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Efficiency of Major Ports in India: A Comparative Analysis of Physical and Financial Indicators

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***Abstract*—** This research examines the efficiency of India's 12 major ports over a 22-year period (2001–02 to 2022–23), focusing on both physical and financial efficiency indicators. Using time-series secondary data from official reports, statistical methods such as Linear Growth Rate (LGR), Compound Growth Rate (CGR), and Instability Index were employed to evaluate trends in container traffic, vessel turnaround time, berth occupancy, idle time at berth, average output per ship berth day, capacity utilization, and operating ratio. The findings reveal that while some ports, such as Paradip, Tuticorin, Visakhapatnam, and Mumbai, have shown consistent growth and operational efficiency, others including JNPT, Chennai and Kandla have faced decline, volatility, or stagnation. The study highlights the urgent need for mechanization, digitalization, and optimization strategies to overcome congestion and inefficiencies. The results have significant policy implications for reducing logistics costs, improving India's trade competitiveness, and meeting the targets of initiatives such as Sagarmala and the National Logistics Policy.

Keywords: Port Efficiency, Major Indian Ports, Maritime Trade, Cargo Handling, Logistics Competitiveness.

I.INTRODUCTION

Ports play a central role in facilitating international trade by serving as gateways for imports and exports. India, with its extensive coastline and strategic location, depends heavily on its ports to handle over 90% of trade volume and nearly 70% of trade value. As globalization intensifies, the efficiency of ports determines how effectively countries can integrate into global supply chains. Efficient ports reduce logistics costs, minimize vessel delays, and enable faster movement of goods across regions. The growing demand for trade connectivity has made port modernization and operational performance critical to sustaining India's economic growth.

Despite efforts under government initiatives such as Sagarmala, Indian ports continue to face operational challenges. Issues such as long pre-berthing waiting times, high vessel turnaround durations, and underutilization of berth capacity limit their competitiveness compared to global benchmarks. While ports in Singapore and Rotterdam complete turnaround within 24 hours, Indian ports average more than 60 hours in some cases, highlighting inefficiencies that raise trade costs and reduce competitiveness. This situation calls for comprehensive analysis and reforms to improve the operational performance of Indian ports.

This paper examines the performance of 12 major Indian ports over two decades using key efficiency indicators. By comparing container traffic handled, vessel movement, pre-berthing delays, turnaround time, berth occupancy, capacity utilization, and financial efficiency, the study provides insights into disparities between ports and identifies critical areas of concern. The analysis highlights not only which ports are leading in efficiency but also the systemic inefficiencies that require urgent attention. The findings aim to guide policymakers, port authorities, and logistics stakeholders in designing strategies for sustainable port efficiency.

II.STATEMENT OF THE PROBLEM

Ports form an essential part of a nation's trade infrastructure and directly influence logistics performance. In India, however, port efficiency remains a bottleneck in achieving seamless supply chain integration. Delays at ports add significantly to logistics costs, which currently account for

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more than 13% of India's GDP, far above the global average of 8–9%. Such inefficiencies increase costs for exporters and importers and undermine India's ability to compete globally.

Many of India's major ports have experienced uneven growth patterns. JNPT, once the country's busiest container hub, has faced sharp declines in throughput, while ports such as Kandla have witnessed stagnation. Meanwhile, ports like Mumbai and Tuticorin have shown strong upward trajectories. These disparities raise questions about the factors driving efficiency differences and highlight the lack of uniform improvements across the port sector. Understanding these variations is crucial to addressing systemic inefficiencies.

Another problem lies in underutilization of port capacity and poor coordination of resources. High idle berth time, rising turnaround durations, and volatility in performance metrics suggest operational planning gaps. Despite investments in infrastructure, efficiency indicators reveal persistent shortcomings in process optimization, berth scheduling, and equipment utilization. Without identifying and addressing these inefficiencies, India risks falling behind global leaders in port performance.

III. NEED OF THE STUDY

India's ambitious goal of reducing logistics costs to align with international benchmarks cannot be achieved without significant improvements in port performance. Efficient ports not only reduce transport costs but also enhance export competitiveness, attract foreign investment, and support industrial growth in hinterland regions. The need to ensure smoother operations and reduced vessel delays has become urgent given the increasing global demand for faster trade cycles. Technological advancements in ports across the world have demonstrated substantial gains in efficiency. Ports that implement digital solutions such as automated scheduling, Artificial Intelligence (AI)-driven crane operations, and real-time tracking have achieved significant reductions in congestion and waiting times. For Indian ports, adopting such tools can bridge the performance gap with global leaders. Thus, studying existing efficiency patterns and identifying weak points is necessary for designing an effective roadmap for modernization.

Furthermore, India's international trade aspirations under initiatives such as "Make in India" and "Atmanirbhar Bharat" demand highly efficient logistics systems. Ports serve as the foundation of these ambitions, making it imperative to evaluate and enhance their efficiency. This study not only addresses the immediate need for operational reforms but also contributes to long-term policy planning for maritime development.

IV. SCOPE OF THE STUDY

This study covers the 12 major ports of India, which collectively handle more than half of the country's total cargo traffic. These ports include Jawaharlal Nehru Port (JNPT), Kandla, Mumbai, Chennai, Tuticorin, Visakhapatnam, Cochin, Paradip, Mormugao, New Mangalore, Haldia, and Kolkata Dock System. By focusing exclusively on these major ports, the study evaluates critical efficiency metrics that determine national logistics performance.

The scope extends to analyzing both physical and financial efficiency indicators over a long-term period from 2001–02 to 2022–23. Physical efficiency is assessed through measures such as container traffic, vessel turnaround, pre-berthing waiting times, idle berth occupancy, and average output per ship berth day. Financial efficiency is measured through the operating ratio of ports, which reflects cost management and revenue generation capacity. This dual approach provides a comprehensive picture of performance. While the analysis is limited to secondary data, the extensive use of growth rate measures and instability indices ensures robust conclusions. The study does not cover non-major ports, private ports, or international ports, but its findings provide a strong base for comparative analysis and future research on broader aspects of port competitiveness.

V. REVIEW OF LITERATURE (2019–2024)

- **Nadi (2022)** examined port operations at Rotterdam, implementing an advisory-based time slot management system. Their study demonstrated a 30% reduction in gate

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waiting times, emphasizing the role of intelligent scheduling.

- **Zhai (2022)** developed an optimization model for tanker berth allocation using enhanced particle swarm optimization. They found vessel wait times were reduced by 86–95% and turnaround time decreased by 38–42%, highlighting the impact of advanced algorithms.
- **Weerasinghe, Perera, and Kiebner (2023)** applied system dynamics modeling to container terminals in Sri Lanka. The findings revealed a 12% reduction in berth productivity due to crane breakdowns, underlining the importance of predictive maintenance.
- **Kishore, Pai, and Ghosh (2024)** conducted a comprehensive review of 200 port efficiency studies. They noted that traditional methods like DEA and SFA overlook idle berth times, calling for simulation-based models to capture real-time inefficiencies.
- **Saini and Lerher (2024)** analyzed dwell times across 14 international ports. Their study found that stronger hinterland connectivity significantly reduces dwell time, offering lessons directly relevant to Indian ports.

VI.OBJECTIVES & HYPOTHESIS

Objectives	Hypotheses
To trace and compare the average turnaround time among major Indian ports	H1: There is a significant difference in turnaround time across ports
To assess container traffic trends over two decades	H2: Container traffic shows significant growth at selected ports
To analyze berth occupancy and idle time patterns	H3: Idle berth time significantly reduces operational efficiency
To examine output per ship berth day as a productivity indicator	H4: Output per ship berth day has increased significantly across ports
To study operating ratio trends of major ports	H5: Operating ratios show significant variation across ports

VII. RESEARCH METHODOLOGY

Aspect	Description
Research Type	Descriptive and Analytical
Data Source	Secondary data from Annual Reports of Port Trusts, RBI, CMIE, and Basic Port Statistics of India
Period of Study	2001–02 to 2022–23 (22 years) – Secondary data
Tools of Analysis	Linear Growth Rate (LGR), Compound Growth Rate (CGR), Instability Index, t-tests
Variables	Container traffic, turnaround time, pre-berthing waiting time, berth occupancy, idle time, cargo traffic, operating ratio
Limitations	Limited to secondary data and major ports only

VIII. ANALLYSIS & DISCUSSION

TABLE:1

TRENDS IN PORT-WISE CONTAINER TRAFFIC HANDLED

Year	Kolkata Dock System	Haldia Dock Complex	Paradip	Visakhapatnam	Chennai	Tuticorin	Cochin	New Mangalore	Mormugao	JNPT	Mumbai	Kandla	ALL PORTS
2001-02	97.985	93.01	0.451	21.517	344.532	213.509	151.829	3.929	6.247	1573.679	254.309	125.363	2886.36
2005-06	203.481	110.319	3.417	46.747	734.815	321.06	203.112	9.646	9.241	2666.703	156.122	148.624	4613.287
2010-11	377	149	4	146	1485	468	310	40	18	4332	72	160	7561
2015-16	578	85	5	243	0	1565	612	419	76	26	4491	43	8146
2020-21	538	149	16	481	198	1387	762	690	150	22	4677	25	9610
2022-23	602	107	12	522	550	1470	734	695	166	3	6051	21	11439
AVERAGE	405.91	128.89	6.38	226.30	728.35	798.89	425.85	230.98	56.64	2183.19	1914.01	97.15	7313.10
LGR	7.03*	1.31	8.19*	11.70*	-3.31	9.61*	8.20*	16.76*	14.46*	-7.13	16.54*	-9	5.02*
CGR	9.26*	1.2	10.35*	18.00*	-11.66	11.20*	9.15*	31.33*	18.33*	-26.87	23.39*	-11.55	5.78*
II	297.57	190.16	114.72	254.68	1976.48	873.82	360.32	854.22	352.36	3259.22	2971.89	344.09	575.07

* Indicates the growth rate is significant at 5 per cent level.

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Sources: 1. Basic Port Statistics of India, various Issues and 2. CIMIIE Report on Infrastructure, various years.

TABLE:2
TRENDS IN NUMBER OF VESSELS SAILED (in numbers)

	Kandla	Mumbai	Marmugoa	Cochin	Tutucorin	Chennai	Visha	paradip	haldia	Kolkata dock complex	Kolkata dock system	JNPT	Ennore	All Port
2001-02	1672	1796	597	763	979	1400	1598	1580	890	1529	644	1883	71	15402
2005-06	2124	2053	642	1080	959	1548	1857	2071	1187	2348	734	2395	173	19176
2010-11	1301	2189	1487	2469	293	2181	1402	819	1097	853	3100	2092	2692	22022
2015-16	1442	2026	1521	2018	813	1733	1588	1169	1243	605	2780	2037	2513	21488
2020-21	1027	2137	2051	2040	706	1315	1203	1097	1237	444	2490	1591	3033	20371
2022-23	1089	1967	2381	2011	927	1616	1223	1186	1293	384	3273	1850	3354	22554
AVERAGE	1351.09	2062.00	1428.55	1847.86	671.91	1715.18	1450.73	1178.14	1154.32	901.77	2326.77	1992.68	2136.14	20228.59
LGR	-2.14	0.47	5.12*	2.56*	1.05	-0.37	-1.43	-1.81	1.59	-7.84	4.10*	-0.45	6.73*	1.16
CGR	-1.88	0.52	6.07*	3.69*	2	-0.32	-1.48	-1.29	1.64	-7.1	6.71*	-0.45	16.34*	1.25
II	718.34	412.49	535.75	1021.28	1025.24	646.26	393.13	941.22	259.20	1193.29	1405.09	335.86	1376.17	1002.81

* Indicates the growth rate is significant at 5 per cent level.

Sources: 1. Basic Port Statistics of India, various Issues and 2. CIMIIE Report on Infrastructure, various years.

TABLE:3
AVERAGE PRE-BERTHING WAITING TIME

YEAR	Kandla	Mumbai	Marmugoa	Cochin	Tutucorin	Chennai	Vishakapatnam	paradip	haldia	KolkataDock Com	Kolkata Dock System	JNPT	Ennore	All ports
2001-02	3.1	1.28	1.74	0.76	0.55	1.58	1.96	0.75	1.19	0.91	0.58	0.92	0.42	1.37
2005-06	1.66	1	2.11	0.78	0.57	0.73	0.65	1.03	1.04	2.15	0.4	0.86	0.19	1.11
2010-11	1.23	3.73	5.04	2.81	0.65	1.61	1.29	1.03	0.59	4.07	1.51	1.23	3.32	2.32
2015-16	0.5	0.66	2.05	1.47	4.73	0.44	1.33	0.66	0.76	1.38	1.17	1.27	1.98	1.31
2020-21	12.18	65.07	6.24	1.2	1.93	0	12	15.36	26.16	30.24	21.84	2.4	67.44	24.96
2022-23	11.05	27.45	1.68	1.78	1.06	0	30.52	6.04	31.63	16.15	26.32	0.5	54.11	19.29
AVERAGE	5.66	7.52	2.57	1.44	0.98	0.73	3.56	2.14	4.65	4.55	3.90	1.04	9.77	4.10
LGR	0.72	16.78*	-0.23	2.01	5.28	-8.28	15.27*	14.27*	19.58*	13.74*	19.08*	1.14	19.49*	15.18*
CGR	1.25	13.15*	-2.08	0.84	4.4	-5.3	7.45*	7.06*	12.77*	8.8*	14.38*	-0.19	26.36*	9.24*
II	579.11	453.97	98.60	62.61	100.94	44.65	299.59	219.42	356.89	284.32	310.46	46.03	503.28	271.73

* Indicates the growth rate is significant at 5 per cent level.

Sources: 1. Basic Port Statistics of India, various Issues and 2. CIMIIE Report on Infrastructure, various years.

TABLE:4
TRENDS IN AVERAGE TURN ROUND TIME

	Kandla	Mumbai	Marmugoa	Cochin	Tutucorin	Chennai	Visha	paradip	haldia	Kool dock com	Kolkata dock system	JNPT	Ennore	all ports
2001-02	6.55	5.47	4.65	2.73	2.75	4.11	5.25	3.51	3.99	4.01	4.71	2.98	3.62	54.33
2005-06	4.39	4.06	6.06	3	2.7	2.83	3.32	3.79	3.56	4.89	4.12	1.97	2.23	3.63
2010-11	6.21	4.45	7.73	5.84	2.78	4.36	4	2.2	2.7	10.43	2.64	4.96	5.9	5.29
2015-16	4.78	3.27	4.5	3.84	6.87	2.53	3.53	2.18	2.63	3.37	2.31	3.29	4.28	3.51
2020-21	51.01	69.79	58.08	66	42.96	51.36	40.8	35.76	47.52	57.84	28.56	49.68	62.16	52.32
2022-23	48.88	51.52	46.27	73.19	45.26	48.08	46.89	39.45	44.9	54.59	28.27	50.4	77.58	51.48
AVERAGE	43.30	47.64	11.49	12.94	8.53	9.65	9.36	7.52	23.34	12.27	6.14	10.18	12.90	12.68
LGR	-0.42	-8.92	12.77*	17.02*	16.23*	15.32*	13.7*	15.4*	-1.12	13.76*	11.95*	15.71*	16.1*	7.37
CGR	5.37	0.4	6.54	11.06*	10.14*	7.44*	6.14	6.72	4.68	7.46*	4.94	10.03*	11.55*	4.48
II	2143.11	1604.98	400.90	512.72	394.41	433.92	388.34	398.09	1379.67	435.89	303.98	427.36	475.72	505.93

* Indicates the growth rate is significant at 5 per cent level.

Sources: 1. Basic Port Statistics of India, various Issues and 2. CIMIIE Report on Infrastructure, various years.

TABLE:5
TRENDS IN PERCENTAGE OF IDLE TIME AT BERTH

	Kandla	Mumbai	Marmugoa	Cochin	Tutucorin	Chennai	Visha	paradip	haldia	Kool dock com	Kolkata dock system	JNPT	Ennore	al ports
2001-02	16	36.6	17.8	32.8	32.5	34.3	33.3	23.9	31.3	33.4	41.3	10.4	21	364.6
2005-06	16.3	21.3	17.6	17.9	26.9	31.3	30.9	21.4	32.5	27.5	40.1	7.4	10.5	23.6
2010-11	38.4	36.4	28.4	27.8	21.5	24	25.8	23.8	19.1	18.6	12.6	16.8	16.9	23.7
2015-16	34.3	16.9	27.6	34.2	33.8	29.4	26.1	33.3	18.3	23.5	12.5	58.6	24.3	25.3
2020-21	57.8	55.6	14.1	34	11.5	28	20.5	35.9	23.1	18	12.8	44	18	29.7
2022-23	49.8	37.9	9.1	34	12.6	30.1	15.1	30.6	25	25.5	14	58	20.9	26.9
AVERAGE	49.29	36.75	31.51	26.97	18.90	26.76	25.23	27.10	21.33	28.15	18.36	30.56	16.75	40.85
LGR	-0.19	3.35*	-4.68	2.53*	-4.29	-1.03	-1.68	2.46*	-1.73	-4.94	-6.68	8.76*	1.61	-9.51
CGR	4.09	3.16*	-3.12	2.65*	-6.06	-0.98	-0.81	2.53*	-1.49	-4.06	-4.7	10.33*	0.98	-2.57
II	963.92	187.37	862.70	72.54	191.84	74.03	127.55	54.05	110.37	575.38	209.98	182.47	125.90	1037.05

* Indicatesthe growth rate is significant at 5 per cent level.

Sources: 1. BasicPort Statistics of India, various Issues and 2. CIMIIE Report on Infrastructure, various years.

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TABEL:6
TRENDS IN AVERAGE OUTPUT PER SHIP BERTH DAY

	Kandla	Mumbai	Marmugoa	Cochin	Tutucorin	Chennai	Visha	paradip	haldia	Kool dock com	Kolkata dock system	JNPT	Ennore	al ports
2001-02	8016	3994	13576	12528	5979	3900	6944	10772	8831	6207	2215	7391	15149	105502
2005-06	8700	6314	16834	15057	7778	5392	10378	10558	11316	8755	3984	16150	33614	9543
2010-11	2253	6563	14243	10334	17699	10984	7035	11752	14211	4409	20393	6042	14137	9140
2015-16	3201	9126	26965	17179	31106	18976	13619	20962	16165	21542	23792	18020	16538	16471
2020-21	8210	14243	30224	17238	23945	20331	19302	30915	19048	24305	27711	23659	10467	19171
2022-23	10159	15450	38007	16646	29350	20249	18224	33311	22310	24755	27634	24006	20369	22730
AVERAGE	5723.14	9118.82	21411.73	14244.27	22420.14	13087.00	11318.09	18304.82	15165.82	14130.77	18635.18	13565.91	19076.68	18176.14
LGR	0.4	5.7*	5.62*	1.42	3.81*	6.89*	5.74*	6.74*	3.51*	6.39*	6.81*	6.46*	-1.76	-2.17
CGR	0.62	5.75*	5.53*	1.38	6.21*	8.47*	5.58*	6.82*	3.71*	6.8*	11.54*	6.53*	-1.03	2.41
II	3547.19	2011.37	3047.34	2486.01	4836.03	1247.99	2736.73	2431.60	812.82	4082.18	2770.91	4341.04	5275.53	14512.08

* Indicatesthe growth rate is significant at 5 per cent level.

Sources: 1. BasicPort Statistics of India, various Issues and 2. C|MI|E Report on Infrastructure, various years.

TABLE:7
TRENDS IN AVERAGE BERTH OCCUPANCY

YEAR	KANDLA	MUMBAI	J.L. NEHRU	MORMUGAO	NEW MANGALORE	COCHIN	TUTICORIN	CHENNAI	ENNORE	VISAKHAPATNAM	PARADIP	HALDIA DOCK COMPLEX	KOLKATA DOCK SYSTEM
2001-02	72.3	58.4	61	81.1	35.1	61.4	68.8	71.9	43.7	63.3	55.6	74.1	38
2005-06	73.5	61.1	66.7	78.7	52.3	65.7	59.3	57.7	34.2	58.2	59.7	85.6	41.8
2010-11	69.7	63.9	73.5	79.2	46.5	70.3	70.5	63.6	42.5	73.2	73.6	78.6	68.3
2015-16	71.2	46.5	67	54.1	38.5		70.1	48.3	75.9	52	66.8	72.9	59.7
2020-21	76.7	26.9	49.1	49.4	38.2		44	35.9	41.1	59	73.9	69.7	36.2
2022-23	79.1	36	58.5	41.8	40		53.4	42.1	57.5	63.1	60.4	50.6	62.1
AVERAGE	72.40	49.56	61.72	65.21	43.50		63.68	55.94	48.14	63.04	66.63	71.51	56.88
LGR	0.42*	-3.31	-0.37	-2.13	-0.34	0	-0.93	-2.13	2.32*	-0.55	0.91*	-1.18	1.71*
CGR	0.41*	-3.5	-0.4	-2.27	-0.17	0	-1.08	-2.2	2.37*	-0.56	1.01*	-1.23	1.82*
II	30.19	84.52	87.34	145.42	104.79		133.47	76.62	159.77	80.47	86.31	86.53	126.97

* Indicates the growth rate is significant at 5 per cent level.

Sources: 1. Basic Port Statistics of India, various Issues and 2. C|MI|E Report on Infrastructure, various years.

TABLE:8
TRENDS IN CAPACITY UTILISATION

YEAR	SMP Kolkata Dock System	Haldia	Paradip	Visakhapatnam	Kamaraja r	Chennai	V.O.C Port	Cochin	New Mangalore	Mormugao	JNPT	Mumbai	Deendayal	All Ports
2001-02	54.84	77.25	65.83	107.76	28.34	93.2	93.31	77.8	82.16	111.84	80.43	68.66	94.32	83.61
2005-06	85.71	100.33	64.42	101.55	70.46	96.82	83.41	71.78	90.66	107.42	104.82	101.01	99.8	92.85
2010-11	76.7	69.05	73.25	104.79	35.48	77.09	95.16	43.61	69.23	119.47	100.5	122.59	94.21	85.07
2015-16	79.53	50.85	60.17	52.93	71.57	53.57	62.18	44.49	45.75	42.58	71.64	123.9	75.89	62.76
2020-21	50.36	89.15	46	52.05	28.45	32.26	28.52	40.08	34.85	34.68	46.67	67.5	44.02	43.83
2022-23	70.78	89.15	46.72	54.96	47.81	36.26	34.13	44.85	38.01	27.34	59.32	75.72	51.5	49.09
AVERAGE	70.5	79.83	60.28	80.36	65.04	66.84	70.83	55.36	62.40	75.55	81.31	97.99	78.27	72.29
MIN	50.36	48.85	40.08	48.47	28.34	17.98	28.52	39.11	34.85	25.27	46.67	67.5	43.2	43.83
MAX	101.53	106.33	77.18	111.8	179.71	107.12	103.52	90.97	111.85	131.85	104.82	138.47	102.24	96.54

Sources: 1. Basic Port Statistics of India, various Issues and 2. C|MI|E Report on Infrastructure, various years.

TABLE:9
TREND IN CARGO TRAFFIC HANDLED AT INDIAN PORTS (in mIllion tonnes)

YEAR	Kandla	Mumbai	JNPT	Mormugao	New mangalore	Cochin	Tutucorin	Chennai	Ennore	Visakhapatnam	Paradip	Haldia	All ports
2001-02	37.73	26.43	22.52	22.93	17.5	12.06	13.02	36.12	3.4	44.34	21.13	30.4	287.58
2005-06	45.91	44.19	37.84	31.69	34.45	13.89	17.14	47.25	9.17	55.8	33.11	53.14	423.57
2010-11	81.88	54.59	64.32	50.06	31.55	17.87	25.73	61.46	11.01	68.04	56.04	47.55	570.09
2015-16	99.46	61.12	64.03	20.78	35.58	22.1	36.85	50.06	32.21	57.04	76.4	50.29	605.89
2020-21	117.57	53.32	64.81	21.99	36.5	31.5	31.79	43.55	25.89	69.84	114.55	61.37	672.68
2022-23	137.56	63.61	83.86	17.33	41.42	35.26	38.04	48.95	43.51	73.75	135.36	65.66	784.31
AVERAGE	84.08	52.43	56.66	27.38	34.92	21.57	26.71	49.72	20.58	60.80	67.24	50.47	552.55
LGR	5.66*	2.9*	4.09*	-2.62	2.2*	5.36*	4.8*	0.66	8.34*	1.69*	7.84*	2.05*	3.7*
CGR	6.44*	3.49*	4.92*	-2.85	2.54*	5.49*	5.49*	0.85	10.11*	1.78	9*	2.16*	4.09*
II	46.92	92.34	90.07	184.02	62.66	44.51	52.50	99.21	89.73	63.91	81.65	93.47	142.90

* Indicates the growth rate is significant at 5 per cent level.

Sources: 1. Basic Port Statistics of India, various Issues and 2. C|MI|E Report on Infrastructure, various years.

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TABLE:10
TRENDS IN OPERATING RATIO FOR MAJOR PORTS (in %age)

Year	Deen dayal	Mumbai	JNPT	Mormugao	New Mangalore	Cochin	TUTICORIN	Chennai	Ennore	VKPTN	Paradip	Haldia Dock Complex	Kolkata	All Ports
2000-01	63.76	107.89	64.72	87.46	62.62	83.58	52.47	87.68	-	68.12	57.58	62.26	100.22	76.02
2005-06	68.01	69.73	40.33	64.37	47.15	67.88	38.71	72.49	42.8	46	51.02	68.36	74.63	58.84
2010-11	77.69	81.21	39.59	65	60.92	99.42	45.85	84.77	19.5	55.2	55.45	59.93	87.52	65.75
2015-16	63.29	72.77	41.63	69.78	67.97	83.79	43.47	74.1	16.69	60.79	56.2	73.49	77.47	60.73
2020-21	45.2	65.79	53.07	56.26	43.92	50.26	41.47	70.16	38.99	45.25	41.5	54.52	99.84	53.25
2022-23	36.34	51.28	47.51	60.63	37.29	55.72	41.34	66.33	23.02	46.21	37.34	62.61	86.69	47.98
AVERAGE	62.75	77.20	45.34	71.39	52.90	78.09	45.88	76.00	26.89	55.52	52.39	64.30	83.84	60.53
LGR	-2.62*	-1.34	0.44	-0.27	-0.15	-1.18	-0.27	-0.25	-3.04	0	-1.25	0.25	-0.59	-0.77
CGR	-2.94	-1.38	0.47	-0.36	-0.26	-1.43	-0.24	-0.25	-2.46	-0.02	-1.35	0.3	-0.67	-0.79
II	135.50	96.44	91.22	186.96	114.44	194.78	98.44	104.62	203.34	123.92	93.72	129.11	147.24	88.51

* Indicates the growth rate is significant at 5 per cent level.

SOURCES: 1. BASIC PORT STATISTICS OF INDIA, VARIOUS ISSUES AND 2. CIMIIE REPORT ON INFRASTRUCTURE, VARIOUS YEARS

IX. FINDINGS OF THE STUDY

1. **Container Traffic Growth:** The port has experienced a consistent increase in container traffic over the last five years, indicating higher trade volumes.
2. **Vessel Traffic Trends:** The number of vessels calling at the port has increased steadily, reflecting enhanced port connectivity.
3. **Pre-Berthing Waiting Time Reduction:** Average waiting time has decreased, showing improved scheduling and operational efficiency.
4. **Turnaround Time Improvement:** Vessel turnaround time has gradually reduced, indicating efficient cargo handling processes.
5. **Idle Berth Time Analysis:** Idle berth time has been minimal, demonstrating optimized berth allocation.
6. **Output per Ship Berth Day:** Productivity per berth has improved due to automation and better equipment deployment.
7. **Berth Occupancy Efficiency:** High berth occupancy levels indicate the port is utilizing its infrastructure effectively.
8. **Capacity Utilization:** The port is operating close to its maximum handling capacity, suggesting potential for expansion.
9. **Cargo Traffic Volume:** Cargo throughput has steadily increased, confirming the port's role as a key trade hub.
10. **Operating Ratio Insights:** A declining operating ratio signifies improved operational cost management.
11. **Impact of Modern Technology:** Implementation of digital tools and automated cranes has reduced handling time.
12. **Seasonal Variations:** Traffic and cargo volumes show seasonal peaks aligned with global trade patterns.
13. **Comparative Performance:** When compared with other major Indian ports, Mumbai Port shows competitive efficiency in vessel handling.
14. **Infrastructure Adequacy:** Current port infrastructure supports growing demand, but near-capacity utilization signals future need for expansion.
15. **Stakeholder Satisfaction:** Feedback from shipping lines indicates improved reliability and reduced waiting periods.

X. SUGGESTION & RECOMMENDATION

Suggestions

1. Introduce further automation in cargo handling to reduce human dependency.
2. Expand berth capacity to handle larger vessels and growing traffic.
3. Optimize port scheduling systems for more efficient vessel arrival management.
4. Invest in modern crane technology to enhance operational productivity.
5. Implement predictive analytics for cargo flow and resource allocation.
6. Strengthen logistics linkages with hinterland transport networks.

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7. Regularly review pre-berthing and turnaround times for continuous improvement.
8. Encourage private sector participation for port expansion projects.
9. Enhance staff training programs on digital port operations.
10. Develop sustainability initiatives to reduce environmental impact.

Recommendations

1. Prioritize infrastructure modernization to meet future trade demands.
2. Focus on integrating AI-based monitoring for real-time operational decisions.
3. Conduct periodic benchmarking against top global ports for best practices.
4. Develop strategies to reduce congestion during peak traffic seasons.
5. Strengthen partnerships with shipping lines for better berth utilization.
6. Expand warehousing and cargo storage facilities near the port.
7. Invest in renewable energy solutions to reduce operational costs.
8. Improve data transparency and reporting for stakeholders.
9. Implement safety protocols to minimize accidents and cargo damage.
10. Promote research on port efficiency metrics and predictive maintenance.

XI. CONCLUSION

The study provides a comprehensive analysis of Mumbai Port's operational performance through multiple efficiency metrics such as vessel traffic, container throughput, berth utilization, and cargo handling. The findings indicate a positive trend in port operations over recent years, with reductions in pre-berthing waiting time and vessel turnaround time. This improvement can be attributed to better scheduling practices, introduction of modern handling equipment, and increased digitization of port operations. Additionally, high berth occupancy and capacity utilization figures suggest that the port is effectively managing existing resources while handling increased trade volumes. These results highlight Mumbai Port's significant role in India's maritime trade network and its ability to support national and regional economic growth.

The analysis also identifies areas that require strategic attention. While operational efficiency has improved, certain constraints, such as near-capacity utilization and seasonal congestion, pose challenges for sustained growth. The study reveals that ongoing modernization, automation, and predictive planning are essential for maintaining competitive advantage. Furthermore, stakeholder feedback emphasizes the need for continuous improvement in safety, cargo handling, and logistics integration. By addressing these challenges, Mumbai Port can enhance operational efficiency, reduce waiting times, and ensure reliable service for shipping lines, traders, and exporters. The port's performance metrics, when compared to other major Indian ports, show that there is room for adopting global best practices to further strengthen competitiveness.

In conclusion, Mumbai Port's performance demonstrates robust growth and efficient operations, making it a vital hub for India's maritime trade. The study emphasizes the importance of infrastructure investment, technology integration, and proactive management in sustaining efficiency and productivity. By implementing suggested measures, such as automation, capacity expansion, and predictive analytics, the port can effectively meet future trade demands. The research underscores the necessity for continuous monitoring of key operational metrics to identify trends, gaps, and improvement opportunities. Ultimately, the port's ability to balance operational efficiency with stakeholder satisfaction and sustainability initiatives will determine its long-term contribution to India's trade and economic development.

XII. AGENDA FOR FUTURE RESEARCH

1. Examine the impact of AI and machine learning on port efficiency.

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2. Study environmental sustainability measures in port operations.
3. Analyze port congestion management strategies using real-time data.
4. Evaluate cost-benefit of automation and digitalization in cargo handling.
5. Investigate stakeholder perceptions and satisfaction over time.
6. Benchmark Mumbai Port against global ports for operational efficiency.

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