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International Journal on Research and Development- A Management Review

ISSN: 2319–5479
Volume 14 Issue 01, 2025

Capacity, Velocity, Duration and Transfer Points on Strategic Drivers of Multi-Modal Transportation Efficiency

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Peer Review Information

Submission: 21 May 2025
Revision: 20 July 2025
Acceptance: 15 August 2025

Keywords

Multimodal Transportation, PM Gati Shakti, Capacity, Velocity, Transfer Points, Logistics Efficiency

Abstract

This study investigates the strategic drivers of multimodal transportation efficiency- Capacity, Velocity, Duration, and Transfer Points (CVDT) within the framework of India's PM Gati Shakti National Master Plan for Multimodal Connectivity. Multimodal transportation has emerged as a critical enabler of economic growth, sustainable mobility, and global trade competitiveness. However, efficiency within these systems is not merely an infrastructural challenge but a complex interplay of operational, digital, and policy-driven factors. Drawing from an extensive review of literature and empirical evidence from government reports, this paper examines how each driver shapes logistics outcomes, identifies their interdependencies, and highlights complementarities and trade-offs. The study finds that capacity expansion in isolation yields limited results unless matched with improved transfer points, while gains in velocity and duration are contingent upon synchronized infrastructure and digital integration. PM Gati Shakti addresses these challenges through coordinated investments in dedicated freight corridors, multimodal logistics parks, port modernization, and digital platforms like the Unified Logistics Interface Platform (ULIP). The findings underscore that the CVDT framework provides a holistic lens for understanding multimodal performance and clarifies where efficiency gains can be maximized through integrated strategies. Policy implications include the need for balanced capacity planning, smart transfer point development, and institutional coordination to align efficiency with sustainability and economic objectives. The paper contributes by offering a CVDT-centric analytical framework that situates multimodal efficiency within India's developmental trajectory toward reducing logistics costs, enhancing resilience, and achieving the vision of a globally competitive logistics ecosystem.

INTRODUCTION

The globalization of trade, the rising demand for sustainable logistics, and the continuous urbanization of societies have amplified the need for efficient multimodal transportationsystems. Unlike-unimodal approaches, multimodal transportation integrates multiple modes road,rail,air, and sea within a single coordinated network to enhance connectivity, minimize costs, and optimize environmental outcomes. This integration has been considered a critical solution to congestion, rising carbon emissions, and inefficiencies that plague traditional transport systems (Zhou, Du, & Chen, 2022). Yet, efficiency in multimodal systems is not determined by infrastructure alone; it depends on a strategic interplay between capacity, velocity, duration, and transfer points each acting as a driver that shapes system performance.

Capacity in multimodal transportation extends beyond physical infrastructure to encompass operational throughput, resource allocation, and adaptability under varying demand conditions. Scholars emphasize that capacity is not a static measure but a dynamic characteristic that must account for bottlenecks, transfer delays, and demand uncertainty (Bevrani, 2018; Park & Kim, 2006). Expanding system capacity without strategic alignment often fails to achieve meaningful efficiency gains, particularly when intermodal bottlenecks remain unresolved (Prentice, 2003). For instance, research shows that distributed transfer infrastructures may outperform large centralized hubs by better balancing capacity with demand fluctuations (Jiang, Ye, & Chen, 2020). Thus, efficiency is not only about building more capacity but also about configuring it to align with network-wide flows and multimodal integration strategies.

Velocity, defined as the speed of cargo or passenger movement across modes, has emerged as another key determinant of efficiency. Higher velocity does not necessarily imply efficiency if achieved at the expense of cost, energy, or sustainability. Instead, the goal is to balance velocity with reliability and service quality. Studies on urban mobility indicate that multimodal transportation solutions can enhance velocity by reducing congestion and integrating intelligent technologies such as IoT and AI into logistics operations (Owoade, Uzoka, & Akerele, 2024). Moreover, optimization models demonstrate that shifting cargo from road to rail or sea can accelerate network-wide flows while simultaneously reducing environmental impacts (Dérpich, Durán, & Carrasco, 2024). Consequently, velocity interacts with sustainability and cost-effectiveness, making it a multidimensional driver of efficiency rather than a singular performance metric.

The duration of multimodal operations encompasses not just transit times but also waiting times at transfer points, scheduling coordination, and regulatory delays. Duration is therefore influenced by both infrastructural design and institutional frameworks. Evidence suggests that poorly coordinated transfer points significantly increase journey duration, reducing network throughput and discouraging shippers from adopting multimodal solutions (Zhang, Xia, & Liang, 2023). Conversely, when transfer duration is minimized through advanced planning, optimized routing, and real-time monitoring, the system achieves superior performance. Duration further impacts supply chain resilience, as longer transit and waiting times amplify the risks of disruptions and reduce competitiveness in time-sensitive markets (Sun, Turnquist, & Nozick, 2006). Consequently, duration functions as a critical driver that reflects not only technical efficiency but also service dependability.

Among these drivers, transfer points emerge as a central node where efficiency can be either enhanced or compromised. Transfers involve modal shifts, consolidation, and reallocation of cargo or passengers, making them the most vulnerable elements in multimodal systems. Research indicates that transfer costs and delays are among the largest contributors to inefficiencies in multimodal logistics (Wang & Bilegan, 2014; Zhang et al., 2023). Distributed and strategically located transfer infrastructures, however, can mitigate these inefficiencies by facilitating smoother modal integration and improving accessibility to sustainable transit modes (Ye, Jiang, & Chen, 2021). Transfer points thus act as both constraints and opportunities- when poorly designed, they become bottlenecks, but when strategically optimized, they can unlock significant gains in capacity utilization, velocity, and service quality.

The interrelationship among capacity, velocity, duration, and transfer points underscores their collective role as strategic drivers of multimodal efficiency. For instance, expanding network capacity without addressing transfer delays may reduce velocity and extend duration, negating efficiency gains (Kasikitwiwat & Chen, 2005). Similarly, enhancing velocity by prioritizing high-speed corridors may compromise capacity distribution and increase congestion at transfer nodes (Wang et al., 2022). The interplay of these drivers suggests that efficiency is not achieved by optimizing one factor in isolation but rather through integrated strategies that balance trade-offs across the multimodal system. This perspective aligns with contemporary research emphasizing multi-objective optimization, where capacity, cost, time, and sustainability are jointly considered (Wu, Wang, & Li, 2009; Kumar & Anbanandam, 2019). Furthermore, the growing emphasis on sustainability in multimodal transportation situates these drivers within broader global objectives of reducing carbon emissions and promoting energy efficiency. For example, optimizing capacity utilization can reduce energy waste, while minimizing duration reduces idle times that contribute to unnecessary emissions (Wehner, Halldorsson, & Lumsden, 2015). Similarly, improved transfer point design not only enhances velocity but also reduces reliance on fossil fuel-intensive modes by facilitating smoother modal transitions (Han, Chi, & Xu, 2025). Hence, efficiency in multimodal transportation is not merely an operational concern but also a sustainability imperative.

Technological advancements also reshape how these drivers influence efficiency. The integration of digital platforms, real-time monitoring, and decision-support algorithms enables precise capacity planning, velocity optimization, and duration management (Udomwannakhet, Vajarodaya, & Manicho, 2018). For instance, artificial intelligence and data-driven predictive models can anticipate bottlenecks at transfer points and reconfigure logistics flows dynamically (Jesupelumi Owoade et al., 2024). These advancements highlight a paradigm shift from reactive to proactive management of multimodal networks, where strategic drivers are optimized through continuous monitoring and adaptive decision-making. Moreover, policy frameworks and institutional arrangements significantly mediate the impact of these drivers. Governments play a pivotal role in funding infrastructure capacity, regulating transfer point operations, and setting environmental standards that influence velocity and duration (Regan & Apivatanagul, 2008). Strategic planning efforts, such as the integration of logistics centers in urban freight transport, demonstrate that policy-driven capacity allocation can reduce congestion and emissions while improving service levels (Guimarães, Skroder, & Ribeiro, 2020). Similarly, performance measurement frameworks provide indicators for assessing efficiency across capacity, velocity, and duration dimensions, offering policymakers and planners concrete tools for decision-making (Pratt & Lomax, 1996; Qin, He, & Ni, 2014). The introduction of capacity, velocity, duration, and transfer points as strategic drivers of multimodal transportation efficiency reflects a holistic understanding of transportation networks. These elements are interdependent and collectively shape the ability of multimodal systems to deliver reliable, cost-effective, and sustainable mobility solutions. Capacity determines the system's potential, velocity governs its dynamic flow, duration reflects its temporal reliability, and transfer points act as the nexus where all other drivers converge. Together, they form the foundation of a strategic framework for analyzing and optimizing multimodal efficiency in both freight and passenger transportation .

LITERATURE REVIEW:

Multimodal transportation efficiency has become a critical field of inquiry, particularly in light of growing demands for sustainable and cost-effective mobility solutions. Efficiency in these systems is shaped by strategic drivers such as capacity, velocity, duration, and transfer points, each of which interacts with infrastructure, technology, and policy frameworks. The following section examines existing literature organized around these four dimensions, emphasizing their individual and collective contributions to multimodal performance. Capacity is one of the most fundamental elements in determining the efficiency of multimodal systems. It refers not only to the physical infrastructure such as roadways, rail lines, and ports but also to the system's ability to handle varying demand patterns across modes. Scholars widely agree that multimodal capacity is dynamic, requiring continuous adaptation to congestion, demand fluctuations, and transfer bottlenecks. Zhou, Du, and Chen (2022) introduced an improved multimodal network capacity model that incorporates intermodal transfers within a bi-level programming framework. Their study highlights the importance of modeling capacity as an integrated characteristic of urban multimodal networks rather than as isolated modal capacities. This approach allows planners to identify inefficiencies and redistribute flows to optimize throughput. Similarly, Bevrani (2018) emphasized the role of multicriteria capacity assessment, developing mathematical models that balance trade-offs among cost, time, and functionality. This research illustrates that capacity cannot be maximized in isolation but must be optimized across several competing objectives. Large-scale optimization frameworks also provide valuable insights. Wang, Liu, and Fan (2022) formulated the Multimodal Network Capacity Problem (MNCP), which explicitly considers congestion, transfer overlap, and common line problems. Their model provides a realistic assessment of capacity in dense networks, addressing operational constraints often overlooked in earlier studies. In parallel, Park and Kim (2006) developed a nonlinear bi-level model that evaluates multimodal freight transportation capacity, demonstrating how individual facility constraints such as terminal handling capacity affect overall system performance. The concept of practical versus ultimate capacity further deepens understanding. Kasikitwiwat and Chen (2005) distinguished between these capacity measures, arguing that ultimate capacity reflects theoretical limits while practical capacity considers real-world disruptions and demand distribution. This conceptual distinction is essential for policy and investment decisions, as infrastructure expansion must be evaluated against realistic utilization patterns. Similarly, Sun, Turnquist, and Nozick (2006) extended capacity modeling by incorporating uncertainty and degraded conditions, showing how system flexibility deteriorates as networks approach saturation. In addition to technical modeling, historical reviews of capacity frameworks have shaped the field. Park and Regan (2005) provided a comprehensive overview of the evolution of multimodal capacity models, advocating for bilevel programming methods as a logical approach for strategic assessment. Their work underscores the trajectory of research from static capacity definitions toward dynamic, integrated modeling that accounts for intermodal complexities. Together, these studies demonstrate that capacity remains a cornerstone of multimodal efficiency, requiring both rigorous quantitative models and conceptual refinements to capture its true dynamics. Velocity, or the speed at which goods and passengers move across the multimodal system, is another essential determinant of efficiency.

While often associated with travel speed, velocity in multimodal contexts is multi-dimensional, encompassing not only physical movement but also operational flow, reliability, and responsiveness. Dérpich, Durán, and Carrasco (2024) explored velocity from an environmental and economic perspective. Their optimization model revealed that shifting cargo from road to rail and sea modes accelerates flows while lowering costs and CO_2 emissions. These finding highlights velocity as a strategic driver aligned not only with time efficiency but also with sustainability objectives. Complementing this, Owoade, Uzoka, and Akerele (2024) analyzed urban mobility solutions using digital technologies. They found that integrating artificial intelligence, Internet of Things (IoT), and blockchain enhances real-time monitoring, reduces congestion, and improves flow velocity in urban multimodal settings. These contributions show that velocity is increasingly managed through both modal reallocation and technological innovation. On the methodological front, Zheng and Geroliminis (2013) developed a multimodal macroscopic fundamental diagram to describe traffic dynamics in congested networks.

Their model captures how optimal road space distribution across modes can increase velocity and reduce overall travel time. This research demonstrates that velocity improvements often require structural adjustments, such as prioritizing sustainable modes within limited urban space. Similarly, Agarwal, Tanwar, and Jain (2023) examined strategies for improving travel time performance in multimodal systems, particularly in Indian cities. Their study identified operational interventions such as reducing walking distances, minimizing stops per kilometer, and increasing feeder service frequency- all of which directly enhance velocity. Velocity, however, is not an isolated measure of efficiency. It interacts with capacity and duration, meaning that efforts to increase velocity must be carefully balanced against congestion risks and service reliability. The literature consistently points to the need for multi-objective optimization, where velocity gains are weighed alongside sustainability, cost, and user satisfaction. Duration refers to the total time associated with multimodal journeys, encompassing both transit times and delays at transfer points. This measure is particularly important in evaluating the attractiveness of multimodal systems to shippers and passengers. Extended duration often undermines efficiency and competitiveness, especially in time-sensitive logistics sectors. A significant body of research focuses on transfer-related duration. Jiang, Ye, and Chen (2020) proposed a bilevel model that jointly optimizes transfer location and capacity. They found that distributed transfer infrastructures shorten travel times and increase the adoption of sustainable modes compared to centralized hubs. Expanding on this work, Ye, Jiang, and Chen (2021) examined paradoxes in transfer infrastructure planning, revealing that increased parking and transfer capacities can, under certain conditions, worsen travel time performance.

These findings illustrate the complex relationship between infrastructure investment and duration. Duration is also influenced by broader network efficiency. Qin, He, and Ni (2014) developed a quantitative evaluation method that accounts for network structure, traffic demands, and travel costs.

Their framework highlights how duration is shaped not only by individual transfer points but also by systemic factors such as route connectivity and demand distribution. Similarly, Han, Chi, and Xu (2025) optimized multimodal transport schemes by considering customer classification, reducing waiting times and aligning service duration with demand variability. Urban logistics research adds another perspective. Guimarães, Skroder, and Ribeiro (2020) modeled the strategic location of logistics integration centers in Brazil's soybean transport system. Their results demonstrate that properly placed centers reduce journey duration and congestion, especially in port-influenced urban areas. These studies collectively affirm that minimizing duration requires a combination of infrastructure design, demand management, and system-level coordination. Importantly, duration is closely tied to supply chain resilience. Long and uncertain durations increase vulnerability to disruptions, while predictable and reduced durations improve competitiveness. Therefore, research on duration contributes not only to efficiency optimization but also to building robust multimodal systems.

Transfer points are arguably the most critical and vulnerable elements of multimodal networks. They serve as nodes where goods or passengers shift between modes, making them both potential bottlenecks and opportunities for optimization. A large body of literature underscores their central role in determining overall efficiency. Prentice (2003) was among the earliest to highlight bottlenecks at transfer points as major constraints in intermodal logistics. His work emphasized the need for connectivity and bottleneck elimination to enhance competitiveness. Building on this, Wang and Bilegan (2014) reviewed performance indicators for intermodal barge transportation, stressing the tactical importance of transfer efficiency and the role of revenue management policies in mitigating delays. Their work illustrates that transfer points are not merely operational challenges but also strategic levers for financial sustainability. More recent studies have focused on transfer costs. Zhang, Xia, and Liang (2023) analyzed traffic dynamics in multimodal networks under varying transfer costs, finding that networks with lower transfer costs achieve significantly higher throughput. This suggests that transfer points directly influence network productivity, making cost reduction strategies vital for efficiency. Similarly, Ye, Jiang, and Chen (2021) demonstrated paradoxical outcomes in transfer planning, where additional infrastructure sometimes worsens system performance by inducing modal shifts that increase congestion. Taylor and Burns (2010) investigated synergies between truck and rail operations, revealing trade-offs at intermodal transfer interfaces. Their findings highlight the complexity of coordinating operations across modes, as performance gains for carriers may coincide with inefficiencies for drivers or customers. This reinforces the view that transfer points must be optimized not only technically but also institutionally, balancing the interests of multiple stakeholders. Collectively, these studies underscore the dual role of transfer points as both constraints and opportunities. Efficient transfer design reduces costs, enhances velocity, and shortens duration, while poorly managed transfers create systemic inefficiencies. As such, transfer points remain at the heart of multimodal efficiency debates. The literature demonstrates that capacity, velocity, duration, and transfer points are interdependent drivers of multimodal efficiency. Capacity provides the system's potential, velocity reflects its flow dynamics, duration measures temporal reliability, and transfer points serve as critical junctures where these elements converge. Research consistently shows that optimizing one driver in isolation often leads to trade-offs that reduce overall efficiency. For instance, expanding capacity without addressing transfer delays may extend duration, while increasing velocity without demand management may exacerbate congestion. Recent trends emphasize integrated optimization approaches, where mathematical models and digital technologies jointly consider capacity allocation, velocity enhancement, duration reduction, and transfer point management. Sustainability concerns further align these drivers with global environmental goals, as optimizing them simultaneously reduces costs, emissions, and resource consumption.

Table 1: Contribution by Authors

Driver	Author(s) & Year	Focus of Study	Key Contribution
Capacity	Zhou, Du, & Chen (2022)	Multimodal network capacity model with intermodal considerations.	Developed a bi-level model integrating capacity with modal split and traffic assignment, highlighting capacity planning for urban multimodal systems.
	Bevrani (2018)	Capacity assessment and planning in multimodal systems.	Proposed multi-objective models for capacity planning, addressing trade-offs among cost, time, and functionality.
	Wang, Liu, & Fan (2022)	Multimodal network capacity problem (MNCP).	Presented algorithms for large-scale capacity and design optimization, capturing congestion and transfer dynamics.
	Park & Kim (2006)	Freight transportation capacity model.	Developed a nonlinear bi-level model to measure multimodal freight network capacity, identifying gaps in individual facilities.
	Kasikitwiwat & Chen (2005)	Network capacity concepts.	Compared ultimate and practical capacity measures, addressing spatial demand distribution.
	Sun, Turnquist, & Nozick (2006)	Freight system capacity and flexibility.	Extended models to incorporate uncertainty, degraded conditions, and service quality constraints.
	Park & Regan (2005)	Capacity modeling in multimodal freight.	Reviewed evolution of capacity models, proposing bilevel frameworks for strategic capacity planning.
Velocity	Dérpich, Durán, & Carrasco (2024)	Multimodal optimization minimizing costs and CO_2.	Showed how shifting to rail/sea improves velocity while lowering emissions and costs.
	Owoade, Uzoka, & Akerele (2024)	Digital multimodal mobility.	Demonstrated velocity improvements through AI, IoT, and blockchain integration in urban multimodal systems.
	Zheng & Geroliminis (2013)	Urban multimodal macroscopic fundamental diagram.	Developed models to optimize space allocation, enhancing velocity and flow reliability.

	Agarwal, Tanwar, & Jain (2023)	Travel time performance strategies.	Identified methods like reducing stops/km and increasing feeder services to enhance velocity.
Duration	Jiang, Ye, & Chen (2020)	Joint optimization of transfer location and capacity.	Found that distributed infrastructure reduces travel duration and improves sustainable mode share.
	Ye, Jiang, & Chen (2021)	Transfer location and capacity paradoxes	Showed duration effects of parking/transfer capacities under elastic demand.
	Qin, He, & Ni (2014)	Network efficiency evaluation.	Introduced a method capturing impacts of travel time, costs, and network structure on efficiency duration.
	Han, Chi, & Xu (2025)	Multimodal scheme optimization.	Reduced customer waiting times by optimizing allocation and scheduling across modes.
	Guimarães, Skroder, & Ribeiro (2020)	Freight logistics centers in smart cities.	Reduced duration of journeys and congestion by strategically locating logistics centers.
Transfer Points	Prentice (2003)	Bottlenecks in intermodal transport.	Highlighted transfer points as major causes of inefficiency in multimodal logistics.
	Wang & Bilegan (2014)	Performance indicators for barge transport.	Provided measures to assess transfer efficiency and tactical planning.
	Zhang, Xia, & Liang (2023)	Transfer costs in multimodal networks.	Showed that high transfer costs reduce throughput, while low-cost transfer points enhance efficiency.
	Ye, Jiang, & Chen (2021)	Capacity and transfer point paradox.	Demonstrated trade-offs where added transfer infrastructure sometimes worsens performance.
	Taylor & Burns (2010)	Truck-rail intermodal synergies.	Found performance trade-offs at transfer interfaces between truck and rail operations.

Research Objectives:

RO1:To examine how the four strategic drivers- capacity, velocity, duration, and transfer points jointly shape multimodal transportation efficiency in the Indian context.

RO2:To assess the extent to which PM Gati Shakti interventions (e.g., DFCs, MMLPs, ULIP, last-mile connectivity) address the CVDT constraints and enable measurable improvements in logistics performance.

RO3:To propose a CVDT-centric analytical framework that clarifies where complementarities and trade-offs occur, and to derive policy and managerial implications for designing resilient, cost-efficient, and sustainable multimodal networks.

CVDT (Capacity-Velocity-Duration-Transfer Point) Model:

The CVDT model provides a structured framework to understand the strategic drivers of multimodal transportation efficiency. It emphasizes how Capacity, Velocity, Duration, and Transfer Points interact to determine the overall performance of logistics networks, while PM Gati Shakti acts as a moderating force that strengthens these relationships through integrated planning and policy interventions.

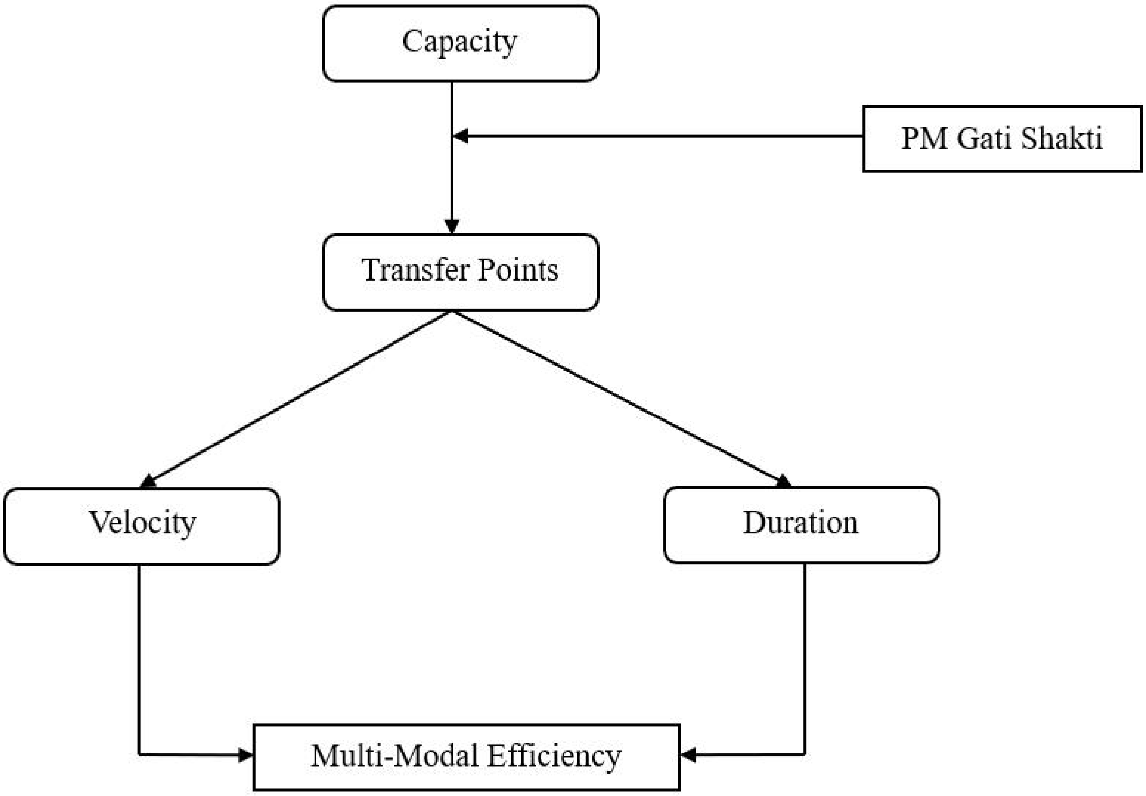

Figure 1: CVDT Model

At the top of the model, Capacity represents the fundamental ability of transport infrastructure to handle freight and passenger flows. This includes physical infrastructure such as highways, rail lines, and ports, as well as operational and digital capacities enabled by geospatial platforms and scheduling systems. However, capacity alone does not guarantee efficiency. Its benefits can only be realized when it is effectively mediated by Transfer Points- the nodes where goods or passengers move between modes. Transfer Points sit at the center of the model because they act as the hinge that connects capacity to real-world outcomes. If transfer points are poorly managed, capacity gains at one level of the system may remain underutilized due to bottlenecks at modal interfaces. Conversely, well-designed multimodal logistics parks (MMLPs), dry ports, and integrated hubs amplify capacity by ensuring smoother modal shifts, lower handling costs, and better synchronization. From transfer points, the model branches into two critical outcomes: Velocity and Duration. Velocity refers to the speed and smoothness with which goods flow across the network. It is not just about raw speed but about reducing congestion, avoiding unnecessary detours, and ensuring continuous flow. Duration, on the other hand, reflects the total time taken for a journey, including waiting times, delays, and regulatory clearances. Together, velocity and duration translate infrastructural and operational capacity into actual efficiency. At the base of the model, both velocity and duration converge into Multimodal Efficiency. This outcome is the cumulative expression of how well the system's drivers interact.

An efficient system delivers faster, more reliable, and cost-effective logistics services while also reducing emissions and resource wastage. The role of PM Gati Shakti is highlighted as a moderator that strengthens these relationships. Through coordinated investments, geospatial planning, and digital platforms like the Unified Logistics Interface Platform (ULIP), Gati Shakti ensures that capacity creation, node upgrades, and regulatory streamlining are aligned. By moderating the interactions among CVDT drivers, it transforms fragmented logistics infrastructure into a cohesive and competitive multimodal system.

Capacity, Velocity, Duration, and Transfer Points with PM Gati Shakti:

- **Capacity and PM Gati Shakti**

Capacity in multimodal transportation refers to the system's ability to accommodate and manage freight and passenger flows across different modes, including road, rail, air, waterways, and pipelines. PM Gati Shakti directly addresses this by creating an integrated infrastructure framework that enhances both physical and operational capacity across India. Traditionally, capacity expansion in India was fragmented, with different ministries and departments investing in isolated projects that often created underutilized or overlapping assets. The National Master Plan harmonizes this process by bringing together 16 ministries on a single digital platform, ensuring that capacity creation is demand-driven, complementary, and strategically aligned. For example, the Dedicated Freight Corridors (DFCs) under Gati Shakti enhance the rail network's capacity to move bulk commodities, thereby relieving congestion from highways. Similarly, the expansion of inland waterways complements road and rail networks by offering alternative freight channels with higher load capacity and lower environmental impact. Ports are being modernized under Sagarmala and integrated into the Gati Shakti framework to handle larger container volumes efficiently. This alignment prevents bottlenecks at individual nodes by synchronizing upstream and downstream infrastructure capacities. Moreover, digital capacity is enhanced through the Gati Shakti digital platform, which provides geospatial data for better planning and monitoring. By synchronizing investments and reducing redundancy, Gati Shakti ensures that multimodal capacity is optimized rather than maximized blindly, thereby supporting long-term resilience and efficiency.

- **Velocity and PM Gati Shakti**

  Velocity, understood as the speed and smoothness of freight and passenger movement across modes, is a critical determinant of logistics efficiency. PM Gati Shakti accelerates velocity by focusing on seamless multimodal integration and eliminating chokepoints that slow down flows. The initiative integrates road, rail, air, and waterways under a unified planning mechanism, ensuring that freight moves swiftly from origin to destination without unnecessary detours or delays. One of the flagship goals of PM Gati Shakti is to reduce logistics costs from 13–14% of GDP to about 8%, and velocity improvements are central to achieving this. For instance, economic corridors and multimodal logistics parks (MMLPs) being developed under Bharatmala and Gati Shakti ensure that goods can be shifted between modes with minimal handling and maximum speed. The focus on last-mile connectivity to ports, airports, and industrial hubs also directly improves velocity, as cargo no longer gets delayed due to poor feeder infrastructure. Additionally, the integration of digital tools like GIS-based monitoring and real-time dashboards enables dynamic re-routing and optimization of traffic flows, thereby increasing the operational velocity of the entire system. By reducing dwell times, streamlining clearances, and strengthening intermodal linkages, PM Gati Shakti transforms velocity into a multidimensional outcome that balances speed, cost, and sustainability.

- **Duration and PM Gati Shakti**

  Duration in multimodal transportation captures total transit time, including movement, waiting, and transfer delays. Extended durations not only reduce competitiveness but also increase logistics costs and vulnerability to disruptions. PM Gati Shakti addresses this challenge by reducing both physical and procedural delays across the transport chain. Physically, the plan emphasizes eliminating first- and last-mile gaps that historically extended transit times. For example, connecting coal mines directly to railheads, or linking agricultural mandis to highways and cold storage facilities, reduces unnecessary detours that prolong journey durations. Similarly, the establishment of logistics integration centers under the Gati Shakti framework provides shippers with centralized hubs where multimodal transfers are pre-coordinated, thereby cutting waiting times. Procedurally, the plan leverages digital single-window systems for regulatory approvals and cargo clearances, minimizing bureaucratic duration. A concrete case is the reduction of turnaround times at ports. By aligning road, rail, and inland waterway capacities with port handling facilities, Gati Shakti reduces idle time for vessels and trucks, which traditionally inflated logistics duration. Moreover, integration with the Unified Logistics Interface Platform (ULIP) allows stakeholders to track and manage cargo in real time, leading to proactive interventions when delays occur. The outcome is not only shorter transit times but also improved predictability, which is vital for industries such as pharmaceuticals, FMCG, and agriculture that operate on time-sensitive supply chains.

- **Transfer Points and PM Gati Shakti**

Transfer points, the nodes where goods or passengers shift modes, are often the weakest links in multimodal systems. Delays, inefficiencies, and costs at these points can nullify gains achieved elsewhere. PM Gati Shakti directly targets this by reimagining transfer points as integrated logistics hubs, rather than isolated choke nodes. The development of Multimodal Logistics Parks (MMLPs) is central to this vision. These hubs are designed to co-locate warehousing, cargo handling, and value-added services near major industrial and consumption centers. By integrating road, rail, air, and waterways, they minimize cargo handling times, reduce transfer costs, and improve reliability. For instance, the proposed MMLPs at Nagpur, Bengaluru, and Guwahati are strategically located at the intersections of economic corridors, making them natural transfer points where modal shifts can happen seamlessly. Beyond physical hubs, PM Gati Shakti also invests in smart transfer point management. With geospatial planning, digital mapping, and predictive analytics, the initiative identifies where transfer infrastructure is most needed and ensures it is proportionate to surrounding capacity. This reduces the risk of bottlenecks at high-volume nodes. Additionally, integration with initiatives like FASTag-enabled tolling, RFID-based cargo tracking, and electronic data interchange systems reduces paperwork and congestion at transfer points. By transforming transfer nodes from bottlenecks into facilitators, Gati Shakti ensures that the other three drivers' capacity, velocity, and duration are optimized holistically.

The true strength of PM Gati Shakti lies in its recognition that capacity, velocity, duration, and transfer points are interdependent. For example, expanding rail capacity through DFCs directly improves velocity by reducing congestion, but this benefit materializes only when transfer points like terminals and dry ports are equally upgraded. Similarly, reducing transit duration through better highways will be ineffective if bottlenecks at ports continue. Gati Shakti's National Master Plan (NMP) addresses this interdependence by using a whole-of-government approach to infrastructure planning, aligning investments, and synchronizing timelines. This integrated framework ensures that trade-offs between drivers are balanced rather than magnified. Capacity is aligned with demand flows, velocity is improved without compromising sustainability, duration is shortened through better connectivity, and transfer points are optimized through strategic hubs. The result is a multimodal ecosystem that is not just operationally efficient but also aligned with national economic and environmental goals. In essence, PM Gati Shakti operationalizes the theoretical drivers identified in multimodal transportation research. It provides the policy, digital, and infrastructural backbone to make capacity, velocity, duration, and transfer points work in tandem, thereby unlocking India's ambition of building a world-class logistics network.

Table 2: Linking Strategic Drivers of Multimodal Efficiency with PM Gati Shakti

Driver	Meaning in Multimodal Transportation	PM Gati Shakti Interventions	Expected Outcomes
Capacity	Ability of transport networks to handle freight/passenger flows across modes. Includes physical, operational, and digital capacity.	• Dedicated Freight Corridors (DFCs) to expand rail freight capacity. • Port modernization under Sagarmala. • Inland Waterways integration. • Unified geospatial digital platform for coordinated planning.	• Optimized capacity utilization. • Reduced congestion and bottlenecks. • Better alignment of infrastructure with demand.
Velocity	Speed and smoothness of cargo/passenger movement across modes without compromising cost or sustainability.	• Development of Economic Corridors under Bharatmala. • Last-mile connectivity to ports, airports, and industrial hubs. • Real-time monitoring and	• Faster transit speeds. • Lower logistics costs (target 8% of GDP). • Balanced trade-off between speed,

		GIS-enabled dashboards. • Digital integration via ULIP.	cost, and sustainability.
Duration	Total transit time, including movement, waiting, scheduling, and regulatory delays.	• Elimination of first-/last-mile gaps. • Logistics Integration Centers to minimize waiting times. • Port turnaround time reduction through synchronized rail-road-waterway connectivity. • Digital single-window clearance systems.	• Shorter and more predictable transit times. • Improved reliability for time-sensitive supply chains. • Reduced idle times and emissions.
Transfer Points	Nodes where goods or passengers shift between modes; critical for efficiency but prone to bottlenecks.	• Establishment of Multimodal Logistics Parks (MMLPs). • Smart planning of transfer hubs using geospatial data. • RFID, FASTag, and digital cargo-tracking systems. • Integration of warehousing and value-added services.	• Lower transfer costs and delays. • Seamless modal integration. • Enhanced reliability and service quality.

PM Gati Shakti and Multimodal Efficiency:

PM Gati Shakti – the National Master Plan for Multimodal Connectivity represents one of India's most ambitious initiatives to transform its logistics landscape by integrating infrastructure planning across transport modes. Its central objective is to reduce logistics costs, currently accounting for nearly 13–14% of GDP, to a globally competitive level of about 8%. This reduction is not only an economic necessity but also a strategic imperative for enhancing India's manufacturing competitiveness and export potential. At its core, PM Gati Shakti focuses on improving the efficiency of multimodal transport systems by addressing the four critical drivers: capacity, velocity, duration, and transfer points. Capacity enhancement under Gati Shakti is pursued through coordinated investments in highways, railways, ports, airports, and inland waterways. Instead of piecemeal expansion, the initiative ensures that capacities are aligned and complementary, avoiding the bottlenecks created by unbalanced growth. For example, the development of Dedicated Freight Corridors (DFCs) expands rail freight capacity, while port modernization and multimodal logistics parks provide matching handling capabilities, ensuring seamless flows. These efforts ensure that the multimodal system's throughput is optimized rather than constrained by the weakest link. Velocity, defined as the speed and smoothness of freight movement, is addressed by Gati Shakti through the creation of economic corridors, last-mile connectivity projects, and digital monitoring systems. The initiative integrates geospatial planning and real-time dashboards to enable better traffic management and predictive logistics. By reducing congestion and eliminating detours, freight velocity is improved without compromising sustainability. The emphasis on shifting goods from road to rail and waterways also contributes to higher velocity with lower emissions, aligning efficiency with environmental goals. Duration, or the total transit time, is another focus area. Gati Shakti minimizes duration by eliminating first- and last-mile gaps, streamlining regulatory processes, and leveraging the Unified Logistics Interface Platform (ULIP) for digital clearances. For example, reducing turnaround times at ports by linking them directly with rail and road networks cuts waiting times significantly. Shorter and more predictable durations are particularly beneficial for time-sensitive sectors such as agriculture, pharmaceuticals, and e-commerce, where delays directly affect competitiveness. Finally, transfer points often the most vulnerable nodes in multimodal systems are strengthened under Gati Shakti through the establishment of multimodal logistics parks and smart transfer hubs. By integrating warehousing, cargo handling, and value-added services, these hubs reduce costs and delays associated with modal shifts. Together, these interventions ensure that capacity, velocity, duration, and transfer points function in harmony, transforming India's fragmented logistics system into an efficient, sustainable, and globally competitive multimodal network.

Table 3: Government Data on PM Gati Shakti and Multimodal Transportation Efficiency

Aspect	Numerical Data	Source
Logistics Cost (% of GDP)	Reduced to 7.8–8.9%, down from 13–14%	NCAER (2024) via ET CFO
Annual Economic Savings	Lowering costs by 4–5% = ₹10 lakh crore savings annually	Economic Times (2022); The Statesman (2022)
Total Investment	434 projects worth ₹11.17 lakh crore identified under PM Gati Shakti	Cargo Insights (2023)
Cargo Terminals	91 commissioned, 234 approved, 339 under review	Cargo Insights (2023)
Digital Platform Spend	₹1,458 crore allocated for Gati Shakti GIS platform	Moneycontrol (2023)
Network Expansion Targets	Highways: 200,000 km; Rail freight: 1,600 Mtpa; Airports: 200–220 new	Bharat Express (2023); NCAER (2024)
Economic Multiplier	Every ₹1 invested yields ₹2.5–4 in output	Bharat Express (2023)
Institutional Integration	43 ministries, 1,530 GIS layers, 36 digital systems integrated	Moneycontrol (2024)
Trade Facilitation Score	Improved from 90.3% (2021) to 93.5% (2023)	Moneycontrol (2024)
Itarsi–Nagpur Rail Line	₹5,451 crore; +10 Mtpa freight; ₹1,206 crore savings; 16 crore liters oil saved; 515 crore kg CO_2 cut (20 crore trees equivalent)	Times of India (2024a)
Wardha–Ballarshah & Ratlam–Nagda Lines	₹3,399 crore; +18.4 Mtpa freight; benefits 19.74 lakh people; 74 lakh human-days of jobs; 784 villages connected	Times of India (2024b)

- **Logistics Cost Reduction**

  The National Council of Applied Economic Research (NCAER, 2024) reported that India's logistics costs have reduced to 7.8–8.9% of GDP, down from the earlier estimate of 13–14%. This is a significant improvement attributed to integrated planning under PM Gati Shakti. Moreover, Commerce Minister Piyush Goyal emphasized that bringing logistics costs down by 4–5 percentage points could save the Indian economy about ₹10 lakh crore annually (Economic Times, 2022; The Statesman, 2022).

  Implication: This demonstrates how policy-led multimodal integration improves velocity and duration in the transport system.

- **Project Investments under PM Gati Shakti**

  The Ministry of Finance (2023) identified 434 infrastructure projects worth ₹11.17 lakh crore under the PM Gati Shakti framework, of which 91 cargo terminals have been commissioned, 234 have received in-principle approvals, and 339 are under review (Cargo Insights, 2023). The Economic Survey (2023) also notes that about ₹1,458 crore has been allocated for the development of the PM Gati Shakti digital platform (Moneycontrol, 2023).

  Implication: These figures highlight capacity-building and the strengthening of transfer points across modes.

- Infrastructure Targets and Multiplier Effect

  According to the Government of India's National Master Plan projections, Gati Shakti aims to expand national highways to 200,000 km, increase railway freight capacity to 1,600 million tonnes, and establish 200–220 new airports over the coming years (Bharat Express, 2023; NCAER, 2024). The Ministry of Finance also notes that each rupee invested in infrastructure yields an economic return of ₹2.5–4 (Bharat Express, 2023).

  Implication: These bold targets illustrate strategic expansion of capacity and improvement of velocity.

- **Institutional and Digital Integration**

  As of March 2024, 43 ministries were onboarded onto the Gati Shakti portal, with 1,530 GIS data layers (642 from central ministries and 888 from states) uploaded for planning purposes. In parallel, 36 logistics-related digital systems covering 1,800 data fields have been integrated through the Unified Logistics Interface Platform (ULIP) (Moneycontrol, 2024). India also improved its score in the UNESCAP Global Survey on Digital and Sustainable Trade Facilitation from 90.3% in 2021 to 93.5% in 2023 (Moneycontrol, 2024).

  Implication: Digital integration reduces delays at transfer points and improves coordination, impacting duration and velocity.

Railway Multi-tracking Projects and Environmental Gains

- **Itarsi–Nagpur 4th Rail Line:** The Government approved an investment of ₹5,451 crore, enabling an additional 10 million tonnes of freight annually. The project is expected to save ₹1,206 crore in logistics costs, reduce fuel use by 16 crore liters, and cut 515 crore kg of CO_2 emissions, equivalent to planting 20 crore trees (Times of India, 2024a).
- **Wardha–Ballarshah and Ratlam–Nagda Lines:** These projects involve a combined investment of ₹3,399 crore, enabling 18.4 million tonnes per annum of freight capacity. They directly benefit 19.74 lakh people, connect 784 villages, and generate about 74 lakh human-days of employment (Times of India, 2024b).
- **Implication**: These examples show how capacity and velocity improvements align with sustainability and socio-economic development.

DISCUSSION:

The efficiency of multimodal transportation systems depends on the strategic interplay of capacity, velocity, duration, and transfer points (CVDT), each of which shapes logistics performance in unique yet interdependent ways. This paper contextualizes these drivers within India's PM Gati Shakti National Master Plan, which provides the policy and infrastructural framework to optimize multimodal connectivity. The discussion here synthesizes insights from the literature, empirical data, and policy interventions to analyze the implications of CVDT for logistics efficiency, sustainability, and economic competitiveness. One of the most significant findings of this study is that none of the four drivers can be treated in isolation. For example, expanding capacity through the construction of new highways or rail lines is ineffective if transfer points remain bottlenecks where delays and congestion negate throughput gains. Similarly, improvements in velocity can sometimes worsen duration if they are not matched by coordinated scheduling, regulatory clearances, and terminal handling capacity. This aligns with earlier research emphasizing multi-objective optimization approaches, where trade-offs among cost, time, and sustainability must be managed holistically (Wu, Wang, & Li, 2009). The CVDT model proposed in this study highlights how transfer points act as the hinge around which the other three drivers revolve, making them critical leverage points for achieving systemic efficiency.

India's logistics system has historically been constrained by fragmented capacity expansion, where different ministries developed isolated assets. PM Gati Shakti addresses this challenge by integrating planning across 16 ministries through a unified geospatial platform. Dedicated Freight Corridors (DFCs) significantly expand rail capacity, while Sagarmala modernizes port handling and Bharatmala expands highway connectivity. Inland waterways and pipeline networks are also being integrated into the multimodal framework. These interventions ensure that capacity creation is strategic and synchronized rather than fragmented. Importantly, digital capacity in the form of geospatial data, dashboards, and the Unified Logistics Interface Platform (ULIP) provides predictive planning tools that enable real-time adjustments to demand fluctuations. This reflects a paradigm shift from physical expansion alone to digitally enabled capacity management, aligning with global best practices. Velocity in logistics is not simply about achieving higher transport speeds; rather, it involves ensuring smooth, reliable, and sustainable flows across the network. PM Gati Shakti enhances velocity by creating economic corridors, strengthening last-mile connectivity, and leveraging digital monitoring systems to reduce congestion. For instance, last-mile connectivity to ports, airports, and industrial clusters reduces unnecessary detours and handling delays, directly improving velocity. Moreover, digital dashboards provide real-time information that enables rerouting during disruptions, thus maintaining flow continuity. The emphasis on shifting freight from road to rail and waterways also highlights how velocity is aligned with sustainability, since these modes have lower carbon footprints. Thus, Gati Shakti reconceptualizes velocity as a multi-dimensional driver that integrates speed, cost efficiency, and environmental objectives. Duration, encompassing total transit time including waiting, regulatory clearances, and transfer delays, is particularly critical for industries that operate on time-sensitive supply chains such as agriculture, pharmaceuticals, and e-commerce. PM Gati Shakti reduces duration by addressing both physical and procedural sources of delay. First- and last-mile gaps are being systematically eliminated, ensuring direct connectivity between production centers, consumption markets, and transport nodes. Logistics integration centers and multimodal logistics parks provide pre-coordinated hubs that reduce waiting times during modal shifts. Furthermore, regulatory reforms, including single-window digital clearance systems, reduce bureaucratic delays that traditionally inflated journey times. The integration of ULIP ensures that stakeholders can monitor cargo in real time, improving predictability. This transformation of duration into a predictable, shortened, and manageable metric enhances competitiveness in global trade, where reliability often matters more than raw speed. Transfer points emerge as the most critical yet vulnerable nodes in multimodal systems. Poorly designed or congested transfer points can undermine gains in capacity, velocity, and duration. PM Gati Shakti directly addresses this challenge by developing multimodal logistics parks (MMLPs) strategically located near industrial hubs and economic corridors. These parks integrate warehousing, cargo handling, and value-added services, transforming transfer points from bottlenecks into efficiency enablers. Digital tools such as RFID tracking, FASTag-enabled tolling, and electronic data interchange further streamline transfer operations, reducing handling times and costs. This represents a paradigm shift in logistics planning viewing transfer points not merely as nodes but as strategic facilitators of efficiency.

A major economic objective of PM Gati Shakti is to reduce logistics costs from 13–14% of GDP to about 8%, bringing India in line with global benchmarks. Empirical data suggests significant progress: the National Council of Applied Economic Research (2024) reports that logistics costs have already declined to 7.8–8.9% of GDP. This reduction translates into annual savings of nearly ₹10 lakh crore, which can be reinvested in industrial growth and exports. Lower logistics costs also enhance the competitiveness of Indian manufacturers in global markets, particularly under initiatives such as "Make in India" and "Atmanirbhar Bharat." The CVDT model provides clarity on how these savings are achieved: capacity optimization reduces congestion, velocity improvements cut operational costs, shorter durations enhance reliability, and efficient transfer points reduce handling expenses. Beyond economic gains, the optimization of CVDT drivers contributes significantly to sustainability objectives. For instance, the Itarsi–Nagpur rail line project is expected to reduce 515 crore kg of CO_2 emissions annually, equivalent to planting 20 crore trees. Shifting cargo from road to rail and waterways reduces fuel consumption and emissions, aligning logistics operations with India's climate commitments under the Paris Agreement. Reduced duration minimizes idle times and resource wastage, while optimized transfer points facilitate transitions to greener transport modes. Thus, CVDT drivers, when aligned through Gati Shakti, not only enhance efficiency but also advance environmental stewardship. The effectiveness of CVDT drivers is also contingent on institutional coordination and policy alignment. PM Gati Shakti's success lies in its ability to integrate 43 ministries and multiple stakeholders onto a single planning platform. By bringing transparency through GIS data layers and ULIP, the initiative reduces redundancies, fosters accountability, and encourages data-driven decision-making. This institutional integration is essential because inefficiencies in multimodal systems often arise not from lack of infrastructure but from fragmented governance and regulatory overlaps. Thus, the policy dimension of Gati Shakti provides the enabling environment for CVDT optimization. The COVID-19 pandemic and subsequent disruptions have highlighted the importance of supply chain resilience. Multimodal efficiency under the CVDT framework enhances resilience by diversifying transport modes, reducing reliance on congested corridors, and ensuring flexibility during disruptions. For example, when highway transport is disrupted, rail and waterways provide viable alternatives if transfer points are well integrated. Duration predictability ensures that industries can maintain inventory control and just-in-time operations, while digital platforms enable real-time adaptation to shocks. In this sense, Gati Shakti operationalizes resilience by embedding adaptability within the multimodal ecosystem. This paper contributes theoretically by developing the CVDT model as an analytical framework for multimodal transportation efficiency. Unlike prior studies that examined capacity, velocity, duration, or transfer points in isolation, the CVDT model emphasizes their interdependence and situates them within policy interventions like Gati Shakti. By doing so, it bridges the gap between theoretical constructs and practical applications. The model demonstrates that efficiency is not the outcome of optimizing a single driver but the result of their balanced and integrated optimization, mediated by transfer points and reinforced by policy frameworks.

CONCLUSION :

This study examined the strategic drivers of multimodal transportation efficiency- capacity, velocity, duration, and transfer points (CVDT)- within the context of India's PM Gati Shakti initiative. The findings highlight that multimodal efficiency is not determined by infrastructure expansion alone but by the dynamic interplay of infrastructural, operational, digital, and policy-driven factors.

First, capacity is essential but insufficient in isolation. Expanding highways, rail corridors, or ports enhances system potential, but without efficient transfer points, much of this capacity remains underutilized. Gati Shakti addresses this by harmonizing investments across modes, ensuring that capacity is strategically aligned rather than fragmented. Second, velocity contributes to cost reduction and competitiveness, but it must be understood as a balance of speed, reliability, and sustainability. Gati Shakti accelerates velocity through economic corridors, last-mile connectivity, and digital monitoring systems, while promoting modal shifts that reduce emissions. Third, duration is critical for supply chain competitiveness, especially for time-sensitive industries. Gati Shakti reduces duration through elimination of first- and last-mile gaps, digital clearance systems, and integrated logistics centers, ensuring shorter and more predictable transit times. Fourth, transfer points emerge as the most decisive factor. Poorly managed transfer nodes negate gains in capacity, velocity, and duration. Through the creation of multimodal logistics parks, smart hubs, and digital integration, Gati Shakti transforms transfer points into facilitators of efficiency.

The proposed CVDT model offers a structured framework to analyze how these drivers interact to shape multimodal efficiency. By positioning transfer points at the center and treating Gati Shakti as a moderating factor, the model captures the interdependencies among drivers and provides a basis for evaluating policy and managerial interventions. This represents a theoretical contribution by integrating literature on logistics efficiency with contemporary policy reforms. One of the most tangible outcomes of CVDT optimization under Gati Shakti is the reduction of logistics costs. Bringing costs down to 8% of GDP saves the economy nearly ₹10 lakh crore annually, which can be reinvested in infrastructure, exports, and industrial competitiveness. Reduced costs enhance India's attractiveness as a global manufacturing hub, particularly in industries such as electronics, textiles, and automotive manufacturing, where logistics is a critical determinant of global competitiveness. CVDT optimization contributes significantly to India's sustainability agenda. By shifting freight from road to rail and waterways, fuel consumption and carbon emissions are reduced. Projects like the Itarsi–Nagpur rail line demonstrate tangible environmental gains equivalent to planting millions of trees. Optimized transfer points further reduce energy-intensive delays, while shorter durations minimize resource wastage. Thus, Gati Shakti aligns multimodal efficiency with climate resilience and environmental sustainability, supporting India's commitments to net-zero emissions. The study underscores the importance of institutional coordination in achieving multimodal efficiency. Gati Shakti integrates 43 ministries through a unified platform, reducing redundancies and ensuring that infrastructure projects are complementary. The institutionalization of digital platforms like ULIP ensures transparency, accountability, and real-time coordination. These developments highlight that logistics efficiency is not merely a technical challenge but also a governance challenge. Future policy must continue to prioritize institutional integration, capacity-building, and digital innovation. For industry stakeholders, the CVDT framework provides a lens to evaluate logistics strategies. Businesses must recognize that investments in capacity (e.g., warehouses, trucks, terminals) must be complemented by attention to velocity (routing, congestion management), duration (scheduling, clearance), and transfer points (integration, automation). Firms that leverage digital platforms to monitor and optimize these drivers are more likely to achieve competitive advantage in cost and service quality. The framework also provides a diagnostic tool for identifying where inefficiencies lie and where interventions are most needed.

While this study offers a conceptual and policy-based analysis, future research could adopt empirical approaches to measure the quantitative impacts of CVDT drivers on logistics outcomes. For example, econometric models could assess the relationship between investment in transfer points and logistics cost reduction. Simulation models could evaluate how velocity improvements interact with capacity constraints under different demand scenarios. Comparative studies with other countries implementing multimodal reforms could also provide global benchmarks for India. Additionally, future research could explore the role of emerging technologies such as artificial intelligence, digital twins, and blockchain in further optimizing CVDT drivers. In conclusion, the optimization of capacity, velocity, duration, and transfer points is fundamental to building efficient, resilient, and sustainable multimodal transportation systems. India's PM Gati Shakti represents a landmark initiative that operationalizes these drivers through integrated planning, digital innovation, and institutional coordination. The results are already evident in reduced logistics costs, improved trade facilitation scores, enhanced supply chain resilience, and environmental gains. The CVDT model developed in this study not only provides a theoretical contribution but also serves as a practical guide for policymakers and industry stakeholders. By emphasizing the interdependence of the four drivers and situating them within the policy framework of Gati Shakti, the model bridges the gap between academic research and practical application. Ultimately, multimodal efficiency is not about maximizing one dimension but about balancing all four in a coordinated manner. As India advances toward its ambition of becoming a global logistics hub, the integration of CVDT drivers through PM Gati Shakti will be instrumental in achieving cost competitiveness, sustainability, and resilience. This study reinforces the idea that strategic, policy-driven multimodal integration is the cornerstone of logistics transformation in the 21st century.

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