

A comparative analysis of port connectivity index of transshipment ports in Caribbean Sea and Central America (CACM) region

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ABSTRACT

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Significant research gaps persist in the field of international trade and logistics, particularly in understanding how countries in regions such as the Caribbean and Central America have optimized their capabilities to enhance port connectivity with leading global ports, positioning themselves as crucial participants in global supply chains. This study delves into the examination of global connectivity indexes for transshipment seaports in the Caribbean Sea and Central America (CACM) region, specifically focusing on Puerto Rico, Cuba, and the Dominican Republic. The study's findings reveal that all Caribbean ports assessed exhibit the United States within the top ten countries with the highest port connectivity index. Notable rankings include Panama (.425), Jamaica (.364), Dominican Republic (.361), Bahamas (.338), and Costa Rica (.307). In the case of Colombia, the data indicates that the United States holds the third position in the port connectivity index (.382), trailing behind Panama (.405) and Mexico (.388). Moreover, the analysis highlights that transshipment ports in the Dominican Republic, Cuba, and Costa Rica have not achieved significant connectivity levels with ports in thriving economies of Southeast Asia, including China, Hong Kong, South Korea, and Singapore. These Southeast Asian ports are prominent in both the port connectivity index and global port trade. A comparative analysis establishes that traditional transshipment hubs like the Bahamas and Jamaica have experienced challenges due to the growth of the Panama port, the expansion of maritime connections at the Cartagena port, and the integration of the Dominican Republic port into the global maritime routes spanning Central America.

Keywords: Port Connectivity, Transshipment, port performance indicator.

Introduction

The growth of international trade, the interconnectedness of countries' economic activities, and global goods distribution systems necessitate the development of robust port logistics capabilities. This development relies on the establishment of modern infrastructures and administrative processes in each country, enabling the global linkage of local ports with intricate, geographically dispersed, and flexible maritime supply chains that demand advanced port logistics (Rodrigue, 2012). Previous studies by Nogué-Algueró (2019), Notteboom and Haralambides (2021), Munim and Schramm (2018), Rodrigue and Notteboom (2020), and Talley (2017) emphasize that the most competitive countries in the current global economy have strategically fostered port activities with positive socio-economic effects, including GDP and employment growth, as well as an expansion of maritime trade. Furthermore, port activity plays a pivotal role in global supply chain integration, acting as a gateway to globalization, a facilitator of trade between port regions, and a connection point for the country (Sanchez & Wilmsmeier, 2010). It

adds value through economic activities, port-related businesses, innovation, research, and development clusters within emerging global industries (Merck, 2013).

In recent years, there has been an escalating interest in each country's need to develop top-tier port infrastructure, equipped to handle freight efficiently and swiftly. This is crucial for establishing and integrating into the global maritime routes of leading economies, thereby enhancing competitiveness (Wilmsmeier & Monios, 2016; Miller & Hyodo, 2021). However, significant research gaps exist in the field of international trade and logistics, particularly in understanding how countries in regions such as the Caribbean and Central America have maximized their capacity to handle the latest generation of container ships, restructure for greater institutional efficiency, and effectively respond to the evolving global market.

In the case of Caribbean countries, observers have noted unique challenges due to their relatively small and open specialized economies, heavily dependent on maritime transportation for foreign goods trade. They import a significant proportion of consumer goods, relying on local production that, in turn, depends on imports of raw materials and unfinished parts (Harding & Hoffmann, 2003). The regional trade and local economies have long relied on seaborne international trade for income, driven by exports of agricultural products and extractive industries, and the purchase of consumer goods with capital accrued from commodity exports (Sarriera et al., 2013). Academic discussions persist on the most effective strategies to enhance global port route interconnectivity in Central American and Caribbean countries, considering challenges such as fragmented economic development, the need for foreign direct investment in supply chain components, underdeveloped integrated logistics systems, and the fragmentation of different transport modes hindering efficiency. Historically, research on global transshipment ports in the Caribbean has highlighted concentration within the "Caribbean transshipment triangle" formed by Freeport, Colon, and Port of Spain, with limited growth outside this triangle (Harding & Hoffmann, 2003; Miller & Hyodo, 2021; Rodrigue, 2012; Sanchez & Wilmsmeier, 2010). Responding to challenges and aiming to integrate into international trade, Caribbean and Central American countries-initiated efforts in 2000 to increase transshipment activities within the global maritime transportation network. From 2010 onwards, new transshipment seaports were planned and constructed in Punta Caucedo, Dominican Republic, the Moin area, Costa Rica, Mariel in Cuba, and the Port of the Americas in Guayanilla, Puerto Rico (Harding & Hoffman, 2003). Previous research suggests that these new facilities would enhance the region's transshipment port supply, diversify options, and boost competitiveness in the global economy.

Yet, academic research has not adequately addressed the new realities of strategic development for transshipment ports in the Caribbean Sea and Central America (CACM) region. Specifically, there is a lack of research on the level of connectivity of new transshipment ports within global shipping routes, the countries and economic regions with which these ports have established maritime routes, making them integral to global trade, and the port infrastructure developed over the past two decades. This research aims to fill these gaps by assessing the competitive capabilities and interconnectivity established within the global logistics network of eight Caribbean transshipment seaports, including Punta Caucedo in the Dominican Republic (14), Moín in Costa Rica (16), Mariel in Cuba (38), Port of the Americas in Puerto Rico (N/A), compared with traditional leading ports such as Puerto Colon in Panama (1), Cartagena, Colombia (4), Kingston in Jamaica (9), and Freeport in the Bahamas (12) (Miller & Hyodo, 2021). The study will delve into analyzing the connectivity levels achieved by these ports and their interactions with the main ports of global economies.

Objectives

This study endeavors to scrutinize the evolution of seaports in the Caribbean Sea region, with a particular focus on port connectivity and transshipment. Its specific objectives are to address the following topics:

1. Compile the global connectivity indexes for transshipment seaports in the Caribbean Sea and Central America (CACM) region, specifically focusing on Puerto Rico, Cuba, and the Dominican Republic.
2. Provide a comprehensive description and comparative analysis of the port connectivity indexes associated with transshipment seaports in the Caribbean Sea and Central America (CACM) region.

Justification

In recent years, there is a pressing need for a more in-depth quantitative analysis of transshipment port development in the Caribbean Sea and Central America (CACM) region. As highlighted in prior research by Pinnock and Ajaguana (2011), the absence of renewed trade facilitation measures—encompassing physical infrastructure, land use planning, logistics corridor establishment, and regulatory frameworks to simplify procedures—poses a risk of the region being excluded from the self-reinforcing networks of production and trade. Despite this, the literature is marked by a scarcity of empirical studies evaluating the achieved level of port connectivity and integration into global maritime routes for both traditional transshipment ports like Colon in Panama, Freeport in the Bahamas, Kingston in Jamaica, and emerging ports such as Moin in Costa Rica, Caucedo in the Dominican Republic, Mariel in Cuba, Las Americas proposed in Puerto Rico, and the port of Cartagena, Colombia. Importantly, there is a notable gap in research regarding the cases of the Dominican Republic, Puerto Rico, and Cuba, with no comparative analysis against other port powers in the Caribbean, including Panama, Colombia, Jamaica, Bahamas, and Costa Rica.

Methodology

Previous studies, exemplified by Merck's (2013) "The Competitiveness of Global Port-Cities: Synthesis Report," have demonstrated a tendency for universities in port cities to focus their research on seaports, particularly from a local port efficiency perspective, with a predominant emphasis on ports or container terminals. This conventional academic approach, while insightful, has often overlooked crucial relationships. The comparative study of port evolution across eight countries with transshipment ports in the Caribbean Sea and Central America (CACM) opens new avenues for identifying significant dynamics, as underscored by Cuervo et al. (2016). Our research aims to add layers of complexity by conducting a qualitative exploratory study, updating, consolidating, and enriching the analysis of port capacities in the CACM region. This goes beyond describing port infrastructures to explore, for the first time, the interconnectivity lines developed by this region within global maritime routes.

The process of secondary data collection commenced with researching and compiling statistical and descriptive data on seaports from sources such as the Economic Commission for Latin America and the Caribbean (ECLAC) database, providing the port activity report of

container throughput for 31 countries and 118 port and port zones. Additional data sources include the port performance indicator (PPI), the liner shipping bilateral connectivity index (LSBCI Index) published by the United Nations Conference on Trade and Development (UNCTAD), and logistics development indicators from the World Bank (2020). The data was classified according to the conceptual model developed for this research, facilitating a comparative analysis of the infrastructural state of transshipment ports, along with their advantages, disadvantages, and challenges.

The subsequent sections are organized as follows: the theoretical background is presented in the next section, followed by the literature review in Section 3. Section 4 delves into the data and empirical results, and Section 5 provides the conclusion.

Theoretical Background

The theoretical framework of this qualitative research combines the three leading indicators for defining the characteristics, strengths, weaknesses, and competitive conditions of seaports at the global level: Port performance indicator (PPI), Liner shipping bilateral connectivity index (LSBCI Index) published by UNCTAD and logistics development indicators developed by the World Bank. It also included performance parameters defined in the Port Dwell Time (D.T.), the Geographical location, and Maritime Connectivity. For this article, we have brought us to contextualize these identified indicators through a qualitative exploratory study highlighting the confrontation of these indicators in the Caribbean Sea and Central America (CACM) context.

Port Performance Indicator (PPI)

The port performance indicators (PPI) are mostly crucially used for measuring port performance and were identified through industry best practices and the broad areas of literature on port and shipping, logistic and supply chain management (SCM) and strategic management (Ha & Yang, 2017). The PPI index measures the performance of a port by monitoring activities, checking their efficiency, and comparing current performance with past performance (Shetty & Dwarakish, 2018; Ouariti & Jebrane, 2020; Notteboom & Haralambides, 2021) and weight of indicators to measure various aspects of a seaport's performance that vary depending on location, throughput volumes, nature of cargoes, port infrastructure, equipment, and port facilities (Talley, 2017). This indicator requires a set of metrics related to vessel dwell time, cargo volumes, berthing area, port depth, storage quality, and inland transportation (Kahuina & Tetsuro, 2022).

Liner Shipping Bilateral Connectivity Index (LSBCI Index, 2018)

The United Nations Conference on Trade and Development (UNCTAD) has published the Liner Shipping Connectivity Index (LSCI or LSBCI) at the country level since 2004. Developed to assess the quality of maritime connections between pairs of countries and how well a country links to the global shipping networks (Fugazza & Hoffmann, 2017; UNCTAD, 2021). According to Sarriera et al. (2013) LSBIC index number, with which the highest index in 2004 is equal to 100, contains five elements: 1) the number of transshipments required to get from a country A to country B; 2) the number of standard direct connections in both countries A and B; 3) the number of shared connections between pairs of countries with one transshipment; 4) Competition in services connecting countries A and B; 5) Size of the largest vessel on the weakest route connecting

countries A and B. That measures according to Hoffman (2012), Gomez and Sanchez (2021), and Miller and Hyodo (2022), the number of companies that provides services from/to a country's ports, the size of the largest ship that is deployed to services from/to a country's port measures in Twenty-foot Equivalents Units (TEU), the number of services that connect the country port to other countries, number of ships that are deployed on services from/to country ports and the total container carrying capacity of shipments that provides services from/to my country, measured in TEUs. Finally, as Jouili (2019) showed, the liner shipping connectivity (LSC) index can study the transportation system's performance, which will help decision-makers prioritize investment in transport and decide on termination. UNCTAD (2015) indicated that liner shipping connectivity is crucial in determining trade performance for coastal and landlocked countries.

Logistics Performance Indicators (World Bank)

These indicators developed by the World Bank to assess the conditions of global port systems measure: Efficiency of the clearance process (i.e., speed, simplicity, and predictability of procedures) by border control agencies, including customs; the quality of trade and transport-related infrastructure; the facility that exists in each port area to arrange shipments at competitive prices; the existence of competence and quality of logistics services (e.g., transport operators, customs brokers); the technological capacity to track and trace shipments to and from the seaport reliably; the timeliness of shipments in reaching their destination within the planned or scheduled delivery time. They constructed the LPI through a survey of freight forwarders and express carriers. It measured the impact of infrastructure available, port procedures, and costs of transporting goods through ports in 150 countries. The measure includes customs clearance; quality of infrastructure (ports, rail, and ICT); ease and affordability, ease and affordability of arranging shipments; ability to track and trace; cost of local transport, port, and terminal of local handling; storage; predictability of on-time arrival; criminal activities; request for informal payments; and improvement or deterioration.

Geographical Location

The geographical location of ports can also influence their performance. Technical constraints affected the changing geography of seaports, such as port users, intermodal connectivity, and shipping networks (Miller & Hyodo, 2022). According to Wilmsmeier and Hoffmann (2008) and Wilmsmeier and Sanchez (2009), a country that can double its centrality in liner shipping networks by a significant increase in direct liner services to a larger number of countries will decrease the transport costs by up to 15.4% and will imply a potential freight reduction of USD 287 per arrival to the port.

Maritime Connectivity

As Tovar and Wall (2022) pointed out, maritime connectivity refers to performing shipping transport networks and comprises facets such as, among others, the number of destinations served, frequency of services, and logistics costs and is essential to establish the level of competitiveness of ports in the global arena, as it determines the frequency of maritime transport services. The maritime connectivity index refers to the number of connections to other ports and the place of a particular port in international global transportation and logistics networks (centrality). Port

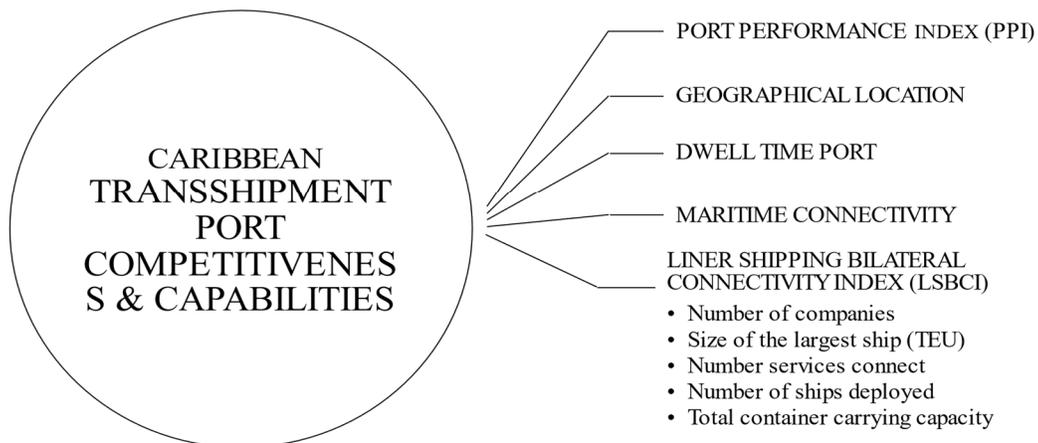
centrality, interrelationship centrality, and clustering coefficient indicators can measure this aspect of port competitiveness.

Previous research has shown that more competitive seaports will be more attractive for various reasons (e.g., port efficiency or good hinterland connections), attract new traffic for that reason, and thus achieve more extensive shipping routes. Recognizing Merck (2013) that larger port systems in the Caribbean zone are more connected and occupy a more central position in maritime networks as it connects with the new maritime routes in Asia, Europe, North America, and South America that the expansion of the Panama Canal has increased. According to this quantitative measure, ports with more extensive maritime connections are considered more attractive to global logistics companies. These ports can offer direct services and faster delivery of goods to more destinations. If they shipped a sufficient volume between these ports, the frequency of shipping services and, thus, could guarantee excellent reliability.

Port Dwell Time (D.T.)

According to Kourouniotti, Polydoropoulou, and Tsiklidis (2016), dwell time (D.T.) is the time a container spends in one or more terminal stacks or the time a cargo or ship spends within a dock and is an excellent indicator of a seaport's efficiency levels measuring the impacts of productivity and efficiency of ports. Some of the main factors influencing D.T. that were identified in the literature are 1) the location of the terminal; 2) the efficiency of terminal operations; 3) the implemented port policies such as monetary penalties for delayed shipments or extended gate hours; 4) customs; 5) the freight forwarder or the shipping company; 6) the hinterland connections; 7) the mode of transport used; 8) the cargo being transferred; and 8) the business relationships developed between the involved parties (Rodrigue & Notteboom, 2021). Previous studies by Talley (2017) and Miller and Hyodo (2022) have shown that reducing D.T. improves port productivity and is often used to measure and compare the output-to-input ratio performance of a firm.

THEORETICAL FRAMEWORK



Literature Review

According to Hoffman (2012), maritime transport continues to be the dominant mode for long-distance transport; they estimated it to account for 90 percent of the volume and 80 percent of the value of international trade. Ports have gone from traditional interfaces between land and sea providers to complete logistic networks. Within the Caribbean and Latin America, the economic development achieved in the past decades by transforming material mobility, turning these regions into emerging transshipment hubs on the map of world container trade. We root this importance of ports to the economic growth of the Caribbean and Latin American countries in colonial history and the region's natural endowment. For a seaport to be prosperous, the number of services, the size of vessels that can sail and berth at the docks, the frequency of services, the speed of cargo movement, and the interconnectivity of the ports must increase, making the transshipment hub an essential link in integrating the global liner shipping network. Others, such as Yochum and Agarwal (1987, 1988), cited by Merk (2013), state that port-related industries are distinct from firms that provide services necessary for maritime trade (port-required industries), from firms that are attracted to the region by a port (port-attracted industries) and firms that expand their markets by exporting through the port (port-induced industry).

As stated by Sanchez and Wilmsmeier (2010), there are four categories of ports in the Caribbean area. First, there are the pure transshipment hubs that handle their operations with a minimum of 70% transshipment cargo; second, there are the so-called hybrid ports in which between 30% and 70% of cargo handled at the port terminals are from transshipment operations; and third, the ports of entry primarily of goods for the country's economy and where less than 30% of the cargo handled in the port terminal is transshipment operations) Finally, many transshipment ports have developed in the Caribbean to interconnect local ports and generate inter-island trade activities within the region's countries. The growth of transshipment activities in the Caribbean is linked to issues such as Latin America's economic growth, being at the crossroads of transatlantic and north-south trade flows, and the need for shippers to reconcile many inbound and outbound trade flows within their transportation networks. Some factors determining the growth in importance of maritime trade in the Caribbean area is the growth and development of the Panama Canal, as the vital route of the East-West trade axis of the world economy, which has transformed the ports of Central America and the Caribbean into natural shipping centers, not only for the commercial exchange between the northern and southern hemispheres but also between the Caribbean countries with the economic bloc developed in the European Union, with the emerging economies in Southeast Asia and by the natural capacities of being able to connect in a relatively straightforward way with the two coasts of the United States of America. Recognizing Freire, López, and De La Pena (2020) and Bernal-Meza, (2015) that, in the past decades, trade activities and commercial maritime routes coming from Asian countries to the U.S. and European markets have become important trade partners of Latin America.

In the Caribbean Sea and Central America (CACM) area, they have identified three types of marine terminals impacting the economies of the countries in the area. First are the global transshipment hubs with extensive interconnecting networks, the main transportation hubs for major carriers. Within this top category is the port of Kingston, Jamaica, and Freeport in the Bahamas. A second category is the regional transshipment hubs serving interregional trade in the Caribbean, at the port of Bridgetown, Barbados, and Port of Spain terminal, Trinidad. Finally, the inter-island transshipment hubs are in Bridgetown, Barbados, and Castries, St. Lucia (Sanchez & Wilmsmeier, 2010). Other research conducted by (Harding & Hoffman, 2003) has delineated that

shipping services in the Caribbean area can be defined as those that offer regional "North-South" services calling at one or more Caribbean ports, arriving at ports in the East or the Gulf area of the United States and coming from Europe, but which within their routes will not pass through the Panama Canal. The primary commercial activity between the ports of the Caribbean area. A second category is the East-West maritime service routes that pass through the Panama Canal and then through the Caribbean making interconnected calls at one or more of the Caribbean or Central American ports along the route but not systematically. The third category is the intra-regional service routes that serve the local and interconnected economies and trade operations of the countries within the Caribbean Basin.

Analysis of mega ports and transshipment ports in the Caribbean

Table 1. Main ports of the Caribbean Sea and Central America (CACM) regarding Containerized Cargo Capacity (TEUs) and Transshipment Loads 2019

Ranking	Country	Port	Cargo Containers TEUs	Cargo Transshipment	% Port Transshipment Cargo
1	Panamá	Colón / Cristóbal / Manzanillo (Caribbean)	4 379 477	3 804 511	86.9
3	Colombia	Bahía de Cartagena	2 933 808	2 118 642	72.2
4	Bahamas	Freeport	1 396 568	1 354 671	97.0
5	Jamaica	Kingston	1 647 609	1 319 760	80.1
8	Dominican Republic	Caucedo	1 263 991	581 795	46.0

Source Sánchez, R. J., and Barletta, E. (2020). Latin America and the Caribbean: The port terminal industry and activity indicators for 2019.

Table 1 provides compelling insights into the transshipment operations of the maritime ports under examination in this qualitative research. Notably, 97% of the port activities in the Bahamas are dedicated to handling maritime cargo and transshipment goods, involving a substantial volume of 1.3 million containers. The port of Panama follows closely, allocating 86% of its operations to manage over 3.8 million containers, positioning itself as a satellite port fostering maritime connectivity for other ports in the region to integrate into global maritime routes. In the third position, the port of Jamaica handles 1.3 million containers, with 80% of its port activities focused on transshipment services. The data further reveals that the port of Cartagena, Colombia, has successfully integrated itself into global maritime routes, overseeing the handling of 2.1 million containers and dedicating 72% of its port activities to cargo transshipment services. Concerning the port of Caucedo in the Dominican Republic, the information indicates that this emerging transshipment hub has secured a prominent position in maritime transport, handling an impressive 58 million containers annually, with 46% of its activities dedicated to the transshipment of goods. In contrast, Puerto Rico, despite its unique position in the Caribbean Sea and Central America (CACM) region, does not exhibit significant transshipment activities within the studied area. Meanwhile, the data underscores that Cuba's transshipment ports have not managed to establish themselves as primary ports in the region, despite being the Caribbean Island with the largest population and the closest proximity to North America.

Table 2. Port Infrastructure Quality (QPI) of Major Ports in the Caribbean Sea and Central America (CACM)

Country	Years									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Panamá	6	6.4	6.4	6.4	6.3	6.3	6.3	6.2	5.7	5.7
Puerto Rico (San Juan)	5.4	5.3	5.2	5.3	5.4	5.4	5.5	5.4	5.4	5.4
Jamaica	5.3	5.3	5.1	5.1	4.9	4.7	4.7	4.9	5.1	5.1
Dominican Republic	4.4	4.4	4.7	4.6	4.6	4.5	4.5	4.8	4.6	4.9
Costa Rica	2.7	2.3	2.4	2.9	3	3.1	3.1	3.4	3.5	3.9
Colombia	2.9	2.7	2.6	2.7	2.7	2.7	2.7	3.1	3.1	3.2
Mexico	3.7	4	4.3	4.4	4.3	4.3	4.3	4.3	4.3	4.3
Bahamas	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Source World Bank (2020) Note: Port Infrastructure Quality Index (QPI) measured company executives' perception of their country's port facilities where the WEF (1 = significantly underdeveloped to 7 = well developed and efficient by international standards).

Table 2 presents intriguing contradictions regarding the developed port infrastructure in the Caribbean and Central America. Notably, the port of Cartagena in Colombia, despite positioning itself as one of the most competitive in the area, receives one of the poorest ratings in the Port Infrastructure Quality Indexes developed by the World Bank. This rating is lower than that of the new ports in Costa Rica and the Dominican Republic. In contrast, Panama maintains its leading position in this index, highlighting that its competitive advantages extend beyond its location, encompassing robust infrastructure that solidifies its status as the premier port in the Caribbean and Central America.

It's noteworthy that Puerto Rico, although not successfully integrating into the global transshipment port system, secures a solid second place in the quality analysis of seaports. This underscores the paradox that, while Puerto Rico may not be a major transshipment hub, it maintains high-quality port infrastructure. In the case of Cuba, the absence of reliable data on port infrastructure accepted by international entities poses a challenge in determining the quality of the developed infrastructure on the island. However, it is suggested that the infrastructure in Cuba, particularly in the Mariel area, is of high quality, considering significant investments by Brazilian investors totaling hundreds of millions of dollars for the creation of the transshipment port.

Table 3. Key Indicators of the Port Infrastructure of the Caribbean Sea and Central America (CACM)

Country	Growth	Throughput Cargo (TEU) 2010–2019	Berth Length (Meters)	Average Berth	Port Area (Meters ²)
Panamá (1)	56%	3,577,481	1,258	4	384,000
Colombia (4)	86%	2,309,143	270	8	225,000
Jamaica (9)	-13%	1,710,747	138	11	1,037,671
Bahamas (12)	-24%	1,226,886	1,294	3	320,125
Dom Rep (14)	-34%	1,040,944	922	15	800,000
Costa Rica(16)	-56%	1,090,248	210	6	677,276
Cuba (38)	N/A	340,000	700	2	180,000
Ponce, PR	N/A	-	-	-	-
*San Juan (11)	-1.9%	1,361,670	610	46	287,273

Miller and Hyodo (2021)

Table 3 provides a comparative summary of the port infrastructure and container handling equipment established at the transshipment ports examined in this study. The data reveals that the fastest-growing transshipment ports in the Caribbean are Panama (56%) and Cartagena, Colombia (56%), securing the top two positions. Jamaica's two historically significant ports experienced a decline (-13%), as did the Bahamas (-24%), causing them to lose their prominent positions in terms of cargo arriving at their transshipment hubs until 2019. The substantial expansion of the Panama Canal has positioned the country as a major player in transshipment activities, which are ten times greater than those achieved by the port of Mariel in Cuba. The data further highlights that the Cuban transshipment port has the least developed infrastructure and container handling equipment, lacking the availability of development areas. This places it at a significant disadvantage compared to the cargo handling capabilities and expansion opportunities of the new transshipment port in the Dominican Republic and the existing but unused facilities at the Ponce transshipment port.

In the case of Puerto Rico, the transshipment port does not appear among the top fifty ports in the Caribbean and Central America. This can be attributed to the strong position of the port of San Juan, where maritime cargo handling is centralized, preventing the displacement to this new transshipment center.

Table 4. Caribbean and Central America Liner Port Index

Port Country	LPI Rank		Customs		Infrastructure		International shipments		Logistics competence		Tracking & Tracing		Timeliness	
Panama	41	3.26	44	2.95	42	3.14	33	3.35	38	3.2	43	3.25	42	3.63
Colombia	71	2.81	89	2.5	81	2.58	60	2.93	66	2.79	70	2.84	80	3.17
Costa Rica	79	2.74	88	2.5	97	2.45	77	2.79	81	2.67	65	2.88	92	3.09
Dominican Republic	86	2.68	102	2.43	102	2.39	83	2.77	93	2.59	71	2.84	99	3.03
Bahamas	90	2.65	59	2.72	84	2.56	100	2.66	105	2.51	102	2.58	118	2.87
Jamaica	111	2.52	99	2.45	106	2.36	114	2.53	110	2.48	120	2.48	123	2.81
Cuba	152	2.23	144	2.15	148	2.09	144	2.3	151	2.2	155	2.18	160	2.46

An intriguing discovery in Table 4, focusing on key indicators of infrastructure and transport activity, is that, based on data for the year 2020, Colombia takes the top position in the number of arrivals, median time in port (dwelling time), average vessel size, and average TEU per container ship. Remarkably, Colombia outperforms the port of Colon in Panama across all these metrics. This superiority is further reinforced by Table 7, which indicates that Panama holds the foremost position in the port connectivity index. Following closely is its primary competitor for transshipment activity in the region, the port of Cartagena in Colombia, maintaining a robust position.

Simultaneously, it's evident that the ports of the Bahamas and Jamaica have experienced a decline in their competitive positions in the Caribbean and Central America, being surpassed in this index by the new ports in Costa Rica and the Dominican Republic. This shift underscores the evolving dynamics in the region's maritime connectivity landscape. This is something very interesting because both ports have been operating for less than ten years and have already been

positioned in better positions than the two traditional ones and represents great challenges for other ports such as Cuba or Puerto Rico to be inserted in the port connection chains of the Caribbean Sea region. This is why the new competitive edge in port interconnectivity in the Caribbean Sea area has shifted to the relationship between the ports of Panama, Colombia and the Dominican Republic and has led the port entities of the Bahamas and Jamaica to initiate extensive renovations of their port structures to avoid becoming obsolete and losing the leadership in the global port industry that they once had. Demonstrating that of the three major economies of the Greater Antilles, the port infrastructure of the Dominican Republic's transshipment port has allowed them to overtake Puerto Rico and Cuba in global port competitiveness rankings.

Table 5. Caribbean to World Countries Liner Shipping Connectivity Index

Countries	Bahamas	Colombia	Costa Rica	Cuba	Dominican Republic	Jamaica	Panama	Total LSC	
LPI	111	71	79	152	86	90	41		
Germany	1				.324			1	
Netherland	2	.335	.365	.225	.351		.356	5	
Belgium	4	.335	.361				.355	3	
Singapore	5	.315				.313		2	
United Kingdom	6				.344			1	
Hong Kong	9	.317	.366			.316	.356	4	
USA	10	.338	.382	.308	.226	.361	.364	.425	7
France	15	.334		.285	.337	.297		4	
Canada	17			.239				1	
Spain	18		.287	.238				2	
Italy	21		.279	.233				2	
South Korea	23		.365			.323	.371	2	
China	27	.325	.377			.323	.377	4	
Portugal	28			.230				1	
Mexico	53		.388	.301	.233	.347	.338	.381	6
Malta			.274					1	
Peru	74		.364				.357	2	
Guatemala	115			.221				1	
Total LSC	7	8	6	8	6	7	7		

Table 6. Caribbean to the Caribbean Countries Liner Shipping Connectivity Index

Port Country	Bahamas	Colombia	Costa Rica	Cuba	Dominican Republic	Jamaica	Panama	Puerto Rico	Total LSC
LPI	111	71	79	152	86	90	41		
Bahamas	-----							N/A	0
Colombia	.316	-----	.300		.378	.357	.405	N/A	5
Costa Rica			-----					N/A	0
Cuba				-----				N/A	0

Dominican Republic	.318	.378	.293	.231	-----	.356	.356	N/A	6
Jamaica			.287	.233	.356	-----		N/A	5
Panama	.320	.405	.307		.356	.350	-----	N/A	5
Puerto Rico	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-----	0
Total LSC	3	2	4	2	3	3	2	0	

Table 7. Caribbean Vessel Activity Track, Liner Shipping Connectivity Index by Regions, and U.S. Distance

Port Country	Vessel Tracker		Liner Shipping Connectivity Index				Distance	
	In Port	Expected	Asia	Europe	America	Caribbean	USA	Miles / Days
Panamá	110	90	3	2	3	2	1,479	6.2
Colombia	57	48	3	2	3	2	1,382	5.8
Jamaica	25	30	4	1	2	3	952	4
Dom Rep	9	14	0	5	2	3	1,101	4.6
Costa Rica	6	10	0	4	2	4	1,258	5.2
Bahamas	30	10	3	3	1	3	107	.4
Cuba	1	6	0	4	4	2	288	1.2
Ponce, PR	0	1	N/A	N/A	N/A	N/A	1,180	4.9

The findings on port connectivity in the four regions show that the countries with the busiest transshipment ports, Panama, Bahamas, Bahamas, and Colombia, have the highest connectivity with Asian ports. While according to the findings in Tables 5 and 6, the emerging transshipment ports in the Dominican Republic, Costa Rica, and Cuba have focused on developing connectivity with ports in the European region, which are their main international trading partners. Regarding the Americas region, Cuba has developed connectivity with four ports being the only one with high connectivity with the ports of Canada and Guatemala. In the case of the Bahamas, its primary focus, due to its relationship with China, is to have the most solid connectivity to the United States market. In the Caribbean and Central America regions, although all the countries studied have high port connectivity with other countries, our findings show no reciprocity among them. Table 7 mentions the cases of the Bahamas, Costa Rica, and Cuba, which are not part of the ports of significant connectivity for transshipment operations of shipments from Colombia, Panama, the Dominican Republic, or Jamaica.

Discussion

The comprehensive data presented in this paper on the maritime line connectivity index aligns with the predictions made by Rodriguez (2012), who foresaw that Panama would be the primary beneficiary of transshipment growth. The maritime trade expansion in Panama, specifically from East Asia with manufactured or semi-manufactured products, was a key driver for the Panama Canal's expansion in the mid-2010s. As per tables 5 and 6, Panama's leading connectivity destinations include China (.377) and Hong Kong (.356). These ports serve as hubs for receiving goods from Asia, conducting the transshipment process, and furthering shipping

routes to global markets such as the United States (.425) and Europe in ports like Holland (.335) and Belgium (.335), occupying the 2nd and 4th positions in the Liner Shipping Connectivity Index.

Research, such as that by Wilmsmeier and Monios (2016), emphasizes the substantial growth of the Colon Container Terminal (CCT) port system in Panama over the past decade, claiming a market share of around 50%. The port connectivity index values affirm the ongoing significance of Panama's ports as global connectivity hubs, not only Colon. These ports play a crucial role in the growth of cargo transport activity, positioning them as the fastest-growing transshipment ports in the Caribbean area. The research underscores their ambition to surpass the traditional transshipment ports in the Bahamas and Jamaica in the coming years.

The findings highlight the substantial connectivity levels of the Port of Cartagena in Colombia with five of the seven additional ports evaluated in this study: Panama (.405), Dominican Republic (.378), Jamaica (.357), Bahamas (.316), and Costa Rica (.300). This connectivity extends to three major ports in the Asian region: China (.377), Hong Kong SAR (.366), and South Korea (.365). The study emphasizes that the Caribbean transshipment triangle has been reshaped by the Port of Cartagena, displacing traditional ports in the Bahamas and Jamaica. The Caucedo Terminal in the Dominican Republic has implemented an innovative port connectivity strategy, achieving high connection levels with the ports of Germany (.324) and the Netherlands (.351), ranking 1st and 2nd in the 2020 Connectivity of Seaports Index. Caucedo has notably strengthened its connectivity with leading European ports, including the United Kingdom (.344) and France (.337). However, with Asian maritime ports, particularly those in Southeast Asia, the Dominican Republic's ports exhibit lower connectivity, potentially attributed to their nascent status and focus on solidifying connections with major transshipment ports like Panama (.356), Jamaica (.356), and Colombia (.378).

The findings shed light on the competitive dynamics of transshipment ports, with Panama and Cartagena leading in connectivity, reshaping traditional routes, and embracing global shipping trends. Caucedo's success in connecting with European ports demonstrates a nuanced approach, while the Bahamas faces challenges despite maintaining high connectivity with leading global ports. Costa Rica's Moin port shows progress, particularly in connecting with the Americas, but lags in Asian connectivity. Jamaica's prominence in the Asian region is highlighted, though it faces challenges in establishing high connectivity with neighboring ports. The Mariel container terminal in Cuba reveals a strategic focus on European and North American connections but lags in Asian connectivity. Lastly, Ponce, Puerto Rico, faces impediments, primarily due to the Jones Act, restricting its commercial maritime activities compared to neighboring ports. This study contributes valuable insights into the evolving landscape of transshipment ports in the Caribbean Sea and Central America, showcasing the intricate web of global maritime connectivity and highlighting the competitive positioning of these crucial hubs.

Findings

The findings underscore the Dominican Republic's significant connectivity with all transshipment ports in the Caribbean, particularly having the highest connectivity indexes with the major ports in Colombia and Panama. Notably, Cuba and Costa Rica, despite commencing transshipment activities in 2018, already exhibit a substantial level of connectivity with ports in the Dominican Republic. Colombia, in turn, boasts connections with five Caribbean country ports, achieving the highest port connectivity index in the region with Panama. Panama itself maintains

the highest port connectivity indexes with the two primary transshipment centers in the Caribbean, namely Colombia and the Dominican Republic.

Interestingly, the Bahamas' port does not rank among the top ten ports with connectivity indexes with other countries in the study, despite being one of the world's most comprehensive operating port centers. Cuba's port interconnectivity remains minimal, attributed to factors such as trade restrictions and the U.S. blockade, preventing it from securing a spot among the top ten port connectivity centers of other countries, despite its proximity to the U.S. market. An overarching observation is that 100% of the Caribbean ports evaluated place the United States in the top ten countries with the highest port connectivity index. Panama, Jamaica, the Dominican Republic, Bahamas, and Costa Rica lead in port connectivity levels, highlighting the substantial focus on transporting cargo to and from the United States in these countries. Colombia, while ranking third, still exhibits a notable level of connectivity with the United States.

In terms of connectivity with robust economies in Southeast Asia, the ports of the Dominican Republic, Cuba, and Costa Rica do not display high levels of connectivity with ports in China, Hong Kong, South Korea, and Singapore. The global connectivity index emphasizes that the Bahamas has developed extensive trade and merchandise exchange activities with major ports in leading global economies, including the United States, Belgium, the Netherlands, France, China, Hong Kong SAR, and Singapore. South Korea, as a trading partner, exhibits high connectivity primarily with Colombia and Jamaica. Notably, the ports of the Panama Canal do not feature in the top ten connectivity ports for South Korea, while China and Hong Kong SAR maintain their positions. The connectivity index findings suggest that the new transshipment ports in Costa Rica and Cuba have strategically focused on ports in countries with high trade exchange rates, such as Spain and Italy. For Cuba, ports in Canada, Portugal, and Guatemala hold high importance in the connectivity indices of port lines. The nuanced insights provided by the study enhance understanding and decision-making in the context of global trade connectivity for these Caribbean and Central American ports.

Conclusions

The present study makes a notable contribution to the maritime economics literature by providing a comprehensive and comparative analysis of the main transshipment ports in the Caribbean Sea and Central America (CACM) region. By examining structures, equipment, and compliance with global operational standards, the study identifies Panama, Colombia, and the Dominican Republic as the region's most robust and competitive transshipment ports. It goes on to establish a transshipment triangle, noting the shift of traditional transshipment activities from Panama, Bahamas, and Trinidad Tobago towards the center of the CACM region.

The empirical confirmation that CACM ports have successfully inserted themselves into maritime routes, with connections to essential ports in Europe, Asia, South America, and North America, adds valuable insights. The analysis of Cuba's port, despite limitations imposed by the U.S. embargo, reveals linkages with countries engaged in commercial activities. The study stands out for its multidimensional approach, combining various indicators of port infrastructure and global connectivity to highlight the importance and integration of the CACM region within international maritime trade routes.

The research acknowledges its limitations, such as the lack of precise, accurate, and uniformly measured data on port infrastructure and connectivity indices across the eight evaluated countries. Furthermore, the need for more extensive and reliable data on the operations of

transshipment ports in Puerto Rico and Mariel in Cuba is recognized for a more comprehensive evaluation against the main ports in Panama, Colombia, and the Dominican Republic. The researchers also express the need for global research on the post-COVID-19 insertion of CACM ports into the global economy.

Despite these limitations, the study serves as a foundational step, offering a nuanced understanding of the interconnectivity of global maritime routes in the Caribbean Sea and CACM region. The findings provide valuable insights for decision-makers, aiding them in ensuring the competitiveness and interconnectedness of the region's maritime transshipment ports amid growing global competition. The call for further research indicates the researchers' commitment to deepening the understanding of the subject in the evolving landscape of global trade.

References

- Bernal Meza, R. (2015). La inserción internacional de Brasil: el papel de BRICS y de la región. *Universum (Talca)*, 30(2), 17-35.
- Cuervo-Cazurra, A., Andersson, U., Brannen, M. Y., Nielsen, B. B., and Reuber, A. R. (2020). From the editors: Can I trust your findings? Ruling out alternative explanations in international business research. In *Research Methods in International Business* (pp. 121-157). Palgrave Macmillan, Cham.
- Freire-Seoane, M. J., López-Bermúdez, B., and De la Peña Zarzuelo, I. (2020). The effects of maritime container transport on economic growth in the countries on the west coast of Latin America. *CEPAL Review*.
- Fugazza, M., & Hoffmann, J. (2017). Liner shipping connectivity as determinant of trade. *Journal of Shipping and Trade*, 2(1), 1-18.
- Gómez Paz, M. A., and Sánchez, R. J. (2021). Conexiones de carga marítima entre Asia y el Pacífico y América Latina: análisis de fletes de transporte, sus determinantes y restricciones.
- Ha, M-H and Yang, Z (2017) Comparative analysis of port performance indicators: Independency and interdependency. *Transportation Research Part A: Policy and Practice*, 103. pp. 264-278. ISSN 0965-8564
- Harding, A. S., & Hoffmann, J. (2003). *Trade between Caribbean Community (CARICOM) and Central American Common Market (CACM) countries: the role to play for ports and shipping services*. ECLAC
- Haskoning, R. (2008). Plan Maestro para el complejo portuario Limón-Moín.
- Hoffmann, J. (2012). Corridors of the Sea: An investigation into liner shipping connectivity. *Les Corridors de Transport. Les océanides*.
- Jouili, T. A. (2019). Determinants of liner shipping connectivity. *Int. J. Adv. Appl. Sci*, 6, 5-10.
- Kahuina, M., & Tetsuro, H. (2022). Assessment of port efficiency within Latin America. *Journal of Shipping and Trade*, 7(1).
- Kourounioti, I., Polydoropoulos, A., and Tsiklidis, C. (2016). Development of models predicting dwell time of import containers in port container terminals—an Artificial Neural Networks application. *Transportation Research Procedia*, 14, 243-252.
- Merk, O. (2013). The competitiveness of global port-cities: synthesis report.
- Miller, K., & Hyodo, T. (2022). Assessment of port efficiency within Latin America. *Journal of Shipping and Trade*, 7(1), 1-27.

- Monios, J., & Wilmsmeier, G. (2012). Giving a direction to port regionalization. *Transportation Research Part A: Policy and Practice*, 46(10), 1551–1561.
- Munim, Z. H., & Schramm, H. J. (2018). The impacts of port infrastructure and logistics performance on economic growth: the mediating role of seaborne trade. *Journal of Shipping and Trade*, 3(1), 1-19.
- Nogué-Algueró, Borja. "Growth in the docks: Ports, metabolic flows and socio-environmental impacts." *Sustainability Science* 15.1 (2020): 11-30.
- Notteboom, T. E., and Haralambides, H. E. (2020). Port management and governance in a post-COVID-19 era: quo vadis? *Maritime Economics and Logistics*, 22(3), 329-352.
- Ouariti, O. Z., & Jebrane, E. M. (2020, December). Port Performance Indicators: An Exploratory Study in the Moroccan Context. In *2020 IEEE 13th International Colloquium of Logistics and Supply Chain Management (LOGISTIQUA)* (pp. 1–8). IEEE.
- Pinnock F. and Ajagunna, I (2009). The dilemma facing Latin America and the Caribbean. *Caribbean Maritime No. 7 I May - September 2009 No. 14* 28-31
- Rodrigue, J. P. (2012). The benefits of logistics investments: Opportunities for Latin America and the Caribbean. *Inter-American development bank*.
- Rodrigue, J. P., & Notteboom, T. (2020). Ports and economic development. *Port economics, management, and policy*.
- Sánchez, R. J., & Wilmsmeier, G. (2010). Contextual port development: a theoretical approach. *Essays on port economics*, 19-44.
- Sánchez, R. J., and Barleta, E. (2020). Latin America and the Caribbean: the port terminal industry and activity indicators for 2019.
- Sarriera, J. M., Araya, G., Serebrisky, T., Briceño-Garmendía, C., and Schwartz, J. (2013). Benchmarking container port technical efficiency in Latin America and the Caribbean: a stochastic frontier analysis. *World Bank Policy Research Working Paper*, (6680).
- Shetty, D. K., & Dwarakish, G. (2018). Measuring port performance and productivity. *ISH J Hydraul Eng* 26 (2): 221–227.
- Talley, W. K. (2017). *Port economics*. Routledge.
- Tovar, B., and Wall, A. (2022). The relationship between port-level maritime connectivity and efficiency. *Journal of Transport Geography*, 98, 103213.
- United Nations Conference on Trade and Development (UNCTAD). (2023). Liner Shipping Connectivity Index [Data file]. <https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=92>
- Urbina, D. M. Mega-Puerto de Moín: una puesta a la facilitación del comercio exterior ya la dinamización de la economía regional.
- Wilmsmeier, G., & Hoffmann, J. (2008). Liner shipping connectivity and port infrastructure as determinants of freight rates in the Caribbean. *Maritime Economics & Logistics*, 10, 130-151.