Spatial analysis of multimodal connectivity in Mexico to identify strategic states for nearshoring

Analyse spatiale de la connectivité multimodale au Mexique pour identifier les états stratégiques en vue du nearshoring

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ABSTRACT: Nearshoring is a strategic approach that allows companies to establish operations close to their consumer markets, offering a key opportunity for Mexico given its geographic location, skilled workforce, and trade agreements with North America. This strategy helps businesses reduce costs, improve supply chain resilience, and enhance operational efficiency by relocating production or services to closer locations. Infrastructure plays a crucial role in nearshoring, as efficient connectivity between roads, railways, ports, airports, and intermodal terminals is essential for logistics and transportation. This research evaluates multimodal connectivity in Mexico using geographic information systems (GIS) to identify the states best positioned for nearshoring operations. The methodology consists of two stages: the first includes a comprehensive literature review and data collection, while the second focuses on spatial data analysis by applying the concepts of location, distribution, accessibility, and spatial association. The results determine multimodal connectivity levels across Mexican states and identify those with the highest potential, advantages, or challenges for nearshoring development and investment.

KEY WORDS: Nearshoring, multimodal freight transport, spatial analysis, connectivity, geographic information systems.

RÉSUMÉ: Le nearshoring permet aux entreprises d’implanter leurs opérations près de leurs marchés, offrant au Mexique une opportunité stratégique grâce à sa position géographique, sa main-d'œuvre qualifiée et ses accords commerciaux avec l’Amérique du Nord. Cette approche réduit les coûts, améliore la résilience de la chaîne d’approvisionnement et optimise l’efficacité opérationnelle.

L’infrastructure est clé, car une connectivité efficace entre routes, chemins de fer, ports, aéroports et terminaux intermodaux est essentielle pour la logistique. Cette étude évalue la connectivité multimodale au Mexique via les systèmes d’information géographique (SIG) pour identifier les États les mieux positionnés pour le nearshoring.

La méthodologie comprend une revue de la littérature et une collecte de données, suivies d’une analyse spatiale basée sur la localisation, la distribution, l’accessibilité et l’association spatiale. Les résultats révèlent les niveaux de connectivité multimodale des États mexicains et identifient ceux ayant le plus fort potentiel ou les défis à relever pour attirer des investissements en nearshoring.

MOTS CLÉS: Nearshoring, transport de fret multimodal, analyse spatiale, connectivité, systèmes d'information géographique.

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1. Introduction

Multimodal transportation in Mexico plays a key role in the country's logistics efficiency and economic development by integrating various modes of transport, including road, rail, maritime, and air. Its importance lies in reducing costs, delivery times, and environmental impact, while optimizing the movement of goods both domestically and internationally. Furthermore, multimodal transportation is economically significant, as it facilitates connections between Mexico's production centers and international markets, particularly in North America and Asia (Bank of Mexico, 2024). Consequently, a well-developed multimodal infrastructure is essential for attracting foreign investment, enhancing supply chain efficiency, and positioning Mexico as a strategic hub for global trade, leveraging commercial strategies such as nearshoring.

Nearshoring is a business strategy that enables companies to establish operations closer to their consumer markets. In recent years, it has become a key driver of economic growth, foreign direct investment, and, consequently, national competitiveness (Vásquez, 2024). This trend has been largely driven by the effects of the COVID-19 pandemic on global trade, as restrictions on the movement of people and goods exposed vulnerabilities in global supply chains and underscored the importance of geographic proximity, leading to productive relocation strategies (Van Hassel et al., 2022).

With the growing interest in nearshoring, countries aiming to attract investment in this area must consider fundamental factors such as transportation infrastructure to meet the demands of freight movement. At this point, multimodal freight transport, which involves the movement of goods using at least two different modes of transportation (such as road, rail, maritime, and air) under a single contract covering the journey from origin to final destination, becomes a critical element in the success of this economic strategy (Colfecar, 2014).

Bravo (2006) asserts that multimodal transport is not only a modern expression of logistics but also an efficient approach adapted to new market requirements for moving goods between origin and destination. Thus, it can be regarded as one of the pillars of nearshoring.

For multimodal transport to be efficient, it must be well-connected, meaning that transportation infrastructure and facilities must be accessible and integrated. This integration reduces costs and transit times, enhances business competitiveness, and facilitates access to both domestic and international markets (Castro et al., 2015; Rivera, 2009).

Recent research in this area has pursued various objectives, such as identifying the country's strengths and weaknesses for this business strategy and analyzing its impact on economic growth in the short, medium, and long term (Cedillo et al., 2024); examining the relationship between nearshoring growth, wage disparities with the Asian market, and trade conflicts between the United States and China (Vásquez, 2024; Santillán et al., 2024); investigating socioeconomic factors influencing nearshoring (IMCO, 2023); and assessing its potential environmental impact (Lara & Li, 2024; Cruz, 2024).

Multimodal connectivity can be analyzed from a spatial perspective using tools such as Geographic Information Systems (GIS), which allow for the integration, manipulation, visualization, and representation of large volumes of spatially referenced data (Olaya, 2020). Additionally, GIS tools enable the application of various analytical methods and techniques to determine the location, distribution, association, interaction, and spatial evolution of physical processes and human activities that impact the territory (Buzai, 2015). Given their analytical potential, these tools have proven valuable for studying freight transportation systems, as demonstrated by research on zoning systems for freight transportation planning (Chandra et al., 2020), critical freight corridors (Machado & Kaisar, 2024), connectivity patterns of international multimodal hubs (Zhang et al., 2023), and GIS modeling of multimodal road networks (Kotikov, 2017).

The objective of this research is to evaluate multimodal connectivity in Mexico using Geographic Information Systems (GIS) to identify the states best positioned for implementing nearshoring operations.

2. Study area

In this study, an analysis of Mexico was conducted, considering all its federal entities. Nearshoring presents a key opportunity for the country due to its geographic location, which provides proximity to the North American market and has attracted interest from companies, primarily from China, that have reduced exports to the U.S. following government policies implemented over the past five years. Additionally, trade agreements such as the USMCA, which serves as a regulatory framework for trade relations between Mexico, the United States, and Canada, facilitate cooperation and the exchange of goods and services with the North American market, strengthening Mexico's position as a potential nearshoring hub (Vásquez, 2024; Glover, 2024).

Mexico consists of 32 federal entities, shares borders with the United States to the north and Belize and Guatemala to the south, and has a continental area of 1,960,190 km², making it the sixth-largest country in the Americas and the fourteenth-largest in the world. Its Exclusive Economic Zone spans 3,149,920 km², encompassing islands and territorial waters, along with a continental shelf of 10,570 km². In 2020, Mexico's population exceeded 126 million (INEGI, 2020). Currently, it ranks as the third most competitive economy in Latin America, behind only Chile and Puerto Rico (Melo, 2024).

3. Methods

This study employs a quantitative analysis of infrastructure and facilities for multimodal freight transport in Mexico, using various spatial analysis tools to assess the country's multimodal connectivity conditions. The research was conducted in two stages: the first involved a comprehensive literature review and extensive data collection, while the second focused on spatial data analysis, applying the concepts of location, distribution, accessibility, and spatial association with the support of Geographic Information Systems (GIS). These systems have become essential analytical tools, as they enable the storage, manipulation, analysis, visualization, and representation of data tied to specific geographic locations.

3.1. Literature Review and Data Collection

During the literature review, the most recent studies on nearshoring in Mexico were identified, along with the factors analyzed in each (Vásquez, 2024; IMCO, 2024; Silva, 2024; Ramos, 2014). Data collection involved gathering information on key infrastructure and facilities for freight transport from official institutions, including the Mexican Institute of Transportation, the Secretariat of Infrastructure, Communications, and Transportation, the National Institute of Statistics and Geography, the Railway Transport Regulatory Agency, and the Federal Civil Aviation Agency.

The geospatial data used included the road network, freight rail network, cargo airports, maritime freight ports, border ports, and intermodal terminals at the national level, as well as polygons representing federal entities. All data were downloaded in vector shapefile format, as detailed in Table 1.

Table 1 Data used.

Data	Year	Source
Road Network	2023	Mexican Institute of Transportation (IMT)
Railway Network		Railway Transport Regulatory Agency (ARTF)
Border Ports		
Ports	2024	Secretariat of Infrastructure, Communications and Transportation (SICT)
Intermodal Terminals		
Airports		Federal Civil Aviation Agency (AFAC)

3.2 Spatial Analysis

The second stage involved spatial data analysis, applying the concepts of location, distribution, and spatial association (Buzai, 2015). The analysis was conducted using QGIS version 3.28, a geographic information system.

In the location analysis, it was necessary to validate the position of each facility and infrastructure element obtained from various institutions, as well as to update certain data layers by digitizing missing infrastructure.

For spatial distribution, vector analysis tools provided by the software were used to examine both point facilities (cargo ports and airports, intermodal terminals, and border ports) and linear infrastructure (the road and freight rail networks). This allowed for the determination of the number of freight transport modes present in each state. First, the Count Points in Polygon tool was used to calculate the number of point facilities within each state polygon. This algorithm takes a layer of points (facilities) and a layer of polygons (states) and counts the number of points in each polygon, generating a new polygon layer with an additional field containing the corresponding point count. For linear data, the Sum Line Length tool was applied to obtain the total number and length of linear elements by state. This algorithm processes a polygon layer and a line layer, measuring the total length of the lines and the total number of lines that intersect each polygon. The resulting layer retains the original polygon objects but includes two additional attributes indicating line length and count per polygon.

The spatial association analysis focused on two aspects: the connectivity of facilities to road and rail networks and the overall connectivity level by state. The connectivity of road and rail infrastructure to existing freight transport facilities was assessed by generating buffer zones. This algorithm defines an influence area around all objects in an input layer using a fixed distance of 500 meters, following CONEVAL's recommendation for very high accessibility to the road network (CONEVAL, 2018). Additionally, a spatial query using the Intersects geometric predicate was performed to identify elements lacking connectivity, allowing for the calculation of the percentage of facilities connected to road and/or rail infrastructure in each state.

To determine the connectivity level by state, a standardization process was applied to the following attributes: number of transport modes, number of ports, number of airports, number of border ports, number of intermodal terminals, road length, railway length, and connectivity percentage. Standardization was performed using the Z-score method to ensure values were expressed in the same units (Buzai et al., 2012), calculated using the following formula:

$$Z = \frac{x - \mu}{\sigma}$$

where *x* is the observed value, μ is the mean of the data, and σ is the standard deviation of the data set.

Once the variables were standardized, the sum of the Z-score values for each analyzed attribute was calculated. It is important to note that no weighting was applied to either the modes of transportation or the infrastructure components, as this study assigns equal importance to each attribute due to their collective significance in the broader nearshoring context. Consequently, the analysis does not target any specific industry, acknowledging that each sector has unique requirements and that the dynamics of intermodal transport vary accordingly. This analysis is intended to provide a baseline for subsequent research focused on particular industrial sectors.

4. Results and discussion

The results can be divided into two parts: the first presents the outcomes of applying the concepts of location and spatial distribution, while the second focuses on the spatial association of the analyzed elements, which were ultimately used to determine the connectivity level of each state.

4.1. Location and spatial distribution of key infrastructure for multimodal transport in Mexico

Due to its geographical location, Mexico’s multimodal transportation system comprises land, maritime, and air transport. The land transport network includes an extensive system of paved roads, railways, intermodal terminals, and border ports. Maritime transport is facilitated through cargo ports, while air transport relies on a network of airports handling cargo operations.

During the spatial analysis stage, specifically regarding the location and spatial distribution of data, the main infrastructure and facilities for freight transport were identified. These include cargo ports and airports, intermodal terminals, border ports, the road network, and the railway network across the country.

Mexico has a road network that connects all federal entities, consisting of 51,020 km of federal highways, 133,228 km of state highways, and 144,535 km of rural roads used for transporting goods (SICT, 2023). The state with the longest road and highway network is Chihuahua, followed by Sonora and Veracruz. However, in terms of road density per 100 km^2, the entities with the highest density are Mexico City, Morelos, and the State of Mexico, while Campeche, Baja California Sur, and Coahuila have the lowest density.

The freight railway system spans 23,389 km and is operated by seven assignee and concessionary companies across 29 states. The states with the longest railway networks are Sonora and Chihuahua, while those with the highest rail density per 100 km^2 are Tlaxcala and Mexico City. In contrast, Baja California Sur, Guerrero, and Quintana Roo lack rail infrastructure.

A total of 86 intermodal terminals were identified, serving as facilities that enable the interaction of different modes of transport. These terminals are distributed across 22 states, with the highest concentration in the State of Mexico, followed by Tamaulipas and Nuevo León. In contrast, Tlaxcala, Morelos, Nayarit, Zacatecas, Campeche, and Guerrero do not have such facilities.

Additionally, seven border ports handle the highest volume of goods: Tijuana and Mexicali in Baja California, Nogales in Sonora, Ciudad Juárez in Chihuahua, Piedras Negras in Coahuila, and Nuevo Laredo and Matamoros in Tamaulipas.

Maritime transportation plays a crucial role in Mexico's multimodal system by facilitating the movement of goods through maritime routes. The cargo port system consists of 16 commercial ports located in 12 of the 17 coastal states. These ports include:

- Pacific Coast: Ensenada (Baja California); Pichilingue and La Paz (Baja California Sur); Guaymas (Sonora); Topolobampo and Mazatlán (Sinaloa); Manzanillo (Colima); Lázaro Cárdenas (Michoacán).
- Gulf of Mexico and Caribbean: Salina Cruz (Oaxaca); Chiapas (Chiapas); Progreso (Yucatán); Chiltepec and Dos Bocas (Tabasco); Coatzacoalcos, Veracruz, and Tuxpan (Veracruz); Altamira and Tampico (Tamaulipas).

Finally, air cargo transportation in Mexico relies on a network of airports that facilitate the efficient movement of goods. Fifteen main cargo airports are considered, primarily located in the central and northern parts of the country. The airport handling the highest cargo volume is Felipe Ángeles International Airport, located in the State of Mexico, followed by Mexico City International Airport, Guadalajara, and Monterrey (SICT, 2024).

Figure 1 and Figure 2 show the distribution of existing facilities and infrastructure for multimodal freight transport in Mexico.

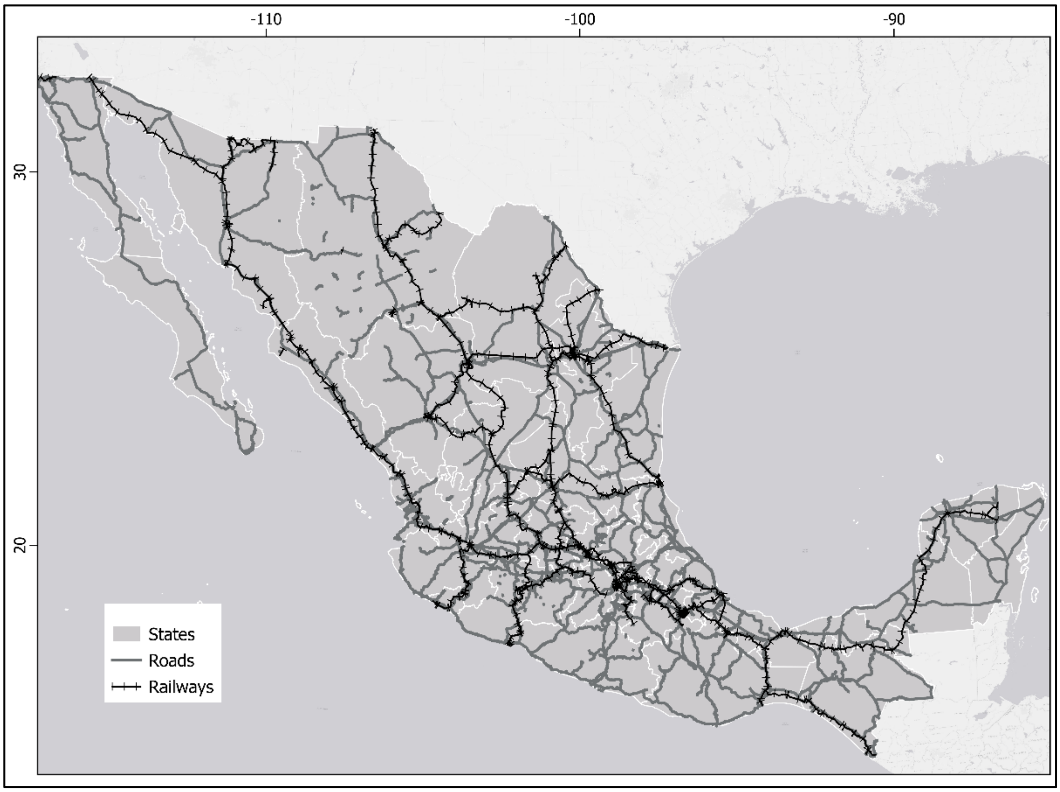

Figure 1 Infrastructure for multimodal freight transport in Mexico. (Source: Secretariat of Infrastructure, Communications, and Transportation, SICT 2024).

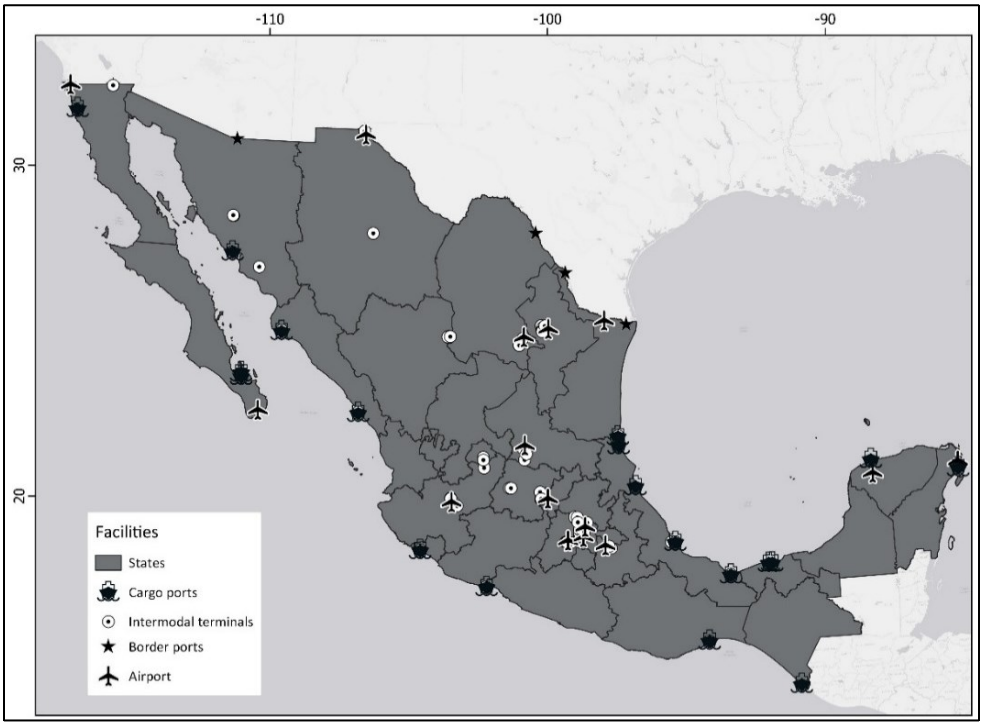

Figure 2 Facilities and infrastructure for multimodal freight transport in Mexico. (Source: Secretariat of Infrastructure, Communications, and Transportation, SICT 2024).

4.2. Spatial Association

The results of the spatial association analysis highlight five key aspects: (1) the modes of freight transport available in each state, (2) the number of multimodal transport facilities per state, (3) Road density, (4) Rail density, and (5) the connectivity level of each state based on the analyzed elements. The cartographic analysis helped identify the states with the greatest nearshoring potential, as well as those with the most significant deficiencies for these practices.

4.2.1. Freight Transport Modes by States

Only three states have the capability to transport goods using all four modes of transport—road, rail, maritime, and air: Baja California and Tamaulipas, both located on the United States border, and Yucatán, in the southwest of the country.

Of the 32 federal entities, 19 (nearly 60%) have three out of the four modes. Northern border states such as Chihuahua, Coahuila, and Nuevo León, as well as central states like Jalisco, San Luis Potosí, Querétaro, the State of Mexico, Mexico City, and Puebla, have road, rail, and air transport. In the south, Chiapas, Oaxaca, and Tabasco; in the east, Veracruz; in the west, Michoacán and Colima; and in the northwest, Sonora and Sinaloa, are characterized by road, rail, and maritime transport. Meanwhile, Quintana Roo and Baja California Sur rely on port, road, and air transport.

Approximately 28% of the states have only two transport modes, specifically road and rail. These include, in the northwest, Durango, Zacatecas, Nayarit, and Aguascalientes; in the central region, Guanajuato, Hidalgo, Morelos, and Tlaxcala; and in the southeast, Campeche.

Finally, it is notable that Guerrero is the only state with only road transport, highlighting a significant deficiency in meeting freight transport demand. Figure 3 illustrates these findings.

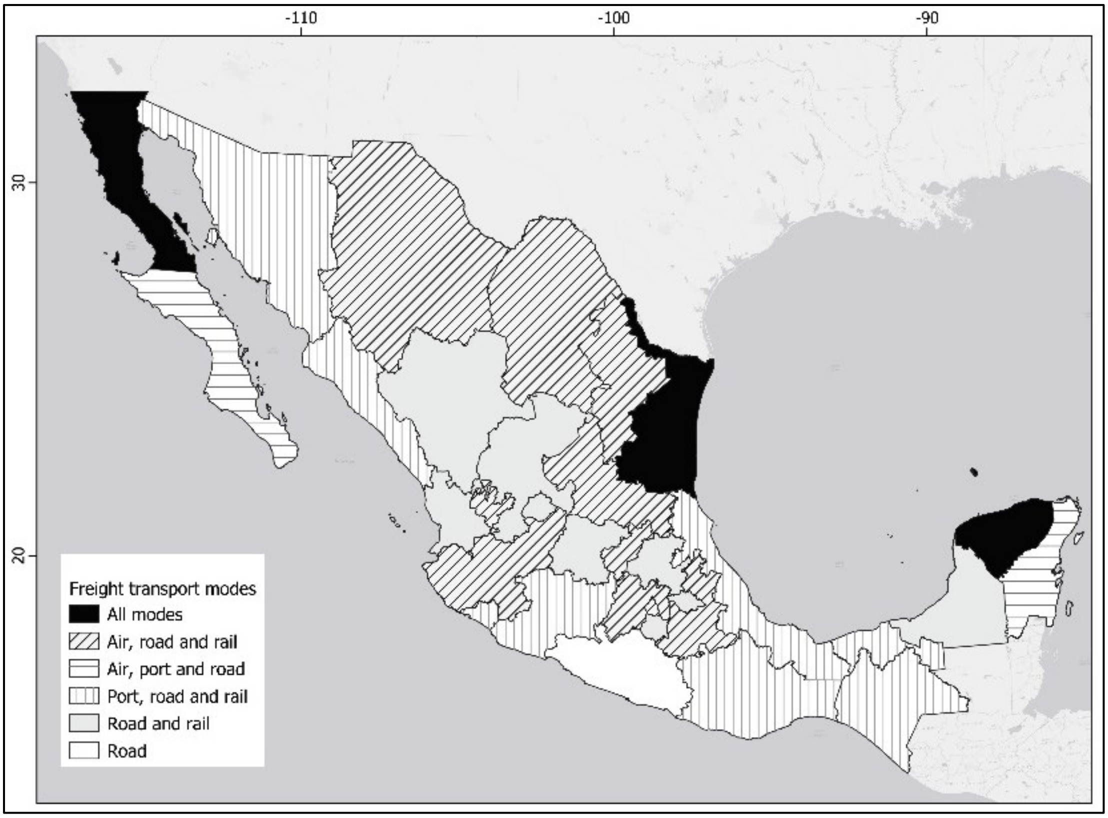

Figure 3 Freight transport modes by state. Source: Own elaboration.

4.2.2. Number of Facilities for Multimodal Freight Transport

The facilities considered in this analysis include cargo ports, border ports, cargo airports, and intermodal terminals, as these are essential components of an efficient multimodal transport system. Well-connected infrastructure plays a crucial role in optimizing logistics operations, reducing transportation costs, and enhancing trade competitiveness at both national and international levels. The integration of these facilities ensures seamless freight movement across different modes of transport, strengthening supply chains and facilitating economic growth.

According to the results, Tamaulipas, Nuevo León, Veracruz, and the State of Mexico have the highest number of multimodal transport facilities, underscoring their strategic role as logistical hubs. These states benefit from well-developed transport infrastructure, enabling them to efficiently handle high volumes of goods and support key industries such as manufacturing, trade, and exports. Maintaining and further improving their multimodal connectivity is essential to sustaining their competitive advantage and reinforcing their position within national and global supply chains.

In contrast, Nayarit, Zacatecas, Guerrero, Morelos, Tlaxcala, Chiapas, and Campeche have the fewest multimodal transport facilities, limiting their capacity to integrate into major logistics networks. This lack of infrastructure creates significant challenges, including higher transportation costs, longer delivery times, and reduced accessibility to key markets. As a result, businesses in these states may face logistical inefficiencies that hinder their economic growth and attractiveness for investment. Addressing these deficiencies through targeted infrastructure development and policy support is crucial for promoting regional equity and fostering broader economic integration.

Figure 4 illustrates these findings, providing a spatial representation of the distribution of multimodal transport facilities across the country.

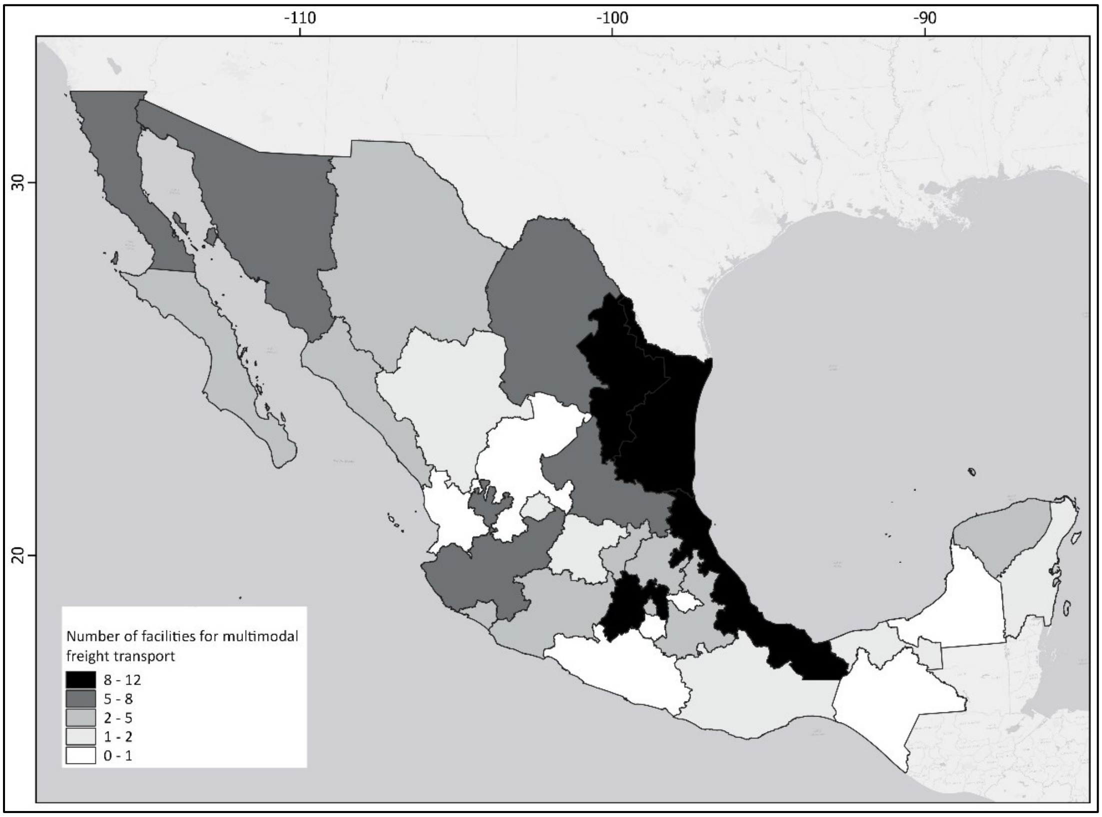

Figure 4 Number of facilities for multimodal freight transport. Source: Own elaboration.

4.2.3. Multimodal Connectivity

The results indicate that all the facilities analyzed are connected to the national road infrastructure, a crucial factor for economic development and competitiveness. As noted by Cedillo et al. (2024), the road network is one of the primary determinants of a state's potential for nearshoring. This is reflected in the significant reliance on road transport for freight movement. According to the Secretariat of Infrastructure, Communications, and Transportation, more than 80% of goods in Mexico are transported by road, underscoring the critical role of this infrastructure in logistics and supply chain efficiency.

In terms of rail connectivity, some cargo ports lack full integration with the railway network, which may limit their logistical efficiency. These include the ports of Ensenada (Baja California), Pichilingue and La Paz (Baja California Sur), Tuxpan (Veracruz), Dos Bocas and Chiltepec (Tabasco), and Puerto Morelos (Quintana Roo). The absence of direct rail connections in these locations may increase transportation costs and transit times, affecting their competitiveness in multimodal freight transport.

Identifying the location and distribution of transport infrastructure provides a comprehensive understanding of each state's strengths and weaknesses in addressing the challenges posed by nearshoring. States with well-integrated multimodal facilities are better positioned to attract investment and optimize trade flows, while those with infrastructure gaps may face logistical disadvantages.

Regarding the states with the greatest potential for nearshoring, the Mexican Institute for Competitiveness (IMCO, 2023) highlights Nuevo León, Coahuila, and Aguascalientes as key locations. The findings of this research align with Nuevo León’s potential; however, they do not fully correspond with the other two states, as the results indicate that Coahuila and Aguascalientes have only a medium level of multimodal connectivity. This discrepancy suggests an opportunity for further investigation and targeted infrastructure improvements to enhance their positioning within nearshoring strategies.

This represents a critical area of opportunity, emphasizing the need to improve port connectivity and strengthen multimodal transport networks to support economic growth and trade competitiveness. Figure 5 illustrates these findings.

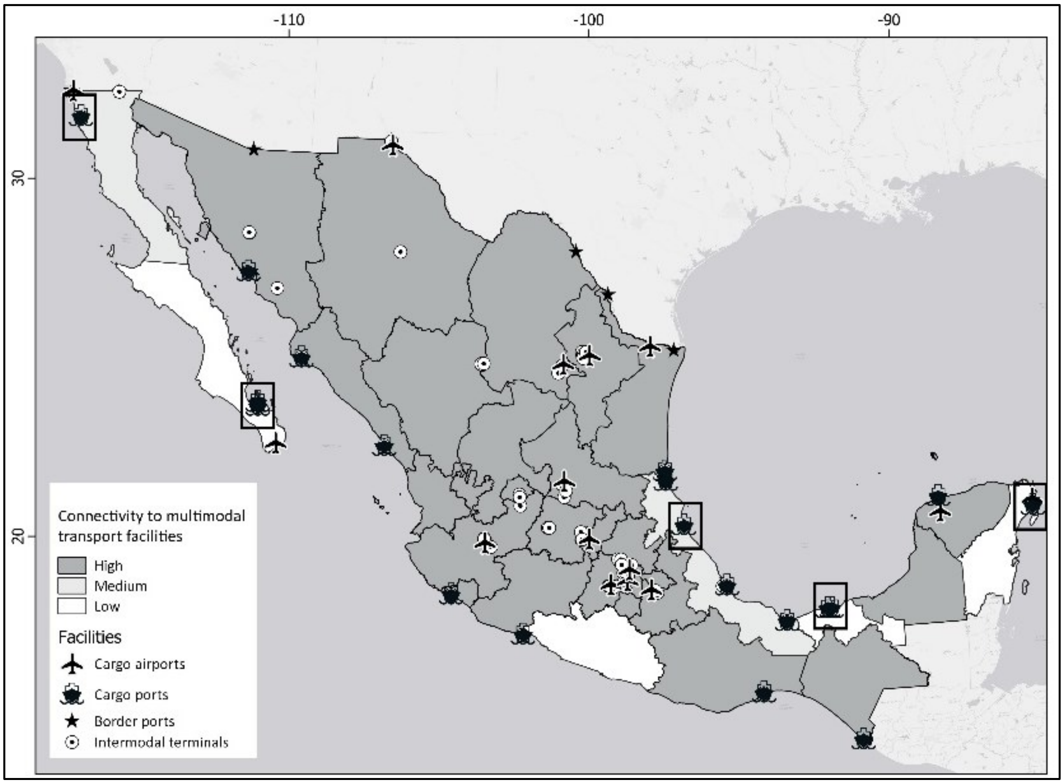

Figure 5 Multimodal connectivity. Source: Own elaboration.

The z-scores for each of the indicators analyzed by entity served as the basis for obtaining a final value, which was subsequently classified into connectivity levels, see Table 2.

Table 2 Z-scores of the indicators calculated by entity.

Entity	Modes	Facilities	Connectivity	Road density	Rail density
Aguascalientes	-1.13	-0.59	0.40	0.33	0.79
Baja California	1.89	0.84	-0.02	-0.68	-1.00
Baja California Sur	0.38	-0.30	-2.64	-0.78	-1.16
Campeche	-1.13	-1.16	0.40	-0.75	-0.67
Coahuila de Zaragoza	0.38	1.12	0.40	-0.80	-0.44
Colima	0.38	-0.02	0.40	0.47	0.92
Chiapas	0.38	-0.87	0.40	-0.26	-0.62
Chihuahua	0.38	0.27	0.40	-0.66	-0.65
Ciudad de México	0.38	-0.30	0.40	4.52	1.74
Durango	-1.13	-0.59	0.40	-0.67	-0.73
Guanajuato	-1.13	-0.59	0.40	0.17	0.70
Guerrero	-2.65	-1.16	-2.64	-0.27	-1.16
Hidalgo	-1.13	-0.02	0.40	0.65	1.00
Jalisco	0.38	1.12	0.40	-0.21	-0.52
México	0.38	2.26	0.40	1.14	1.57
Michoacán de Ocampo	0.38	-0.30	0.40	-0.11	-0.11
Morelos	-1.13	-1.16	0.40	1.49	0.32
Nayarit	-1.13	-1.16	0.40	-0.35	-0.26
Nuevo León	0.38	1.98	0.40	-0.40	-0.11
Oaxaca	0.38	-0.59	0.40	-0.47	-0.82
Puebla	0.38	-0.30	0.40	0.20	-0.23
Querétaro	0.38	-0.02	0.40	0.21	1.28
Quintana Roo	0.38	-0.59	-2.64	-0.75	-1.16
San Luis Potosí	0.38	0.55	0.40	-0.53	0.09
Sinaloa	0.38	-0.02	0.40	-0.46	0.10
Sonora	0.38	1.12	0.40	-0.66	-0.46
Tabasco	0.38	-0.59	-2.64	-0.33	-0.30
Tamaulipas	1.89	1.98	0.40	-0.41	-0.53
Tlaxcala	-1.13	-1.16	0.40	1.09	3.53
Veracruz de Ignacio de la Llave	0.38	1.69	0.10	0.07	-0.02
Yucatán	1.89	-0.30	0.40	-0.30	-0.56
Zacatecas	-1.13	-1.16	0.40	-0.49	-0.53

Source: Own elaboration.

The final connectivity value for each entity, derived from the z-scores of each indicator, enabled the determination of each entity's position according to its connectivity level, as presented in Table 3.

Table 3 Sum of z-scores calculated by entity.

Entidad	Sum of z-scores
Ciudad de México	6.74
México	5.75
Tamaulipas	3.33
Tlaxcala	2.73
Querétaro	2.25
Nuevo León	2.24
Veracruz de Ignacio de la Llave	2.22
Colima	2.16
Jalisco	1.18
Yucatán	1.13
Baja California	1.02
Hidalgo	0.91
San Luis Potosí	0.89
Sonora	0.78
Coahuila de Zaragoza	0.67
Puebla	0.44
Sinaloa	0.40
Michoacán de Ocampo	0.26
Morelos	-0.08
Aguascalientes	-0.20
Chihuahua	-0.26
Guanajuato	-0.45
Chiapas	-0.98
Oaxaca	-1.10
Nayarit	-2.49
Durango	-2.72
Zacatecas	-2.90
Campeche	-3.31
Tabasco	-3.47
Baja California Sur	-4.50
Quintana Roo	-4.76
Guerrero	-7.87

Source: Own elaboration.

Five connectivity levels were determined based on the sum of standardized values: very high, high, medium, low, and very low. The results indicate that 25% of the states have very high or high connectivity, while 50% fall into the medium category. The remaining 25% exhibit low to very low connectivity levels, highlighting significant disparities in multimodal transport infrastructure across the country. Table 4 and Figure 6 illustrate these findings.

Table 4 Connectivity level.

Connectivity level	Percentaje	States
Very High	6%	Mexico City and the State of Mexico
High	19%	Nuevo León, Tamaulipas, Veracruz, Querétaro, Tlaxcala, and Colima
Medium	50%	Baja California, Sonora, Chihuahua, Coahuila, Sinaloa, San Luis Potosí, Aguascalientes, Jalisco, Guanajuato, Michoacán, Morelos, Puebla, Hidalgo, Oaxaca, Chiapas, and Yucatán.
Low	22%	Baja California Sur, Durango, Zacatecas, Nayarit, Tabasco, Campeche, and Quintana Roo.
Very Low	3%	Guerrero

Source: Own elaboration

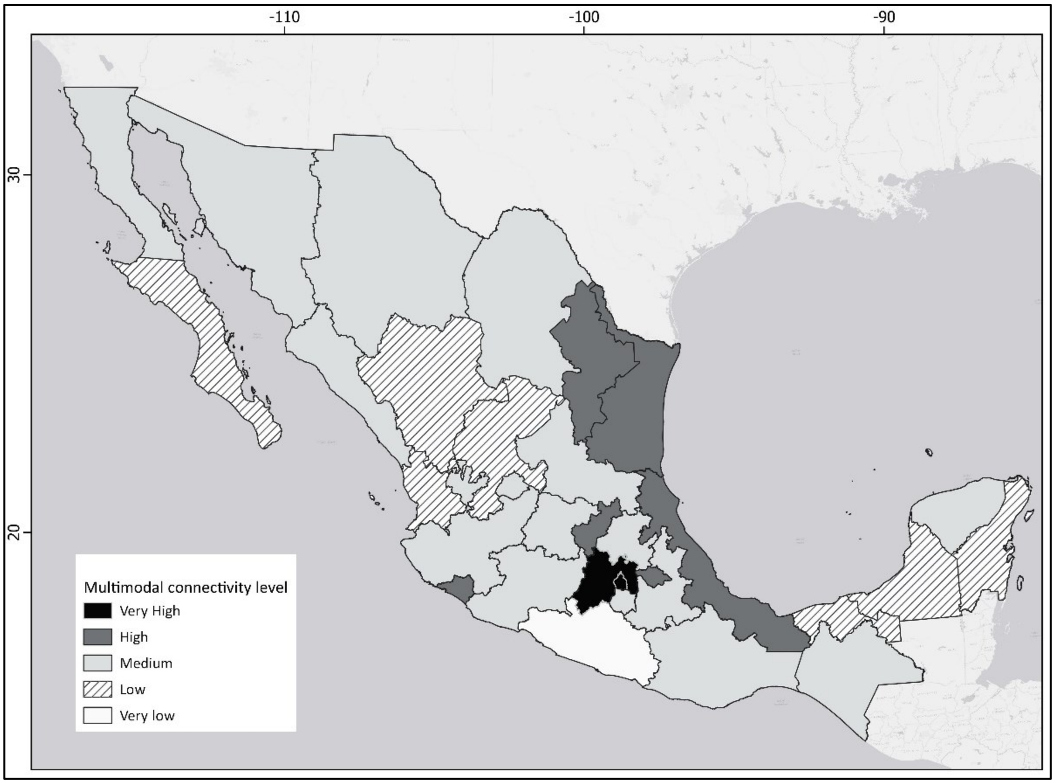

Figure 6 Multimodal connectivity level by state. Source: Own elaboration.

The findings of this research confirm that Guerrero is one of the states facing the greatest logistical challenges, as previously identified by the Mexican Institute for Competitiveness (IMCO, 2023) and USMF & Schneider (2023). However, the results differ regarding Veracruz and Oaxaca; in this study, these states exhibit high and medium connectivity levels, respectively, whereas the aforementioned studies classify them among the states with the most significant logistical deficiencies. Additionally, the results regarding states with the greatest challenges align with findings published by the Inter-American Development Bank (IDB, 2022), which confirms that the southern-southeastern region of Mexico is at a disadvantage and underscores the need to integrate this area into global supply chains.

Several states that receive significant foreign direct investment (FDI), according to the 2023 report by the Secretariat of Economy (SE, 2023), correspond to those with the best multimodal connectivity. Although FDI was not explicitly analyzed in this study, the results help confirm which states possess the greatest strengths for nearshoring, as well as those that lack the necessary infrastructure to support these operations effectively.

The results obtained are based on the year 2024, reflecting Mexico's overall multimodal connectivity conditions for each of its states, which can generally be considered good. However, in 2025, trade tensions and the protectionist policies promoted by the current U.S. president, who foresees the possibility of new unilateral tariff measures despite the existence of a free trade agreement, could impact the country's competitiveness.

The potential imposition of tariffs on Mexican steel and aluminum presents risks and uncertainties that may discourage foreign direct investment in Mexico and, consequently, hinder nearshoring. Therefore, stability in trade policies and bilateral cooperation will be crucial for the country to establish itself as a reliable destination for nearshoring and global logistics.

5. Conclusion

This research distinguishes itself from previous studies by incorporating spatial analysis concepts—such as location, distribution, and spatial association. This was made possible through the use of Geographic Information Systems (GIS), which enable the operationalization of geographic principles by storing, processing, analyzing, and visualizing spatial data related to multimodal transportation in Mexico. This approach provides a spatially integrated and comprehensive perspective on the sector, demonstrating the feasibility of applying spatial analysis principles to the multimodal transportation system. As a result, it generates valuable insights that build upon prior research while leveraging geographic information technologies.

Undoubtedly, nearshoring represents a significant opportunity to enhance Mexico's competitiveness. The country's strategic geographic location and trade agreements offer distinct advantages that can position Mexico as a key international logistics hub with high potential for this business strategy. However, optimizing the multimodal transportation system is crucial for nearshoring success. A well-integrated road network and efficient multimodal connectivity are essential for ensuring the effective movement of goods and strengthening supply chains.

To address the persistent logistical challenges in states like Guerrero, it is essential to prioritize investment in transportation infrastructure—particularly road, rail, and port systems—through targeted federal funding and public-private partnerships. Simultaneously, revisiting and updating existing regional logistics assessments is necessary to ensure they reflect current conditions and support evidence-based decision-making. In this context, promoting the use of spatial indicators and geographic analysis is key to capturing territorial heterogeneity with greater precision.

The findings of this study can serve as a foundation for more in-depth analyses at the regional or city level, or even within specific industrial sectors. For example, the automotive industry in Mexico's Bajío region—which includes the states of Guanajuato, Querétaro, San Luis Potosí, and Aguascalientes—could be explored further. Future studies are encouraged to incorporate additional criteria or apply weighting to the attributes analyzed across various transportation modes and infrastructure components, in order to refine the assessments presented here. These results may complement existing research on multimodal transportation and nearshoring in Mexico, contributing to a more holistic and comprehensive understanding of the logistics potential of each region or state.

References

Bank of Mexico (2024). Imports and Exports by Country. https://www.economia.gob.mx/datamexico/es/profile/geo/mexico?tradeCountryInegiBanxico=banxicoOption. Last Accessed: September 23, 2024.

Bravo, M. (2006). Analysis of the challenges in the implementation of multimodal transport in Colombia. [Monograph]. Universidad Tecnológica de Bolívar, Faculty of Economic and Administrative Sciences, Cartagena D.T y C.

Buzai, G. (2015). Fundamental concepts of spatial analysis supporting scientific research based on geotechnologies. In Geography, Geotechnology, and Spatial Analysis: Trends, Methods, and Applications (1st ed.). Santiago de Chile: Editorial Triángulo.

Buzai, G., & Baxendale, C. (2012). Socio-spatial analysis with Geographic Information Systems. Territorial Planning: Vector-Based Themes. Buenos Aires: Lugar Editorial.

Castro, M., & Delgado, L. (2015). Multimodal connectivity strategies as support for cluster initiatives in Valle del Cauca. Fundación Universitaria Católica Lumen Gentium.

Cedillo, M., Pérez, C., & Martner, C. (2024). Considerations for strengthening the transportation system in the face of Nearshoring. Mexican Institute of Transportation.

Chandra, A., Pani, A., & Sahu, P. (2020). Designing Zoning Systems for Freight Transportation Planning: A GIS-based approach for Automated Zone Design using Public Data Sources. Transportation Research Procedia, 48, 605–619. https://doi.org/10.1016/j.trpro.2020.08.063

Colfecar. (2014). Multimodality: How does it affect road freight transport? Retrieved on July 13, 2017, from the Economic Studies Unit of Colfecar: http://www.colfecar.org.co/ESTUDIOS%20ECONOMICOS%20PDF/Informes%20Especiales/2015/2.%20FEBRERO%202015_INFORME%20Multimodalidad%20y%20transporte%20de%20carga%20por%20carretera.pdf. Last Accessed: September 23, 2024.

Cruz, I. (2024). Nearshoring's Environmental and Social Impacts and the Need for Trade Reform. Baker Institute. https://www.bakerinstitute.org/research/nearshorings-environmental-and-social-impacts-and-need-trade-reform. Last Accessed: September 5, 2024.

Federal Civil Aviation Agency, AFAC. (2024). Operational Statistics of Airports. https://www.gob.mx/afac. Last Accessed: October 23, 2024.

Glover, A. (2024). Nearshoring: An Opportunity that is Mexico's to Lose. Wilson Center. https://www.wilsoncenter.org/article/nearshoring-opportunity-mexicos-lose. Last Accessed: October 28, 2024.

Inter-American Development Bank (IDB). (2022). IDB joins forces with Mexico to promote nearshoring. https://www.iadb.org/en/news/idb-joins-forces-mexico-promote-nearshoring#:~:text=MEXICO%20CITY%20%E2%80%93%20The%20Inter%2DAmerican,the%20country's%20south%2Dsoutheastern%20states. Last Accessed: August 15, 2024.

Kotikov, J. (2017). GIS-Modeling of Multimodal Complex Road Networks and Their Traffic Organization. Transportation Research Procedia, 20, 340-346. https://doi.org/10.1016/j.trpro.2017.01.043

Lara, M., & Li, J. (2024). Mexico: Emissions and Sources of Greenhouse Gases. https://www.bbvaresearch.com/wp-content/uploads/2024/01/2024-Emisiones-y-fuentes-GEI-Mexico.pdf. Last Accessed: October 28, 2024.

Machado, A., & Kaisar, E. (2024). Spatial Decision Support Systems for Study Critical Freight Corridors. *IFAC PapersOnLine* 58-10, 81–86. 10.1016/j.ifacol.2024.07.322

Melo, M. (2024). The most competitive economies in Latin America. Statista. Available at: https://es.statista.com/grafico/19668/paises-latinoamericanos-con-mayor-indice-de-competitividad/. Last Accessed: October 25, 2024.

Mexican Institute for Competitiveness, IMCO. (2023). Nearshoring: A challenge and an opportunity for Mexican states.

Mexican Institute of Transportation, IMT. (2023). National road network. https://www.gob.mx/imt/acciones-y-programas/red-nacional-de-caminos. Last Accessed: September 5, 2024.

National Council for the Evaluation of Social Development Policy, CONEVAL. (2018). Degree of accessibility to paved roads. https://www.coneval.org.mx/Medicion/MP/Documents/Accesibilidad_carretera/Documento_metodologico.pdf. Last Accessed: November 23, 2024.

National Institute of Statistics and Geography, INEGI. (2020). Population and Housing Census 2020. https://www.inegi.org.mx/programas/ccpv/2020/ January 23, 2025].

Olaya, V. (2020). Geographic Information Systems. Last Accessed: November 23, 2024 https://volaya.github.io/libro-sig/

Railway Transport Regulatory Agency, ARTF. (2023). Cargo services. https://datos.gob.mx/busca/dataset/servicio-de-carga-1-0. Last Accessed: September 5, 2024.

Ramos, M. (2014). Multimodal transport as a facilitator of Sonora's economic integration in globalization. [Master's Thesis]. Graduate Program in Economic Integration. Universidad de Sonora.

Rivera, F. (2009). Multimodal transport: New challenges for international trade and regional integration. Department of Studies, Outreach, and Publications, National Library of Congress of Chile.

Santillán, I., Ceja, J., & Pineda, D. (2024). Practical Strategies for Mexico's Economic Development: The Nearshoring Trend. Mercados y Negocios, (52), 109-130. https://doi.org/10.32870/myn.vi52.7727

Secretariat of Economy, SE. (2023). Foreign direct investment in Mexico. https://www.gob.mx/se/acciones-y-programas/competitividad-y-normatividad-inversion-extranjera-directa?state=published. Last Accessed: October 25, 2024.

Secretariat of Infrastructure, Communications, and Transportation (2024). Transport Infrastructure. https://www.gob.mx/sct. Last Accessed: August 8, 2024.

Silva, S. (2024). The impact of nearshoring in Mexico: Challenges and opportunities. Ciencia, 75(2), 15-20. https://amc.edu.mx/el-impacto-del-nearshoring-en-mexico/ Last Accessed: October 25, 2024.

USMF & Schneider. (2023). Perspectives on the Mexico-United States Cross-Border Market. https://schneider.com/resources. Last Accessed: September 8, 2024.

Van Hassel, E., Vanelslander, T., Neyens, K., Vandeborre, H., Kindt, D., & Kellens, S. (2022). Reconsidering nearshoring to avoid global crisis impacts: Application and calculation of the total cost of ownership for specific scenarios. Research in Transportation Economics, 93(C), 2-11. https://doi.org/10.1016/j.retrec.2021.101089

Vásquez, B. (2024). Nearshoring investment in Mexico explained by the wage gap with China. Análisis Económico, XXXIX (101), 23-41. https://doi.org/10.24275/uam/azc/dcsh/ae/2024v39n101/Vasquez

Zhang, X., Liu, C., Peng, Y., & Lu, J. (2023). Connectivity-based spatial patterns and factors influencing international container multimodal hubs in China under the Belt and Road initiative. Transport Policy, 143, 10-24. https://doi.org/10.1016/j.tranpol.2023.09.006