Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 43 No. 4 (2022)

Containers in Latin America and the Caribbean (LAC) "throughput"

Julián Ricardo Romero Garibello

Magister en Administración de Negocios MBA.

Docente ocasional de tiempo completo de la Universidad Colegio Mayor de Cundinamarca. Bogotá, Colombia. jrromero@unicolmayor.edu.co; https://orcid.org/0000-0001-5873-1226

Jairo Jamith Palacios Rozo

Magíster en Educación

Doctorando en Socioformación y Sociedad del Conocimiento – CIFE.

Docente de Planta de la Universidad Colegio Mayor de Cundinamarca, Colombia. jjpalacios@unicolmayor.edu.co; https://orcid.org/0000-0002-1437-9838

Lugo Manuel Barbosa Guerrero

Magíster en informática Educativa.

Docente de planta de la Universidad Colegio Mayor de Cundinamarca. Bogotá, Colombia. Correo electrónico: lmbarbosa@unicolmayor.edu.co; https://orcid.org/0000-0002-0871-8637

Abstract

Although there is progress regarding the total movement of containers in movement of full and empty units, there is a need for a breakdown at the port level or at the country level and the lack of knowledge regarding what is measured in "TEU", a unit equivalent to twenty feet. The purpose of this study was to analyze the throughput trend of container ports in Latin America and the Caribbean (LAC), the information was taken from a secondary source with the participation of 43 countries. They completed the instrument of the Economic Commission for Latin America and the Caribbean (hereinafter referred to by its acronym, ECLAC), which includes the Latin American and Caribbean Institute for Economic and Social Planning (ILPES). The analysis of the behavior of trade (sum of exports and imports via full containers) in the period focuses on LAC and analyzing exports and imports, transshipment and throughput by coast, there are two divisions or main branches of the decision tree can be seen in which 35 observations can be seen in the first set of data and 28 for the second, additionally, the data is recorded in a Split Point contained between 0.194 and -0.513, inputs and equipment for productions are also imported. In conclusion, the model does not respond with respect to the classification in which precision and completeness present low or null values in the decision tree where the highest values locate the Brazil node; On the other hand, the smaller values point to the Aruba node, finally, the larger values are for Anguilla.

Keywords: port competitiveness, containers, Latin America, Caribbean, throughput

Introduction

In today's globalized environment, international trade and logistics play a crucial role in the Latin America and the Caribbean (LAC) economy. One of the key indicators that reflects the efficiency and dynamism of these activities is the throughput of containers in the region's ports and terminals. For the research project, container throughput is very important, because it is a key indicator in the transportation and logistics industry that allows measuring the amount of containers handled in a port or terminal during a period of time certain. In fact, the main reason for the high performance of some ports in Latin America and the Caribbean is transshipment activity, especially in the Caribbean because it has intermediate ports; these end up being used as transfer points for goods headed to other destinations. Thus driving the high volume of containers in the region. On average, Caribbean ports in the sample move 574,157 TEUs annually, driven by transshipment activity anchored in Puerto Rico, Jamaica, the Bahamas and the Dominican Republic, among other smaller countries, which is more throughput than the average in other LAC subregions. (Serebrisky et al., 2016). Most of the findings of previous research tend to focus on the handling of merchandise, addressing aspects such as cargo volume in terms of exports, imports and, in particular, the volume of transshipment cargo, which is significantly related to the use of containers, considering it as the primary factor, but they do not take into account an indicator such as "throughput" which is higher in some ports, this is due to multiple factors such as geography, infrastructure, market demand, including government policies. These factors may vary depending on the location and specific circumstances of each port. Transport in the Caribbean is largely made up of the traffic of ships that have a docking port in the area and of ships that are in transit or heading to other destinations. (Ospina Arias, 2022).

The way in which ports are articulated with the territory has always been a critical aspect for their evolution and development. It is a complex link, mediated and determined both by the technological and organizational development of transportation, and by the imperatives of the dominant economic model in a given historical period. (Martner-Peyrelongue, 2020).

Most of the existing research outcomes tend to treat cargo volume including export & import cargo volume, transshipment cargo volume, especially created by containers as the most important factor. (Lee et al., 2014). The research aims to analyze in depth the "throughput" of containers in Latin America and the Caribbean (LAC), evaluating current and future trends, this is why the study will focus on a comparison of different countries that have port infrastructure, economic factors, trade policies, investment in logistics and connectivity in the region, in addition to having strategic alliances between some countries. Strategic alliances between them have exerted a profound influence on maritime network structure and also on a region’s integration in the global maritime transport network. (Wilmsmeier et al., 2014). The challenge for the countries of LAC was to develop modern and efficient ports that, by improving comercial relations, would contribute to regional development. A series of reforms and modernizations were carried out in the LAC port sector, since the opportunities in maritime transport would be lost if the ports were not operated properly. (Pérez et al., 2016). In the conceptual space of port performance, various terms with lithe precision are used such as traffic, capacity, productivity, occupation, efficiency… (Gesé Bordils et. al, 2021). It is important that the countries of Latin America and the Caribbean (LAC) develop modern and efficient ports to improve their trade relations and contribute to the development of the region. It is also important that reforms and improvements be considered in the port sector in LAC, which will generate opportunities in maritime transport.

The continued growth of maritime trade across Latin America and the increase in vessel sizes have both contributed to the expansion of container handling facilities, and enabled new institutional reforms to accommodate the increasing demand. (Lopez-Bermudez et al., 2018)

In Latin America, historically imports of containerized goods have been greater than exports. The fact that the impacts of the pandemic on imports have been stronger than those on exports has resulted, to some extent, in a convergence of both variables. (Barleta & Sánchez, 2021).

Furthermore, in the evaluation of port performance, several terms are used, such as traffic, capacity, productivity, occupation and efficiency, although they are often used vaguely, making it a complex topic that requires a precise definition of these terms and metrics to effectively evaluate the efficiency and effectiveness of ports in the region. Measuring container throughput is essential to evaluate port activity, efficiency and competitiveness in international trade. It provides a solid basis for decision-making in port management and the development of logistics and transportation strategies. For this reason, the necessary support must be provided for the movement of cargo in order for them to be safe and operational. Today, cargo support functions (handling, storage, inspection, consolidation and deconsolidation), services associated with ships (repair, auxiliary services and supply) and information management are crucial services for the proper port operation. (Tapía et al., 2014). These functions include activities such as loading and unloading goods into containers, storing them in port facilities, inspecting cargo to ensure its safety and compliance with regulations, and consolidating and deconsolidating goods, which involves grouping and separation of different shipments.

An efficient container terminal uses least investment to earn maximum profit, which can help the regional economy and develop the port.The lack of efficient container terminals leads to excessive waste of production resources. (Li et al., 2021). The growth of container traffic has led to the emergence of new routes and the construction of ever-larger ships and ports. (Fancello et al., 2022). Higher capacity ships, such as giant container ships, optimize cargo transportation and reduce costs per unit transported, resulting in greater profitability.

Regardless, the progressively improving performance on all the indi- cators of international ships in Latin-America may very well be regarded as a measure of success of the various initiatives adopted by the IMO for enhancing global maritime safety, particularly the IMO member State audit scheme. (Hebbar & Geymonat, 2021).

Additionally, larger and more modern ports are able to accommodate these massive vessels and streamline loading and unloading operations, contributing to efficiency in global trade. Container shipping has become a competitive industry with shipping companies constantly looking for ways to improve profits. (McGinley, 2014). Globalization has caused transformations in the structure of the world economy, and the maritime and port industries have had to face the challenges that this entails. Through a mixed approach where quantitative data is taken and qualitative analysis is applied, it is expected to contribute to the understanding of the factors that drive international trade in the region and, ultimately, to the sustainable economic development of the countries that comprise it. For data analysis in the mixed approach, it is suggested "(…) to include a section where the method, collection and analysis of both quantitative and qualitative data are presented. Hernández et al. (2003). Consequently, the research project proposes to analyze and understand in depth the "throughput" of containers in Latin America and the Caribbean, identifying its drivers and limitations, and providing conclusions that contribute to informed decision-making at both the government and business levels and will serve as a valuable reference for researchers, professionals and others interested in this topic.

Methodology

The research is based on data collected from various reliable sources, including government agencies, international organizations, shipping companies and other relevant actors in the logistics industry. The validity of decision-making depends on the quality of the information available; in this sense, it is necessary that the information be collected from reliable data sources. (Miranda Soberón & Acosta, 2009).

The methodology used will allow a rigorous analysis of the patterns and factors that influence container throughput in LAC, and the results are expected to shed light on the areas in which measures should be taken to improve regional competitiveness. A wide variety of data sources will be used, ensuring the representativeness and integrity of the information collected. An important part of the methodology involves the analysis of quantitative data, since the historical records of container throughput in the different ports of the region will be examined. This will include collecting annual and quarterly data, if available, to assess trends over time. There are different types of research and depending on the nature of the information that is collected to respond to the research problem, these can be carried out under two paradigms, quantitative or qualitative research. (Sarduy Domínguez, 2007). Evaluation metrics were used to compare the different countries in Latin America and the Caribbean. These metrics made it possible to evaluate the performance of container ports in these countries. Some of the metrics included are accuracy, true positive rate, false positive rate, and negative predictive value.

Results

Table 1 shows the results of the decision tree classification. Two divisions or "splits" of the tree were made, corresponding to the two coasts of the region (Atlantic and Pacific), with a total of 35 observations in the training data set and 8 observations in the test data set. However, the precision or accuracy of the classification is 0.000, which indicates that no correct predictions were obtained in any of the cases. This raises questions about the reliability of the model to predict and analyze variables such as throughput in container ports.

Table 1. Decision Tree Classification

Splits	**n(Train)**	**n(Test)**	**Test Accuracy**
2	35	8	0.000

Table 2 shows the results of data splitting. In the confusion matrix, the predictions made for each class are presented in comparison with the actual observations. For the country of Belize, no correct prediction was made. For Antigua and Barbuda, an incorrect prediction was made for the Belize class. For Argentina, an incorrect prediction was made for the Guatemala class. For Aruba, no predictions were made. And so on for each country in the table. It is emphasized that the model yields positive predictions for the following cases: Argentina, El Salvador, Guatemala, Nicaragua, Paraguay, Puerto Rico, Dominican Republic and Sint Maarten.

Table 2. Data Split

Confusion Matrix

		Predicted							
		Belice	**Costa Rica**	**Curazao**	**Guatemala**	**Guayana Francesa**	**M.xico**	**Nicaragua**	**Paraguay**
Observed	Anguila	0	0	0	0	0	0	0	0
	Antigua y Barbuda	1	0	0	0	0	0	0	0
	Argentina	0	0	0	1	0	0	0	0
	Aruba	0	0	0	0	0	0	0	0
	Bahamas	0	0	0	0	0	0	0	0
	Barbados	0	0	0	0	0	0	0	0
	Belice	0	0	0	0	0	0	0	0
	Bermuda	0	0	0	0	0	0	0	0
	Brasil	0	0	0	0	0	0	0	0
	Chile	0	0	0	0	0	0	0	0
	Colombia	0	0	0	0	0	1	0	0
	Costa Rica	0	0	0	0	0	0	0	0
	Cuba	0	0	0	0	0	0	0	0
	Curazao	0	0	0	0	0	0	0	0
	Dominica	0	0	0	0	0	0	0	0
	Ecuador	0	0	0	0	0	0	0	0
	El Salvador	0	0	0	0	0	0	0	1
	Granada	0	0	0	0	0	0	0	0
	Guadalupe	0	0	0	0	0	0	0	0
	Guatemala	0	0	0	0	0	0	0	0
	Guayana Francesa	0	0	0	0	0	0	0	0
	Guyana	0	0	0	0	0	0	0	0
	Hait.	0	0	0	0	0	0	0	0

Honduras	0	0	1	0	0	0	0	0
Islas Caiman	0	0	0	0	0	0	0	0
Jamaica	0	0	0	0	0	0	0	0
M.xico	0	0	0	0	0	0	0	0
Martinica	0	0	0	0	0	0	0	0
Montserrat	0	0	0	0	0	0	0	0
Nicaragua	0	0	0	0	0	0	0	0
Panam.	0	0	0	0	0	0	0	0
Paraguay	0	0	0	0	0	0	0	0
Per.	0	0	0	0	0	0	0	0
Puerto Rico	0	0	0	0	0	0	1	0
República Dominicana	0	1	0	0	0	0	0	0
San Cristóbal y Nieves	0	0	0	0	0	0	0	0
San vicente y las granadinas	0	0	0	0	0	0	0	0
Santa Lucia	0	0	0	0	0	0	0	0
Sint Maarten	0	0	0	0	1	0	0	0
Surinam	0	0	0	0	0	0	0	0
Trinidad y Tobago	0	0	0	0	0	0	0	0
Uruguay	0	0	0	0	0	0	0	0
Venezuela	0	0	0	0	0	0	0	0

Table 3 shows the Evaluation Metrics, showing the results of the prediction model for different countries. Results include metrics such as precision, completeness, false positive rate, false discovery rate, and F1 score. However, in this case, the values of these metrics are NaN (not a number) for all classes, indicating that no results are presented on these metrics. The true negative rate is 100% for all classes, meaning no false negatives occur. A support of 1 is presented, that is, for the eight countries, a record is presented, in this way a precision of 0.875 is presented for each class. Regarding the true positives, Not a Number is given indicating that these do not occur in any of the classes. In addition, the exhaustiveness figures with 0.0000 reveal that there are no false positives. The false discovery rate coincides with the Not a Number results, this added to the precision and completeness converge to the non-existence of results in F1 Score. The false negative rate measures the proportion of false negatives relative to all true positive cases which for the case is 1,000 for all classes.

Table 3. Evaluation Metrics

	Antigua y Barbud	Argentina	Colombia	El Salvador	Honduras	Puerto Rico	República Dominicana	Sint Maarten	Average / Total
Support	1	1	1	1	1	1	1	1	8
Accuracy	0.875	0.875	0.875	0.875	0.875	0.875	0.875	0.875	0.875
Precision	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	0.000

(Positive Predictive Value)									
Recall (True Positive Rate)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
False Positive Rate	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
False Discovery Rate	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
F1 Score	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	0.000
Matthews Correlati Coefficie	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
Area Under Curve (AUC)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Negative Predictive Value	0.875	0.875	0.875	0.875	0.875	0.875	0.875	0.875	0.875
True Negative Rate	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
False Negative Rate	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
False Omission Rate	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Threat Score	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Statistical Parity	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note. All metrics are calculated for every class against all other classes.

Table 4 provides information about the splits in the decision tree. It shows that there are two main splits in the tree, with 35 observations in the first set of data and 28 observations in the second set. It also shows the split points and improvement in deviation for each split. Two divisions or main branches of the decision tree can be seen in which 35 observations can be seen in the first set of data and 28 for the second. Additionally, the data are recorded in a Split Point contained between 0.194 and -0.513.

Table 4.

Splits in Tree

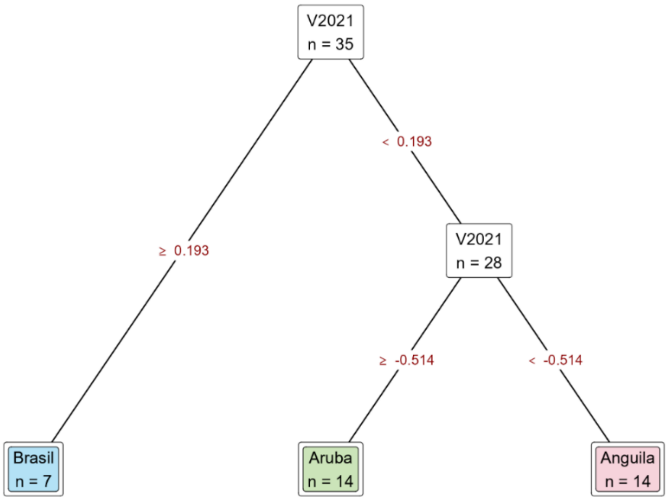
	Obs. in Split	Split Point	Improvement
V2021	35	0.193	1.000
V2021	28	-0.514	1.000

Note. For each level of the tree, only the split with the highest improvement in deviance is shown.

Figure 1 shows the decision tree graph with two main splits and is based on two different data sets. The first set of data has 35 observations and the second set has 28 observations. The split point for the first set of data is 0.194, while for the second set it is -0.513. The decision tree graph provides information about how data is classified into different nodes of the tree.

The decision tree provides elements of value for the analysis, thus, the values that are greater than 0.193 will be located in the Brazil node that has 7 observations; On the other hand, values less than 0.193 that are greater than -0.514 will appear in the Aruba node with 14 observations, finally, values greater than -0.514 will be located in Anguilla n=14.

Figure 1.Decision Tree Plot



Conclusions

For the year 2021, growth is evident in the Regional throughput, which for the Pacific zone is most evident on the Pacific coast of Mexico and Central America, in an expected scenario that is Panama, this total movement of containers in a territory that can be a port or a nation, in which all movements of full units are considered, this in order to be a more reliable indicator in terms of transportation and in which South America registered lower increases than its northern neighbors. The theory collects recurring information on container movement, a high degree of international purchases in the world, particularly in the Pacific basin, notable facts for analysis in decision-making for trade policy and/or for re-evaluation of the geopolitical scenario linked to the commercial that reorients the conversation towards scenarios of negotiation and integration. In addition, the machine learning Decision TreeClassification algorithm model showed that the possibilities occur mainly towards the Brazil node, additionally and resorting to analysis tools, findings are evident in eight countries. However, doubt remains at the time of precision and exhaustiveness in the context of the non-appearance of true positives, it occurs with one root, two divisions and again two divisions that run in the Caribbean, in addition to the Decision Tree.

With the methods and techniques for decision making, they move towards the use of artificial intelligence that allows the creation of extremely complex and effective decision trees for decision making that have demonstrated levels of recovery but can present precision challenges and thoroughness. The decision tree provides elements of value for the analysis, thus, the values that are greater locating the Brazil node; On the other hand, the smaller values point to the Aruba node, finally, the larger values are for Anguilla. Globalization has had a significant impact on the maritime and port industry, generating transformations in the structure of the world economy where the largest and most modern ports have the capacity to accommodate massive ships and streamline loading and unloading operations, which contributes to efficiency in global trade, consequently, the analysis of key performance indicators in container terminals can help evaluate the environmental sustainability of port systems. Finally, the importance of globalization in the maritime and port industry is highlighted, the need to evaluate the environmental sustainability of port systems and the importance of understanding the drivers and limitations of international trade in Latin America and the Caribbean. The importance of efficiency in container terminals is also highlighted and methodologies to evaluate it are presented.

References

1. Barleta, E. P., & Sánchez, R. J. (2021). Informe Portuario 2020: el impacto de la pandemia del COVID-19 en el comercio marítimo, transbordo y throughput de los puertos de contenedores de América Latina y el Caribe.
2. Fancello, G., Vitiello, D.M. & Serra, P. (2022). The Impact Of Globalization On Mediterranean Container Terminals. International Maritime Transport and Logistics Conference, 11(1), pp. 86–95
3. Gesé Bordils, M., González-Cancelas, N. & Molina Serrano, B. (2021). Indicadores clave de rendimiento en terminales de contenedores y su relación con la sostenibilidad ambiental. Aplicación al sistema portuario español. Ingeniare. Revista chilena de ingeniería, 29(4), 647-660. https://dx.doi.org/10.4067/S0718-33052021000400647
4. Hebbar, A.A. & Geymonat, S.J. (2021). Simple, intuitive key performance indicators for flag state performance and its pilot application in Latin-America, Journal of Safety Science and Resilience, Volume 2, Issue 3, 2021, Pages 101-110, ISSN 2666-4496, https://doi.org/10.1016/j.jnlssr.2021.06.003
5. Hernández, R., Fernández, C. y Baptista, P. (2003). Metodología de la investigación (3ª ed.). México: Editorial Mc Graw-Hill.
6. Lopez-Bermudez, B., Freire-Seoane, M. J., & de la Peña Zarzuelo, I. (2018). The impact of port governance and infrastructures on maritime containerized trade on the West Coast of Latin America. European Journal of Government and Economics, 7(1), 85-101. https://doi.org/10.17979/ejge.2018.7.1.4334
7. Lee, S. W., Song, J. M., Park, S. J., & Sohn, B. R. (2014). A study on the comparative analysis of port competitiveness using AHP. KMI International Journal of Maritime Affairs and Fisheries, 6(1), 53-71.
8. Li, L.-L., Seo, Y.-J. and Ha, M.-H. (2021), "The efficiency of major container terminals in China: super-efficiency data envelopment analysis approach", Maritime Business Review, Vol. 6 No. 2, pp. 173-187. https://doi.org/10.1108/MABR-08-2020-0051
9. Martner-Peyrelongue, Carlos. (2020). Globalización, conectividad interespacial y articulación territorial de los puertos mexicanos. EURE (Santiago), 46(139), 233-257. https://dx.doi.org/10.4067/S0250-71612020000300233
10. McGinley, K. (2014). Preparing port container terminals for the future: Making the most of intelligent transport systems (ITS). WIT Transactions on the Built Environment, 138, pp. 419–427
11. Miranda Soberón, U.E. & Acosta E.Z. (2009). Fuentes de información para la recolección de información cuantitativa y cualitativa. Lima; DGPP; 2009. 20 p. tab, ilus, mapas. Não convencional em Espanhol | LILACS, Repositório RHS | ID: biblio-885032
12. Ospina Arias, J. C. (2022). Visión logística portuaria y del tráfico marítimo en el Caribe. Servicio Nacional de Aprendizaje (SENA). https://hdl.handle.net/11404/7994
13. Pérez, I., Trujillo, L. and González, M.M. (2016). Efficiency determinants of container terminals in Latin American and the Caribbean, Utilities Policy, Volume 41, 2016, Pages 1-14, ISSN 0957-1787, https://doi.org/10.1016/j.jup.2015.12.001

14. Sarduy Domínguez, Y., (2007). El análisis de información y las investigaciones cuantitativa y cualitativa. Revista Cubana de Salud Pública, 33(3), 0.
15. Serebrisky, T., Morales Sarriera, J., Suárez-Alemán, A., Araya, G., Briceño-Garmendía, C. and Schwartz, J. (2016). Exploring the drivers of port efficiency in Latin America and the Caribbean, Transport Policy, Volume 45, 2016, Pages 31-45, ISSN 0967-070X, https://doi.org/10.1016/j.tranpol.2015.09.004
16. Tapia, R.J., Zárate, C., Esteban, A., Vieira, G.B.B. & Senna, L.A.S. (2014). Proposal and evaluation indicators cargo movement for the port of Mar del Plata. Espacios, 35(11), 9
17. Wilmsmeier, G., Monios, J. and Pérez-Salas, G. (2014). Port system evolution – the case of Latin America and the Caribbean, Journal of Transport Geography, Volume 39, 2014, Pages 208-221, ISSN 0966-6923, https://doi.org/10.1016/j.jtrangeo.2014.07.007