"Ports face inadequate capacity, efficiency and competitiveness in a developing country: Case of India"

***Hypothesis**: "Indian ports are constrained by capacity"*

Prakash Gaur
Research Scholar, Department of Transport and Regional Economics, University of Antwerp, Belgium
Assistant Vice President, IL&FS Infrastructure Development Corporation Limited,
Ahmedabad, India. prakash.iidc@gmail.com

Shivani Pundir

B. Arch, M. Tech. (Infrastructure Planning),
Faculty of Planning & Public Policy,
Centre for Environmental Planning and
Technology (CEPT) University,
Ahmedabad, India, pundirshivani@gmail.com

Tarun Sharma

M. Tech. (Infrastructure Planning), Faculty of
Planning & Public Policy, CEPT University
Manager, IL&FS Infrastructure Development
Corporation Limited, Ahmedabad, India
tarunsharma2005@gmail.com

Abstract

India on a high economic growth path faces a sharp increase in cargo throughput at the ports. Indian Ports are handling about 723 MMT of cargo in 2008-09 and are growing very fast. Government of India is making efforts to increase the capacity of Indian ports to meet the growing demand, since, the Indian exports/imports are typically carried through trans-shipment centers in Colombo, Singapore and Dubai. The major ports function under common decision maker because of their institutional structure resulting in no competition between them.

Though major programme and measures have been initiated to increase the capacity of ports, but the immediate need to increase the efficiency in port operations is lacking. This paper highlights that how the ports in a developing country should increase their capacity from Effective Capacity to Potential Capacity and further to Absolute Capacity. Indian ports need to enhance their efficiencies at par with their international counterparts on all the parameters. This paper develops an efficiency index for Indian ports and recommends institutional cooperation among ports to achieve Potential Capacity and learn from best international practices to achieve Absolute Capacity.

Keywords:

Effective Capacity, Potential Capacity, Absolute Capacity, Institutional Cooperation, Port Efficiency and Port Performance Index

(I) Indian Port Sector

India's economic growth path has been quite impressive in the recent years and is one of the best performers in the world economy, with an average growth rate of about 9% per annum in the last three years and about 7% growth in the decade.[1] India has about 7,517 km of natural peninsular coastline strategically located on the East West trade route which links Europe and Far East. The Indian coastline spread over 13 States/Union Territories (UTs), is dotted with 12 major ports and 187 non-major ports[2]. The total traffic handled by both the major and non-major ports during 2007-08 was estimated at around 723 Million Metric Tons (MMT). The 12 major ports carry about ¾ th of the total maritime transport of the country. According to the Indian Ports Association, these major ports together handled 530.4 MMT[3] , 519.24 MMT and 463.78 MMT in 2008-09, 2007-08 and 2006-07 respectively. The share of non-major ports in cargo traffic has increased from less than 10 per cent in 1990 to the current level of 26 per cent due to congestion and inefficiencies at major ports and simultaneously development of minor ports by the respective states. There is an impressive growth of about 15% per annum in container traffic during the five years ending 2007-08. The container trade went up to 7.2 million twenty-foot equivalent units (TEUs) by 2007 from 2.47 million TEUs in 2000[4].

To consolidate its position in the backdrop of the requirements to meet the ever growing demands and capture the potential from convergence of the global economy and competitive markets, there has emerged a dire need to build up capacities and efficiency in the Indian port sector supported by a strong back up infrastructure to face competitiveness from the international ports like Colombo and Far East ports as hub port for Indian ports. As a strategic intervention towards port sector development, an enabling policy framework has been put in place by the Government for private investment and development on varying formats of Public Private Partnerships (PPP) in various areas of the maritime sector with the objective of bringing in fresh investments for meeting the infrastructure requirement and efficiency improvement. Among the various benefits and incentives planned, 100 % FDI is permitted and 100 % income tax exemption is provided for a period of 10 years for port development projects. At the State level, the proactive policies by

[1] http://www.ibef.org

[2] Major ports are those under the jurisdiction of Union Government whereas non-major ports are in the jurisdiction of respective Provincial Governments.

[3] http://www.ibef.org

[4] http://www.ibef.org

some of the maritime states especially like Gujarat has boosted the development of non-major ports and hence the growth of maritime traffic.

The Draft Maritime Policy by the Government of India (GoI) proposes to adopt a holistic approach encompassing major and non-major ports, shipping, shipbuilding and inland water transport (IWT) thereby building in synergies for integrated development. The policy objectives emphasize on adopting complementary approaches rather than merely focusing on competitive aspects in the overall supply chain integration elements. The focus is towards cost effective movement of cargoes and efficiency of operations. The programme under the policy addresses aspects such as modernization and upgradation of facilities, new ports, hinterland connectivity, port specialization, inter-port complementarities, institutional safeguards, multi-modal transport, strengthening shipbuilding, ship-repair and ship-breaking activities, qualified maritime personnel and integration with modes of transport.

The Ministry of Shipping, Road Transport and Highways (MoSRTH) mandated each of the major ports to prepare the Business Plans for the respective Major Ports and thereafter came up with the Consolidated Port Development Plan for coordination of business plans for Major Ports with the overall goal: *"To transform Indian ports into world class facilities suited to requirements of the future economy of India"*. In a major thrust to expand capacity at important ports in the country, the MoSRTH has awarded seven projects worth over US$ 387 mn, to be developed through the PPP route. Another 19 projects, estimated to cost around US$ 3.9 bn, are expected to be awarded on similar PPP basis by early 2010. These 26 projects together will expand capacity at the major ports in the country by 42 per cent, or 245.97 MMT.[5]

The National Maritime Development Plan (NMDP) has been formulated by the Indian Government to complement the maritime sector development and aims at improving facilities at Indian major ports at an expenditure of around US$ 12.4 bn. A further investment of over US$ 9.07 bn will be made for 111 Shipping Sector Projects by 2015.

Emphasis is being laid on improving the port performance and efficiency. The average turnaround time at the Indian ports has increased marginally from 3.6 to 3.9 days, in comparison with 10 hours in Hong Kong. The average output per ship berth-day has improved from 9,745

[5] www.ibef.org

tons in 2006-07 to 10,071 tons in 2007-08. The pre-berthing waiting time at major ports on port account, however, increased from 10.05 hours in 2006-07 to 11.40 hours in 2007-08 and reduced to 9.59 hours in 2008-09.[6] For port-hinterland interface development, emphasis is laid on improving the road-rail connectivity, wherein groups with representatives from National Highway Authority of India (NHAI), the railways and State Governments have been set up by the port trusts to prepare comprehensive plans in enhancing port connectivity.

(II) Defining the Capacity of Ports

In this paper, it is attempted to consider the physical capacity of a port. The definition of capacity from an economics perspective is a limitation to the scope of this paper considering that developing country like India are more focused on physical capacity rather than economic capacity of ports.

It is essential to define physical port capacity in an integrated manner rather than a fragmented approach as the port operations have changed and many more functions have been added. While analyzing the port operations, it is essential to dwell upon the infrastructure and the operations involved that influence the determination of the port capacity. Capacity is a function of ultimate output of production at each level of operation of the port. It is pertinent to consider that the deterministic functions of physical capacity are associated with the infrastructure provided, processes involved, most efficient and other factors of production deployed in each of the port operations. From an economics perspective, Benathan and Walters (1979) have defined optimum capacity at a point of time on the basis of cost (supply) and revenue (demand) curves of port which can be changed by using variable costs.

According to Manheim (1984), capacity can be defined as the maximum number of items that can be squeezed through a system or its components per unit of time at a certain level of service quality. According to Ashford and Wright (1992) capacity is determined considering (a) Design variables such as numbers, sizes and surface areas; (b) Quality and reliability of services determined by labor, applied technologies, and service schedules; (c) Nature of the demand such as arrival rates and the handling characteristics of the transported items, and (d) Environmental factors such as the function of the surrounding area and weather conditions.

[6] http://indiabudget.nic.in

The mathematical empirical formulation of capacity for handling containers (in TEU's) given by United Nations Conference of Trade and Development (UNCTAD) considers Number of Berths, Berth Occupancy, Intensity of working, Ship to Shore moves per hour, Number of Cranes working per ship, Ratio of 40'to 20' container. Another mathematical empirical of handling capacity per berth given by Professor Velsink of Delft University of Technology considers Production per gang per hour, Average number of gang per vessels, Effective number of working hours per day, Effective number of working days per year, Average berth Occupancy, Average efficiency of cargo handling.

While analyzing the port capacity, it is essential to consider the dynamic factors that relate it with aspects so as to optimize capacity planning in the short run and the long run. This requires that ports are not treated as "points", rather they should be treated as a set of "stages" or "links" as part of the overall supply chain from point to point. Improvements in hinterland links should be integrated into models for capacity management (Fontejin et. al. 2006). Ports must offer adequate (reserve) capacity to maritime traffic, both in terms of goods-handling facilities and hinterland transport options. Rail transport must therefore be regarded in the broader context of (control over) the total supply chain. For the port of Antwerp in Belgium, the Iron Rhine is a valuable addition to available transport capacity, which will allow the port to continue to grow (Meersman et.al 2008).

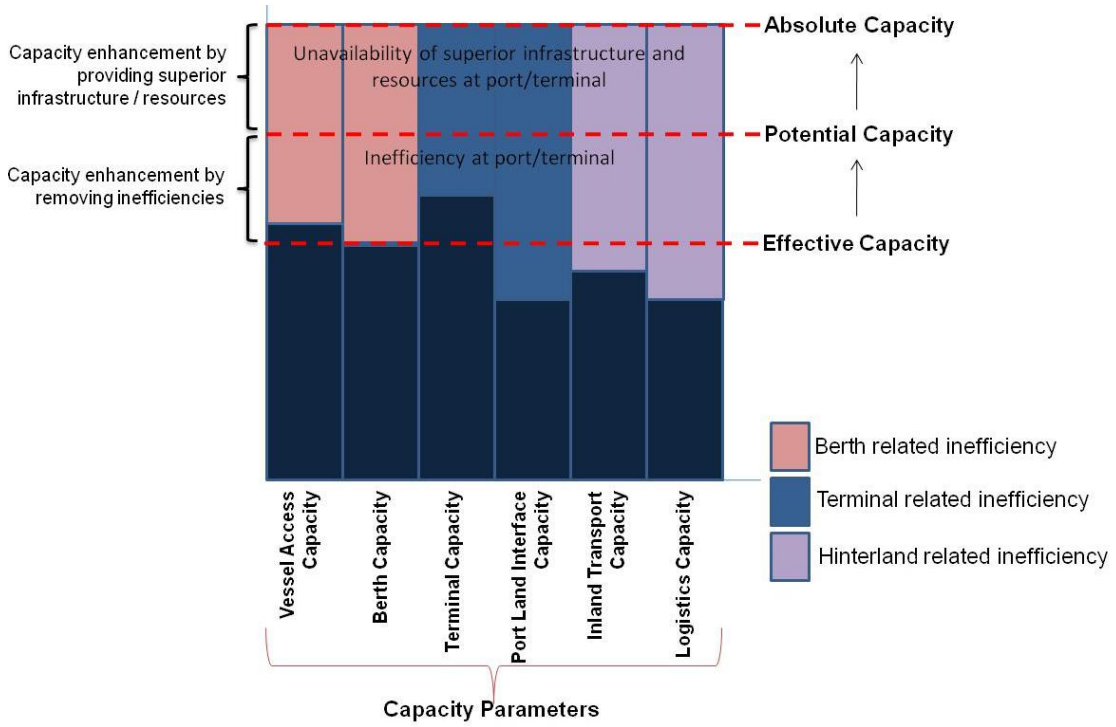
Physical capacity may not only be constrained to be considered in terms of maximum berth utilization rate or maximum throughput rate in a port. From an integrated development perspective, it should include aspects associated with port operations from arrival of ship to departure of inbound cargo or vice-versa and the associated supply chain in the hinterland. The parameters to define physical capacity thus include fixed inputs like infrastructure (maritime access channel, breakwater, locks, berth, dock, terminal, hinterland connectivity) etc. that are highly capital intensive and need to be build up in coordination with demand for peak and off peak period and the other are the variable inputs like port superstructure (quay cranes, labor, marine equipments, IT etc.) that can be changed in a shorter period of time with low investment and can be created to utilize the slack capacity of the port.

Compositely, the port capacity is a function of output at each level of port operation and is thus dependent on vessel access capacity, berth capacity, terminal capacity, logistics center capacity and last mile capacity.

The above mentioned Port Capacity can thus be achieved in three stages in relation to output efficiencies:

- *Absolute Capacity*: meaning highest level of capacity or ultimate capacity at highest efficiency level of operations and availability of superior level of infrastructure and technology.
- *Potential Capacity*: meaning where ports attain capacity with available resources and technology at highest level of efficiency within the same.
- *Effective Capacity*: meaning capacity estimated at the given efficiency level of operations.

The concept in an abstract form exhibiting the above mentioned capacity level is explained in Figure 1.



(The heights of the bars in this Figure are in an abstract form)

Figure-1: Port Capacity Parameters

Source: Developed by Authors

The parameters considered for computation of these capacity levels is provided in Table 1:

Table-1: Computation of Capacity Levels

Port Capacity	Capacity Parameters Considered for Definition	Capacity computation	Application
Effective Capacity	All the capacity parameters are to be considered	Output to be estimated with the given level of resources and competencies.	In general port conditions where resources are not efficiently utilized
Potential Capacity	All the capacity parameters are to be considered	Effective capacity plus highest level of efficiency with better management and competencies	Ports in developing countries try to attain this capacity with better management practice and international learning
Absolute Capacity	All the capacity parameters are to be considered	Effective capacity in given resources plus highest level of efficiency of operations and superior level of technology and resources	Ideal condition where all best means of resources all available considering best ports of the World

Source: Developed by Authors

Physical Capacity of Indian Ports

In the Indian scenario, the physical port capacity is defined based on the throughput / cargo handling considerations with given level of resources and competencies.

As per the Report of the Task Force for Tariff Setting and Bidding Parameters for PPP Projects in Major Ports (2007), capacity is determined taking into consideration various components of the facility that may be required to be created, equipment and plant and machineries to be provided, productivity level and utilization level as per the norms prescribed. The norms for calculation of optimal capacity of terminal as per this report are provided as follows:

The optimal capacity of the terminal is reckoned as 75%[7] of the maximum capacity. The optimal capacity of the terminal is the lower value of the optimum quay capacity and optimal stack yard capacity.

- **Optimal Quay Capacity**: The optimal quay capacity is 75%[8] of the maximum number of TEUs that can be handled across the quay over a period of one year.

[7] Report of the Task Force for Tariff Setting and Bidding Parameters for PPP Projects in Major Ports (2007), Ministry of Shipping, Road Transport and Highways, Department of Shipping, Government of India, India

Optimum Quay Capacity = A x B x C x D x E TEUs where
A = Number of gantry cranes deployed for work in an year
B = Number of working hours of gantry cranes in an year
C = Average number of moves per gantry crane
D = TEU ratio
E = 75%
The norms for the above parameters are given as:
Parameter A = Berths length/100 (rounded off)
Parameter B = 24 X 365 hours
Parameter C = 25 movers/hour (Gross value)
Parameter D = 1.3
Parameter E = 75%

- **Optimal Yard Capacity**: The optimal yard capacity is 75%[9] of the maximum number of Containers (in TEUs) that could pass through the yard in a year.

  Optimal Yard capacity = $0.75 \times \frac{G \times H \times P}{S \times D}$ TEUs where
  G = Total ground slot in TEUs
  H = Average Stack height
  P = Period in No. of days
  S = Surge factor
  D = Average Dwell Time (measured as the time in days from the time a container is placed in the yard until it leaves it irrespective of the free time allowed in the Scale of Rates)
  The norms for the above parameters are given as:
  G = 720 TEUs per hectare
  H = 2.5
  P = 365
  S = 1.3
  D = 4 days for export; 2 days for import

From the above mentioned parameters, it can be inferred that the definition of capacity in the Indian context has been narrow. The capacity of Indian ports have been defined as terminal capacity rather port capacity. However, one constraint needs to be discussed that most of the Indian ports are developed as Service ports rather than as Landlord port[10] where all emphasis has been given to improve terminal capacity rather than port capacity in holistic manner. While determining port capacity from these approaches, it is limited to the perspective of berth or terminal stack yard.

[8] Report of the Task Force for Tariff Setting and Bidding Parameters for PPP Projects in Major Ports (2007), Ministry of Shipping, Road Transport and Highways, Department of Shipping, Government of India, India
[9] Report of the Task Force for Tariff Setting and Bidding Parameters for PPP Projects in Major Ports (2007), Ministry of Shipping, Road Transport and Highways, Department of Shipping, Government of India, India,
[10] Port Reform Tool Kit, Second Edition, 2007, Module 3 - Alternative Port Management Structures and Ownership Models, pg 81

As per the Report on Reducing Dwell Time at Indian Ports (2007) by Ministry of Shipping, Road Transport and Highways, Department of Shipping, GoI, the parameters that are considered to define the capacity (while referring to recommendation to improve the efficiency at port on port account capacity augmentation) include:

1. Berths – more as dedicated facilities
2. Equipments – higher capacity superstructures at berth
3. Handling systems – state of the art systems and TQM implementation
4. Uniform national policy for creating a minimum 14 meters draught

The major measures on non-port account include creating exclusive cargo freight corridors i.e. hinterland connectivity.

Further, the Report of Working Group for Ports Sector for the 11th Five Year Plan (2007-2012), definition on account of capacity addition[11] [12] measures for container ports/terminals, includes the following:

1. Committed throughput of the operator (in ports / terminals wherein the private parties are concessionaire for the berths)
2. Private sector/captive port projects
3. Addition of container handling facilities
4. Modernization of berths
5. Conversion to container berths
6. Addition of new container berths / terminals
7. Extension of berths / terminals

The above said factors relate majorly to the port premises, handling systems and processes. Inadequate port capacity has been considered as one of the constraints that inhibits the efficiency at the ports. The Indian port capacity definition is confined to only considering partly the Vessel Access Capacity, Berth Capacity and Terminal Capacity.

[11] http://shipping.nic.in

[12] Report of Working Group for Ports Sector for the 11th Five Year Plan - 2007-2012 (2007) by Ministry of Shipping, Road Transport and Highways, Department of Shipping, Government of India, India

Limitation of Indian Port Capacity:

The capacity definition in the Indian Port system context has the following limitations:

- A major limitation in defining the port capacity is that ports are treated as points instead of networks that are in a set of stages or links
- Hinterland links are not considered while defining the capacity in the system and not on a node. The port land interface capacity and the inland transport capacity are not been taken into account.
- Indian ports lack being characterized with sufficient and superior port infrastructure in terms of port superstructure and services that acts as a constraining factor when compared with the international ports.
- Owing to the inefficiencies in the system and optimized usage of infrastructure, inefficiencies are built up. Minimization of these inefficiencies would further serve to add up the capacity.

The definition of port capacity in Indian context is limited since

- the berth or the terminal capacity is construed as the port capacity because of institutional structure of port development models
- except few ports which are landlord ports most ports are either service/tool ports or are coming up as private ports, wherein capacity is considered in nodes rather as set of links and nodes.
- lack of a dynamic planning approach exists that leads to static consideration and
- low level of operations leads to Effective Capacity even rather reaching to Potential Capacity

(III) Analysis of Indian Port Capacity:

Aggregate capacity of major Indian ports are always ahead than throughput, however the gap is quite narrow between the two. . Figure 2 presents the aggregate capacity and throughput of Major Ports of Indian Ports.

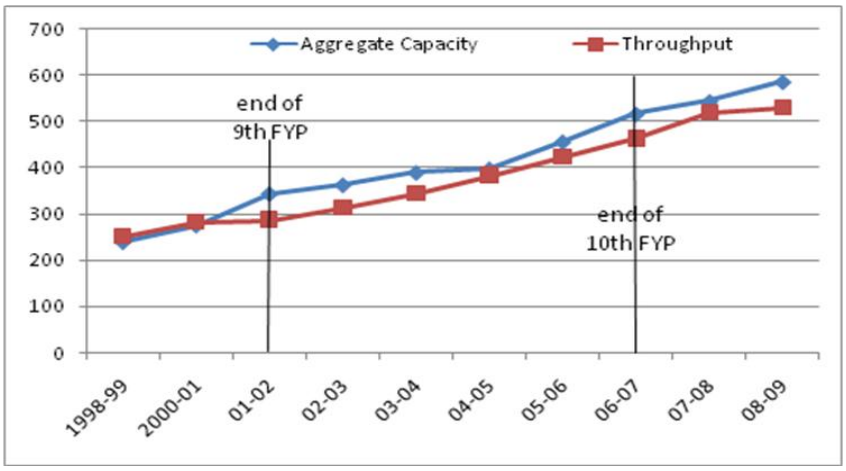


Figure 2 Capacity and Throughput of Indian Ports

The capacity of the major ports at the terminal of the Ninth and Tenth Five Year Plan (1997-2002 & 2002-2007) was 344.40 MMTPA and 516.15 MMTPA while the throughput had increased from 287.59 MMTPA to 463.78 MMTPA respectively during the same period. The capacity utilization has increased from 83% to 90% during these terminal years of the FYP. Thereafter, in the last two years (2007-2009), the throughput has increased to 530.5 MMTPA, while the capacity has been augmented to 586.07 MMTPA. The capacity augmentation under the Eleventh FYP (2007-2012) is targeted to be augmented to 1016.55 MMTPA. The capacity augmentation has been estimated on account of implementation of projects from the spill over of the previous FYP's, new projects in the FYP and the improvement in productivity.

The container handling capacities at the Indian major ports has more than doubled in the last seven years from 39 MMTPA in Year 2002-03 to 100 MMTPA in Year 2008-09 as shown in Figure 3. The containers handled at the Indian major ports have also increased from 0.68 MTEU in 1990-91 to 6.59 MTEU in 2007-08 thereby registering an annual growth rate of 14% doubled from 43 MMTPA in Year 2002-03 to 93 MMTPA in Year 2008-09.

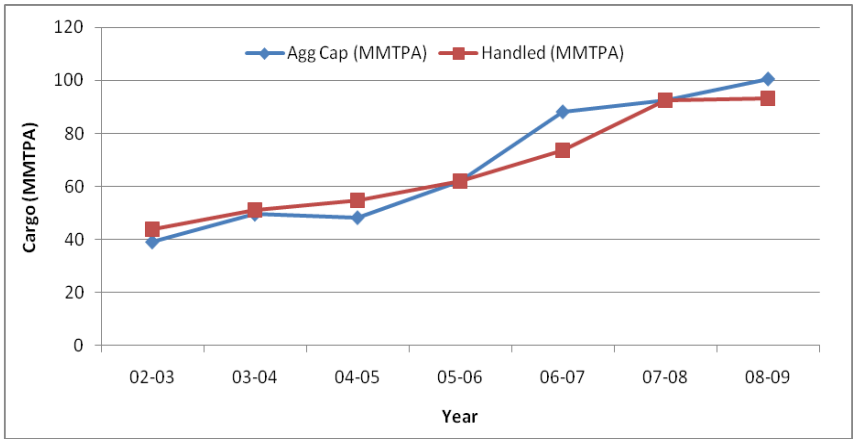


Figure-3: Container Capacity and throughput at Major Indian Ports

Future Capacity enhancement programme and Projected Capacity

It is estimated that a capacity of 1002 MMT would be required at major ports for handling the projected traffic of 708 MMT for container, Petroleum Oil Lubricants (POL) and other cargos for the year 2011-12, thereby requiring a capacity addition of 546 MMT during the period 2006-07 to 2011-12 at the given efficiency level of operations of Indian ports[13]. Further, the Consolidated

[13] *Report of the Task Force – Financing Plan for Ports, Planning Commission, Government of India, July 2007*

Port Development Plan prepared by Port of Rotterdam Authority for Indian Ports Association (2007) forecasts cargo handling of 1595.07 MMT for the year 2025-26[14].

Economic Analysis of Capacity enhancement of Indian Ports

The projected investment for the 2006-07 to 2011-12 period at major ports in terminals, capital dredging, equipment, connectivity projects and others is Rs 574 bn. Of this total investment, about 57% is in development of terminals (container, POL and other cargo), 10% in dredging works, 6% in equipments, 5% in connectivity development and 21% in other works. This shows that Indian ports are more focused on enhancing capacity of terminal. Table 2 presents that the investment estimated for capacity enhancement per MT is Indian National Rupee (INR) 0.7 bn for terminals while capital dredging may not be right to estimate in similar manner.

Table-2: Capacity enhancement and Investment estimated for Major Indian Ports

Sl. No.	Component	Capacity Enhancement (MMT)	Investment (in INR bn)	Cost per MMT (in INR bn)
a	Terminals	467	328.75	0.70
a1	Container Terminals	129	115.02	0.89
a2	POL Terminals	113	103.14	0.91
a3	Other Cargo Terminals	225	110.59	0.49
b	Capital Dredging	16	58.13	3.63
c	Equipment	57	36.04	0.63
d	Connectivity and other Projects	8	151.62	18.95
	Total	548	574.54	1.05

Source: Report of the Task Force – Financing Plan for Ports, Planning Commission, Government of India, July 2007

The per unit (MMT) investment required for setting up a terminal is about INR 1 – 1.50 bn. (while the unit investment required for dredging works is about INR 4 bn. However, it can be clearly analysed that major Indian ports need INR 1050 mn (about US$ 21 mn) per MMT for capacity enhancement to match the throughput requirements. It is evident from the investment that the investment made/committed are more focused on adding capacity in system at effective capacity level as defined in earlier section.

[14] *Consolidated Port Development Plan Volume 1 (2007), Indian Ports Association, Prepared by Port of Rotterdam Authority*

It is required to analyse whether Indian ports should focus on enhancing its physical capacity as a short term approach or look for longer term and achieve Effective Capacity → Potential Capacity → Absolute Capacity as defined in earlier section by enhancing the efficiency levels from the overall supply chain consideration and bringing in competitiveness thereby attracting private sector participation (private management) for capacity enhancement in the system.

(IV) Efficiency of Indian Ports

The Indian ports efficiency is constrained by the degree of mechanization of the facilities and application of latest technologies involved in various port operations for cargo handling. The business processes are characterized by various layers of interfaces in the supply chain and less involvement of e-information systems at the Indian Ports.

- **Vessel Related Efficiency:**

  The average dwell time at Indian Major Ports is 1.88 days for import and 3.78 days for export of containers. In comparison, the dwell time at Singapore Port is 0.6 days for import or export of containers. The average turnaround time under port account has increased from 3.62 days in year 2006-07 to 3.85 days in year 2008 - 09. Though, the average output per ship at national level has increased very marginally by about 4% during the same period shows the low level of improvement in berth productivity. On the contrary, average pre-berthing time has increased substantially from 9 hours to 13 hours at national level due to increase in congestion at ports. Ports where percentage of idle time to total time at berth is high have low outputs per ships berth days shows lower level of efficiency. More interestingly, data varies very largely from 11 % at JNPT port to 41 % at Haldia port. The variation of vessel related efficiency shows that Indian ports infrastructure varies across the major ports. The design channel at JNPT has 11 m draft and with tidal flows it can reach up to 12.5 m draft and can thus cater up to 6000 TEUs vessel which is most efficient, largest and modern container port of India. The efficiency at Indian Ports is also constrained largely by the unavailability of space or buffer zones for expansion or addition of facilities for supply chain enhancement requirements. The lack of seamless intermodal connectivity at ports further creates congestion in handling of cargo and hence deteriorates the service levels.

- **Terminal Related Efficiency:**

  Terminal related efficiency parameters are based on berth availability and its productivity with supported infrastructure and super-structure. The berth occupancy factor at major ports

of India varies from 60 % to 75 %[15] as mentioned in table below. Whereas UNCTAD recommends much lower level berth occupancy factor to reduce the congestion at ports to achieve higher level of efficiency in operations.

Table-3: Berth Occupancy Factor on Major ports of India

Berths	**Max BoF**
Dedicated Berths	
One Berth	60 %
More than one Berth	70%
Common Berth	
Upto 3 berths	70%
More than 3 berths	75 %

Source: Consolidated Port Development of India by Port of Rotterdam 2007

The berth output varies among major ports of India from 900 TEUs (Chennai) to 2000 TEUs (JNPT) per meter of berth per annum currently as mentioned in Table 4. JNPT seems to be most efficient container port of India. The berth output of JNPT is comparative to the best International ports like Hong Kong, Singapore and ports of Western Europe whereas tariffs for handling container are highest at JNPT as compare to other major Indian ports.

Table-4: Berth output in TEUs/mt/year

Port	**Berth output in TEUs/mt/year**
JNPT	2000
Cochin	1400
Tuticorin	1200
Chennai	900
Ennore	1200

Source: Consolidated Port Development of India by Port of Rotterdam 2007

The equipments are manually handled wherein the average move per hour is about 20/25 and the crane rate is about 60/70 per hour, thereby increasing the turn round time. At the leading international ports, the cranes are operated largely by automation thereby attaining the move per hour to about 25-30 and achieving a crane rate of 100 per hour.

[15] *Consolidated Port Development Plan Volume 1 and 2 (2007),* Indian Ports Association, Prepared by Port of Rotterdam Authority

- **Hinterland Related Efficiency:**

  In hinterland related or port interface related efficiency aspect, custom clearance and hinterland connectivity are major issues on Indian port, since most of the ports have not reached to provide logistics service which can be measured.

  Report on Reducing Dwell Time at Indian Ports (2007) by MoSRTH, GoI has identified custom related efficiency as major bottleneck. The custom department works only five days in a week whereas port operations will have to work 24/7 to achieve the highest level of operational efficiency. Besides, manual paper works and detailed scrutiny process further delays the evacuation of cargoes.

  As per World Bank study (Connecting to Compete-Trade Logistics in the Global economy - 2007) India ranks at 39 with the score of 3.07 on the scale of 1 to 5 in overall logistics performance at country level. With the development of Special Economic Zones (SEZ) especially nearer to ports may add to logistics performance in near future.

  Last mile hinterland connectivity is a major issues on all Indian major ports since most of the port fall within core city area or surrounded by dense development that restrict the faster evacuation of cargo.

  The productivity improvement measures are also related to cargo handling systems at berth, equipments and modernization of facilities. The factors attributable to affecting dwell time and port efficiency parameters as discussed in the Report on reducing Dwell Time at Indian Ports (2007) by MoSRTH, GoI include: (a) Infrastructure constraints (Inadequate port capacity, Inadequate navigational aids and facilities, poor road network within the port, low cargo handling capabilities, Bunching of vessels) (b) Inadequate resources (Inadequate cargo handling equipments / machinery, high down time of equipments, low labour productivity, shortage of storage spaces, regulatory restrictions on operation time) (c) Low IT applications (d) Cargo evacuation / aggregation constraints (e) Statutory inspection and procedures (f) Deployment of private cargo handling equipments

  A series of recommendations for all stakeholders are made in this report[16] with the objective to reduce dwell time and improve the efficiency of the ports so as to enhance network

[16] Report on Reducing Dwell Time at Indian Ports (2007) by Ministry of Shipping, Road Transport and Highways, Department of Shipping, Government of India

capacity. The short term measures recommended to be implemented on port account include a range of measures that include infrastructure development, infrastructure modernization, and regional corridor planning and institutional solutions

- **Reduction of non-working time and improvement of output per ship berth day:**

  The measures proposed include – optimization of cargo handling systems and equipments, deploying advanced technologies that to achieve enhanced efficiency in cargo handling; synchronization of land side operations with seaside operations; attitudinal changes amongst workforce; maintenance and management of cargo handling equipments

- **Round the clock port working:**

  The measures proposed include – round the clock navigation, operations and documentation; deployment of VTMS and AIS system; hot seat exchange system; enhance navigation efficiency

- **Strengthen the roads to and within the ports:**

  The measures proposed include – four lane rigid pavement roads within the port area and six lane rigid pavement approach roads to the ports; traffic management measures; elimination of crossings

- **Improve labour productivity** – by multi skilled trained workforce for optimum deployment
- **Automated communication systems**, strengthen IT systems, Port Community System, real time information, eliminate physical interface

(V) Port Competitiveness in India

Comparison with International Port Efficiency System:

The berth productivity of International terminal like Singapore, Hong Kong, Hamburg, and Bremen where Quay productivity is in the range of 2000 TEUs/mt berth length while except for JNPT, none of Indian container ports are comparable and thereby making it evident that the Indian Ports are still constrained at the Effective Capacity levels and need to remove these inefficiencies to advance up to the stage of Potential Capacity and Absolute Capacity levels.

Table-5: Productivity of major port of Western Europe and Asia

Port	Terminal	Throughput Capacity (Mn-TEU/year)	Max. Throughput Density (TEU / ha)	Max. Crane Productivity (TEU / Crane)	Max. Quay Productivity (TEU/m)
Hamburg	Eurogate	4.0	28,500	222,200	1,950
Bremen	Eurogate	6.0	29,850	222,200	1,975
Dalian	Dalian Terminals	3.4	30,900	188,900	1,350
Hong Kong	Hong Kong Terminals	12.55	67,470	199,200	2,050
Singapore	Singapore Terminals	24.00	56,740	172,700	1,920
Tuticorin	Tuticorin Container Terminals	00.45	45,000	150,000	1,220

Source: Consolidated Port Development of India by Port of Rotterdam 2007

Port competitiveness in India seems to be absent considering the fact that institutional structure of Port i.e. Tool port model where all major ports are under governed by the Port Trust Act 1908 of India. The board and management of these ports including operations are governed and controlled by GoI. This is also reflected from the fact that major terminal operator like PSA and DP World and P&O are present at few ports. Most of terminals are operated by the port authorities by themselves. The tariffs at major port are regulated by Tariff Authority for Major Ports (TAMP) as mentioned in section below on cost plus basis. The influence areas of major ports are determined by GoI and hence these are quite defined. The major ports largely remain confined to their respective hinterlands and are thus captive in nature. This creates lack of competiveness between the major ports to gain prominence and enhance their market share. Currently with the development of private ports like Mundra and Pipavav port in Gujarat and Krishnapatnam and Gangavaram port in Andhra Pradesh are becoming threat or creating competitiveness to major ports of India. It is evident that the absence of port competitiveness leads to inefficiency in the system.

Port Pricing System in India

Port pricing system in India has been segregated according to market structure. TAMP controls port tariff structure for major ports which are regulated by Central Government while tariffs for non-major and private ports are controlled by the respective State Governments. Currently, tariff for major ports in India are being setup on the cost plus basis with return on capital employed of

15 % on capital employed. The tariffs for handling container at different ports of India range between Rs 971 to Rs 3,540 per container. Even for different terminals of at same port (JNPT), the tariffs range[17] between Rs 2,550 to Rs 3,540. There is a revision proposed to bring in efficiency in the system for determining port pricing. However, there is also a proposal to setup Port regulatory commission or authority for all major and non-major ports including PPP project on existing ports.

Application of PPP in port reform and its impact on efficiency

It is difficult to define the efficiency of port operation for port management. It again depends on the professionals that are managing the ports and as well as changes in technological environment with research and development from region to region e.g. efficiency in port itself changed in case of port of Cartagena[18], Columbia after privatisation in 1994. Since the private operator took over the port operations, the throughput had grown in ten years from about 93,000 TEUs to 400,000 TEUs. The waiting time for vessels got reduced from 10 days to 0 days resulting in increase in overall throughput at each point of operation. Consequently, operation cost per move of the port reduced drastically from $984/move to $222/move as shown in below mentioned table (Refer: The broad economic impact of port inefficiency, 2004 by USAID). This proves that Effective Capacity can reach up to Potential Capacity with private sector participation.

Table-6: Port of Cartagena Performance Improvements since Private Concessioning in 1994

Performance Measure	**Pre-reform (1993)**	**Post-reform (2003)**
Containership waiting time	10 days	0
Containership turnaround time	72 hours	7 hours
Gross productivity / hour	7 moves / ship hour	52 moves / ship hour
Berth occupancy	90 percent	50 percent
Bulk cargo productivity	500 tons / vessel / day	3,900 – 4,500 tons / vessel / day
Hours worked per day	16	24

[17] Revision of Guidelines for the Regulation of Tariffs in the Major Ports (2007), Ministry of Shipping, Road Transport and Highways, Department of Shipping, Government of India, India

[18] Paul E. Kent and Alan Fox (2004), The Broad Economic Impact of Port Inefficiency: A Comparative Study of Two Ports, USAID

Cargo dwell time	30+ days	2 days
Port costs	$984 / per move	$222 / per move

Source: Paul E. Kent and Alan Fox (2004) The Broad Economic Impact of Port Inefficiency: A Comparative Study of two ports, USAID

(VI) Development of Performance Index

A performance index framework is attempted to be developed based on the various performance / efficiency parameters of the ports with respect to the respective efficiency parameters of the best performing port of the study area. The various efficiency parameters related to vessel access, berth, terminal, port-land interface, inland transport, logistics can be considered for developing a robust port performance index from the overall supply chain consideration.

Upon development of base performance index considering best performing ports in India or internationally i.e. Bpi, a two-stage framework is envisaged to be developed for formulating the Performance Index

- Stage-1: Development of Individual Port Performance index for major ports of India separately i.e. IPi
- Stage-2: Development of Composite Port Performance index for major ports of India collectively i.e. CPi

The above mentioned performance index has been benchmarked at three levels:

- **Effective Port Performance (EPP) Index**: The first level relates to developing the index considering the current efficiency levels of the various ports with respect to the efficiency level of the best performing port amongst them in the base year. The assumption is that these ports form a homogenous set with respect to their given level of resources and competencies and the framework in which these ports are developed, implemented, managed and operated.
- **Potential Port Performance (PPP) Index**: The second level of developing the index would consider enhanced efficiency levels of the various ports that are determined in previous level and benchmarking it with respect to the efficiency level of the best performing international port. The assumption is that the base performance parameter with which enhanced efficiencies of the ports are to be indexed has to be of a higher order port range/system. For this computation, international ports that have higher level of efficiencies with better management and competencies are considered.

- **Absolute Port Performance (APP) Index**: APP is the third level of benchmarking index. The ports upon performing / attaining at EPP Index would attain Effective Capacity and target towards Potential Capacity. Further, ports upon performing / attaining at PPP Index would attain Potential Capacity and target towards absolute performance. Absolute Performance would be an ideal condition that would be the attainment of Absolute Capacity, wherein all best means of resources available on the best global ports are available.

Port Performance Index Formulation:

To assimilate the relativity of the various performance parameters with respect to their individual effectiveness in the port system the Port Performance Index is formulated by developing a base benchmarking index and individual ports index and thereafter the composite index.

Base Benchmarking Index: For constructing this index, each of the performance parameters are considered for the current year / benchmarked port with respect to the base year / best port. A Weightage is applied to each of the efficiency parameter ratio to qualify the sensitivity of the efficiency parameter.

The current form of the equation considers output of performance parameters such as Pre berth detention time (PBDT) and Turnaround time (TT), where the objective is towards minimizing the duration (hours/days) the minimization function is used and the ratio of performance in base year / best port to current year/benchmarked port is considered. With regards to the performance parameters such as Average Output per Ship Berth Day (tonnes) and Vessels handled (in numbers), the objective being maximizing the output (tones/number of vessels), the maximizing function is used and the ratio of performance in current year/benchmarked to base year / best port is considered

(The base to be considered depends upon whether the index is being benchmarked at the Efficiency Port Performance Index Level / Potential Port Performance Index Level / Absolute Port Performance Index Level)

The following equation (1) is for preparing base benchmarking index from best performing ports for ith year is as follows:

$$BPi = \sum_{i=1}^{i=n}\left(\frac{P0i}{Pi}\right)Wi + \sum_{j=1}^{j=p}\left(\frac{Pj}{P0j}\right)Wj = [(P_{01}/P_1)*W_1 + (P_{02}/P_2)*W_2 + \ldots\ldots\ldots] + [(P_3/P_{03})*W_3 + (P_4/P_{04})*W_4 + \ldots\ldots\ldots] \quad \text{equation (1)}$$

Where

P_1 = Pre berth detention time (PBDT) (in hours) for current year/benchmarked port

P_2 = Turnaround time (TT) (in days) for current year/ benchmarked port

P_3 = Average Output per Ship Berth Day (tones) O/SBD for current year/ benchmarked port

P_4 = Vessels handled (in numbers) for current year / benchmarked port

P_{01} = Pre berth detention time (PBDT) (in hours) for base year/best port

P_{02} = Turnaround time (TT) (in days) for base year/ best port

P_{03} = Average Output per Ship Berth Day (tones) O/SBD for base year/ best port

P_{04} = Vessels handled (in numbers) for current year / best port

W_1 = Weightage given for P_1 indicator

W_2= Weightage given for P_2 indicator

W_3= Weightage given for P_3 indicator

W_4= Weightage given for P_4 indicator

Where i, j, p are positive non zero integers and n & p are finite non-zero positive integers

Individual Port Benchmarking Index: The base benchmarking index is developed for performance parameters and for the individual ports. The individual port performance index is developed for the study period by considering the performance parameters as considered above. A Weightage factor (w1……wn) is applied to each of the efficiency parameter ratio to qualify the sensitivity of the efficiency parameter.

The following equation (2) is for preparing performance index for individual major port for ith year

$$IPi = \sum_{\substack{i=1 \\ j=1}}^{\substack{i=n \\ j=m}} \left(\frac{P0ji}{Pji}\right) Wj + \sum_{\substack{i=1 \\ k=1}}^{\substack{i=n \\ k=p}} \left(\frac{Pki}{P0kj}\right) Wk = [(P_{01i}/P_{1i})*W_1 + (P_{02i}/P_{2i})*W_2 + \ldots\ldots..] +$$

$$[(P_{3i}/P_{03i})*W_3 + (P_{4i}/P_{04i})*W_4 + \ldots.]\ldots \qquad \text{equation (2)}$$

Where

IPi…n = Individual port Index for all major ports from i to n

Where i, j, k are positive non zero integers and n, m, p are finite non-zero positive integers

Composite Port Index: Upon determination of the base benchmarking index on the individual port w.r.t. base year/base port, the composite index is developed. It takes into the consideration the

summation of individual port performance index along with Weightage that these individual ports carry in the respective port system. This Weightage may be based on the market share / throughput of the respective ports against the total throughput of the port system.

The following equation (3) is formulated for preparing composite port index for ith year

CPi=

$$IP_q * w_q = \sum_{q=1}^{q=r}\left[\sum_{\substack{i=1\\j=1}}^{\substack{i=n\\j=m}}\left(\frac{P0ji}{Pji}\right)Wj + \sum_{\substack{i=1\\k=1}}^{\substack{i=n\\k=p}}\left(\frac{Pki}{P0kj}\right)Wk\right] * wq \ldots\ldots\ldots\ldots$$

equation (3)

CPi= Composite Index for all major Indian ports for i^{th} year

wq = Weightage given for individual Indian major ports based on their market share against total throughput

Where i, j, k, q are positive non zero integers and n, m, p, r are finite non-zero positive integers

Evaluation of Performance Index for Indian Major Ports

Using the above Performance Index Formulation, it has been applied to the case of Indian Major Ports. The Infrastructure and operations for these major ports are provided and controlled by the Government of India. Hence, the efficiency and capacity of major ports are analysed considering the applicability of the similar policy structure.

The index is based on four parameters for efficiency viz,

- pre berth detention time
- turnaround time
- output per ship berth day and
- total vessels handled by the port

The port performances of the twelve Indian major ports over the last five years for the year 2004-05 to 2008-09 and their throughput in the respective years as provided in Annexure 1 are considered for analysis and development of the performance index.

Average Pre-Berthing Time

Overall, the major ports have not performed consistently well in pre-berthing time (on port account) during the last five years. Kandla port has the highest average pre-berthing time of 28.08 hours in 2008-09, whereas Ennore port has the lowest average pre-berthing time of 0.73 hours, thereby implying greater efficiency.

Average Turnaround Time

The average turnaround time for the major ports is inconsistent during the last five years. Kandla port has the highest average turnaround time of 5.2 days in 2008-09, whereas JNPT port has the lowest average turnaround time of 1.96 days, thereby implying greater efficiency.

Average Output per Ship Berth Day

The Average Output per Ship Berth Day for the major ports has remained almost constant during the last five years. Ennore port has the highest Average Output per Ship Berth Day of 28,429 tonnes in 2008-09, while KDS has the lowest Average Output per Ship Berth Day of 3,417 tonnes.

Vessels Handled

The vessels handled by the major ports have remained consistent over the past five years. Maximum vessels have been handled by JNPT while minimum vessels have been handled by Ennore port. The throughput of the major ports has increased over the years. The absolute number of total vessels handled by the port is considered. Its distribution into small and medium vessels is a limitation to the scope of this study.

An important point needs to be considered here is that, because of time and data limitation the analysis has been done with macro level data and distribution analysis of data has not been considered for cargo and vessel type. All types of cargo have been considered as similar category. Hence, economies of scope have not been considered and in case of vessels, classification of vessels as large, medium and small has also have not been considered. It might be more interesting to analyse the financial performance of these ports and subjective analysis of the cause of low performance.

Port Performance Index for Indian Major Ports

The port performance index is developed for the Indian major ports are shown in figure 4. The individual port performance index for the twelve major ports in developed considering the afore mentioned port efficiency parameters for the individual years with respect to the efficiency parameter of the respective best performing port in the base year i.e. 2008-09. A Weightage factor of 25% was assigned equally to all the port efficiency parameters considering that each parameter is independent and has equal impact on port efficiency. The individual port performance index for the major ports is thus obtained for the years 2004 – 2009. The composite port performance index is then developed from the individual port performance index by assigning a Weightage to the ports based on their respective throughput share against the total through put of major ports using the above mentioned index formulation. The Efficiency Index for major ports is provided in Annexure-1: Table-3. It is observed that the composite port performance index of the Indian major ports varies between 47.28 and 53.67. The port performance has been inconsistent in the last five years when benchmarked with the best performing port for the respective parameter in the year 2008-09. The individual performance index of most of the ports in the base year 2008-09 is lower than the composite port index. Analysing these efficiency indexes reveals that none of the Indian ports except in few years are performing their best at very low economies of scale and scope.

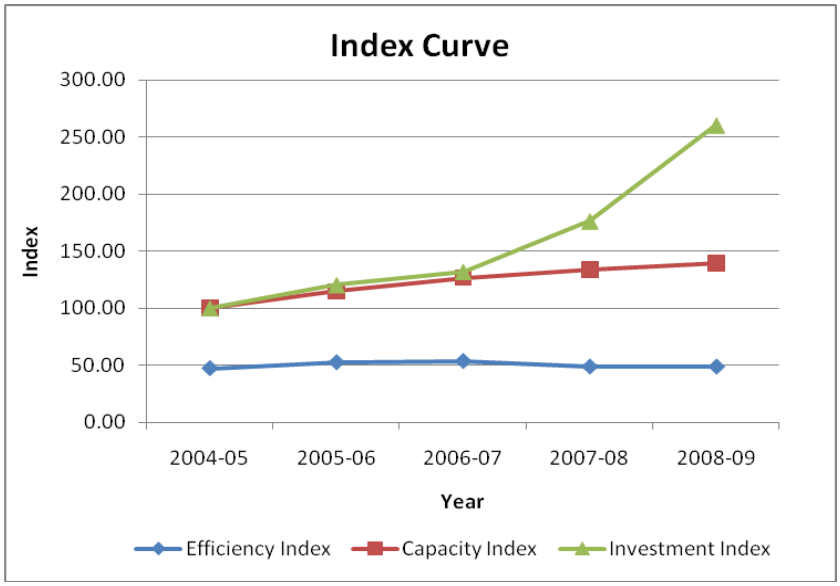


Figure 4 Efficiency Index of Major Ports (India)

The efficiency index derived for the years 2004-09 is analysed with respect to the capacity development and investments index in the port sector during this period.

While capacity additions and investments have consistently increased during the period 2004-2007, the efficiency index marks a marginal increase during this period. Although relatively higher investments and capacity additions have been made for years 2007-09, efficiency has not considerably improved much. This inverse relation indicates that the investment hasn't been stressed on efficiency improvement; rather it has been singularly focused on physical capacity additions.

VIII Conclusions

The paper tests the hypothesis that Indian ports are constrained by capacity. It is evident from analysis of capacity, if Indian ports develop at a very high growth rate, they may face capacity constraint. The capacity that has been estimated at Indian ports are only *effective capacity* and it needs to first improve to *potential capacity* by attaining operational efficiency and thereafter Indian ports should learn best international practices and superior technology to achieve *absolute capacity*. The research reveals that Indian ports lack in port competitiveness and thereby port pricing reflects that the market is inefficient and distorted in economic sense. The general economic theorem proves that bringing capacity in an inefficient system will only increase inefficiency. Hence, first Indian port system needs to be made more efficient i.e. achieve potential capacity and then absolute capacity should be enhanced.

It is evident that there is gap of about 30-40 % throughput between Effective Capacity to Absolute Capacity. It indicates the vast scope that exists in improving the efficiencies at the individual port level in the system and thus enhancing the current capacity to the Absolute Capacity. Physical handling capacity has been significantly added into the system by construction of additional facilities at the ports or building new ports. This capital intensive augmentation of infrastructure development has required large sums of investment at the ports. However, not much emphasis is laid on improving the existing efficiencies at various levels in the port system viz, vessel access, berthing, cargo handling and storage, port land interface etc. It is thus observed that the efficiency index has remained almost constant over the past five years.

Addition of capacity without improvising on the efficiencies of the system results in under-utilisation of the potential capacity of the system. Capacities are constantly required to be built up to meet the ever growing demands with increasing levels of investments. Effectively, if stress is laid upon enhancing the performance of the existing systems in the first level and thereafter upgradation of the systems in the second level, these unused capacities can be effectively utilised without requiring much investment. These port development initiatives must consider creating

capacities by enhancing port performances initially and then capacity addition in an improvised performing port system, thereby realising higher efficiencies and capacity.

Being a homogenous port system for major ports from institutional point of view as defined earlier, institutional co-operation can be initiated by mechanism of information sharing, knowledge, operations and technology transfer. The efficiency can be increased double fold within country and if management efficiency and technology brought in from best international port there can be many fold increase.

The institutional cooperation can be used as strategic tool among the regional ports in case of India where all major ports are governed by single authority with having same organization to monitor and regulate. Though, institutional cooperation is more of informal type of cooperation. It does not include any commercial decision like price fixation but the object is to improve the efficiency and reduce cost in common infrastructure for end user. It also aims to optimally use of public resources.

This will automatically increase potential capacity of Indian ports without major investment in physical capacity enhancement. Thereafter, private sector initiative can be applied to port system to enhance the capacity with international benchmarking of technology and management to the Indian Major Port system.

Public Private Partnership approach (PPP) can be one of the most effective ways to improve operational efficiency for not only improving absolute capacity but attaining potential capacity. A developing country like India needs to first develop a Capacity Building Plan rather enhancing physical capacity of ports. For instance, international terminal operators, technology providers and partners need to be attracted into the system for which the entire port system needs to improve from managerial to operational aspect.

Government of India has already shown some initiative in this regard, but major thrust should be given on improving efficiency so that potential capacity can be automatically achieved in short term and then absolute capacity can be enhanced based on development projects.

This paper can be applied to similar developing countries where ports are not mature enough and are still struggling with management and operational efficiency issues and thereby improving potential capacity like in the case of Port of Cartagena in Latin America, which will not only reduce huge capital investment in short term but also provide opportunity to optimize resources in a more meaningful manner in the long term.

Acknowledgements:

The authors give special thanks to University of Antwerp, especially Prof Eddy Van de Voorde and Dr Thierry Vanelslander for providing their valuable guidance and comments. The authors are also thankful to the students of CEPT University, who have provided laboratory analysis to understand the efficiency of Indian Ports. This paper has been developed out of research being under taken on "Strategy for capacity Optimization for the integrated development of Port in a region/cluster: case study Hamburg-Le Havre range" in the Department of Transport and Regional Economics, University of Antwerp

Annexure – 1:

Table 1: Throughput/Capacity and Investment at Indian Major Ports

		Throughput (000 tons)				
	Major Ports	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**
1	**Kandla**	41,541	45,907	52,982	64,893	72,225
2	**Visakhapatnam**	50,147	55,801	56,386	64,597	63,908
3	**Chennai**	43,806	47,248	53,414	57,154	57,491
4	**JNPT**	32,809	37,836	44,818	55,756	57,281
5	**Kolkata**					
	KDS	9,945	10,806	12,596	13,741	12,428
	HDS	36,212	42,337	42,454	43,541	41,623
6	**Mumbai**	35,125	44,190	52,364	57,039	51,876
7	**Paradip**	30,104	33,109	38,517	42,438	46,412
8	**Mormugao**	30,659	31,688	34,241	35,128	41,680
9	**New Mangalore**	33,891	34,451	32,042	36,019	36,691
10	**Tuticorin**	15,811	17,139	18,001	21,480	22,011
11	**Cochin**	14,095	13,887	15,314	15,810	15,228
12	**Ennore**	9,480	9,168	10,714	11,563	11,500
	All Major Ports	**383,625**	**423,567**	**463,843**	**519,159**	**530,354**
	Capacity of Ports	**397,500**	**456,200**	**504,750**	**532,070**	**555,670**
	Investment (in Rs cr)	**341**	**410**	**450**	**601**	**888**

Source: Compiled from various sources (Report from Planning Commission, Parliament of India and Indian Port Associations)

Table 2(A): Efficiency Parameters at Indian Major Ports – PB DT and TT

PBDT: Average Pre-Berthing Detention time on Port Account (hours)

TT: Average Turnaround Time on Total Account (days)

	Major Ports	PBDT					TT				
		2004-05	2005-06	2006-07	2007-08	2008-09	2004-05	2005-06	2006-07	2007-08	2008-09
1	Kandla	16.56	19.68	35.28	32.64	28.08	4.62	4.39	5.46	5.13	5.2
2	Visakhapatnam	1.11	1.54	4.78	5.1	4.35	3.2	3.8	3.65	3.91	3.93
3	Chennai	0.9	0.9	0.8	1	0.93	3.8	3.3	3.4	4.6	4.15
4	JNPT	8.35	7.4	5.45	10.2	9.84	1.84	1.96	1.67	1.85	1.96
5	Kolkata										
	KDS	0.0	0.09	0.13	0.24	1.27	4.17	4.12	3.89	4.87	4.6
	HDS	7.42	30.37	26.05	33.44	24.46	3	4	3.97	4.26	4.21
6	Mumbai	6	4.8	5.22	5.07	7.2	4.21	4.09	4.63	4.44	4.73
7	Paradip	1.62	1.48	1.41	1.48	1.3	3.41	3.56	3.54	5.54	4.78
8	Mormugao	25.25	17.56	19.34	18.35	11.48	4.35	4.08	4.46	4.03	3.61
9	New Mangalore	2.64	0.96	1.87	1.92	0.96	2.96	3	3.14	3.21	3
10	Tuticorin	1.68	3.06	3.22	4.32	3.36	2.66	2.83	3.67	3.8	3.66
11	Cochin	4.16	2.9	0.29	1.21	1.31	2.33	2.13	2.19	1.99	2.14
12	Ennore	0.42	0.36	0.3	0.75	0.73	1.68	2.23	1.89	2.08	2.35

Source: Ports in India, Volume I&II (October 2009) India Infrastructure Publishing Pvt. Ltd. New Delhi, India

Table 2(B): Efficiency Parameters at Indian Major Ports – O/SBD and Vessels Handled

	Major Ports	O/SBD					Vessels Handled				
		2004-05	2005-06	2006-07	2007-08	2008-09	2004-05	2005-06	2006-07	2007-08	2008-09
1	**Kandla**	8,434	8,700	9,843	11,082	12,998	1,940	2,124	2,318	2,596	2,517
2	**Visakhapatnam**	12,241	10,557	10,868	10,600	11,171	1,843	2,109	2,099	2,346	2,347
3	**Chennai**	9,697	10,378	10,165	10,385	10,893	1,669	1,857	2,059	2,052	2,078
4	**JNPT**	13,077	15,717	16,727	20,171	22,472	2,324	2,395	2,775	2,712	2,962
5	**Kolkata**										
	KDS	3,771	3,984	4,490	3,702	3,417	767	777	904	1,030	1,096
	HDS	8,395	8,755	8,770	8,353	7,643	2,086	2,348	2,300	2,343	2,399
6	**Mumbai**	6,191	6,552	6,472	7,196	6,156	1,883	2,153	2,236	2,236	1,931
7	**Paradip**	11,048	11,316	11,796	11,181	12,635	1,053	1,330	1,452	1,513	1,581
8	**Mormugao**	17,084	16,834	17,799	17,106	20,797	748	642	699	664	435
9	**New Mangalore**	15,576	15,048	13,080	12,664	13,644	1,067	-	1,039	1,166	1,201
10	**Tuticorin**	5,280	5,392	5,051	5,348	5,574	1,479	1,576	1,533	1,602	1,524
11	**Cochin**	8,499	7,767	8,282	10,934	10,417	1,120	1,225	1,176	1,121	1,121
12	**Ennore**	38,870	33,622	35,087	35,251	28,429	171	173	201	213	250

Source: Ports in India, Volume I&II (October 2009) India Infrastructure Publishing Pvt. Ltd. New Delhi, India

Table 3 Efficiency Index for Major Ports

	Major Ports		Efficiency Index for Major Ports				
			2004-05	**2005-06**	**2006-07**	**2007-08**	**2008-09**
1	**Kandla**	Individual Port Performance Index	35.50	37.67	37.71	41.77	42.75
2	**Visakhapatnam**		58.07	51.83	44.52	45.23	46.30
3	**Chennai**		55.79	59.93	63.54	55.35	58.55
4	**JNPT**		59.93	61.50	70.82	68.90	71.62
5	**Kolkata**						
	KDS		21.54	224.73	164.56	98.05	37.28
	HDS		43.78	40.37	40.17	39.17	39.35
6	**Mumbai**		36.02	39.72	38.64	39.84	34.61
7	**Paradip**		44.24	47.27	49.41	43.78	48.74
8	**Mormugao**		33.32	33.27	33.48	33.80	37.12
9	**New Mangalore**		46.17	48.58	45.64	45.75	57.48
10	**Tuticorin**		46.41	41.32	36.40	35.34	36.58
11	**Cochin**		42.34	46.47	102.51	58.78	55.45
12	**Ennore**		108.24	103.69	119.31	80.69	72.96
	Composite Port Performance Index		**47.28**	**52.58**	**53.67**	**48.69**	**48.68**

Source: Developed by Authors

References

Annual Report (2008-09), Ministry of Shipping, Road Transport and Highways, Government of India, India

Connecting to Compete-Trade Logistics in the Global economy (2007), World Bank, Washington DC - 2007

Consolidated Port Development Plan Volume 1 and 2 (2007), Indian Ports Association, Prepared by Port of Rotterdam Authority

Draft Policy (Modified) for Maritime Sector – Ports, Merchant Shipping and IWT (2005), Ministry of Shipping, Road Transport and Highways, Department of Shipping, Government of India, India

Fonteijn, Henk, Bishop, David and Arvantitidis, Miltiadis (2006), *Presentation on: Port Capacity, Theoretical Framework*, ESPO Statistics Committee, Goteborg

Meersman H., Pauwels Tom, Eddy Van De Voorde and Thierry Vanelslander (2008), *The Relation Between Port Competition and Hinterland Connections – The Case of 'Iron Rhine' and the 'Betuertoute'*

National Maritime Development Programme, Department of Shipping, Government of India, India

Paul E. Kent and Alan Fox (2004), *The Broad Economic Impact of Port* Inefficiency: A Comparative Study of Two Ports, USAID

Policy Research Working Paper - International Competitiveness of Indian Maritime Sector, i-maritime Consultancy Private Limited, Navi Mumbai, India

Port Reform Tool Kit, Second Edition, 2007, Module 3 - Alternative Port Management Structures and Ownership Models, pg 81

Ports in India, Volume I & II (October 2009) India Infrastructure Publishing Pvt. Ltd. New Delhi, India

Report of the Task Force – Financing Plan for Ports (July 2007), The Secretariat for the Committee on Infrastructure, Planning Commission, Government of India, India

Report of the Task Force for Tariff Setting and Bidding Parameters for PPP Projects in Major Ports (2007), Ministry of Shipping, Road Transport and Highways, Department of Shipping, Government of India, India, August 2007

Report of Working Group for Ports Sector for the 11th Five Year Plan - 2007-2012 (2007) by Ministry of Shipping, Road Transport and Highways, Department of Shipping, Government of India, India

Report on Reducing Dwell Time at Indian Ports (2007) by Ministry of Shipping, Road Transport and Highways, Department of Shipping, Government of India, India

Revision of Guidelines for the Regulation of Tariffs in the Major Ports (2007), Ministry of Shipping, Road Transport and Highways, Department of Shipping, Government of India, India

http://www.ibef.org

http://www.indiabudget.nic.in

http://www.ipa.nic.in

http://www.pppindia.com

http://www, shipping.nic.in