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ASSESSING BRAZIL'S POTENTIAL AS A GLOBAL LOGISTICS HUB: A COMPARATIVE ANALYSIS OF LOGISTICS PERFORMANCE AND TRANSPORT INFRASTRUCTURE

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***Abstract**:*

The reconfiguration of global supply chains has increased the strategic importance of economies capable of combining substantial transport capacity with efficient and reliable logistics systems. This study assesses Brazil's potential to develop global logistics-hub functions by explicitly distinguishing between national logistics performance and physical logistics capacity. Rather than applying a binary hub/no-hub classification, logistics-hub potential is operationalised as the degree to which substantial physical cargo-handling activity is accompanied by strong institutional and operational logistics performance. Brazil is compared with Mexico, Chile, South Africa, and Türkiye using the six components of the 2023 World Bank Logistics Performance Index: customs, infrastructure, international shipments, logistics competence and quality, tracking and tracing, and timeliness. Objective criterion weights are determined using the Entropy Weight Method, while the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) establishes each economy's relative position in relation to an ideal logistics-performance profile. Infrastructure receives the highest Entropy weight (0.2232), followed by international shipments (0.2017) and tracking and tracing (0.1897). The TOPSIS results rank South Africa first, followed by Türkiye, Brazil, Chile, and Mexico. Brazil obtains a relative closeness coefficient of 0.3629, indicating an intermediate logistics-performance position within the benchmark sample. However, comparison with physical cargo activity reveals a different pattern. Brazil records the highest container port throughput within the sample, reaching approximately 13.9 million TEU in 2024. The divergence between the logistics-performance ranking and physical cargo scale indicates that Brazil already possesses a substantial logistics base but does not yet achieve a corresponding level of institutional and operational performance. Comparison with the Brazilian National Logistics Plan 2035 indicates strong direct alignment with infrastructure-related weaknesses, indirect alignment with international shipment organisation, digitalisation, tracking, and modal-integration requirements, and more limited alignment with the identified customs gap. Equal-weight TOPSIS and comparison with the overall LPI ranking confirm the stability of Brazil's third position. The scientific novelty lies in the two-layer diagnostic design rather than in the Entropy-TOPSIS algorithm itself: disaggregated LPI diagnostics are combined with an independent physical-capacity measure and policy mapping to reveal a logistics performance–capacity gap that cannot be identified from the overall LPI ranking alone.

Keywords: *Brazil, logistics performance, logistics hub, Entropy Weight Method, TOPSIS*

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1. Introduction

The efficiency of national logistics systems constitutes an important determinant of participation in international trade and global supply chains. Transport infrastructure, customs procedures, logistics-service quality, shipment reliability, information visibility, and the ability to organise international freight flows jointly influence the cost, speed, reliability, and predictability of cross-border operations. Previous empirical studies have demonstrated significant relationships between logistics performance, international trade, exports, and competitiveness (Martí et al., 2014; Gani, 2017; Bugarčić et al., 2024).

The Logistics Performance Index (LPI), developed by the World Bank, provides one of the most widely applied frameworks for international comparison of national logistics systems. The survey-based LPI evaluates six dimensions: customs efficiency, quality of trade and transport infrastructure, ease of arranging international shipments, logistics competence and quality, tracking and tracing, and timeliness (Arvis et al., 2023). These dimensions represent institutional, infrastructural, operational, and service-related conditions affecting international freight movements. The analytical value of the LPI extends beyond the overall country score. Its disaggregated components make it possible to identify specific logistics constraints and to associate them with potential transport and trade-policy priorities. Countries achieving similar overall LPI results may nevertheless display different combinations of infrastructure quality, customs efficiency, service competence, shipment organisation, visibility, and reliability. Consequently, recent research has increasingly applied multi-criteria, efficiency-based, and alternative weighting approaches to national logistics-performance assessment (Rezaei et al., 2018; Pehlivan et al., 2024; See et al., 2024; Stević et al., 2024).

This multidimensional character has important implications for the assessment of logistics-hub potential. A global logistics hub cannot be defined exclusively by the physical movement of large cargo volumes. Hub functions additionally depend on effective border processes, international shipment organisation, specialised logistics services, transport infrastructure, information exchange, multimodal integration, international connectivity, and reliable delivery performance. A country may therefore handle substantial freight volumes while continuing to experience institutional or operational limitations that restrict its ability to convert physical transport capacity into competitive hub functions. Conversely, an efficient logistics system may operate at a smaller absolute cargo scale. The distinction between the scale of logistics activity and the quality of the logistics environment is therefore central to the present study.

For the purposes of this study, a global logistics hub is not treated as a binary status determined by a universal quantitative threshold, because no generally accepted cut-off exists for classifying entire national economies as global logistics hubs. Instead, global logistics-hub potential is operationally defined as the joint presence of two conditions: (1) substantial physical logistics activity capable of supporting international freight flows and (2) relatively strong institutional, infrastructural, service, and operational logistics performance. The empirical analysis therefore evaluates the degree of alignment between physical logistics capacity and logistics-system performance rather than assigning a formal hub/no-hub label. A country with substantial throughput but only intermediate logistics performance is interpreted as possessing physical hub potential that has not yet been fully converted into competitive logistics-hub functions. Brazil constitutes a particularly relevant case for examining this problem. The country combines a large domestic market, continental dimensions, considerable agricultural and industrial production, substantial foreign trade, and extensive access to Atlantic maritime routes. These characteristics create a large freight base and substantial demand for logistics services. At the same time, Brazil's freight system faces structural challenges associated with long inland distances, modal imbalance, infrastructure requirements, and the relationship between inland production areas and maritime gateways. Road transport continues to play a major role in domestic freight movements, while railway, inland-waterway, port, and coastal-shipping development offers opportunities to increase the role of high-capacity modes.

These conditions are reflected in the Brazilian National Logistics Plan 2035 (PNL 2035), which establishes an integrated long-term framework for transport planning. The Plan evaluates scenarios involving infrastructure, macroeconomic conditions, legislation, technology, and environmental sustainability and considers the development of road,

railway, waterway, port, and aviation networks (Empresa de Planejamento e Logística & Ministério da Infraestrutura, 2021).

Recent research demonstrates that expansion and restructuring of Brazilian transport infrastructure can affect logistics costs and the spatial organisation of economic activity. Costa et al. (2022) show that infrastructure developments considered in national logistics planning may reshape port service areas and alter competitive relationships among Brazilian maritime gateways. Wang et al. (2024) demonstrate that planned transport-infrastructure development can influence inland freight costs, agricultural production patterns, land use, and carbon emissions. da Costa et al. (2025) further show that containerised cabotage may become economically and environmentally competitive with road transport on selected long-distance Brazilian routes. These findings indicate considerable opportunities for improving Brazil's freight system through infrastructure development, modal diversification, and stronger integration between inland and maritime transport. Nevertheless, the existence of infrastructure and substantial cargo flows does not itself demonstrate logistics-hub competitiveness. International hub functions also require efficient customs processes, competitive shipment organisation, logistics competence, information visibility, and predictable delivery performance.

The existing literature consequently reveals an analytical gap. Brazil-specific transport research frequently concentrates on infrastructure projects, freight corridors, ports, agricultural logistics, cabotage, or the effects of national transport planning. International logistics-performance research, in contrast, often compares groups of economies using the LPI, efficiency analysis, or multi-criteria decision-making methods. Less attention has been devoted to whether Brazil's substantial physical logistics scale corresponds to the institutional and operational performance required for competitive global hub functions. The present study addresses this gap by explicitly distinguishing between logistics performance and physical logistics capacity. Logistics performance is evaluated using the six dimensions of the 2023 World Bank LPI. Physical logistics capacity is subsequently examined using objective evidence on container port throughput. This two-layer analytical framework makes it possible to determine whether the physical scale of Brazil's participation in international freight flows corresponds to the quality of its national logistics environment.

Brazil is compared with Mexico, Chile, South Africa, and Türkiye. The selected economies constitute a purposive benchmark rather than an exhaustive or statistically representative set of countries. They provide contrasting cases characterised by different combinations of emerging-market conditions, manufacturing activity, commodity flows, maritime dependence, trade integration, and regional gateway functions. Mexico represents a large manufacturing economy extensively integrated with international supply chains. Chile provides a trade-oriented Latin American maritime reference economy. South Africa combines a geographically extensive emerging economy with substantial commodity flows, maritime dependence, and long inland freight distances. Türkiye represents a manufacturing and transport economy with substantial maritime activity and a geographical position linking several international trade regions.

The study applies the Entropy Weight Method to determine objective weights for the six logistics-performance criteria. TOPSIS is subsequently used to evaluate each economy according to its relative distance from an ideal logistics-performance profile. This procedure reduces reliance on subjective assignment of criterion importance and identifies those LPI dimensions that contain the greatest discriminatory information within the selected benchmark sample.

The study addresses four research questions:

RQ1. Which logistics-performance criteria have the greatest discriminatory importance in the comparative assessment?

RQ2. How does Brazil perform relative to Mexico, Chile, South Africa, and Türkiye in terms of national logistics performance?

RQ3. Which components of Brazil's logistics system constitute the principal constraints on its development as a global logistics hub?

RQ4. To what extent do the priorities of the Brazilian National Logistics Plan 2035 correspond to the performance gaps identified in the comparative analysis?

The scientific novelty of the study does not lie in proposing a new multi-criteria decision-making algorithm. Instead, it lies in integrating three analytical layers that are typically examined separately: (1) disaggregated diagnostics of national logistics

performance; (2) an independent measure of physical logistics scale; and (3) policy mapping against PNL 2035. The Entropy-TOPSIS procedure is used as a diagnostic device rather than merely as an alternative country-ranking exercise: it identifies which LPI components contain the greatest discriminatory information within the benchmark set and measures each economy's distance from a sample-specific ideal. The subsequent comparison with container throughput reveals whether logistics-system quality is commensurate with physical cargo scale, while the policy mapping translates the diagnosed gaps into infrastructure and institutional priorities. The resulting logistics performance–capacity gap constitutes the principal scientific contribution of the study.
The remainder of the paper is organised as follows. Section 2 reviews literature concerning national logistics performance, international competitiveness, logistics hubs, Brazilian transport infrastructure, and multi-criteria logistics-performance assessment. Section 3 describes the research design, data, Entropy Weight Method, TOPSIS procedure, robustness assessment, and ethical considerations. Section 4 presents and discusses the empirical results and evaluates their correspondence with PNL 2035. Section 5 summarises the conclusions, contributions, implications, limitations, and future research directions.

2. Literature Review

2.1. National logistics performance and international competitiveness

National logistics performance represents the capacity of an economy to organise freight flows efficiently across domestic and international supply chains. Its determinants extend beyond the availability of transport infrastructure. Customs procedures, logistics-service quality, shipment organisation, information systems, international transport connections, and delivery reliability jointly influence the effectiveness of logistics operations.
The relationship between logistics performance and international trade has been established in several empirical studies. Martí et al. (2014) demonstrated the importance of the LPI for international trade and indicated that logistics improvements can particularly support products characterised by relatively complex transport requirements. Gani (2017) subsequently identified positive relationships between logistics performance and both exports and imports. More recent evidence indicates that physical infrastructure and logistics services can contribute to firms' export capability and competitiveness (Bugarčić et al., 2024). These findings suggest that logistics performance cannot be reduced to transport costs alone. Logistics capability influences access to international markets, the coordination of supply chains, reliability of deliveries, visibility of cargo movements, and the ability of firms to participate in international production networks.
Zaninović and Bugarčić (2023) extend this interpretation by demonstrating the importance of international logistics in global value-chain trade. Their findings indicate that logistics conditions and institutional quality can influence the ability of economies to participate effectively in internationally fragmented production systems. The World Bank LPI provides a structured representation of several of these capabilities. Customs measures the efficiency of customs and border-management procedures. Infrastructure concerns the quality of trade- and transport-related infrastructure. International shipments reflect the ease of arranging competitively priced international shipments. Logistics competence relates to the quality and competence of logistics services. Tracking and tracing represents shipment visibility, while timeliness evaluates the frequency with which shipments reach their destination within scheduled or expected delivery periods (Arvis et al., 2023).
The aggregate LPI score nevertheless conceals some of the variation between these components. Two countries may obtain relatively similar overall LPI values while exhibiting different strengths and weaknesses. For policy analysis, disaggregating the index can therefore provide additional diagnostic value. The methodological literature increasingly reflects this need. Rezaei et al. (2018) applied the Best-Worst Method to estimate the relative importance of individual LPI components, demonstrating that the weighting of logistics dimensions can be made explicit. Martí et al. (2017) developed a Data Envelopment Analysis-based logistics performance index to benchmark the relative efficiency of national logistics systems. More recently, See et al. (2024) proposed an effectiveness-based hierarchical DEA framework, allowing components underlying logistics performance to be evaluated before aggregation. Pehlivan et al. (2024) applied quantitative decision-making methods to G20

logistics performance, while Stević et al. (2024) reassessed global LPI rankings using objective weighting and multi-criteria methods.

These developments indicate that national logistics performance is appropriately treated as a multidimensional decision problem rather than as a single observed variable. The survey-based character of the LPI must nevertheless be recognised. The index reflects assessments provided by logistics professionals rather than direct physical measurement of all national freight activities (Arvis et al., 2023). This feature does not remove its comparative value but supports the use of complementary objective indicators when the research question concerns physical logistics capacity.

2.2. Transport infrastructure, maritime connectivity and logistics-hub development

Transport infrastructure constitutes a necessary condition for logistics-hub development because it determines the physical accessibility and capacity required to consolidate, transfer, and distribute cargo. Ports, road and railway networks, inland waterways, airports, terminals, and hinterland connections influence the extent to which production and consumption locations can be connected with international transport systems. Infrastructure, however, does not automatically generate logistics-hub competitiveness. Physical capacity must interact with operational efficiency, network connectivity, service quality, institutional reliability, and the ability to organise freight movements at competitive cost and reliability levels. This distinction is especially relevant to maritime logistics. Ports simultaneously operate as cargo-handling facilities and as nodes embedded in wider shipping, hinterland, production, and supply-chain networks. Consequently, port throughput provides evidence of the scale of activity but cannot by itself be considered equivalent to logistics competitiveness.

Haralambides (2023) emphasises the increasingly integrated character of maritime economics and logistics research, in which ports are examined in relation to shipping networks, terminal operations, hinterland systems, and global logistics chains. The competitive role of a port is therefore determined by a wider system of relationships than terminal capacity alone.

Martínez-Moya et al. (2025) provide further evidence of the multidimensional character of hub competitiveness. Their analysis of transhipment-port competitiveness identifies geographical location as an important factor but also demonstrates the relevance of connectivity, infrastructure, and operating conditions.

Delfin-Ortega (2025), applying a two-stage DEA approach in an APEC context, similarly demonstrates that port efficiency is associated with broader economic and maritime-connectivity conditions. Port performance thus depends on the interaction between infrastructure, logistics networks, and the surrounding economic environment.

This distinction has direct relevance to Brazil. The country's extensive Atlantic coastline and large trade base generate substantial maritime cargo activity, yet the ability to develop broader logistics-hub functions depends on the integration of ports with inland production regions, transport corridors, logistics services, border processes, and international shipping networks. Accordingly, the concept of logistics-hub potential employed in this study incorporates two complementary dimensions. Physical logistics capacity represents the scale of infrastructure and freight activity available to support international logistics. Logistics performance represents the institutional, infrastructural, service, and operational quality through which these freight flows are organised. The two dimensions are related but not equivalent. A large freight market may handle substantial cargo while continuing to experience institutional or operational inefficiencies. Conversely, an efficient logistics system can operate at a lower absolute cargo scale. This distinction provides the conceptual basis for keeping physical container throughput outside the principal Entropy-TOPSIS performance index.

2.3. Brazil's transport system and logistics-hub potential

Brazil's logistics system is strongly influenced by the country's continental dimensions and the geographical distribution of production and population. Major agricultural and mineral-producing regions are frequently located at considerable distances from maritime gateways. Industrial and population centres are unevenly distributed, resulting in long and complex freight corridors. These conditions increase the importance of high-capacity inland transport and effective integration between roads, railways, inland waterways, coastal shipping, terminals, and ports.

Historically, Brazilian freight transport has been strongly dependent on roads. Road freight provides geographical flexibility and extensive network coverage, but excessive dependence on this mode creates exposure to fuel costs, road conditions, congestion, accidents, capacity constraints, and the inefficiency of long-distance road haulage for certain cargo categories.

The need for greater modal balance therefore represents an important component of Brazilian transport policy. PNL 2035 adopts an integrated approach and evaluates transport-development scenarios involving roads, railways, waterways, ports, aviation, technology, legislation, and environmental sustainability (Empresa de Planejamento e Logística & Ministério da Infraestrutura, 2021). Costa et al. (2022) examined whether the Brazilian National Logistics Plan can influence port competitiveness by reshaping port service areas. Their analysis demonstrates that changes to inland infrastructure can modify port hinterlands and alter competitive relationships between maritime gateways. This finding illustrates an important mechanism for logistics-hub development. Port competitiveness is not determined exclusively within the port boundary. Inland accessibility and corridor configuration can change the geographical areas served by individual ports and therefore alter the distribution of cargo.

Wang et al. (2024) provide further evidence on the broader implications of Brazilian transport-infrastructure expansion. Their results indicate that planned infrastructure can reduce inland transport costs and influence the geographical pattern of agricultural production while also generating environmental consequences. Infrastructure investment therefore affects more than transport efficiency. Changes in accessibility can influence production location, trade corridors, land use, and regional development. Brazilian cabotage provides another opportunity for modal diversification. da Costa et al. (2025) analyse containerised coastal shipping within a multimodal transport network and demonstrate that cabotage can become economically and environmentally attractive relative to road transport on selected long-distance corridors. This finding is especially relevant to Brazil because of its long coastline and the geographical distribution of major cities, industrial regions, and ports. Greater integration between coastal shipping and inland transport can provide alternatives to long-distance road haulage and strengthen multimodal freight chains.

Together, these studies demonstrate substantial opportunities for developing Brazilian freight logistics through railway expansion, port investment, cabotage, waterways, and improved multimodal integration. However, infrastructure expansion does not by itself establish Brazil's relative logistics position internationally. Brazil's logistics-hub potential therefore requires an assessment that distinguishes between physical cargo scale and the performance of the wider logistics environment.

2.4. Multi-criteria approaches to logistics-performance assessment

The multidimensional structure of national logistics performance provides a strong rationale for multi-criteria decision-making methods. These approaches are appropriate where several criteria jointly characterise alternatives and no individual variable provides a complete representation of performance. An important methodological issue concerns criterion weighting. The use of predefined or equal weights may conceal differences in the informational contribution of individual indicators.

Rezaei et al. (2018) demonstrate that explicit weighting of LPI components can generate additional insight into logistics-performance assessment. Martí et al. (2017), using DEA, similarly show that alternative aggregation procedures can be applied to benchmark logistics performance without relying solely on the conventional overall LPI. More recent studies confirm this development. Pehlivan et al. (2024) used quantitative decision-making techniques to evaluate G20 logistics performance. See et al. (2024) applied a hierarchical DEA approach. Stević et al. (2024) used an objective weighting and decision-support framework to reconsider global LPI rankings. Recent country-level sustainability research likewise demonstrates that hybrid MCDM frameworks can integrate objective data, expert-based weighting, and scenario-based robustness analysis to improve the reliability of comparative country assessments (Kara et al., 2026).

Nayak et al. (2024), focusing on an emerging-economy context, further demonstrate the usefulness of multidimensional logistics-performance measurement and the value of supplementing perception-based indicators with quantitative information.

The present study uses entropy as an objective weighting procedure. The conceptual basis of entropy derives from information theory (Shannon, 1948). Within MCDM applications, entropy-based weighting assigns greater importance to indicators that provide greater differentiation among alternatives. A criterion characterised by relatively large variation between the analysed countries contains more discriminatory information. A criterion with comparatively homogeneous observations provides less information for distinguishing alternatives and consequently receives a lower weight.

TOPSIS is then used to generate the country ranking. The method evaluates alternatives according to their relative distance from positive and negative ideal solutions and is rooted in the multiple-attribute decision-making framework developed by Hwang and Yoon (1981). The Entropy-TOPSIS combination is suitable for the present research for three reasons. First, it maintains the analytical visibility of the six individual LPI components. Second, criterion weighting is generated from variation in the observed data rather than imposed solely through researcher judgement. Third, TOPSIS produces a transparent relative ranking that can be subjected to sensitivity analysis and compared with alternative indicators.

The purpose of the procedure is not simply to produce another country league table. The MCDM framework is used as a diagnostic tool to identify which components differentiate the selected countries and to determine whether Brazil's logistics-system quality corresponds to its physical cargo scale.

2.5. Research gap and analytical contribution

Existing research provides substantial evidence on the relationship between logistics performance and international competitiveness, on alternative methods of benchmarking national logistics systems, and on Brazil-specific issues involving infrastructure, ports, hinterland connections, and modal development. However, these streams have rarely been integrated to examine whether Brazil's substantial physical participation in international freight flows is matched by the institutional and operational quality required to perform competitive global logistics-hub functions.

The present study addresses this gap through a two-layer analytical framework. Entropy-TOPSIS is first used to assess Brazil's relative national logistics performance across the six LPI components. The result is then compared with objective container throughput to examine the alignment between logistics-system quality and physical freight scale. Finally, the identified performance gaps are mapped against PNL 2035 to evaluate their correspondence with Brazil's long-term transport-policy priorities. This design links international logistics-performance benchmarking with the specific infrastructure and policy context of Brazil while avoiding the assumption that high cargo throughput alone constitutes logistics-hub performance.

The scientific contribution is therefore conceptual and diagnostic rather than algorithmic. Entropy weighting and TOPSIS are established methods; their role in this study is to reveal which performance dimensions differentiate the selected economies and how far each economy lies from the sample-specific ideal. These diagnostics are subsequently interpreted against an independent physical-capacity ranking and PNL 2035. This provides information that the aggregate LPI ranking alone cannot supply, even when the ordinal country ranking generated by TOPSIS happens to coincide with the overall LPI ordering.

3. Methodology

3.1. Research design and benchmark selection

The study applies a comparative multi-criteria framework to Brazil, Mexico, Chile, South Africa, and Türkiye. Brazil constitutes the focal economy. The comparator set was constructed using a purposive maximum-variation benchmarking procedure designed to compare Brazil with economies displaying different, but analytically relevant, combinations of maritime activity, international trade integration, manufacturing or commodity-based freight demand, and regional gateway functions.

Four eligibility conditions guided the selection. First, complete observations had to be available for all six components of the 2023 World Bank Logistics Performance Index. Second, comparable national container port throughput data had to be available in the World Development Indicators dataset. Third, the economy had to possess material maritime container activity and a meaningful relationship between inland freight systems and seaport gateways. Fourth, the comparator set was designed to represent different structural logistics profiles rather than countries

occupying a predetermined position in the LPI ranking.

Within this framework, Mexico represents a large Latin American manufacturing and export platform integrated with international supply chains; Chile provides a trade-oriented Latin American maritime benchmark; South Africa represents a geographically extensive emerging economy with substantial commodity flows, maritime dependence, and long inland freight corridors; and Türkiye represents a major manufacturing and maritime economy located at the intersection of several international trade regions.

The benchmark set was deliberately designed to combine two Latin American reference economies (Mexico and Chile) with two extra-regional economies performing significant maritime gateway and international freight functions (South Africa and Türkiye). This structure provides variation in manufacturing intensity, commodity dependence, maritime orientation, inland transport distances, and logistics performance while retaining relevance to Brazil's logistics-hub development problem. The countries were not selected on the basis of their eventual LPI or TOPSIS positions, and no calculated Entropy weight was used in the selection process.

The benchmark should therefore be interpreted as a purposefully constructed comparative sample rather than a statistically representative sample of all economies or a matched sample based on a single macroeconomic variable. Importantly, neither the resulting LPI ranking nor the Entropy weights were used as selection criteria. Because Entropy weights depend on cross-country variation within the selected alternatives, all weights and resulting TOPSIS distances remain conditional on this benchmark design, a limitation explicitly addressed in Section 5.3. The research consists of two complementary analytical layers. The first evaluates national logistics performance using the six components of the World Bank LPI. The second evaluates physical logistics capacity using container port throughput. Separating the two layers is important because absolute freight volumes are strongly influenced by economic scale, trade structure, population, and geography. Combining raw throughput directly with perception-based LPI components in one compensatory index could cause the ranking to reflect country size rather than logistics-system performance.

Because Entropy weights are a direct function of variation among the alternatives included in the decision matrix, benchmark composition can influence both criterion weights and TOPSIS relative-closeness coefficients. To assess this influence explicitly, a leave-one-benchmark-out sensitivity test is conducted by removing each comparator economy individually and recalculating the complete Entropy-TOPSIS model.

3.2. Criteria and data sources

The main decision matrix contains six benefit criteria.

Table 1. Criteria included in the Entropy-TOPSIS model

Code	Criterion	Measurement	Reference year	Preference
C1	Customs efficiency	LPI component	2023	Benefit
C2	Trade and transport infrastructure	LPI component	2023	Benefit
C3	International shipments	LPI component	2023	Benefit
C4	Logistics competence and quality	LPI component	2023	Benefit
C5	Tracking and tracing	LPI component	2023	Benefit
C6	Timeliness	LPI component	2023	Benefit

The criterion codes introduced in Table 1 are used consistently in the subsequent calculations: C1 – Customs efficiency; C2 – Trade and transport infrastructure; C3 – International shipments; C4 – Logistics competence and quality; C5 – Tracking and tracing; and C6 – Timeliness. All six criteria are treated as benefit criteria.

The LPI observations correspond to the 2023 edition of the World Bank Logistics Performance Index. Although reported as the 2023 LPI, the underlying international survey was conducted from 6 September to 5 November 2022 and generated 4,090 country assessments by 652 logistics professionals (Arvis et al., 2023). The data and methodological documentation used for the final verification of this study were accessed on 16 September 2026. The overall LPI score is not included as an additional criterion because it is derived from the six component

indicators. Its simultaneous inclusion would duplicate the same underlying information.
Physical logistics capacity is analysed separately using container port throughput measured in twenty-foot equivalent units (TEU). The data are obtained from World Development Indicators indicator IS.SHP.GOOD.TU, Container port traffic (TEU: 20 foot equivalent units), sourced by the World Bank from UNCTAD (World Bank, n.d.). The annual series used in the study extends through 2024 and was accessed on 16 September 2026. Container throughput represents the scale of container movements handled by ports but includes international and coastal shipping, empty containers, and transhipment movements. It should therefore be interpreted as a physical port-activity indicator rather than as a direct measure of unique international trade flows.

3.3. Entropy Weight Method

The Entropy Weight Method is used to determine criterion importance according to the informational differentiation contained in the dataset (Shannon, 1948; Stević et al., 2024).
Let the original decision matrix be:

$$X = [x_{ij}]_{m \times n} \quad (1)$$

where x_{ij} represents the value of criterion j for country i, m denotes the number of alternatives, and n denotes the number of criteria.
Because all criteria are benefit criteria, min–max normalisation is applied:

$$y_{ij} = (x_{ij} - min\, x_j) / (max\, x_j - min\, x_j) \quad (2)$$

The normalised observations are converted into proportions:

$$p_{ij} = y_{ij} / \Sigma_{i=1}{}^{m}\, y_{ij} \quad (3)$$

The entropy value for criterion j is:

$$e_j = -k\, \Sigma_{i=1}{}^{m}\, p_{ij}\, ln(p_{ij}) \quad (4)$$

where:

$$k = 1 / ln(m) \quad (5)$$

For observations where $p_{ij} = 0$, the conventional limit:

$$p_{ij}\, ln(p_{ij}) = 0 \quad (6)$$

is applied.
The degree of diversification is:

$$d_j = 1 - e_j \quad (7)$$

The objective criterion weight is:

$$w_j = d_j / \Sigma_{j=1}{}^{n}\, d_j \quad (8)$$

where:

$$\Sigma_{j=1}{}^{n}\, w_j = 1 \quad (9)$$

A criterion exhibiting larger variation among the analysed economies receives a higher objective weight because it provides greater discriminatory information within the sample.
Entropy values, diversification coefficients, and weights were calculated using unrounded observations. Values displayed in the tables are rounded only for presentation purposes.

3.4. TOPSIS procedure

TOPSIS evaluates alternatives according to their relative distances from a positive ideal and a negative ideal solution (Hwang & Yoon, 1981).
Vector normalisation is first performed:

$$r_{ij} = x_{ij} / \sqrt{(\Sigma_{i=1}{}^{m}\, x_{ij}{}^{2})} \quad (10)$$

The weighted normalised matrix is:

$$v_{ij} = w_j r_{ij} \quad (11)$$

For benefit criteria, the positive ideal solution is:

$$A^{+} = \{v_1{}^{+}, v_2{}^{+}, \ldots, v_n{}^{+}\} \quad (12)$$

where:
$v_j{}^{+} = \max_i(v_{ij})$
The negative ideal solution is:

$$A^{-} = \{v_1{}^{-}, v_2{}^{-}, \ldots, v_n{}^{-}\} \quad (13)$$

where:
$v_j{}^{-} = \min_i(v_{ij})$
The distance of alternative i from the positive ideal is:

$$S_i^+ = \sqrt{[\Sigma_{j=1}^{n}(v_{ij} - v_j^+)^2]} \quad (14)$$

The distance from the negative ideal is:

$$S_i^- = \sqrt{[\Sigma_{j=1}^{n}(v_{ij} - v_j^-)^2]} \quad (15)$$

The relative closeness coefficient is:

$$RC_i = S_i^- / (S_i^+ + S_i^-) \quad (16)$$

where:
$0 \leq RC_i \leq 1$.
A higher value indicates that the country lies closer to the positive ideal logistics-performance profile.

3.5. Robustness assessment and computational procedure

Two principal robustness tests are conducted.
First, TOPSIS is recalculated using equal weights rather than Entropy-derived weights:

$$w_j = 1/6 \quad (17)$$

This test determines whether Brazil's relative position depends materially on the objective weighting structure.
Second, the Entropy-TOPSIS ranking is compared with the ordering obtained from overall 2023 LPI scores.
The overall LPI is not used in the principal decision matrix because the purpose of the MCDM procedure is to identify the contribution of individual components. Nevertheless, agreement between the rankings provides an external consistency check.
Third, benchmark-selection sensitivity is assessed using a leave-one-benchmark-out procedure. Mexico, Chile, South Africa, and Türkiye are removed individually from the original benchmark set, and Entropy weights and TOPSIS coefficients are recalculated using the remaining four countries. This test distinguishes sensitivity of the numerical weights and closeness coefficients from stability of Brazil's relative position against the remaining benchmark economies.
The final calculations reported in the revised manuscript were reproduced and verified using a custom JavaScript implementation based on ECMAScript 2023 and executed in a V8 runtime. No external computational libraries were used. All calculations were performed using full-precision values, whereas the tables present rounded values for readability. The procedure relies exclusively on the transformations and formulas specified in Equations (1)–(17). To facilitate independent replication, the vector-normalised matrix R, weighted normalised matrix V, positive and negative ideal solutions, and Entropy values are reported in Appendix A.

3.6. Ethical considerations

The study uses exclusively publicly available, aggregate, country-level secondary data obtained from institutional and governmental sources. No human participants were recruited by the authors, no experiments or interventions involving individuals were conducted, and no personal or identifiable data were collected or processed.
The Logistics Performance Index data used in the analysis are published by the World Bank in aggregated country-level form. Although the underlying World Bank LPI originates from a survey of logistics professionals, the present study does not access individual survey responses or personal respondent information and relies only on the publicly released aggregate indicators. The container-throughput data are likewise publicly available aggregate country-level statistics.
Consequently, institutional ethics approval and individual informed consent were not required for the present secondary-data analysis. The study involved no processing of confidential information and no attempt to identify individual respondents represented in the source datasets.

4. Results and Discussion

4.1. Comparative logistics performance

Overall LPI is reported for descriptive and robustness purposes only and is not included as an additional Entropy-TOPSIS criterion.
Source: Authors' compilation based on the World Bank Logistics Performance Index 2023 (Arvis et al., 2023). The 2023 LPI international survey was conducted from 6 September to 5 November 2022.
South Africa records the strongest logistics-performance profile within the selected benchmark sample and achieves the highest observed value for each of the six components. Türkiye displays the second-strongest profile and also exceeds Brazil across each criterion.

Brazil occupies an intermediate position. Timeliness represents its strongest component at 3.5, followed by logistics competence and quality at 3.3. Infrastructure and tracking and tracing both reach 3.2.

Customs efficiency and international shipments are Brazil's weakest dimensions at 2.9. These results suggest that part of the country's logistics-performance gap occurs at the interface between domestic freight operations and international trade.

Brazil performs more favourably than Mexico. It achieves higher values for customs, infrastructure, international shipments, logistics competence and quality, and tracking and tracing, while both countries record the same timeliness score.

The comparison with Chile is more differentiated. Chile slightly exceeds Brazil in customs efficiency, whereas Brazil achieves higher values in infrastructure, international shipments, logistics competence and quality, tracking and tracing, and timeliness.

The strongest differences are observed in comparison with South Africa and Türkiye. This is particularly relevant for infrastructure and international shipments, which subsequently receive the largest Entropy weights.

4.2. Entropy-derived criterion weights

Infrastructure (C2) receives the highest objective weight, approximately 0.2232. International shipments (C3) follow at 0.2017, tracking and tracing (C5) at 0.1897, and logistics competence and quality (C4) at 0.1717. Timeliness (C6) and customs efficiency (C1) receive lower weights of approximately 0.1088 and 0.1050, respectively.

These values should not be interpreted as a universal theoretical hierarchy of logistics functions. Entropy measures variation within the present sample. A relatively low customs weight therefore means that customs values differentiate the five countries less strongly than infrastructure or international shipments; it does not imply that customs is intrinsically unimportant.

The result provides a direct answer to RQ1. Within the selected sample, infrastructure and international shipments generate the greatest discriminatory information.

This finding has particular relevance for Brazil because both dimensions are areas in which it remains below South Africa and Türkiye.

Table 2. Logistics Performance Index components, 2023

Country	Overall LPI*	C1 Customs	C2 Infrastructure	C3 International shipments	C4 Logistics competence and quality	C5 Tracking and tracing	C6 Timeliness
Brazil	3.2	2.9	3.2	2.9	3.3	3.2	3.5
Mexico	2.9	2.5	2.8	2.8	3.0	3.1	3.5
Chile	3.0	3.0	2.8	2.7	3.1	3.0	3.2
South Africa	3.7	3.3	3.6	3.6	3.8	3.8	3.8
Türkiye	3.4	3.0	3.4	3.4	3.5	3.5	3.6

Table 3. Entropy values and weights of logistics-performance criteria

Criterion	Entropy e_j	Diversification coefficient d_j	Weight w_j	Rank
C1 Customs efficiency	0.839589	0.160411	0.105037	6
C2 Infrastructure	0.659147	0.340853	0.223189	1
C3 International shipments	0.692025	0.307975	0.201661	2
C4 Logistics competence and quality	0.737783	0.262217	0.171699	4
C5 Tracking and tracing	0.710357	0.289643	0.189658	3
C6 Timeliness	0.833910	0.166090	0.108756	5
Total			**1.000000**	

Source: Authors' calculations based on Arvis et al. (2023)

Note: Calculations were performed using unrounded values. The six weights displayed to six decimal places sum to 1.000000.

4.3. TOPSIS assessment of logistics performance

South Africa constitutes the positive ideal within the selected benchmark sample because it records the highest observed value for all six criteria. This result should not be interpreted as meaning that South Africa represents an absolute global logistics optimum. Türkiye ranks second, with $RC_i = 0.7016$.

Brazil occupies the third position, with $RC_i = 0.3629$. It therefore performs substantially below the two strongest benchmark economies but remains above Chile and Mexico.

The result provides an answer to RQ2. Brazil occupies an intermediate logistics-performance position within the analysed group.

The country does not exhibit a uniformly weak logistics profile. Its timeliness result is relatively strong, and its logistics competence and quality exceeds that of Mexico and Chile. Nevertheless, the larger performance gaps in infrastructure, international shipments, tracking and tracing, and customs limit its proximity to the sample-specific positive ideal.

The result also demonstrates the diagnostic value of disaggregating the LPI. The overall country ordering alone indicates that Brazil ranks behind South Africa and Türkiye. The Entropy analysis additionally identifies which dimensions generate the largest cross-country differentiation.

Table 4. Entropy-TOPSIS results

Country	S_i^+	S_i^-	RC_i	Rank
South Africa	0.000000	0.047941	1.0000	1
Türkiye	0.014466	0.034015	0.7016	2
Brazil	0.031538	0.017962	0.3629	3
Chile	0.045611	0.008281	0.1537	4
Mexico	0.044788	0.005663	0.1122	5

Source: Authors' calculations.

Note: Distances S_i^+ and S_i^- are displayed to six decimal places. RC_i values were calculated from the full-precision distances rather than from the rounded values displayed in the table.

4.4. Physical logistics capacity

The logistics-performance ranking is next compared with the physical scale of containerised maritime activity.

The 2024 value reported for Brazil, 13,893,906 TEU, is approximately 19.6% higher than the corresponding 2023 value of 11,613,563 TEU. Given the magnitude of this annual increase, the observation was subjected to an additional plausibility check. Official Brazilian port statistics also reported exceptionally strong container activity in 2024, including approximately 20% year-on-year growth in containerised cargo measured by tonnage (Ministério de Portos e Aeroportos, 2025). The direction and approximate magnitude of the increase are therefore consistent with independent national evidence.

Table 5. Container port throughput, 2024

Country	Container port throughput (TEU)	Throughput rank
Brazil	13,893,906	1
Türkiye	13,507,070	2
Mexico	9,284,170	3
Chile	4,474,125	4
South Africa	4,303,682	5

Source: Authors' compilation from World Bank, World Development Indicators, indicator IS.SHP.GOOD.TU – Container port traffic (TEU: 20 foot equivalent units), based on UNCTAD data; reference period through 2024; accessed 16 September 2026 (World Bank, n.d.).

Nevertheless, the WDI indicator should be interpreted as a measure of port activity rather than unique international cargo flows. According to its metadata, it includes coastal shipping as well as international journeys, empty containers, and transhipment movements, with transhipment containers counted once when unloaded and once when loaded at an intermediate port (World Bank, n.d.).

The ordering differs substantially from the TOPSIS ranking.

Brazil records the highest container throughput within the selected benchmark sample, followed closely by Türkiye. Mexico occupies the third position, while Chile and South Africa handle lower absolute container volumes. This divergence provides the central empirical result of the study. Brazil already handles a physical volume of containerised cargo characteristic of a major international logistics platform. Its third position in the TOPSIS ranking therefore cannot be explained by an absence of freight activity.

Instead, the result indicates that Brazil's institutional and operational logistics performance does not fully correspond to the scale of cargo already moving through its port system. The comparison with Türkiye illustrates the distinction particularly clearly. Both economies handle more than 13 million TEU,

but Türkiye records a substantially higher logistics-performance coefficient.

South Africa illustrates the opposite configuration. It represents the strongest logistics-performance alternative within the sample while recording the lowest container throughput among the five economies. These results demonstrate why throughput and logistics performance should not be treated as synonymous constructs. Throughput measures the scale of cargo-handling activity.

LPI components represent characteristics of the environment through which international logistics is organised. The divergence between the two rankings is therefore analytically meaningful rather than contradictory.

4.5. Interpretation of Brazil's logistics-performance gap

Three findings characterise Brazil's position.

First, Brazil has a substantial containerised cargo base. Its container throughput confirms participation in large-scale maritime freight activity. Second, its logistics-system quality remains intermediate. Brazil performs below South Africa and Türkiye but above Chile and Mexico. Third, several of the criteria providing the strongest differentiation among the analysed economies correspond to areas in which Brazil remains behind the strongest benchmarks.

Infrastructure is the highest-weighted criterion. Brazil records 3.2, compared with 3.6 for South Africa and 3.4 for Türkiye.

International shipments receive the second-highest weight. Brazil records 2.9, compared with 3.6 and 3.4. Tracking and tracing receives the third-highest weight. Brazil records 3.2, compared with 3.8 and 3.5.

Customs receives a lower Entropy weight but remains a relevant absolute weakness. Brazil's customs value of 2.9 is lower than those of South Africa, Türkiye, and Chile.

The evidence therefore identifies a mismatch between existing logistics capacity and realised logistics performance. This provides the answer to RQ3. Brazil's principal relative constraints concern infrastructure quality, international shipment conditions, tracking and tracing, and customs efficiency, while timeliness represents a comparatively stronger component.

The interpretation also changes the nature of the policy problem. Brazil does not need to create international freight activity from a negligible base. A substantial cargo base already exists. The policy challenge is to improve the environment in which these freight flows are processed, connected with inland production systems, monitored, and integrated with international supply chains.

4.6. Alignment with the Brazilian National Logistics Plan 2035

The final substantive stage compares the identified performance gaps with the priorities of PNL 2035.

The comparison reveals different degrees of correspondence between the performance gaps identified empirically and the interventions described in PNL 2035. The strongest direct alignment concerns infrastructure.

PNL 2035 explicitly focuses on the future development and restructuring of Brazil's multimodal transport network. Railway, waterway, road, port, and aviation infrastructure form central components of its planning framework (Empresa de Planejamento e Logística & Ministério da Infraestrutura, 2021). This priority corresponds directly with the present empirical result because infrastructure receives the highest Entropy weight and Brazil remains behind South Africa and Türkiye in this dimension.

A more balanced freight matrix can also reduce dependence on long-distance road transport and provide higher-capacity alternatives on appropriate corridors. The relationship between PNL 2035 and international shipments is more indirect. Infrastructure development, improved inland access to ports, greater modal integration, and potential reductions in freight costs can create more favourable conditions for international shipments. However, the LPI international-shipments dimension also reflects the ability to organise competitively priced international freight services.

Consequently, infrastructure improvement should be interpreted as an enabling condition, not as a direct equivalent of improved international-shipment performance. A similar distinction applies to logistics competence and quality. Improved infrastructure and multimodal capacity can create more favourable operating conditions for logistics providers and potentially stimulate service development. The Plan can therefore influence this dimension indirectly, but improvement cannot be inferred automatically from infrastructure investment.

Table 6. Alignment between identified logistics-performance gaps and PNL 2035

Logistics-performance gap	Empirical evidence	PNL 2035 correspondence	Interpretation	Remaining gap
Infrastructure	Highest Entropy weight; Brazil below South Africa and Türkiye	Rail, waterway, road, port and airport development	Strong direct alignment	Implementation and financing
International shipments	Second-highest Entropy weight	Lower inland transport costs, modal restructuring and improved gateway access	Indirect positive alignment	International shipment organisation and trade procedures extend beyond infrastructure
Logistics competence and quality	Brazil below strongest benchmarks	More diversified and higher-capacity freight system	Enabling rather than direct effect	Service quality depends strongly on logistics operators
Tracking and tracing	Brazil below South Africa and Türkiye	Digital technologies, data processing and technology-related scenarios	Indirect positive alignment	Diffusion, interoperability and implementation
Timeliness	Strongest Brazilian LPI component	Infrastructure improvement combined with modal diversification	Mixed effect	Speed–cost–capacity trade-off
Customs	Brazil below South Africa, Türkiye and Chile	No customs-reform programme of comparable detail identified within PNL 2035	Limited alignment	Significant institutional gap

Source: Authors' synthesis based on empirical results and Empresa de Planejamento e Logística and Ministério da Infraestrutura (2021).

Technology provides a clearer conceptual connection with tracking and tracing. PNL 2035 considers technological change and data-related developments as part of its scenario structure. Digitalisation can potentially improve routing, cargo visibility, asset utilisation, and operational coordination. However, the effect depends on actual implementation, interoperability, data availability, and diffusion across the public and private organisations participating in Brazilian logistics.

Timeliness requires a different interpretation. Brazil already performs comparatively well in this dimension. At the same time, greater use of railways, inland waterways, and coastal shipping can involve trade-offs between transit speed and other system objectives. A slower mode may provide lower unit costs, higher capacity, lower environmental impact, or reduced pressure on road infrastructure. Consequently, transport policy should not be evaluated solely through the maximisation of speed. System-level efficiency involves trade-offs among time, cost, capacity, safety, resilience, and environmental performance.

The weakest correspondence concerns customs. Brazil's customs score remains below those of South Africa, Türkiye, and Chile. However, no customs-reform programme of comparable detail to the transport-infrastructure interventions was identified within PNL 2035. This finding must be interpreted carefully. It does not demonstrate that Brazil lacks customs-modernisation or trade-facilitation policies outside PNL 2035. Rather, it indicates that customs reform lies largely beyond the principal transport-planning scope of PNL 2035. The distinction is important because physical and institutional connectivity are complementary. A new railway can reduce inland transport costs. A larger port can increase handling capacity. Improved inland waterways can reduce pressure on road transport.

None of these measures automatically simplify customs procedures, improve border-management predictability, integrate administrative systems, or reduce procedural delays affecting international trade. The answer to RQ4 is therefore qualified. PNL 2035 demonstrates strong direct alignment with the infrastructure gap. It provides indirect or enabling alignment with international shipments, logistics competence and quality, tracking and multimodal integration.

Its correspondence with customs efficiency is more limited because detailed customs reform falls outside the central transport-planning focus of the Plan. The development of stronger global logistics-hub functions therefore requires coordination between transport-infrastructure policy and complementary trade-facilitation, border-management, digitalisation, and logistics-service policies.

4.7. Robustness analysis

4.7.1.Equal-weight TOPSIS

The first robustness test replaces the Entropy weights with equal weights: $w_j = 1/6$

Table 7. Comparison of Entropy-weighted and equal-weight TOPSIS results

Country	Entropy-TOPSIS RC_i	Rank	Equal-weight TOPSIS RC_i	Rank
South Africa	1.0000	1	1.0000	1
Türkiye	0.7016	2	0.6815	2
Brazil	0.3629	3	0.3842	3
Chile	0.1537	4	0.2427	4
Mexico	0.1122	5	0.1465	5

Source: Authors' calculations.

The equal-weight model produces exactly the same country ordering.

Brazil remains third even when the differences between Entropy-derived criterion weights are removed. The magnitude of its relative closeness coefficient changes from 0.3629 to 0.3842, but the relative position remains stable. This indicates that Brazil's third position is not produced solely by the Entropy weighting procedure.

4.7.2.Comparison with overall LPI

The identical ordinal ranking does not imply that the Entropy-TOPSIS analysis is redundant. The World Bank overall LPI compresses the six logistics dimensions into a single composite measure, whereas the present procedure produces additional diagnostic information about the structure of cross-country differences. In particular, the Entropy weights identify the dimensions that provide the greatest discriminatory information within the selected benchmark set, while TOPSIS expresses each economy's relative distance from the sample-specific positive and negative ideal profiles.

Consequently, the additional insight lies not in producing a different ranking for its own sake but in explaining the structure underlying that ranking. Infrastructure and international shipments emerge as the two most discriminatory dimensions, providing a more specific diagnosis of Brazil's relative weaknesses than its overall LPI score alone. More importantly, the logistics-performance result is subsequently compared with an independent physical-capacity ranking. Brazil is third in both the overall LPI and Entropy-TOPSIS assessments but first in container throughput. This divergence is not observable from the overall LPI ranking itself and constitutes the central performance-capacity gap investigated in the study.

The agreement between the LPI and TOPSIS rankings should therefore be interpreted as evidence of ordinal robustness, while the criterion weights, ideal-solution distances, physical-capacity comparison, and policy mapping provide the additional explanatory contribution.

Table 8. Comparison with the overall 2023 LPI

Country	Overall LPI	Rank byoverall LPI	Entropy-TOPSIS rank
South Africa	3.7	1	1
Türkiye	3.4	2	2
Brazil	3.2	3	3
Chile	3.0	4	4
Mexico	2.9	5	5

Source: Authors' calculations based on Arvis et al. (2023).

4.7.3.Robustness of the principal finding

The two robustness tests confirm the stability of Brazil's relative position.

Brazil occupies third place under Entropy weighting, equal weighting, and the overall LPI ordering. More importantly, the robustness analysis does not alter the second analytical result concerning physical logistics capacity. Brazil remains the largest container-handling economy within the selected benchmark sample while occupying only the third position in logistics-system performance. Consequently, the central finding: a mismatch between physical logistics scale and realised logistics performance, is not an artefact of the Entropy weighting structure.

4.7.4.Sensitivity to benchmark selection

Because Entropy weights depend on cross-country variation, the benchmark composition was tested by removing each comparator economy individually

and recalculating the complete Entropy-TOPSIS model. Table 9 summarises the resulting position of Brazil.

Table 9. Leave-one-benchmark-out sensitivity analysis

Benchmark omitted	Brazil RC_i	Brazil rank in reduced sample	Ordering of retained countries
Mexico	0.2929	3	South Africa > Türkiye > Brazil > Chile
Chile	0.2884	3	South Africa > Türkiye > Brazil > Mexico
South Africa	0.5027	2	Türkiye > Brazil > Chile > Mexico
Türkiye	0.3624	2	South Africa > Brazil > Chile > Mexico

Source: Authors' calculations.

Brazil's relative closeness coefficient ranges from 0.2884 to 0.5027 across the four reduced samples, confirming that numerical Entropy weights and TOPSIS coefficients are conditional on benchmark composition. When Mexico or Chile is omitted, Brazil remains third. When South Africa is omitted, Brazil ranks second behind Türkiye; when Türkiye is omitted, Brazil ranks second behind South Africa. The rank change from third to second therefore occurs only when one of the two higher-performing benchmark economies is removed. Brazil remains below every retained South Africa or Türkiye observation and above every retained Chile or Mexico observation. The leave-one-benchmark-out analysis thus confirms sensitivity of the numerical coefficients to the comparator set while demonstrating stability of Brazil's pairwise position relative to the remaining economies.

5. Conclusions

This study assessed Brazil's potential to develop global logistics-hub functions by distinguishing between national logistics performance and physical logistics capacity. The comparative analysis included Brazil, Mexico, Chile, South Africa, and Türkiye and used the six components of the 2023 World Bank Logistics Performance Index.

The Entropy Weight Method identified infrastructure as the criterion providing the greatest differentiation within the sample. International shipments ranked second, followed by tracking and tracing and logistics competence and quality. The TOPSIS analysis ranked South Africa first, Türkiye second, Brazil third, Chile fourth, and Mexico fifth. Brazil therefore occupies an intermediate logistics-performance position within the selected benchmark sample. The disaggregated analysis demonstrates that Brazil performs comparatively strongly in timeliness and moderately in logistics competence and quality but remains below the strongest benchmark economies in infrastructure, international shipments, tracking and tracing, and customs.

The analysis of physical logistics activity produces a substantially different result. Brazil records the highest container port throughput among the five economies, handling approximately 13.9 million TEU in 2024. This divergence constitutes the principal empirical finding of the study. Brazil already possesses the physical cargo scale associated with a major international logistics platform, but the institutional and operational performance of its logistics system does not yet correspond to that scale. This distinction is important because high freight throughput does not automatically establish global logistics-hub competitiveness. Cargo volume demonstrates the presence of a substantial freight market and transport demand. Competitive hub functions additionally require infrastructure quality, effective customs procedures, competitive shipment organisation, capable logistics providers, shipment visibility, multimodal integration, and reliable delivery.

Brazil's development challenge should therefore be interpreted as one of converting an already substantial logistics base into higher-quality international logistics performance. The comparison with Türkiye illustrates this problem clearly. Both economies handle more than 13 million TEU, but Türkiye obtains a substantially higher TOPSIS coefficient. The assessment of PNL 2035 indicates that Brazilian transport policy is broadly consistent with several of the performance weaknesses identified empirically. The strongest correspondence concerns infrastructure. The Plan's multimodal transport-development priorities address the criterion receiving the highest Entropy weight.

PNL 2035 can also provide enabling conditions for improvements in international shipments, tracking and logistics competence and quality through greater modal integration, infrastructure capacity, and technological development. The correspondence with

customs is weaker. This should not be interpreted as evidence that customs policy is absent in Brazil. Instead, customs reform falls largely outside the principal infrastructure-planning scope of PNL 2035. The results therefore point to the importance of coordination between transport investment and complementary reforms involving customs, border management, trade facilitation, digital information exchange, and logistics services. The robustness analysis strengthens these conclusions. Brazil remains third under Entropy-based weights, equal weights, and the overall LPI ordering.

The fact that the Entropy-TOPSIS ordering coincides with the overall LPI ordering should therefore be interpreted as a robustness result rather than as evidence that the additional analysis is uninformative. The contribution of the procedure lies in decomposing the aggregate logistics position into criterion-specific discriminatory weights and distances from the ideal profile and, crucially, in enabling this diagnostic result to be contrasted with an independent physical-capacity ranking, which places Brazil third in logistics performance but first in container throughput. The leave-one-benchmark-out analysis further shows that numerical weights and coefficients are sensitive to benchmark composition, while Brazil's pairwise position relative to each retained comparator remains unchanged.

The observed mismatch between physical cargo scale and logistics-system performance is therefore not dependent on the weighting procedure selected for the principal model. Overall, the study identifies substantial but incomplete logistics-hub potential in Brazil. Under the operational definition adopted in this study, Brazil demonstrates a strong physical basis for hub functions but only intermediate institutional and operational logistics performance relative to the benchmark group. Its potential therefore depends on reducing this gap rather than on cargo scale alone. Brazil possesses substantial physical scale, trade activity, market potential, maritime access, and opportunities for infrastructure development. However, further improvements in infrastructure, international shipment organisation, customs efficiency, digital integration, logistics-service capability, and multimodal connectivity are necessary if these structural advantages are to translate into stronger global logistics competitiveness.

5.1. Theoretical and methodological contribution

The study contributes to logistics-performance research by explicitly separating physical logistics scale from logistics-system quality.

Cross-country logistics-performance research frequently concentrates on composite performance indicators, whereas infrastructure and port research often emphasises freight volumes, network capacity, or throughput. The present framework demonstrates that these perspectives can generate different assessments of the same economy. Brazil represents a clear case: it leads the benchmark sample in container throughput but occupies only the third position in the logistics-performance ranking.

Entropy weighting and TOPSIS are established methods; the methodological contribution of their use here lies in decomposing aggregate logistics performance into criterion-specific discriminatory weights and distances from sample-specific ideal profiles. By keeping physical throughput outside the composite index and comparing it only after logistics performance has been assessed, the framework avoids allowing country scale to dominate the ranking. This two-layer design identifies a logistics performance–capacity gap that cannot be observed from the overall LPI ranking alone.

5.2. Managerial and policy implications

For policymakers, the results indicate that infrastructure investment remains necessary but is not sufficient. Additional railway, waterway, port, and intermodal capacity can reduce transport costs, improve accessibility, and strengthen cargo-handling capability. However, the economic effect of such infrastructure can be constrained if customs procedures, shipment organisation, information exchange, and logistics services remain less efficient. The findings therefore support stronger coordination between transport policy and international trade facilitation.

Customs modernisation, administrative simplification, digital information exchange, predictable border clearance, and coordination between public authorities can complement physical infrastructure investment. For port and infrastructure managers, Brazil's substantial existing cargo base implies that incremental efficiency improvements can affect large freight volumes. Better hinterland access, rail-port integration, terminal productivity, digital cargo

management, and coordination between transport modes can therefore produce substantial system-level effects.

For logistics service providers, Brazil combines a large market with significant geographical and infrastructural diversity. Service strategies should account for differences between regions, ports, corridors, and modal alternatives rather than treating Brazil as a homogeneous logistics environment. For international investors and supply-chain managers, the findings suggest that Brazil should not be evaluated solely through market size. Location decisions should additionally consider customs exposure, access to individual ports, inland transport connections, logistics-service capability, digital visibility, and available modal alternatives.

5.3. Limitations

Several limitations should be considered when interpreting the results.

First, the comparative sample consists of five economies selected purposively to provide structurally differentiated benchmarks rather than statistical representation of all economies. Entropy weights and TOPSIS coefficients are therefore conditional on the selected alternatives. The leave-one-benchmark-out analysis confirms numerical sensitivity: Brazil's relative closeness coefficient ranges from 0.2884 to 0.5027 across the reduced samples. However, its pairwise position remains stable: Brazil stays below any retained South Africa or Türkiye observation and above any retained Chile or Mexico observation. Accordingly, the numerical weights and coefficients should not be generalised beyond the present benchmark set.

Second, the principal multi-criteria model uses survey-based LPI data and therefore contains a perception component.

Third, physical logistics capacity is represented primarily through container throughput. This indicator does not capture the full structure of dry bulk, liquid bulk, air cargo, railway freight, inland waterway freight, or domestic intermodal transportation. Moreover, the WDI container indicator includes international and coastal shipping, empty units, and transhipment movements and therefore should not be interpreted as a measure of unique international trade flows.

Fourth, LPI observations are published as the 2023 edition but are based on a survey conducted in September–November 2022, whereas container throughput refers to 2024. This introduces temporal inconsistency between the two analytical layers.

Fifth, PNL 2035 is evaluated through planned interventions and scenarios rather than realised outcomes. Correspondence between a policy plan and an identified performance gap does not guarantee effective implementation or measurable improvement.

Sixth, Brazil is treated as a single national unit. National averages conceal substantial differences among states, ports, production regions, and transport corridors.

Finally, the Entropy procedure determines weights according to variation within the sample rather than according to universal theoretical importance. Consequently, the weights should not be generalised outside the analysed country group without further testing.

5.4. Future research

Future studies could expand the country sample to include additional emerging economies and established global logistics hubs. A broader benchmark would allow the stability of both the Entropy weights and Brazil's relative position to be examined more rigorously.

Future research could also incorporate additional objective indicators of physical logistics connectivity where internationally comparable data are available. Potential variables include vessel calls, direct maritime connections, railway freight activity, port-hinterland accessibility, air cargo, inland-waterway freight, and intermodal terminal capacity. A subnational analysis would be particularly valuable for Brazil. National-level averages can conceal major differences between port regions, transport corridors, industrial areas, and agricultural hinterlands.

Applying MCDM or spatial-analysis techniques to major Brazilian maritime gateways could identify locations with the strongest potential to perform specialised international logistics-hub functions. Longitudinal analysis also offers an important direction. Repeating the assessment as PNL 2035 projects are implemented would allow changes in physical transport capacity to be compared with subsequent changes in infrastructure quality, international shipments, customs efficiency, and overall logistics performance.

Finally, the conceptual distinction between physical logistics capacity and realised logistics performance

could be tested in other large emerging economies. Such research could determine whether the mismatch identified for Brazil is country-specific or represents a broader feature of large freight markets undergoing infrastructural and institutional transformation.

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References

1. Arvis, J.-F., Ojala, L., Shepherd, B., Ulybina, D., & Wiederer, C. (2023). *Connecting to compete 2023: Trade logistics in an uncertain global economy – The Logistics Performance Index and its indicators*. World Bank. https://lpi.worldbank.org/sites/default/files/2023-04/LPI_2023_report_with_layout.pdf. Accessed September 16, 2026.
2. Bugarčić, F. Ž., Stanišić, N., & Marinković, V. (2024). Assessing the effects of logistics performance on export and competitiveness using SEM methodology: Evidence from firm-level data. *The International Journal of Logistics Management, 35*(6), 1847–1866. https://doi.org/10.1108/IJLM-07-2023-0289
3. Costa, W., Soares-Filho, B., & Nóbrega, R. (2022). Can the Brazilian National Logistics Plan induce port competitiveness by reshaping the port service areas? Sustainability, 14(21), 14567. https://doi.org/10.3390/su142114567
4. da Costa, G. A. A., Mendes, A. B., & da Cruz, J. P. G. (2025). Brazilian maritime containerized cabotage competitiveness assessment based on a multimodal super network. *Journal of Transport Geography, 122*, 104062. https://doi.org/10.1016/j.jtrangeo.2024.104062
5. Delfín-Ortega, O. (2025). Maritime logistics and economic growth in the context of APEC: A two-stage data envelopment analysis study. *Journal of Shipping and Trade, 10*, Article 2. https://doi.org/10.1186/s41072-024-00191-y
6. Empresa de Planejamento e Logística & Ministério da Infraestrutura. (2021). *Plano Nacional de Logística 2035*. Brasília, Brazil. https://www.gov.br/transportes/pt-br/assuntos/planejamento-integrado-de-transportes/politica-e-planejamento/RelatorioExecutivoPNL_2035final.pdf. Accessed September 16, 2026.
7. Gani, A. (2017). The logistics performance effect in international trade. *The Asian Journal of Shipping and Logistics, 33*(4), 279–288. https://doi.org/10.1016/j.ajsl.2017.12.012
8. Haralambides, H. (2023). The state-of-play in maritime economics and logistics research (2017–2023). *Maritime Economics & Logistics, 25*, 429–451. https://doi.org/10.1057/s41278-023-00265-x
9. Hwang, C.-L., & Yoon, K. (1981). *Multiple attribute decision making: Methods and applications: A state-of-the-art survey*. Springer-Verlag.
10. Kara, K., Yalçın, G. C., Özekenci, E. K., Simic, V., Bentyn, Z., Kazancoglu, Y., & Pamucar, D. (2026). Green innovation performance assessment in European Countries: A quartile-based decision support framework. *Technology in Society*, 89, 103543. https://doi.org/10.1016/j.techsoc.2026.103543
11. Martí, L., Martín, J. C., & Puertas, R. (2017). A DEA-logistics performance index. *Journal of Applied Economics, 20*(1), 169–192. https://doi.org/10.1016/S1514-0326(17)30008-9
12. Martí, L., Puertas, R., & García, L. (2014). The importance of the Logistics Performance Index in international trade. *Applied Economics, 46*(24), 2982–2992. https://doi.org/10.1080/00036846.2014.916394
13. Martínez-Moya, J., Vanelslander, T., Feo-Valero, M., & Debón, A. (2025). Transhipment port competitiveness assessment: The importance of port location. *WMU Journal of Maritime Affairs, 24*, 179–199. https://doi.org/10.1007/s13437-025-00372-x
14. Ministério de Portos e Aeroportos. (2025, February 18). *Portos brasileiros registram maior movimentação da história com 1,32 bilhão de toneladas em 2024*. Governo Federal do Brasil. https://www.gov.br/portos-e-aeroportos/pt-br/assuntos/noticias/2025/02/portos-brasileiros-registram-maior-movimentacao-da-historia-com-132-bilhao-de-toneladas-em-2024. Accessed September 16, 2026.

15. Nayak, N., Pant, P., Sarmah, S. P., & Tulshan, R. (2024). Development of in-country logistics performance index for emerging economies: A case of Indian states. *International Journal of Productivity and Performance Management, 73*(9), 2926–2950. https://doi.org/10.1108/IJPPM-03-2023-0122
16. Pehlivan, P., Aslan, A. I., David, S., & Bacalum, S. (2024). Determination of logistics performance of G20 countries using quantitative decision-making techniques. *Sustainability, 16*(5), 1852. https://doi.org/10.3390/su16051852
17. Rezaei, J., van Roekel, W. S., & Tavasszy, L. (2018). Measuring the relative importance of the logistics performance index indicators using Best Worst Method. *Transport Policy, 68*, 158–169. https://doi.org/10.1016/j.tranpol.2018.05.007
18. See, K. F., Guo, Y., & Yu, M.-M. (2024). Enhancing logistics performance measurement: An effectiveness-based hierarchical data envelopment analysis approach. *INFOR: Information Systems and Operational Research, 62*(3), 449–479. https://doi.org/10.1080/03155986.2024.2309420
19. Shannon, C. E. (1948). A mathematical theory of communication. *The Bell System Technical Journal, 27*, 379–423, 623–656. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x
20. Stević, Ž., Ersoy, N., Başar, E. E., & Baydaş, M. (2024). Addressing the global Logistics Performance Index rankings with methodological insights and an innovative decision support framework. *Applied Sciences, 14*(22), 10334. https://doi.org/10.3390/app142210334
21. Wang, Z., Martha, G. B., Jr., Liu, J., Lima, C. Z., & Hertel, T. W. (2024). Planned expansion of transportation infrastructure in Brazil has implications for the pattern of agricultural production and carbon emissions. *Science of the Total Environment, 928*, 172434. https://doi.org/10.1016/j.scitotenv.2024.172434
22. World Bank. (n.d.). *World Development Indicators: Container port traffic (TEU: 20 foot equivalent units), indicator IS.SHP.GOOD.TU*. Data source: United Nations Conference on Trade and Development (UNCTAD). https://databank.worldbank.org/metadataglossary/world-development-indicators/series/IS.SHP.GOOD.TU. Accessed September 16, 2026.
23. Zaninović, P. A., & Bugarčić, F. Ž. (2023). The effects of international logistics in global value chain trade. *Journal of Business Economics and Management, 24*(5), 841–856. https://doi.org/10.3846/jbem.2023.20443

Appendix A. Intermediate matrices for reproducibility

The following matrices report the intermediate results used in the Entropy-TOPSIS calculations. Values are displayed to six decimal places, whereas calculations were performed using full-precision values.

Table A1. Vector-normalised TOPSIS matrix R

Country	C1	C2	C3	C4	C5	C6
Brazil	0.439444	0.450570	0.418318	0.440235	0.429385	0.443999
Mexico	0.378831	0.394249	0.403893	0.400214	0.415967	0.443999
Chile	0.454598	0.394249	0.389468	0.413554	0.402549	0.405942
South Africa	0.500057	0.506891	0.519291	0.506937	0.509895	0.482057
Türkiye	0.454598	0.478731	0.490441	0.466916	0.469640	0.456685

Table A2. Weighted normalised TOPSIS matrix V

Country	C1	C2	C3	C4	C5	C6
Brazil	0.046158	0.100562	0.084358	0.075588	0.081436	0.048287
Mexico	0.039791	0.087992	0.081450	0.068716	0.078891	0.048287
Chile	0.047750	0.087992	0.078541	0.071007	0.076346	0.044148
South Africa	0.052525	0.113133	0.104721	0.087041	0.096705	0.052426
Türkiye	0.047750	0.106848	0.098903	0.080169	0.089071	0.049667

Positive ideal solution
A^{+} = {0.052525; 0.113133; 0.104721; 0.087041; 0.096705; 0.052426}

Negative ideal solution
A^{-} = {0.039791; 0.087992; 0.078541; 0.068716; 0.076346; 0.044148}
The resulting distances and relative closeness coefficients are reported in Table 4. Because all displayed matrix elements are rounded to six decimal places, direct recalculation from the printed Appendix may generate differences in the final decimal place. The reported RC_i values are based on the full-precision computational matrix.