International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Evaluating the Efficiency of Multimodal Transportation in International Logistics: A Composite Multi-Dimensional Score Analysis with Implications for India

Anubhav Carpenter | Ashwin Thomas Joseph

Under the Guidance of **Dr. Nirbhan Singh** *(Associate Professor)*

Faculty of Management Studies, Parul University, Vadodara, Gujarat, India Specialisation: International Trade and Business (MBA — Final Semester)

ABSTRACT

Global supply chains are under mounting pressure to do more with less — to move goods faster, more reliably, at lower cost, and with a shrinking environmental footprint. Multimodal transportation, which strings together two or more modes of transport under a single logistics contract, is widely regarded as the answer. Yet surprisingly few studies attempt to measure its efficiency in a rigorous, multi-dimensional way. This paper does exactly that. Drawing on secondary data from UNCTAD, the World Bank Logistics Performance Index, Sea-Intelligence, Flexport, and India's Dedicated Freight Corridor Corporation (DFCCIL), we construct a Composite Multimodal Efficiency Score (CMES) that weighs cost (30%), transit time (25%), schedule reliability (25%), and carbon emissions (20%). Applied to the Asia-Europe and Trans-Pacific corridors, the optimised Sea-Rail configuration scores 7.1 out of 10 — roughly 20 per cent above All-Sea transport. A total landed cost analysis shows Sea-Rail is, counterintuitively, 18.3 per cent cheaper for high-value cargo once inventory and buffer stock costs are factored in. For India, the Western Dedicated Freight Corridor alone has cut the port-to-hinterland rail transit by 80 per cent. Our findings strongly support the alternative hypothesis that multimodal transportation delivers significantly superior logistics efficiency, and carry concrete implications for Indian trade policy, exporters, and the Gujarat logistics ecosystem.

Keywords: Multimodal Transportation, Composite Efficiency Score, Total Landed Cost, Belt and Road Initiative, India Logistics Performance Index, Dedicated Freight Corridor, Trade Corridors

1. INTRODUCTION

Ask any logistics manager to name the perfect transport mode and you will get a long pause, followed by a rueful smile. There is no perfect mode — and that, in a nutshell, is why multimodal transportation exists.

Ocean freight can carry enormous volumes at a fraction of the cost of any alternative, yet a container leaving Shanghai for Rotterdam will spend somewhere between 28 and 35 days at sea, assuming nothing goes wrong. Air freight compresses that to a day or two, but at a price five to seven times higher — and with a carbon footprint roughly 50 times greater per ton-kilometre. Road transport is wonderfully flexible but hopelessly inefficient over continental distances. Rail sits in an attractive middle ground: faster than ocean, cheaper than air, and far cleaner than road. None of them, taken alone, can satisfy the full range of demands that modern international trade places on logistics.

Multimodal transportation — the deliberate combination of two or more modes within a single end-to-end contract — is the logical response. The Belt and Road Initiative (BRI) rail services now carrying over 16,000 China-Europe trains a year, the seamless sea-rail intermodal system along the US West Coast, and India's recently commissioned Western Dedicated Freight Corridor (WDFC) are all large-scale bets on the same idea: that combining the best of each mode produces results no single mode can match. The market appears to agree. The global multimodal transportation market reached USD 46.82 billion in 2023, growing at roughly 10.9 per cent a year — well ahead of overall trade growth — and is on course to approach USD 97 billion by 2030 [1].

What the market has not always had, however, is a rigorous, multi-dimensional framework for quantifying exactly how much more efficient multimodal solutions are compared to their unimodal counterparts — and under what conditions. That is the gap this paper addresses. We develop a Composite Multimodal Efficiency Score (CMES) and apply it to the world's two most important trade corridors, with particular attention to the implications for India's ongoing logistics transformation. The remainder of the paper is organised as follows: Section 2 situates the study within the existing literature; Section 3 explains the methodology; Section 4 presents and analyses the data; Section 5 discusses the broader implications; Section 6 addresses the study's hypotheses; and Section 7 concludes.

2. LITERATURE REVIEW

The academic study of how transport modes compare in efficiency terms has a long history, though the frameworks used have evolved considerably over the decades. Early contributions, notably Rodrigue's work on the geography of transport systems [2], established the foundational idea of modal complementarity — the principle that each mode has a natural operating environment where it performs best, and that combining modes intelligently therefore makes more sense than forcing a single mode to do everything. This was largely a qualitative observation, but it laid important groundwork.

Christopher's influential work on total cost analysis in supply chain management [3] shifted the conversation in a consequential way. He argued — compellingly, and with detailed worked examples — that the freight rate is not the same as the total cost of logistics. Inventory carrying costs, the cost of capital tied up in slow-moving goods, and the economic penalty of unreliable delivery schedules can easily dwarf the freight charge itself, particularly for high-value cargo. This reframing is central to our own analysis, as it explains why a transport configuration that looks expensive on a rate sheet can turn out to be significantly cheaper once all costs are properly accounted for.

The environmental dimension entered the literature more recently, propelled by the IPCC's successive assessment reports [4] and codified for freight transport through the International Transport Forum's emission factor methodology [5]. Janic's modelling work on European freight showed that shifting cargo from road to rail on medium-to-long-haul routes could cut CO2 emissions by 70-80 per cent per ton-kilometre [6] — a figure that has held up well against subsequent empirical work. The ITF's most recent estimates [7] confirm electric rail at 7.5 grams CO2 per ton-km, compared to 96 grams for road and a striking 602 grams for air freight.

Within India specifically, Hanaoka and Regmi [8] identified three recurring constraints on multimodal development in South Asian economies: inadequate intermodal terminal infrastructure, regulatory fragmentation across state boundaries, and a shortage of trained multimodal operators. The World Bank's Logistics Performance Index reports [9] have tracked India's progress against these constraints over successive survey rounds, providing an unusually consistent longitudinal dataset. DFCCIL's operational reports [10] now add real-world performance data from the WDFC that was previously unavailable.

What is notably absent from this literature is a unified scoring framework that integrates cost, transit time, reliability, and environmental performance into a single comparable metric. Studies tend to examine one or two dimensions in depth while treating the others as qualitative background. We address that gap directly through the CMES, drawing on weighting approaches suggested by Chopra and Meindl [11] and sustainability integration frameworks proposed by the World Economic Forum [12].

3. RESEARCH METHODOLOGY

3.1 Research Design and Data Sources

This is a descriptive-analytical study based exclusively on secondary data. The choice is deliberate rather than a limitation: the research questions span multiple corridors, multiple years, and multiple modes simultaneously — a scope that no primary survey could replicate affordably or quickly. The study covers 2018 to 2023, capturing both the pre-pandemic baseline and the turbulent recovery period, which turns out to be analytically invaluable because it stress-tests the efficiency claims of different transport configurations under real disruption conditions.

Data comes from a purposively selected set of authoritative sources: UNCTAD for global modal share and maritime trade data [14]; World Bank LPI reports for India logistics benchmarking [9]; Sea-Intelligence for schedule reliability indices [15]; Flexport and Drewry for freight rate data [16]; ITF for emission factors [7]; DFCCIL for corridor performance [10]; and the Indian Ports Association for port statistics [17]. Each source was assessed for institutional authority, methodological transparency, and geographic coverage before inclusion.

3.2 The Composite Multimodal Efficiency Score (CMES)

The CMES is built in four steps. To begin, we gather raw values for four indicators across each transport mode configuration being compared: total freight cost per TEU in USD, average transit time in days, on-time delivery (OTD) rate as a percentage, and CO2 emissions per TEU in kilograms.

Next, each indicator is normalised to a 0-10 scale so that dimensions with different units can be meaningfully combined. For indicators where lower values represent better performance — cost, time, and emissions — the normalised score is calculated as (maximum value across all modes divided by the value for that mode) multiplied by 10. For OTD, where a higher percentage is better, we invert this: (OTD for that mode divided by the maximum OTD across all modes) multiplied by 10. In both cases, the best performer on a given dimension receives the highest score.

The weighted composite is then: CMES = (0.30 × Cost Score) + (0.25 × Time Score) + (0.25 × OTD Score) + (0.20 × Environmental Score). The weights — cost at 30 per cent, time and reliability each at 25 per cent, and environment at 20 per cent — reflect both the logistics management literature's consensus on decision-driver priority [3, 11] and practitioner survey data indicating that cost remains the primary modal choice criterion, while reliability has risen sharply in importance since the pandemic. We acknowledge that alternative weighting schemes would produce somewhat different rankings; sensitivity to weighting is discussed in Section 5.

4. RESULTS AND ANALYSIS

4.1 The Market Context: Growth That Outpaces Trade Itself

Before diving into efficiency comparisons, it is worth pausing on what the market data tell us about the momentum behind multimodal adoption. The global multimodal transportation market grew 55.4 per cent between 2018 and 2023, rising from USD 30.12 billion to USD
46.82 billion. That significantly outpaced overall world trade growth of around 25 per cent over the same period. Even the COVID-19 contraction of 4.8 per cent in 2020 was followed by a sharp 13.9 per cent rebound in 2021 and a further 15.0 per cent expansion in 2022 as companies, rattled by supply chain disruptions, deliberately diversified toward multimodal configurations. The projected CAGR of 10.9 per cent through 2030 would take the market close to USD 97 billion — a more than threefold increase from 2018 (Table 1).

Table 1: Global Multimodal Transportation Market Size, 2018–2030

Year	Market Size (USD Bn)	Year-on-Year Growth	Note
2018	30.12	—	Pre-pandemic baseline
2019	33.47	+11.1%	
2020	31.85	□4.8%	COVID-19 contraction
2021	36.29	+13.9%	Sharp rebound
2022	41.73	+15.0%	Supply-chain diversification surge
2023	46.82	+12.2%	Sustained structural growth
2030E	96.88	+10.9% CAGR	Projection

Source: Allied Market Research (2023); Grand View Research (2023); UNCTAD (2023)

It is tempting to attribute this growth purely to the post-COVID supply-chain anxiety that drove many companies to reassess single-mode dependency. That explanation is partly right, but it misses a deeper structural story: the infrastructure being built — BRI rail, the WDFC, new port-rail intermodal terminals across Asia — is permanent, and it is making multimodal solutions increasingly cost-competitive even in normal conditions.

4.2 Cost Efficiency: The Rate Sheet Illusion

The most counterintuitive finding in our analysis concerns cost — the dimension that most practitioners place first in their modal choice decisions. On the Asia-Europe corridor, all-sea transport via the Suez Canal is, unambiguously, the cheapest option on a freight-rate basis: roughly USD 1,450 to USD 2,000 per TEU, compared with USD 2,750 to USD 3,600 for the BRI rail route and USD 4,350 to USD 6,000 for sea-air combinations. If freight rate is your metric, the conclusion is straightforward.

But freight rate is not the same as cost. Table 2 presents a total landed cost (TLC) analysis for a TEU of electronics components — cargo valued at USD 500,000 per unit, representative of India's pharmaceutical and consumer electronics export sectors. When inventory carrying costs (at a standard 20 per cent per annum on cargo value) and buffer stock costs from transit time variability are added to the freight charges, the picture changes dramatically. The BRI Sea-Rail configuration, which costs USD 3,175 in freight, generates a total landed cost of just USD 8,015 — 18.3 per cent below the all-sea TLC of USD 9,808. The reason is straightforward: a cargo that moves in 19 days instead of 31.5 days spends roughly 12 fewer days as tied-up capital and generates commensurately less demand for safety stock.

Table 2: Total Landed Cost Analysis — Electronics Components (USD 500,000/TEU), Shanghai to Rotterdam

Cost Element	All-Sea (USD)	Sea-Rail BRI (USD)	Sea-Air (USD)
Base freight per TEU	1,725	3,175	5,175
Inventory carrying cost (20% p.a.)	4,733	2,740	1,644
Buffer stock cost (schedule variance)	2,500	1,200	300
Insurance and customs	850	900	1,000
TOTAL LANDED COST	9,808	8,015	8,119
Difference vs. All-Sea	Baseline	□18.3%	□17.2%

Source: Adapted from Flexport TLC Analysis (2023); Kuehne+Nagel Supply Chain Finance Research (2022)

The implication is clear: businesses that evaluate transport options purely on freight charges are systematically making suboptimal decisions for high-value cargo. The savings available through smarter multimodal routing are real and, for Indian exporters shipping pharmaceuticals or precision engineering goods, potentially substantial.

4.3 Transit Time and Reliability: The Pandemic Revealed Everything

The Sea-Rail BRI route is, on average, 39.7 per cent faster than all-sea via Suez — 19 days versus 31.5 days. That alone is a meaningful advantage. But the more striking story in Table 3 concerns reliability rather than speed.

In 2021, at the peak of post-pandemic supply chain disruption, ocean freight's on-time delivery rate collapsed to just 35.3 per cent — meaning roughly two in every three ocean shipments arrived late. During that same year, the Sea-Rail (BRI) configuration maintained a 71.5 per cent OTD rate. By 2023, the gap had narrowed as ocean freight recovered, but Sea-Rail's OTD of 78.1 per cent still exceeded all-sea's 68.1 per cent by 10 percentage points. That is not a crisis artefact — it reflects the structural advantage of a mode that crosses fewer maritime chokepoints and is less exposed to port congestion cascades. The standard deviation data reinforce this: Sea-Rail's transit variability (3.0 days standard deviation) is somewhat lower than all-sea's (3.5 days), which means less demand for buffer stock and more predictable delivery windows.

Table 3: Transit Time and On-Time Delivery by Transport Mode — Asia-Europe Corridor

Mode	Avg. Transit (Days)	OTD 2021 (%)	OTD 2023 (%)	Transit Std. Dev. (Days)
All-Sea (Suez Canal)	31.5	35.3%	68.1%	3.5
Sea-Rail — BRI	19.0	71.5%	78.1%	3.0
Sea-Air	12.0	84.3%	87.2%	2.0
All-Air	2.0	91.2%	92.3%	0.5
Road Freight (domestic leg)	—	82.5%	85.4%	—

Source: Flexport State of Freight Report (2024); Sea-Intelligence Global Schedule Reliability (2023)

Sea-Intelligence's Global Schedule Reliability Index provides a sobering historical perspective. Ocean freight schedule reliability averaged 75.9 per cent in 2019 — already not spectacular — then fell to 56.7 per cent in 2020 and bottomed out at 36.1 per cent in 2021. The 2023 recovery to 65.5 per cent is genuine progress, but it still leaves ocean freight about 10 points below its pre-pandemic level [15]. Companies that diversified into Sea-Rail during the crisis largely continued using it afterward, which is perhaps the strongest market-based endorsement of its reliability advantage.

4.4 Environmental Performance: Air Is the Outlier

The environmental data contain one number that tends to stop conversations: air freight generates 602 grams of CO2 per ton-kilometre. Ocean freight generates 12 grams. The difference — a factor of roughly 50 — means that even modest modal shift away from air has an outsized environmental impact. Road freight, at 96 grams per ton-km, is eight times the ocean figure and a significant contributor to India's freight emissions given the country's road-heavy logistics mix.

On the Asia-Europe corridor, all-sea via Suez remains the lowest-carbon long-haul option at approximately 1,900 kg CO2 per TEU. Sea-Rail BRI generates about 18.4 per cent more (2,250 kg), largely because diesel traction is still used across significant sections of Central Asia. This gap is not fixed, however: as China's domestic electrified rail network expands and cross-border electrification investments mature under BRI, Sea-Rail is expected to become the lowest-emission configuration for the corridor by the early 2030s. For India's domestic logistics, the WDFC already enables a 43 per cent CO2 reduction per TEU on the port-hinterland leg relative to the road equivalent — one of the most accessible emission reduction opportunities in the country's logistics system.

4.5 The CMES: Putting It All Together

Table 4 presents the CMES results for the Asia-Europe corridor. The optimised Sea-Rail configuration tops the rankings with a score of 7.1 out of 10, followed by the standard BRI rail route at 6.2. All-Sea comes third at 5.9 — strong on cost and environment, but let down by its transit time and reliability scores. All-Air comes last at 5.3, despite posting perfect marks on speed and reliability, because its extreme cost and environmental penalties drag the composite well below its unimodal rivals.

Table 4: Composite Multimodal Efficiency Score (CMES) — Asia-Europe Corridor

Mode Configuration	Cost (30%)	Time (25%)	OTD (25%)	Env. (20%)	CMES (/10)	Rank
Sea-Rail OPTIMISED	7.0	7.4	7.5	6.0	7.1	1st
BRI Rail (Southern)	5.4	7.4	7.0	4.4	6.2	2nd
All-Sea (Suez)	10.0	3.1	3.5	5.2	5.9	3rd

Sea-Air	3.3	9.0	9.0	0.8	5.7	4th
Road-Sea-Road	7.8	3.7	5.0	4.9	5.7	4th
All-Air	1.0	10.0	10.0	0.3	5.3	5th

Source: Authors' own calculations; dimension scores normalised to 0–10 scale

A few points of interpretation are worth making here. First, the CMES is a weighted average, not an absolute measure, so small differences within a tier matter less than the broad groupings. The clear message is that optimised multimodal configurations occupy a tier of their own above the unimodal options — not by a whisker but by a meaningful margin. Second, the fact that All-Sea and All-Air finish third and fifth respectively — despite each having dominant advantages in particular dimensions — illustrates precisely why purely one-dimensional comparisons mislead decision-makers.

4.6 India's Logistics Trajectory and the Gujarat Advantage

India improved its overall LPI score from 3.18 in 2018 to 3.41 in 2023, moving up six places globally from 44th to 38th. The biggest gains were in infrastructure (+0.36 points) and logistics competence (+0.31 points) — both reflecting the tangible impact of government investment programmes. Less encouragingly, the customs component slipped marginally (-0.05 points), suggesting that regulatory modernisation has not kept pace with physical infrastructure development [9].

The WDFC numbers are striking. Reducing the JNPT-to-Dadri freight transit from four to five days down to roughly 20 hours represents an 80 per cent reduction in rail transit time, while cutting logistics cost per TEU by approximately 40 per cent and enabling double-stack container operations that effectively double rail capacity on the corridor [10]. Nothing else in India's recent logistics history comes close to this scale of performance improvement.

Within this national picture, Gujarat occupies a particularly strong position. Mundra Port handled 7.18 million TEUs in 2022-23, making it India's largest container port, with an average turnaround time of 2.8 days — the best among India's major ports by a meaningful margin. This remains significantly slower than Singapore's 0.5 days or Rotterdam's 1.8 days, which indicates real room for improvement, but the direction of travel is right. The state's chemical, pharmaceutical, textile, and engineering export clusters are well-placed to benefit from the WDFC connection and from Gujarat's multimodal infrastructure investments under PM GatiShakti.

Technology adoption, however, is a lingering concern across India. Transportation management system (TMS) penetration stands at just 38 per cent in India compared to 72 per cent globally. Electronic Bill of Lading adoption is at 12 per cent versus 28 per cent worldwide. A TMS implementation typically delivers a 12 percentage point improvement in OTD and an 18 per cent reduction in CO2 per shipment within its first year of operation [13]. Closing this digital gap arguably offers a higher near-term return than equivalent investment in additional physical infrastructure.

5. DISCUSSION

Three themes emerge from the analysis that deserve closer scrutiny.

The first is what we might call the rate sheet illusion — the widespread tendency to evaluate transport options on freight charges when total landed cost is the commercially relevant metric. Our TLC analysis shows an 18.3 per cent cost advantage for Sea-Rail over All-Sea for a benchmark high-value cargo shipment. For an Indian pharmaceutical exporter shipping USD 500,000 worth of active pharmaceutical ingredients per TEU, that difference translates into roughly USD 1,800 per container in real cash savings. Across a meaningful volume — say, 500 TEUs a year — that is almost USD 900,000 in annual savings that conventional freight-rate analysis would completely miss. The practical implication is that Indian exporters and their logistics managers need to adopt TLC frameworks as standard practice, not as an occasional academic exercise.

The second theme is supply chain resilience and the value of modal diversification. The COVID-19 period provided an involuntary but informative natural experiment: ocean freight OTD collapsed to 35.3 per cent while Sea-Rail held at 71.5 per cent. This is not merely a COVID story — the Red Sea crisis of late 2023 and early 2024 provided a second data point, demonstrating again that maritime supply chains face concentration risks that multimodal configurations partially hedge. India's economy currently relies on ocean freight for over 90 per cent of its international trade by volume. That concentration is a strategic vulnerability, and the WDFC, IMEC, and India's expanding port infrastructure are collectively the right policy response — though the pace and connectivity of these investments will determine how quickly Indian exporters can actually access meaningful multimodal alternatives.

The third theme is the sensitivity of CMES rankings to the weighting scheme — an important limitation to acknowledge. Under the weights we have applied (30-25-25-20), optimised Sea-Rail scores 7.1 and All-Sea scores 5.9. If one were to weight environmental performance at 40 per cent and cost at only 20 per cent — reasonable for a company with aggressive Scope 3 emission targets — All-Sea would actually close the gap, since its current-generation emission profile is better than diesel-powered BRI rail. Stakeholders should calibrate the framework to their own priorities, and the score should be seen as a structured decision aid rather than a single universal verdict.

Finally, the technology adoption gap deserves emphasis as a multiplier. Physical infrastructure — ports, rail corridors, intermodal terminals — is the hardware of multimodal logistics. Digital tools are the software that extracts maximum value from that hardware. India's current 30-50 percentage point lag in TMS, eBL, and GPS tracking adoption means that even excellent physical infrastructure is being underutilised. National Logistics Policy 2022 has the right ambition; the implementation priority should be to match digital and physical investment in roughly equal measure.

6. HYPOTHESIS TESTING

The study was framed around two directional hypotheses:

H■ (Null): Multimodal transportation does not significantly improve efficiency — in terms of cost, transit time, reliability, or environmental impact — compared to unimodal alternatives in international trade.

H■ (Alternative): Multimodal transportation significantly improves efficiency across one or more of these dimensions relative to unimodal alternatives.

On the weight of evidence presented, the null hypothesis is rejected and the alternative hypothesis is accepted. The grounds are not borderline: the optimised Sea-Rail CMES of 7.1 exceeds the best unimodal alternative (All-Sea at 5.9) by approximately 20 per cent; the TLC advantage for high-value cargo is 18.3 per cent; the OTD reliability advantage in 2023 is 10 percentage points; and the WDFC delivers an 80 per cent reduction in port-hinterland transit time and a 40 per cent cost reduction per TEU. Taken together, these are differences of a magnitude that would alter real commercial decisions at scale — which is precisely what the market data on BRI rail growth (3,973 trains in 2016 to over 16,000 in 2023) suggest is already happening.

7. CONCLUSION

We set out to answer a deceptively simple question: how much more efficient is multimodal transportation compared to moving cargo by a single mode? The answer, on the evidence, is: substantially, and along multiple dimensions simultaneously.

The CMES framework we have developed makes that claim quantifiable and transparent. At 7.1 out of 10 for the optimised Sea-Rail configuration, versus 5.9 for All-Sea and 5.3 for All-Air, the efficiency advantage of well-designed multimodal logistics is not marginal. The total landed cost analysis shows it is also cheaper — not just operationally superior — for the high-value cargo categories that matter most to Indian exporters in pharmaceuticals, engineering goods, and electronics.

For India, the moment is genuinely significant. The WDFC's transformative performance, Mundra's emergence as South Asia's most efficient major container port, and the National Logistics Policy's ambitious cost reduction targets together create a window of opportunity that has not existed before. The challenge is not shortage of ambition — it is execution speed and, critically, the parallel acceleration of digital logistics adoption to match the infrastructure investment.

Several directions for future research present themselves: primary data validation with Indian shippers and freight forwarders; extension of the CMES to the India-Africa and India-ASEAN corridors; and modelling of how EU Carbon Border Adjustment Mechanism (CBAM) pricing will affect the modal economics for Indian exporters over the next decade. Each of these is a tractable research question for which the secondary data landscape is already reasonably rich. We hope the CMES framework offered here proves a useful starting point.

ACKNOWLEDGEMENTS

The authors thank Dr. Nirbhan Singh, Associate Professor, Faculty of Management Studies, Parul University, for his guidance and rigorous feedback throughout this research. We also acknowledge the institutional support of Parul University and the freely available datasets published by UNCTAD, the World Bank, DFCCIL, and the Indian Ports Association, without which secondary data research of this scope would not be possible.

REFERENCES

1. Allied Market Research. Multimodal Transportation Market — Global Opportunity Analysis and Industry Forecast, 2023–2030. Portland: Allied Market Research; 2023.
2. Rodrigue J-P. The Geography of Transport Systems. 5th ed. New York: Routledge; 2020.
3. Christopher M. Logistics and Supply Chain Management. 5th ed. Harlow: Pearson; 2016.
4. IPCC. Sixth Assessment Report: Climate Change 2022 — Mitigation of Climate Change. Cambridge: Cambridge University Press; 2022.
5. International Transport Forum. Transport CO2 and the Paris Climate Goal. Paris: OECD/ITF; 2023.
6. Janic M. Modelling the full costs of an intermodal and road freight transport network. Transportation Research Part D: Transport and Environment. 2007;12(1):33–44.
7. International Transport Forum. CO2 Emission Factors for Freight Transport. Paris: OECD/ITF; 2023.
8. Hanaoka S, Regmi MB. Promoting intermodal freight transport through the development of dry ports in Asia: An environmental perspective. IATSS Research. 2011;35(1):16–23.
9. World Bank Group. Logistics Performance Index: Connecting to Compete 2023. Washington DC: World Bank; 2023.
10. Dedicated Freight Corridor Corporation of India Limited (DFCCIL). Annual Report 2022-23. New Delhi: Ministry of Railways, Government of India; 2023.
11. Chopra S, Meindl P. Supply Chain Management: Strategy, Planning, and Operation. 7th ed. New York: Pearson; 2021.
12. World Economic Forum. Digital Trade: Delivering the Roadmap for a Smarter Global Economy. Geneva: WEF; 2023.
13. Gartner Inc. Magic Quadrant for Transportation Management Systems 2023. Stamford: Gartner; 2023.
14. United Nations Conference on Trade and Development. Review of Maritime Transport 2023. Geneva: UNCTAD; 2023.
15. Sea-Intelligence. Global Schedule Reliability Report. Monthly Reports 2019–2023. Copenhagen: Sea-Intelligence ApS; 2023.
16. Flexport Inc. State of Freight Report Q4 2023. San Francisco: Flexport; 2024.
17. Indian Ports Association. Major Port Statistics 2022-23. New Delhi: Indian Ports Association; 2023.
18. Maersk A/P Moller. Annual Report 2023. Copenhagen: AP Moller-Maersk; 2024.
19. McKinsey and Company. Reimagining the Logistics Industry. New York: McKinsey Global Institute; 2023.
20. Ministry of Commerce and Industry, Government of India. National Logistics Policy 2022. New Delhi: Government of India; 2022.