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Major Ports of India – Paradigm strategy

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Abstract

(Hammer & Champy, 1993) defined reengineering as the fundamental rethink and radical redesign of business processes to generate dramatic improvements in critical performance measures such as cost, quality, service and speed. This paper combines the concepts of leanness and agility and uses Business Process Reengineering (BPR) techniques to suggest the future strategy for Major Ports of India. The study is specific for dry bulk coal cargo in this paper, however, it can be replicated for other cargo as well. BPR is generally limited to departments, functions or organizations. An attempt is made to extend BPR to all Major Ports in its entirety.

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Keywords: Major Ports of India; Strategy; Lean; Agile; Business Process Reengineering; Terminal efficiency

1. Introduction

Indian ports are classified into Major Ports and Minor Ports. There are 12 major ports and 205 minor ports in India. Major Ports are those ports that are either placed in the Union list of the Constitution of India or ports that are declared Major Ports by the Central Government through a notification in the Official Gazette. The Major ports in India are Chennai, Kamarajar and V.O.Chidambaranar (in Tamil Nadu); Cochin (in Kerala); Deendayal (in Gujarat); Kolkata (in West Bengal); Mumbai Port and Jawaharlal Nehru Port Trust (in Maharashtra); Mormugao (in Goa); New Mangalore (in Karnataka); Paradip (in Orissa); and Vishakhapatnam (in Andhra Pradesh). Out of the 12 Major ports, eleven ports are governed by Major Port Trusts Act 1963. The 12th Major port, Kamarajar port, is the only corporate port which is governed by the provisions of the Companies Act, 2013.

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Table 1. Cargo handled at Indian ports

Year	Cargo (MMT)			% share of Minor ports
	Major Ports	Minor Ports	Total	
2009-10	561	289	850	34
2010-11	570	315	885	36
2011-12	560	353	913	39
2012-13	546	388	934	42
2013-14	556	417	973	43
2014-15	581	471	1052	45
2015-16	606	466	1072	43
2016-17	648	485	1133	43
2017-18	679	492	1171	42

Source : Indian Port Association

The largest coal terminal in Rotterdam can unload 200,000 MT of cargo in a day, as per information furnished on the port's website.

Terminal efficiency = 200,000/24 = 8333 MT per hour.

(Terminal efficiency is taken as tons of cargo loaded/unloaded per hour (cargo handling rate) i.e. Total cargo unloaded from ship divided by service time. Service time is the time between berthing and departure of a ship (United Nations Conference on Trade and Development, n.d.)

Mundra port, a Minor port in India, achieved highest coal discharge rate of 164000 MT in a day, as per annual report of Adani Ports and Special Economic Zone Limited for Financial Year (FY) 2016-17.

Terminal efficiency = 164000/24 = 6833 MT per hour

Minor ports are handling a substantial share of cargo and are offering stiff competition to the Major ports (See Table 1). A study on dry bulk cargo handling at select Major Ports of India, by the author, revealed that the cargo handling rate for coal cargo at these ports ranged from 1384 MT per hour at CBS001 berth at Kamarajar Port to 284 MT per hour at Mumbai port. Major ports are following the traditional method of working and need to transform into lean and agile organizations to remain relevant and competitive. This paper suggests future strategy for Major Ports of India using agile and lean concepts and Business Process Reengineering (BPR) tools.

2. Literature Review

Business reengineering was introduced by(Hammer, 1990). (Hammer & Champy, 1993) defined reengineering as the fundamental rethink and radical redesign of business processes to generate dramatic improvements in critical performance measures such as cost, quality, service and speed. (Kettinger, Teng, & Guha, 1997) describes and analyses the major stages and activities conducted in reengineering**.**

The lean principles were first applied by Japanese automaker, Toyota. The concept was studied and popularized in the book 'The machine that changed the world' by (Womack, Jones, & Roos, 1990). Since then, numerous studies have been conducted and papers published on lean principles. (Karim & Arif-Uz-Zaman, 2013) developed a

methodology for implementing lean manufacturing strategies. Lean principles were first introduced in manufacturing organizations, but later applied to Supply chains and service organizations including ports.

(Nagel, 1991) laid down the 21st Century Manufacturing Enterprise Strategy to revive American competitiveness through adoption of agile manufacturing strategies. Agility means using market knowledge to exploit profitable opportunities in a volatile market place and leanness means developing a value stream to eliminate all waste including time (Naylor, Naim, & Berry, 1999). They recommended 'leagilitya – that is carefully combining both lean and agile paradigms'. (Paixão & Marlow, 2003) defined fourth generation ports and suggested a methodology for implementing the concept of agile ports.

(Theotokas, Broumas, & Lagoudis, 2017) finds room for future research in port management related to strategy among others. There are few studies on Indian ports on problems faced by Indian ports, which include (Monie, 2011), (Sasikumar & Bhasi, 2003). These studies suggest incremental changes in port operations. (Government of India - Ministry of Shipping, 2011) has also laid down the Maritime Agenda for the decade ending 2020. This paper proposes a differentiated strategy for the Major ports, in divergence to the Maritime Agenda. The study is specific for dry bulk coal cargo in this paper, however, it can be replicated for other cargo as well. BPR is generally limited to departments, functions or organizations. An attempt is made to extend BPR to all Major Ports in its entirety.

3. Methodology

The population of the study comprises of 12 Major ports, of which a sample of 4 ports were selected based on expert opinion. Data on ships berthed at Cochin Port, Chennai Port, Kamarajar Port and Mumbai port for the FY 2014-15 and FY 2017-18 was collected from the ports. Ship wise data on cargo type, cargo quantity and service time has been used for this study. Cargo handling rate was calculated for 15 ships berthed at Cochin port with dry bulk cargo (coal, salt, sand, murate of potash, etc), 392 ships at Kamarajar Port with coal cargo, 162 ships at Mumbai port handled carrying pulses and coal and 61 ships at Chennai port with limestone and dolomite cargo in 2014-15. Cargo handling rate has also been calculated for 8 ships at Cochin Port with different bulk cargo, 366 ships at Kamarajar Port with coal cargo, 127 ships at Mumbai port with coal and 33 ships at Chennai port carrying limestone and dolomite cargo in 2017-18. Secondary data has been obtained from Indian Po rt Association (IPA) and websites of Major Ports.

A lean organization creates capacity based on current demand and focuses on agility to meet unexpected demands. Queueing theory has been used for calculation of optimum capacity. Queuing theory was first applied by (Erlang, 1909) to resolve telephone problems. It has since been widely used for studying traffic systems**.** A top down approach has been taken for assessing the total capacity requirement, instead of the bottom up approach currently followed by individual ports.

Content analysis of Statement of Fact (SOF), a document that records the time log and delays of ships, obtained from 20 ship agents was done to validate the data obtained from ports. Discussions with port officials, ship agents, stevedoring agents and observation of cargo handling operations at the ports also assisted in augmenting information received from the ports. Benchmarking is done to lay down the target performance at ports and highlights opportunities at the ports for capacity enhancement through efficiency improvements and mechanization.

4. Optimum Capacity

The total cargo handled by Indian Ports in 2017-18 was 1171 MMT. The Maritime Agenda for 2011-2020 aims at creating capacity of 3200 MMT at Indian Ports, for handling 2500 MMT of cargo (Government of India - Ministry of

Shipping, 2011), which appears to be excessive based on past trends. Infrastructure projects entail high capital expenditure and hence a realistic assessment of future capacity is essential.

Major Ports have handled total cargo of 679 MMT in 2017-18. The total dry bulk cargo (Coal, Iron ore and fertilizer) handled by Major Ports was 177 MMT in 2017-18, which comprises 26% of the total cargo handled for the year. Composition of cargo handled by Major Ports is furnished in Table 2. A lean organization creates capacity based on current demand and focuses on agility to meet unexpected demands. The total coal cargo handled by the ports was 121 MMT (18%). Hence, optimum capacity for coal handling at Major Ports has been calculated for 120 MMT of coal cargo.

Table 2: Cargo composition at Major ports of India

Cargo	Coal	Iron Ore	Fertilizer	POL	Container	Others	Total
Quantity (MMT)	121	41	15	227	133	142	679
%	18	6	2	33	20	21	100

Queueing theory has been used in this study for calculating optimum number of servers (berths). Optimum capacity being a trade-off between berth occupancy and waiting time for ships, berth occupancy is assumed at 70%. Coefficient of variation is between 0 and 1 for cargo handling at Major ports, as seen in Table 3 and Table 4. M/M/S form of the queueing equation is used for the calculations.

Table 3. Terminal efficiency for dry bulk cargo at four Major Ports in 2014-15

Port/terminal	Count	Sum	Average	Variance	Coefficient of variation
Kamarajar CBS001	170	235334	1384	45818	0.15
Kamarajar CBS002	65	34651	533	9988	0.19
Kamarajar CICT	157	212083	1351	21743	0.11
Chennai (Limestone/Dolomite)	61	28336	465	10260	0.22
Cochin (Bulk Misc)	15	2681	179	10632	0.58
Mumbai Coal	144	40936	284	8758	0.33
Mumbai food	18	1205	67	638	0.38

Table 4. Terminal efficiency for dry bulk cargo at four Major Ports in 2017-18

Port/terminal	Count	Sum	Average	Variance	Coefficient of variation
Kamarajar CBS001	163	227118	1393	35073	0.13
Kamarajar CBS002	97	100852	1040	52735	0.22
Kamarajar CICT	106	180220	1700	33055	0.11
Chennai (Limestone/Dolomite)	33	24727	749	32120	0.24
Kochi (Bulk Misc)	8	2024	253	8322	0.36
Mumbai Coal	127	35972	283	8844	0.33

The size of dry bulk cargo ships handled at Major Ports as per IPA publication 'Major Ports of India – A profile: 2014-15), is furnished in Table 5**.** 5357 ships carrying dry bulk cargo was handled at the major ports in 2014-15. The average GRT of ships handled at CBS001 berth of Kamarajar port in 2014-15 was 35938 MT and average quantity of cargo carried by the ships was 61527 MT. The average GRT of ships with dry bulk cargo handled at Chennai port was 24600 MT and mean quantity of cargo carried by each ship was 35502 MT in 2014-15.

The Maritime Agenda 2020 proposes increase in draft of all Major Ports to 14m to handle larger ships. The total number of ships handled at the ports would vary based on ship size or capacity. In other words, as ship size increases, number of ships handled by the ports decrease. The impact of increase in size of ship handled at the port has been factored in by looking at two scenarios. Case A assumes that each ship carries 40000 MT of cargo (GRT upto 30000) and Case B assumes each ship carries 60000 MT of cargo (GRT above 30000). Actual mean service rate at Chennai port and Kamarajar port for 2014-15 is taken for calculations in Case A and Case B respectively.

Table 5. Size of ships handled at Major Ports in 2014-15

Major Port	upto 30000 GRT	30001-50000 GRT	50001-80000 GRT	Above 80000 GRT
Kolkata	72	45		
Haldia	158	592		
Paradip	205	845	19	
Visakhapatnam	307	486	50	
Kamarajar	82	331		
V. O. Chidambaranar	100	75		
Chennai	153	302		
Cochin	74	7		
New Mangalore	94	179		
Mormugao	35	121	50	
Mumbai	77	289	1	
JNPT	40			
Deendayal	241	294	33	
Total	1638	3566	153	0

Case A

Smaller handymax ships have their own gear for unloading.

The average unloading rate for dry bulk cargo at Chennai port was 465 MT/hr in 2014-15.

Service time for 40000 MT = 40000/465 = 86 hours

Number of ships = 120000/40000 = 3000

Arrival rate = 3000/(365*24) = 0.34 per hour

Table 6. Queueing theory calculation for Case A (Ship cargo upto 40000 MT)

Arrival rate	0.34	per hour		
Service rate	0.012	per hour	Service time	
Servers	42		86.02	hours per ship
Queue capacity	10			
Utilization	0.701297122			
Traffic intensity	0.040516924			
Average number in queue	0.040516924			
Average number in system	29.49499605			
Average time in queue	0.118329262			
Average time in system	86.13983464			
Probability of empty system	1.60347E-13			
Probability of having to wait	0.019092415			
Probability of full system	0.000167706			

Case B

To unload larger ships at the ports, port equipment is to be used and mechanization can be introduced to improve efficiency.

At CBS001 berth at Kamarajar Port, average cargo handling rate using two ship unloaders of 2000 MT/hr capacity and conveyor of 4000 MT per hour was found to be 1384 MT/hr in 2014-15.

Service time = 60000/1384 = 43 hours per ship

Number of ships = 120000/60000 = 2000

Arrival rate = 2000/(365*24) = 0.23 per hour

Table 7. Queueing theory calculation for Case B (Ship cargo at 60000 MT)

Arrival rate	0.23	per hour		
Service rate	0.023	per hour	Service time	
Servers	14		43.35	hours per ship
Queue capacity	10			
Utilization	0.705928599			
Traffic intensity	0.347538996			
Average number in queue	0.347538996			
Average number in system	10.23053938			
Average time in queue	1.524508641			
Average time in system	44.8771098			
Probability of empty system	4.84171E-05			
Probability of having to wait	0.160544595			
Probability of full system	0.001500705			

The required number of servers (berths) reduces from 42 (Case A) to 14 (Case B), if ship cargo increases from 40000 MT to 60000 MT per ship and cargo handling changes from ship crane and trucks to ship unloader and conveyor system.

The increase in draft at Major Ports is evidently to handle larger ships and larger ships do not have unloading gear. Increase in mechanization and size of ships will continue to lead to reduction in required number of berths at Major Ports. The number of berths required to handle entire coal cargo at the Major ports is expected to reduce over time and 3 or 4 Major Ports can cater to the total capacity requirement.

Table 8. Coal cargo handled at Major ports

Port	Coal (MMT)
Kolkata	0
Haldia	10
Paradip	42
Visakhapatnam	9
Kamarajar	23
Chennai	0
V O Chidambaranar	10
Cochin	0
New Managalore	1
Mormugao	11
Mumbai	2
JNPT	
Deendayal	14
Total	121

Currently, Paradip port, Kamarajar port, Chidambaranar port, Mormugao port and Deendayal port are handling most of the coal cargo amongst Major ports. Hence, total of 14 berths at these ports i.e. four berths at Paradip port, three berths each at Kamarajar port and Deendayal port, two berths each at Mormugao port and Chidambaranar port need to mechanize coal cargo handling with specialized equipment since larger ships do not have cargo handling gear. Major ports handling lesser coal cargo will continue to handle smaller ships at general berths and will be unloading cargo using ship cranes.

5. Benchmarking

Lean comprises of Just in time practices, Resource reduction, Improvement strategies, defects control, standardization and scientific management techniques based on (Pettersen, 2008). (Kettinger et al., 1997) has suggested benchmarking as a tool for setting targets and analysing performance. (Cuadrado, Frasquet, & Cervera, 2004) has suggested benchmarking of port processes (Pilotage, towing, mooring, loading and unloading, Customs clearance, administrative control, storage and distribution of goods, intermodal transport, value added activities) across dimensions (infrastructure provision, logistics coordination, time, cost, safety). Among the port processes, loading and unloading time is the most critical in achieving faster turnaround of ships. Hence, benchmark has been laid down for the process in this paper. Benchmarks are generally based on best practices in the industry. (Productivity Commission, 1998) in their report on 'International benchmarking of the Australian waterfront' recognized that the waterfront services used by shippers vary with exports and imports, cargo type, ports and ships. In addition, there are differences in the nature and extent of government involvement, the scale of operation and the physical environment. In view of aforesaid differences, comparison between ports can be difficult. Benchmark should therefore ideally be the optimum performance for the port, based on the engineering method.

5.1 Benchmark for conventional cargo handling

Smaller handymax ships have their own gear for unloading cargo. The ship cranes have a capacity of 25-30 MT each. Since the weight of the grabs attached to the cranes is between 10-12 MT, these cranes can lift around 12 MT of cargo at a time. The cranes can make 15 moves per hour, which works out to 180 MT of cargo per hr. At a time 4 cranes work on the ship, so total cargo unloaded from the ship is 720 MT per hr. (Source : Discussions with stevedoring agent).

Total cargo unloaded per day = 720 * 22 = 15840 MT

(Working time has been taken as 22 hours after reducing time taken for breaks during the day)

Total time for unloading 40000 MT = 40000/15840 * 24 = 61 hours

Time for initial and final draft survey = 4 hours

Collection of cargo at the hatches = 4 (hatches) * 1.5 = 6 hours

Total time at berth = 71 hours

Benchmark for Terminal efficiency = 40000/71 = 563 MT/hour

Actual average time at berth = 86 hours

Average delay per ship = 86 -71 = 15 hours

Major ports also have Mobile Harbour Cranes (MHC) to handle dry bulk cargo at the berths. MHCs with higher cargo handling capacity can drastically improve terminal efficiency. The terminal efficiency at Chennai port has increased from 465 MT per hour in 2014-15 to 749 MT per hour in 2017-18, by using two MHCs of 100 MT to unload cargo. Reduction in delays by 50% can increase port capacity by 10%.

5.2 Benchmark for mechanized cargo handling based on equipment used at CBS001 at Kamarajar port

Total coal unloaded by each ship unloader per hour = 2000 MT (capacity) – 200 MT (assuming, safety factor of 10%)

Total coal unloaded by 2 unloaders per hour = 3600 MT

Total coal unloaded per day = 3600 * 22 = 79200 MT

(Working time has been taken as 22 hours after reducing time taken for breaks during the day)

Time for initial and final draft survey = 4 hours

Collection of cargo at the hatches = 5 (hatches) * 1.5 = 8 hours

Total time for unloading 60000 MT = 60000/3600 = 16 hours

Benchmark for terminal efficiency = 60000/28 = 2142 MT/hour

Actual average unloading time at berth = 43 hours

Average Delay per ship = 43 – 28 = 15 hours

Introduction of additional unloader and higher capacity conveyor can increase terminal efficiency to 4900 MT/hour and capacity upto 50%. Reduction of delays by 50% can increase port capacity by 18%

The actual cargo handling rate at Chennai and Kamarajar port (CBS001 berth) were 465 MT per hour and 1384 MT per hour respectively, as against the benchmarks of 563 MT per hour and 2142 MT per hour in 2014-15. There is ample scope for improving efficiency and enhancing capacity at the Major Ports of India through mechanization, increase in capacity of equipment and better maintenance of equipment to reduce downtime and reduction of delays. Infrastructure projects have long gestation periods and capacity addition must be planned far in advance. However, efficiency improvements and capacity enhancements provide sufficient flexibility and buffer to the ports and must be realized before ports plan capacity additions.

6. Future strategy

In 2014-15, only 3% of the ships carrying dry bulk cargo were larger than 50000 GRT. In 2017-18, 14% of the ships handled by Major ports were larger than 50000 GRT. The increasing ship size calls for better infrastructure and superstructure to handle these ships. This will also lead to consolidation of cargo and need for fewer berths for handling bulk cargo at three or four major ports employing state of the art technology to achieve faster Turnaround Time (TAT). Though this paper delves into bulk cargo handling, it stands true for other cargo as well with increase in scale and scope at some Major ports.

Hence, eventually few Major ports will handle most of the cargo. This will result in evacuation of cargo at these Major ports and redundant capacity at other Major ports becoming major challenges. The solution to both issues lie in Coastal shipping.

In India **r**oad freight constitutes around 63% of the total freight movement with 2.2 million heavy duty trucks and 0.6 million light duty trucks carrying more than 3000 MMT of load annually as per (Novonous Intelligence Redefined, 2015). (Sarkar, 2015) reports that coastal shipping accounts for 8% of the domestic freight. Indian Ports are handling 95% of international trade in terms of volume. Hence, increase in overseas cargo can at best be incremental depending on growth in international trade. India with its vast coastline has huge potential for increase in coastal cargo. The overseas and coastal cargo handled during 2017-18 by Major ports was 524 MMT and 155 MMT respectively, as per IPA. The quantum of coastal cargo should increase over the years to equal and eventually exceed the amount of overseas cargo at the Major ports. The deterrents to coastal shipping include longer transit time for the cargo. However, the congestion on the roads and restrictions on cargo transportation during the day increase the time for cargo

movement on roads in India. As per (Deloitte Touche Private Limited, 2011) increase in efficiency at the ports and regular shipping services can make the transit time by coastal shipping comparable to that on roads.

Major ports should be reclassified into two categories based on their comparative advantages. Major coastal ports category would be mainly handling small ships and should focus on coastal cargo, while the Major International category would be mainly handling large ships with overseas and coastal cargo. Accordingly, strategy of these ports would also be different.

6.1 Major coastal ports

Major ports like Mumbai which faces physical infrastructure limitations and urban congestion, Kolkata with high dredging expenses and Cochin with low international cargo and high dredging expenses should focus on enabling movement of cargo by coastal ships. These ports can divest part of their land holdings and invest the proceeds in developing small subsidiary feeder ports. These ports must primarily aim at low cost operations since smaller ships are more cost sensitive than time sensitive.

These ports can also deploy the excess manpower at the subsidiary ports. Voluntary retirement schemes and options should be offered to reduce manpower. Study can be conducted to identify opportunities for personnel accepting voluntary retirement to be gainfully employed as consultants, tug owners and operators, truck owners, tour guides, etc. Efficiency should be encouraged by offering incentives based on performance. Staggered shifts with some employees starting their shift earlier than others can reduce delays due to shift change.

6.2 Major international ports

Major Ports handling large ships with larger volumes of cargo should use state of the art technology and privatize their terminal operations for improving efficiency. Time is a critical factor for larger ships calling at these ports. The port authority should encourage terminal operators to improve efficiency by factoring it in the agreements. The ports should have sufficient storage space and connectivity to ensure quick evacuation of cargo.

7. Conclusion

Major ports must transform into lean and agile organizations. (Naylor et al., 1999) defines agility as using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile market place. The increase in size of ships carrying overseas cargo and mechanization of cargo handling operations will lead to consolidation of cargo at some Major ports. Meanwhile, there is huge untapped potential in coastal shipping. Coastal cargo can exceed overseas cargo in the years to come. The strategy adopted by Major ports should vary based on their clientele.

Coastal shipping is environment friendly and cheaper mode of transport for larger quantities and distances over 1000 kms. As public sector organizations, Major ports should be in the forefront in enabling modal shift of cargo from roads to waterways by setting up subsidiary feeder ports. The ports endeavor to increase coastal shipping should be supported by the government through a push and pull strategy. The push strategy can be Government directives mandating transfer of a certain amount of cargo through coastal shipping by large manufacturing organizations to accelerate the modal shift from roads to coastal shipping within a fixed time frame. Pull strategy should be laying down and implementation of a comprehensive plan covering development of Major Ports and Minor Ports, with adequate road and rail connectivity and Shipping facilities.

References

Cuadrado, M., Frasquet, M., & Cervera, A. (2004). Benchmarking the port services: a customer oriented proposal. *Benchmarking: An International Journal*, *11*(3), 320–330. https://doi.org/10.1108/14635770410538781

Deloitte Touche Private Limited. (2011). *Final report Preparation of strategy road map cum action plan for development of coastal shipping in Kerala*.

Erlang, A. K. (1909). The theory of probabilities and telephone conversations. *Nyt Tidsskrift for Matematik*. Retrieved from http://www.m-hikari.com/ams/ams-2014/ams-69-72-2014/43179.html

Government of India - Ministry of Shipping. (2011). *Maritime agenda : 2010 - 2020*. Retrieved from https://www.maritimeinvest.in/images/pdf/maritime-agenda.pdf

Hammer, M. (1990). Reengineering work: Don't automate, obliterate. *Harvard Business Review*. https://doi.org/10.1225/90406

Hammer, M., & Champy, J. (1993). The Reengineering Concept. In *Reengineering the corporation*.

Karim, A., & Arif-Uz-Zaman, K. (2013). A methodology for effective implementation of lean strategies and its performance evaluation in manufacturing organizations. *Business Process Management Journal*, *19*(1), 169–196. https://doi.org/10.1108/14637151311294912

Kettinger, W. J., Teng, J. T. C., & Guha, S. (1997). Business Process Change: A Study of Methodologies, Techniques, and Tools. *MIS Quarterly*, *21*(1), 55. https://doi.org/10.2307/249742

Monie, G. De. (2011). The problems faced by Indian Ports today, (November 2013), 37–41.

Nagel, R. N. (1991). *21st Century Manufacturing Enterprise Strategy Report*. *US Defence Technical Information Center*. https://doi.org/http://books.google.co.uk/books?id=dSjsn_ECSSsC&pg=PP2&lpg=PP2&dq=Iacocca+Institute,+21st+Century+Manufacturing+Enterprise+Strategy,+Lehigh+University,+Bethlehem,+PA,+1991&source=bl&ots=uvnVNNf99X&sig=n-ssc_wIoQcntirxsHyi7xUPHbU&hl=en&sa=X&ei=WKHPUtj1GMSB

Naylor, J. Ben, Naim, M., & Berry, D. (1999). Leagility: integrating the lean and agile manufacturing in the total supply chain. *International Journal of Production Economics*, *62*, 107–118. https://doi.org/10.1016/S0925-5273(98)00223-0

Novonous Intelligence Redefined. (2015). *Freight Transport Market in India 2015 - 2020*.

Paixão, A. C., & Marlow, P. B. (2003). Fourth generation ports – a question of agility? *International Journal of Physical Distribution & Logistics Management*, *33*(4), 355–376. https://doi.org/10.1108/09600030310478810

Pettersen, J. (2008). Defining Lean Production : Some conceptual and practical issues, 285–300.

Productivity Commission. (1998). *International Benchmarking of the Australian Waterfront*. Canberra.

Sarkar, U. K. (Indian I. of M. (2015). Operational efficiency of freight transportation by road in India. Retrieved from http://cdn.tcil.in/website/tcil/Study_Report/TCI-IIM Report.pdf

Sasikumar, R., & Bhasi, M. (2003). *Planning and Operation problems of Indian Major ports with special emphasis on Cochin port*.

Theotokas, I., Broumas, D., & Lagoudis, I. N. (2017). A literature review of port competition research. *International Journal of Shipping and Transport Logistics*. https://doi.org/10.1504/IJSTL.2017.10007004

United Nations Conference on Trade and Development. (n.d.). *Port performance indicators*. https://doi.org/TD/B/C.4/131/Supp.1/Rev.1

Womack, J. P., Jones, D. T., & Roos, D. (1990). *The Machine That Changed the World*. https://doi.org/10.1016/S2212-5671(16)30234-9