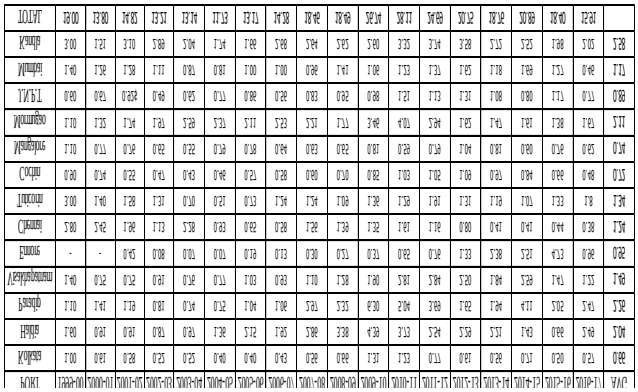

Figure 2 Average Pre-berthing Waiting time at Major Ports (1999-2017)

Average Pre-berthing Waiting time (APBT): Time taken by a vessel from entrance at the dock to the reporting post till it arrives at the operational berth excluding time taken for internal movement, obtained by dividing the total pre-berthing waiting time of all freight containers cruised from the seaport through a period by the number of freight containers navigated during that period.

Results show that (Figure 2) Kandla port registered highest average pre-berthing time of 2.58 days with average growth rate of 15.67%, followed by Paradip Port which registered 2.26 days with an average growth rate of 11.89% and Mormugao port of 2.11 days with average growth rate of 10.87%. Kolkata had the lowest average pre-berthing time of 0.66 days, followed by Cochin with 0.72 days, Mangalore with 0.74 days.

PORT	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	AVG
Kolkata	6.60	5.50	4.71	4.47	4.23	4.17	4.12	4.38	5.46	5.10	6.80	6.21	5.45	4.72	4.51	4.97	4.78	4.43	5.03
Haldia	5.20	3.97	4.01	3.02	2.88	4.05	4.89	3.85	4.26	4.21	5.01	4.45	3.62	3.95	3.77	3.36	3.27	5.47	4.07
Paradip	3.90	4.16	3.99	3.00	3.43	3.41	3.56	3.54	5.54	4.78	9.04	7.73	6.33	4.39	4.62	7.01	4.50	4.99	4.88
Visakhapatnam	4.80	3.71	3.51	3.72	3.33	3.20	3.79	3.65	3.91	3.83	4.78	5.84	5.68	5.39	4.73	5.67	3.84	3.75	4.29
Ennore			3.62	2.22	1.94	1.72	2.23	1.89	2.08	2.35	2.11	2.78	2.17	2.95	4.24	4.32	6.07	2.68	2.89
Chennai	6.40	5.83	5.25	3.66	4.61	3.94	3.32	3.36	4.55	4.15	4.04	4.36	3.91	3.24	2.46	2.54	2.53	2.51	3.93
Tuticorin	6.40	4.10	4.11	3.59	2.59	2.66	2.83	3.67	3.85	3.64	3.90	4.00	4.94	4.31	3.92	3.37	3.53	4	3.86
Cochin	3.20	3.11	2.75	2.66	2.05	2.62	2.70	2.17	1.94	2.14	2.08	2.20	1.82	1.58	1.76	1.69	2.18	1.99	2.26
Mangalore	3.80	2.89	2.73	1.90	2.35	2.96	3.00	3.14	3.21	3.00	3.06	2.70	2.95	3.29	3.18	2.46	2.63	2.35	2.87
Mormugao	4.30	4.25	4.65	3.78	4.45	5.66	6.06	6.15	6.24	5.85	8.91	10.43	7.68	5.06	4.50	3.97	3.27	3.43	5.49
J.N.P.T	2.10	2.21	2.98	1.92	1.73	1.94	1.97	1.43	1.80	1.90	2.01	2.64	1.94	2.48	2.26	2.24	2.21	1.96	2.10
Mumbai	5.60	5.20	5.47	5.06	4.10	4.21	4.06	4.63	4.07	4.95	4.61	4.96	5.22	5.58	4.25	4.09	3.29	2.49	4.55
Kandla	6.20	4.72	6.55	5.94	5.06	4.62	4.39	5.46	5.13	7.26	5.03	5.80	6.42	6.33	5.66	4.90	4.26	4.51	5.46
TOTAL	58.50	49.65	54.33	44.94	42.75	45.16	46.92	47.32	52.04	53.36	61.38	64.20	58.13	53.27	49.86	50.59	47.38	44.55	

Figure 3 Average Turn Round Time at Major Ports (1999-2017)

Average Turn Round Time (ATAT): Total period consumed by a ship at the seaport from its influx at reporting place till its exit from the reporting place, includes pre-berthing waiting time, steering time stay at working and non-working berths and shifting time.

Mormugao Seaport has the maximum (Figure 3) usual change time of 5.49 days with average growth rate of 10.59% during the study period, it was followed by Kandla port of 5.46 days with regular growth rate of 10.72% , Kolkata port of 5.03 days with regular growth rate of 9.81% , while the lowest turnaround time was registered at JNPT Port with 2.10 days followed by Cochin with 2.26 days and Mangalore 2.87 days.

PORT	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	AVG
Kolkata	44.00	42.60	41.30	41.40	37.50	37.40	40.10	35.80	35.50	39.40	39.80	38.40	35.00	32.90	37.10	35.80	34.30	44.8	38.51
Haldia	40.00	34.80	33.40	35.90	32.90	30.10	27.50	37.10	30.80	29.80	28.80	36.40	37.00	28.70	27.90	29.40	16.90	67.2	33.59
Paradip	29.00	25.50	31.30	28.30	27.20	31.30	32.50	29.50	25.60	26.10	28.60	28.40	24.10	19.40	21.10	24.80	27.60	27.5	27.10
Visakhapatnam	30.00	27.20	23.90	19.40	19.70	21.00	21.40	22.00	22.40	21.70	20.40	27.80	24.20	24.70	27.00	29.40	34.20	28.7	24.73
Ennore		-	21.00	16.80	10.30	7.00	10.50	10.50	11.20	17.50	24.50	21.50	7.40	13.20	14.50	24.70	33.80	14.3	16.17
Chennai	37.00	33.10	33.30	34.20	26.60	29.50	30.90	29.07	24.70	24.90	26.70	24.00	22.30	21.10	21.70	18.20	29.40	27.2	27.44
Tuticorin	39.00	35.40	34.30	33.10	31.60	30.60	31.30	30.90	1.60	29.70	27.80	25.80	26.40	25.70	22.10	21.20	26.10	26.3	27.72
Cochin	37.00	34.80	32.50	31.80	29.40	28.70	26.90	26.40	25.30	24.60	22.10	23.80	22.00	25.90	30.70	28.90	33.30	33.9	28.78
Mangalore	40.00	35.00	32.80	23.70	19.10	17.60	17.90	18.00	19.30	16.40	19.30	19.10	15.80	15.90	16.20	14.40	18.30	15.9	20.82
Mormugao	19.00	20.80	17.80	15.80	20.20	19.60	17.60	19.80	17.00	13.40	17.10	18.60	20.20	18.40	16.30	16.00	23.50	19.4	18.36
J.N.P.T	8.00	11.00	10.45	11.10	12.50	7.60	7.40	8.00	8.00	9.10	10.70	12.60	23.70	11.80	10.60	9.40	12.50	12.9	10.99
Mumbai	31.00	30.60	36.60	30.30	24.20	19.90	21.30	25.60	17.80	17.60	17.70	16.80	16.90	15.90	17.10	37.00	58.60	57.7	27.37
Kandla	18.00	15.00	16.00	15.90	16.80	16.40	16.30	17.00	17.40	20.20	18.30	16.90	15.90	15.70	15.60	17.90	24.30	0	16.31
TOTAL	372.00	345.80	354.20	337.70	308.00	296.70	301.60	309.67	256.60	290.40	301.80	310.10	290.90	269.30	277.90	307.10	372.80	375.80	

Figure 4 Percentage of Idle Time at Berth of Major Ports (1999-2017)

Percentage of Idle Time at Berth to Time at Working Berth: This is the amount of time a vessel remains idle at berth, lower idle time would ease cargo handling smoother and readiness for more vessels.

Over the study period 1999-2017 Kolkata has the highest (Figure 4) idle time at berth of 38.51 days with an typical growth rate of 12.28%, followed by Haldia port of 33.59 days with an average growth rate of 10.65%, Cochin port of 28.78 days with an average growth rate of 9.12%. The lowest idle time at berth reported at JNPT port with 10.99 days with an regular annual growth rate of 3.55%.

PORT	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	AVG
Kolkata	2157	2305	2215	2089	3608	3771	3984	4490	3193	3027	1917	2253	2503	2762	2963	3084	3201	6080	3133.44
Haldia	5599	6384	6207	7531	8388	8395	8753	8770	8353	7732	6243	6563	6728	6078	6130	6802	9126	12537	7573.39
Paradip	7106	8503	8831	10763	10257	11049	11316	11795	11181	12635	13853	14243	15995	16625	18179	17736	26965	30245	14295.17
Visakhapatnam	7579	9799	10772	10591	11701	12241	10558	10868	10613	11171	10484	10334	10704	10641	10825	10640	17179	16823	11302.39
Ennore	-	-	15149	26540	32767	38871	33614	35113	35260	26424	21665	17699	27505	27741	22357	22613	31106	26235	27666.19
Chennai	5886	6977	6944	8660	8654	9629	10378	10165	10032	10778	11428	10984	10352	12046	14268	14464	18976	19220	11157.83
Tuticorin	2891	3983	3900	4403	5040	5280	5392	5051	5474	5817	6934	7035	6733	7452	9633	10468	13619	13612	6817.61
Cochin	6023	6138	5979	6877	7813	8506	7778	8282	10881	10599	11089	11752	15784	15878	15881	16906	20962	23530	11703.72
Mangalore	9004	12192	12528	15936	18044	15569	15057	13080	12664	13645	13896	14211	13957	15821	16314	19856	16165	17094	14729.61
Mormugao	11162	12438	13576	14029	16746	17084	16834	17799	10332	6290	5002	4409	10530	11484	10018	12272	21542	30414	13442.28
J.N.P.T	7630	8655	7391	8418	11957	12782	16150	16727	18489	20344	21563	20393	19227	23319	23014	21310	23792	23897	16947.67
Mumbai	3876	4213	3994	5170	5692	5993	6314	5942	4519	5717	6122	6042	6476	8709	7057	11055	19020	20915	7545.89
Kandla	8740	8230	8016	8933	8659	8434	8700	9843	11216	13107	13549	14137	14272	15728	15729	15159	16538	18235	12068.06
TOTAL	77653	89817	105502	130740	158326	157604	154830	157925	152107	149286	143745	140055	160766	174384	172468	182365	237191	258846	

Figure 5 Average Output per Ship Berth Day at Major Ports (1999-2017)

Average Output per Ship Berth Day (AOSD): It is the total capacity held dispersed over the total number of berth days. Average output per ship held by the major ports considered in the study have increased from 77653 tons to 258846 tons during the period 1999-00 to 2016-17 registering a compound annual growth rate of 4.84%.

The Ennore port tops the list (Figure 5) with highest average output per ship at 27666 tons with an regular yearly growth rate of 17.29% during the study retro, followed by JNPT Port whose average output per ship was 16948 tons with an average growth rate of 10.83%, Mangalore port occupies third place with an average output per ship was 14730 tons with an average growth rate of 9.89%. The lowest average output per ship traded was at Kolkata Port with an average productivity per vessel berth day of 3133 tons with a usual progression rate of 2.07%.

Descriptive Statistics & Correlation Matrix

Indicator	Mean	Std. Deviation
VT	1477.77	655.65
APBT	1.40	0.64
ATAT	3.99	1.17
IDLETIME	24.48	7.64
AOSD	12257.66	6061.29

Over the study period the major ports of India witnessed on an average vessel traffic 1477, average pre berthing waiting time 1.4 days, average turn round time was 3.99 days, average ratio of idle period at berth was 24.48 days and average output per ship berth day was 12257 tons. Out of all the five physical indicators variations in average output per ship are higher followed by vessel traffic.

Indicator		VT	APBT	ATAT	IDLETIME	AOSD
Correlation	VT	1	0.277	0.039	-0.101	-0.296
	APBT	0.277	1	0.685*	-0.129	-0.087
	ATAT	0.039	0.685	1	0.262	-0.465
	IDLETIME	-0.101	-0.129	0.262	1	-0.762*
	AOSD	-0.296	-0.087	-0.465	-0.762	1

The above correlation matrix shows how the physical indicators are correlated with each other, there exists a low positive correlation between vessel traffic vs pre berthing waiting time and turn round time, a low negative correlation exists between vessel traffic vs idle time at berth and output per ship berth day. Though not significant, turn round time and idle time at berth are having low positive correlation between them. Pre berthing waiting time and turn round time are moderately positively correlated and the correlation value is significant. There exists a significant negative correlation between idle time and output per ship birth day as the idle time at berth decreases the more the output per ship berth day.

Ranking Port performance

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.954
Bartlett's Test of Sphericity	Approx. Chi-Square	25.559
	df	10
	Sig.	.004

Both the tests (KMO is more than 0.7 and Bartlett's significant value less than 0.05) confirms that factor analysis is appropriate for the current study with the five physical indicators to measure the performance of Indian major ports.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.176	43.517	43.517	2.176	43.517	43.517	1.867	37.347	37.347
2	1.503	30.052	73.569	1.503	30.052	73.569	1.698	33.959	71.306
3	1.010	20.195	93.764	1.010	20.195	93.764	1.123	22.458	93.764
4	.217	4.344	98.107						
5	.095	1.893	100.000						

Extraction Method: Principal Component Analysis.

Factor analysis using the method of principal components extracted a total of three component accounting almost 94% contribution to the study also referred to as factors out of the five physical performance indicators considered in the study. The Eigen values (variances of the principal components) of more than 1 are considered in accounting the total variance explained. The communalities are also high justifying the maximum proportion of each indicator variance that can be explained by the principal components.

Rotated Component Matrixa

	Component		
	1	2	3
VT	.043	.089	.990
APBT	-.138	.923	.214
ATAT	.338	.896	-.070
IDLETIME	.946	-.025	-.153
AOSD	-.915	-.189	-.263

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

The rotated component matrix (factor loadings) using varimax rotation shows the correlation between indicator and factors. The next step contracts with the building of the bulks from the contextual of feature loadings after rotation, given that the square of factor loadings represent the proportion of the total unit adjustment of the indicator which is clarified by the factor. Thus the first component explained variance is 1.867, followed by second component 1.698 and third component explained variance is 1.123. The proportion of factor variance is obtained by dividing the explained variance of each factor by the total variance of all factors combined, thus the proportion of factor variance by first factor is 39.83%, second factor is 36.21% and third factor is 23.95%.

Factor Weights				Proportion of factor variance	Final Weights
VT	0.000977	0.004621	0.872409	0.398310184	0.21102
APBT	0.010176	0.50159	0.040648	0.362172728	0.195451
ATAT	0.061109	0.472476	0.004409	0.239517088	0.196514
IDLETIME	0.47911	0.000376	0.020943		0.195987
AOSD	0.448628	0.020936	0.061591		0.201028

The factor weights are obtained by dividing the square of the factor loadings by the explained variance of that factor (Eigen value), the final weights are obtained as a sum product of proportion of factor variance and factor weights. The following table gives the final weights.

The original variables are transformed in to standardized variables by a suitable transformation then multiplied with the final weights as a sum product to get the total score for each of the major ports of India, higher the total score better the rank in terms of physical performance indicators.

STANDARDIZED	VT	APBT	ATAT	IDLETIME	AOSD
Kolkata	2.76	2.91	1.63	1.00	1.00
Haldia	5.33	1.54	2.59	5.92	2.42
Paradip	3.39	1.32	1.78	12.41	4.56
Visakhapatnam	5.42	2.08	2.37	14.78	3.61
Ennore	1.00	2.62	3.78	23.34	8.83
Chennai	5.02	2.34	2.74	12.59	3.56
Tuticorin	3.82	2.24	2.81	11.79	2.18
Cochin	2.53	2.86	4.41	10.59	3.74
Mangalore	2.81	2.83	3.80	18.69	4.70
Mormugao	1.78	1.51	1.00	21.18	4.13
J.N.P.T	6.68	2.66	4.59	28.39	5.81
Mumbai	5.37	2.37	2.07	11.47	2.48
Kandla	6.12	1.00	1.20	23.19	3.85

WEIGHTS	VT	APBT	ATAT	IDLETIME	AOSD	TOTAL	RANK
21	58.04	55.33	32.59	20.00	20.00	185.96	13
19	111.93	29.23	51.89	118.33	48.34	359.72	12
20	71.24	25.04	35.58	248.11	91.23	471.20	10
20	113.84	39.59	47.46	295.56	72.20	568.65	6
20	21.00	49.86	75.55	466.74	176.59	789.74	2
	105.34	44.41	54.76	251.86	71.22	527.59	7
	80.21	42.54	56.14	235.78	43.52	458.19	11
	53.10	54.25	88.11	211.76	74.70	481.92	8
	59.03	53.85	75.93	373.78	94.02	656.61	4
	37.33	28.67	20.00	423.58	82.59	592.17	5
	140.35	50.57	91.71	567.71	116.14	966.48	1
	112.86	45.02	41.37	229.49	49.52	478.25	9
	128.49	19.00	23.98	463.89	77.03	712.38	3

For the selected physical indicators of port performance JNPT port occupies the first position with a total score of 966 awarded rank 1, followed by Ennore port second rank with a score of 789 and Kandla port occupying with rank three with a total score of 712.

For the selected physical indicators of port performance Kolkata, Haldia and Tuticorin ports showed poor performance and are ranked from last 13, 12 and 11th rank respectively. Mangalore, Mormugao and Visakhapatnam ports stood in the next best with ranks 4, 5 and 6th rank respectively.

V. CONCLUSION

Port performance in physical indicators reflect how efficient the port operations in terms of better cargo handling, managing time lines and efficiency of port. Both inter and intra port competition is required to assess the benchmark performance so that a healthy competition prevail between the ports. The selected physical indicators viz…vessel traffic, average pre-berthing waiting time, middling turn round time, ratio of idle period at dock to time at working dock and average productivity per vessel dock day, analysed by the method of principal component factor analysis had given equal weights to the indicators thereby ranked the ports based on the overall score. JNPT port occupies the first position with a total score of 966 awarded rank 1, followed by Ennore port second rank with a score of 789 and Kandla port occupying with rank three with a total score of 712, Kolkata, Haldia and Tuticorin ports showed poor performance and are ranked 13, 12 and 11th positions respectively.

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