GT-Panama Thesis Series

DISCLAIMER

OCEAN CONTAINERIZED CARGO CONNECTIVITY RESEARCH

A Capstone Project
Presented to
The Academic Faculty

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In Partial Fulfillment
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The top two positions of the 2010 ranking for container throughput of the Economic Commission for Latin America and the Caribbean (CEPAL) were occupied by Panamanian ports. These positions were held by the Atlantic Port Terminals of Colon (MIT, Cristobal, Evergreen), followed by Panama Ports Balboa on the Pacific entrance of the Panama Canal. Together, these Panamanian ports moved about 5.5 million TEUs on 2010 and played a key role in the development of the national economy.

The goal of this document is to establish a better understanding of the role played by Panama in the regional containerized shipping network in order to inform port operators, shipping companies, government and other stakeholders about possible adjustments and necessary investments to maintain regional port leadership and market share and so to protect the national economy.

This study is also intended to benefit companies that are in the decision-making process of establishing regional distribution operations because it will give a comparative evaluation of the connectivity and competitiveness of regional ports.

OBJECTIVE

Our project objective is to understand, model and measure the connectivity of Panamanian container seaports in the Global Shipping Network in order to determine the actual role of Panama in terms of liner service connections, capacities and services provided by its container terminals.

We will define Connectivity as a level of competitiveness given by the access to liner services within the global shipping network (Gonzalez-Laxe 2011).

In addition, the project also includes the assessment of current capacities of the Panamanian container terminals in terms of regional competitiveness. For this purpose we will run scenarios in which the ports of Panama compete with other regional ports as a single macro-port and others in which the ports of Panama are not aggregated in order to demonstrate the importance of achieving sufficient interconnectivity to operate as ONE SINGLE PORT.

VALUE FOR PANAMA

The government of Panama will be able to:

- Measure and compare Panama's Connectivity within the global network of container shipping.
- Analyze Panama's capacities to import, export, or transship containers.
- Identify the benefits of attracting more shipping routes to Panamanian container Terminals.
- Identify the impact and advantages we can get from an integrated intermodal system that effectively ties our country together as ONE logistics hub.

VALUE FOR A COMPANY DECIDING TO ESTABLISH ITS REGIONAL OPERATIONS

- Help decide the best location for a regional distribution of products or services.

VALUE FOR A SHIPPING COMPANY

- Identify the regional ports that offer the most competitive connectivity and efficiency in order to deploy their liner services, offer a better service to their customers and reach multiple markets.

CHAPTER 1: PORTS OF PANAMA

Introduction

Port operations in Panama have shown significant growth, from the privatization process in early 1995. With this growth, the economy in the metropolitan region of the country has benefited from increased foreign investment in the installation of new infrastructure and technology, creating more jobs, higher tax contributions, and an expansion of trade and related activities in the maritime-port industry.

Port operations in Panama have developed, mostly by the movement of containerized cargo, which is an expanding activity in the services sector of the economy. Their operations contribute to the economic and social development of the country.

The wide range of services to shipping business has promoted the creation of new container terminals and expansion of existing ones. Panamanian ports represent key points in efficient and competitive maritime routes.

Description of Panamanian Ports

Manzanillo International Terminal

Manzanillo International Terminal started operations on 1995. This terminal is located at the Atlantic entrance of the Panama Canal immediately adjacent to the Colon Free Trade Zone (CFZ). MIT offers port services to shipping lines transiting the Panama Canal or serving the South American and Caribbean Region. One important competitive advantage is that they have direct access to the CFZ and highway access to the cities in the Republic of Panama and other Central American countries[1].

MIT is considered a regional logistics hub because of the value they can add to the cargo. They have opened warehouses to add new postponement services such as labeling, repackaging, assembly and others. An example of their added value is the service that they

[1] http://www.mitpan.com/

offer to companies that sell heavy equipment such as Caterpillar, Komatsu, Volvo and Hyundai. For these companies, the equipment is received in the port as break-bulk cargo, disarmed. The equipment is assembled and re-exported as finished product.

Colon Container Terminal

Colon Container Terminal (CCT) is a subsidiary company of Evergreen Group. It is a modern port specialized in handling containers, general cargo and rolling stock and the capacity for cargo transshipment[2].

According to representatives of CCT, this is the port with the least time for the dispatch of a container to a truck driver (just one hour). They have highlighted that they can achieve this because all the parts involved in the process (customs, security and administration) are coordinated to expedite the delivery.

CCT has already started their expansion projects to equip their facilities to receive Evergreen post-panamax vessels. This expansion project includes two new berths of 320 meters each, a second turning basin of 500 meters wide and 15 meters depth, 5 panamax gantry cranes, 12 post panamax gantry cranes and additional hectares for container yard.

Panama Ports

Panama Ports Company is a member of Hutchinson Port Holdings. It started operations in Panama in 1997. This port operator is in charge of managing two ports, one on each side of the Panama Canal:

The Port of Balboa is located in the city of Panama (Pacific Ocean) and the Port of Cristobal, in the city of Colon (Atlantic Ocean). The company began operations in Panama through a 25-year extendable concession by granted by the government (Law 5 of January 16, 1997) for the administration of both ports.

[2] http://www.cct-pa.com/

Panama Ports Company provides links and strategic access in the Transatlantic and Transpacific routes[3].

PSA Panama International Terminal

PSA Panama is the newest port operator in Panama. The Port is located at the Pacific entrance of the Panama Canal (former US Rodman Naval Base).

According to information published on the company's website, their goal for establishing their operations in Panama is to "participate in the growth of this strategic hub." The Port is currently under construction but PSA Panama expects to become an important port of call for shipping lines.

Because their strategic location in the Pacific side of Panama and immediate access to the Panama Canal. This terminal has the opportunity to serve as a transshipment point for cargo from important trade blocks such as Asia and the west coasts of North and South America.

[3] http://www.ppc.com.pa/

Table 16: Summary of Panamanian Container Port Infrastructure[4]

Description		MIT	CCT	Cristobal	Balboa	PSA
Location		9° 22' N 79° 53' W	9° 23' N 79° 53' W	9° 21' N 79° 54' W	8° 57' N 79° 34' W	8° 57' N 79° 34' W
Total Area	(hectare)	160	74.33	143	182	22
Total of berths	(number)	6	3	7	7	1
Container berths	(number)	5	3	4	5	1
RoRo Berths	(number)	1	n.a.	0	0	0
General Cargos	(number)	n.a.	n.a.	0	0	0
Multipurpose berths	(number)	n.a.	n.a.	3	2	0
Total Length of berths	(meters)	1940	982	2174	2260	330
Total length of container berths	(meters)	1640	982	1326.96	1712	330
Berth 1	(meters)	1240	312	335.79	299.63	330
Berth 2	(meters)	400	300	341.74	299.63	n.a.
Berth 3	(meters)	n.a.	370	321.95	335.5	n.a.
Berth 4	(meters)	n.a.	n.a.	326.48	335.5	n.a.
Berth 5	(meters)	n.a.	n.a.	n.a.	441.95	n.a.
Total length of RoRo berths	(meters)	300	0	0	0	n.a.
Berth 1	(meters)	300	0	0	0	n.a.
Total length of multipurpose berths	(meters)	n.a.	n.a.	846.66	548.57	n.a.
Berth 1	(meters)	n.a.	n.a.	139.66	227.59	n.a.
Berth 2	(meters)	n.a.	n.a.	347.32	320.98	n.a.
Berth 3	(meters)	n.a.	n.a.	359.68	n.a.	n.a.
Draft alongside	(meters)	14	14-15	13-15	16	14.5
Container storage area	(hectare)	52	37	16	30	n.s.
Container storage capacity	(teus)	48,000	45,000	n.s.	n.s.	n.s.
Quay Cranes (Super Post Panamax)	(22 cntrs)	3	0	0	4	0
Quay Cranes (Super Post Panamax)	(18 cntrs)	3	n.a.	n.a.	n.a.	0
Quay Cranes (Post Panamax)	(up to 17 cnts)	6	5	4	10	3
Quay Cranes (Panamax)	(up to 13 cnts)	2	5	3	8	0
Rubber Tyred Gantry Crane (RTG's)	(6 tiers +1)	24	30	8	37	6
Rubber Tyred Gantry Crane (RTG's)	(5 tiers + 1)	0	n.a.	24	14	0
Top Picks	(5 tiers high)	20	n.a.	4	n.a.	0
Side Picks	(8 tiers high)	18	n.a.	n.a.	n.a.	0
Side Picks	(5 tiers high)	4	n.a.	n.a.	n.a.	0
Reach Stackers	(4 tiers high)	n.a.	5	10	3	0
Empty handlers	(7 tiers high)	n.a.	12	13	21	0
Trucks		86	95	89	230	0
Chassis		94	108	94	233	0
Forklifts	(2.5 - 30 tns)	33	12	29	21	0
Reefer Points		1145	984	722	2184	0
Gates	lanes	10 (5in + 5out)	7 (4in + 3out)	9 (5in + 4out)	4 (2in + 2out)	2 (1in +1out)
Special Gates	(to CFZ)	2 (1in +1out)	0	n.a.	0	n.a.
Special Gates	(to rail)	n.a.	n.a.	1 on dock	2 (1in +1out)	n.a.
Yearly TEU handling volume (2010)		1.6 million	520,000	690,000	2.76 million	operates 2011
Total TEU handling capacity		2.2 million	1.3 million	800,000	3.4 million	450,000
Productivity (approximate)	(cntr/hour)	32	30	30	30	n.s.
Type of cargo:						
a. Container		yes	yes	yes	yes	yes
b. Ro Ro		yes	no	yes	yes	n.s.
c. Bulk (dry)		no	no	yes	yes	n.s.
d. Bulk (liquid)		no	no	yes	yes	n.s.
e. Special Projects		yes	yes	yes	yes	yes
Transshipment (%)		80.0%	85.0%	83.6%	92.8%	n.s.
CFZ (%)		15.0%	10.0%	0.0%	0.0%	n.s.
National (%)		5.0%	5.0%	16.4%	7.2%	n.s.

4 Georgia Tech Panama Logistics & Innovation Research Center July 2011

Panamanian Ports Infrastructure

As indicated in Table 1, Balboa has the largest number of container handling equipment and available infrastructure when compared to the other local terminals. Only when the ports of Colon are aggregated they have more capacity than Balboa. Nevertheless, local port operators indicate that the terminals of the Atlantic do not directly compete with the terminals of the Pacific because they serve different markets and their throughputs depend on the behavior of those markets.

The last 3 rows of Table 1 emphasize Panama’s position not as consuming country but as a strategic point for the cargo to be handled and later forwarded to other countries. Port operators are expecting a growth on the regional transshipment market which currently accounts for 87% of the total containerized cargo handled in the country.

Transshipment operations require sufficient yard space for container storage and handling, efficient customs transaction system, security inspections and necessary infrastructure and equipment such as appropriate number of berths and quay cranes. As previously described, ports such as MIT also integrate their operations with warehouses to provide postponement services that attract more transshipment operations.

As a result of their growing demand and market forecasts, Panamanian port operators are currently expanding their facilities in order to take advantage of future opportunities. These port operators expect to serve more post-panamax vessels after the Panama Canal completes its expansion project on 2014. Most of those post-panamax vessels are expected to be deployed in the Asia-North America trade because this market justifies the use of such economies of scale.

Nevertheless, most port operators are very cautious about the market behavior and expect to grow along with the demand in the upcoming years. For example MIT expansion investments will be done as they perceive the volume increase. They are trying to avoid what happened in Puerto La Union in El Salvador, where large investments were made for the expansion, but the cargo volumes did not increase as expected.

Parallel to the expansion projects of the ports, public and private investments are being done to improve the connecting infrastructure between the port assets. Examples of these types of investments include a new highway system that connects port regions and the expansion projects of the Panama Railway Company.

Analysis of regional port throughput

Table 17: Regional Container Throughput[5]

Rank	Port	Country	TEU 2008	TEU 2009	TEU 2010	Var. 2010/09
1	Colon (MIT, Evergreen, Panama Port)	Panamá	2,468,520	2,210,720	2,810,657	**27.10%**
2	Balboa	Panamá	2,167,977	2,011,778	2,758,506	**37.10%**
3	Santos	Brasil	2,677,899	2,255,862	2,715,568	**20.40%**
4	Kingston	Jamaica	1,915,951	1,728,042	1,891,770	**9.50%**
5	Buenos Aires (includes Exolgan)	Argentina	1,781,100	1,412,462	1,730,831	**22.50%**
6	Cartagena (includes S.P.R. El Bosque, Contecar, ZP)	Colombia	1,064,105	1,237,879	1,581,401	**27.80%**
7	Manzanillo	Mexico	1,409,782	1,110,356	1,509,378	**35.90%**
8	Callao	Peru	1,203,315	1,089,838	1,346,186	**23.50%**
9	Guayaquil	Ecuador	874,955	884.1	1,093,349	**23.70%**
10	Freeport	Bahamas	1,702,000	1,297,000	1,081,000	**-16.70%**

As we can observe on Table 2, Panama's Ports are ahead in the container throughput ranking with the Atlantic Ports grouped in Colon and in the second position with the Port of Balboa. In the last two years these ports have marked a sustainable growth even though the throughput for 2009 was affected by the economic crisis.

According to preliminary numbers of the Panama Maritime Authority, in the first trimester of 2011, Balboa achieved a throughput of 742,856 TEUs whereas the Port Complex of Colon moved 731,864 TEUs followed by Santos with 650,146 TEUs. The Economic Commission for Latin America and the Caribbean indicates that the Port of Balboa moved 32.6% more cargo when compared to the same period of 2010. The increase presented on this preliminary figures allowed the port of Balboa overtake the Port Complex of Colon as the port with the highest throughput in the region. The opinion of the Panamanian port

[5] Economic Commission for Central American and the Caribbean (2011)

operators interviewed is that the growth will continue consistently for the next years. According to these operators, the growth could be explained by the increase of transshipment cargo from Asia destined to the regional market.

Local port operators indicate that the amount of cargo handled ultimately depends on the demand and their capacity to handle such demand. The final throughput of each port also depends on the efficiency of processes such as customs and security inspections. If these processes are not efficient the overall productivity of the port will be decreased.

CHAPTER 2: PORT CONNECTIVITY MEASURING TOOLS

Overview

In the context of this study, port connectivity is defined as the level of competitiveness given by the access to liner services within the global shipping network (Gonzalez-Laxe 2011).

The tools that will be analyzed in this section are: UNCTAD Liner Shipping Connectivity Index and the Georgia Tech Deep Connectivity Index. We will present a comparison of these two indexes and compare their results with ranks of container throughput.

We will compare the most relevant ports in the Atlantic Coast of Central America, the Caribbean and the Northeast Coast of South America. The ports of region that will be compared in the next sections are:

i. Colon - Balboa (aggregated ports of Panama),

ii. Kingston (Jamaica),

iii. San Juan (Puerto Rico),

iv. Freeport (Bahamas),

v. Limon Moin (Costa Rica),

vi. Puerto Cabello (Venezuela),

vii. Cartagena (Colombia),

viii. Puerto Cortes (Honduras),

ix. Rio Haina (Dominican Republic).

UNCTAD[6] Liner Shipping Connectivity Index

The Liner Shipping Connectivity Index (LSCI) is a measure calculated from all the information available about fleet assignment, liner services, and vessel/fleet sizes. This measure helps to distinguish who trades what with whom, and determine the best “connected” countries through the Global Shipping Network.

The indicator is computed from the following individual indicators:

a) The number of ships that call in a country’s ports

b) The total container carrying-capacity of those ships

c) The maximum vessel size

d) The number of liner services that call in a country’s ports

e) The number of carriers that deploy liner services from and to country’s ports.

These indicators are first standardized so they can only have a maximum value of 1.0 and a minimum value of 0.0. After having all 5 indicators standardized, the next step is the calculation of the average indicator for each country. After this, they identify the maximum value, and then all values are divided by this maximum, so the maximum value of the indicator, becomes 1.0.

After this computation, the indicator reflects very logical results. For example, the highest value in 2004 (year in which the LSCI was computed for the first time) was given to Hong Kong followed by Singapore, China, United States and the Netherlands, which are the countries with more total cargo throughput in the world.

The LSCI results indicate that Panama and the Bahamas are the “best-connected countries” in the Americas, for being mostly transshipment ports for the region. Egypt and South

[6] Refers to The United Nations Commission on Trade and Development

Africa are the best-connected countries in Africa, for the cargo they manage as a result of their strategic geographic position.

Because since 2004 countries have presented changes in their LSCI scores, the scores are no longer on a 0 to 1 scale. UNCTAD official reports currently present the scores using a scale where 1=100. Table 3 presents the best-connected countries in the world, based on the LSCI scores for 2010 whereas Table 4 presents the 2010 scores for our region of focus.

Table 18: LSCI - Best Connected Countries by Region[7]

Region	Country	Score
Asia	China	143.56
North America	United States	83.79
Europe	Germany	90.87
Central America	Panama	41.08
Africa	Morocco	49.35
South America	Brazil	31.65

Table 19: LSCI - Regional Scores[8]

Port	Connectivity LSCI 2010
Colon and Balboa (Panama)	41.09
Kingston (Jamaica)	33.09
San Juan (Puerto Rico)	10.92
Freeport (Bahamas)	25.71
Limon Moin (Costa Rica)	12.77
Puerto Cabello (Venezuela)	18.71
Cartagena (Colombia)	26.13
Puerto Cortes (Honduras)	9.09
Rio Haina (Dominican Republic)	22.25

[7] UNCTAD 2004
[8] UNCTAD 2010. The 2010 score for Puerto Rico was not found. Instead, the 2009 score was used.

Georgia Tech Deep Connectivity Index

The Georgia Tech Deep Connectivity Index (GTDCI) computes the strength of position (connectivity) within the network, for each container port, from the perspectives of both import and export.

The model used to compute the index scores is populated using data from existing liner container services. Currently, the adjacency matrix is populated using connections from the four major shipping lines. This initial sample of data is considered to be representative for the computation of the scores for each individual port that forms the Global Liner Shipping Network.

With the adjacency information provided by the liner services, the program computes statistics about nodes and displays the transportation network. These statistics are considered the "deep connectivity index", which is the strength of position within the network, for each port, from the perspectives of both import and export.

What makes this index different from the other existing indexes of the industry is that it is based not only on local data, it is recursive. In other words, the GTDCI ranks the ports based not just on its "neighbors" (where a port sends or receives freight), but what its neighbors are connected to and so on. In other words, it provides a ranking of ports measured recursively from the inbound and outbound direct connections with other ports. This measure is influenced by the importance of the port you have in your network, so it does not only considered the number of links available but to whom are these links connected to.

Table 20: GTDCI - Best Connected Ports by Region[9]

Region	Country	Port	Import	Export
Asia	China	Hong Kong	0.4434	0.5668
North America	United States	Los Angeles/Long Beach	0.0648	0.0147
Europe	Netherlands	Rotterdam	0.0206	0.0295
Central America	Panama	Colon/Punta Manzanillo/Cristobal	0.0147	0.0102
Africa	Egypt	Port Said	0.011	0.0084
South America	Brazil	Santos	0.0052	0.0038

[9] Georgia Tech Deep Connectivity Index (July 2011)

Table 21: GTDCI - Regional scores[10]

Port	Georgia Tech Deep Connectivity Index	
	Import	Export
Colon - Balboa (Panama)	0.0259	0.0145
Kingston (Jamaica)	0.0008	0.0010
San Juan (Puerto Rico)	0.0003	0.0000
Freeport (Bahamas)	0.0002	0.0001
Limon Moin (Costa Rica)	0.0006	0.0012
Puerto Cabello (Venezuela)	0.0000	0.0002
Cartagena (Colombia)	0.0007	0.0011
Puerto Cortes (Honduras)	0.0001	0.0000
Rio Haina (Dominican Republic)	0.0000	0.0002

Table 5 presents the best connected ports by region. These results are similar to the ones given by the LSCI on table 3.

In the results presented on Table 6, Panama (aggregated as single port) ranks first over its regional competitors. In other words, based on the results of the GTDCI we can state that when the ports of Panama are aggregated as one macro port, it becomes the most connected port of the region by a significant amount over its competitors.

The aggregated ports of Panama accomplish the most important characteristics to become the regional transshipment hub because of the following reasons.

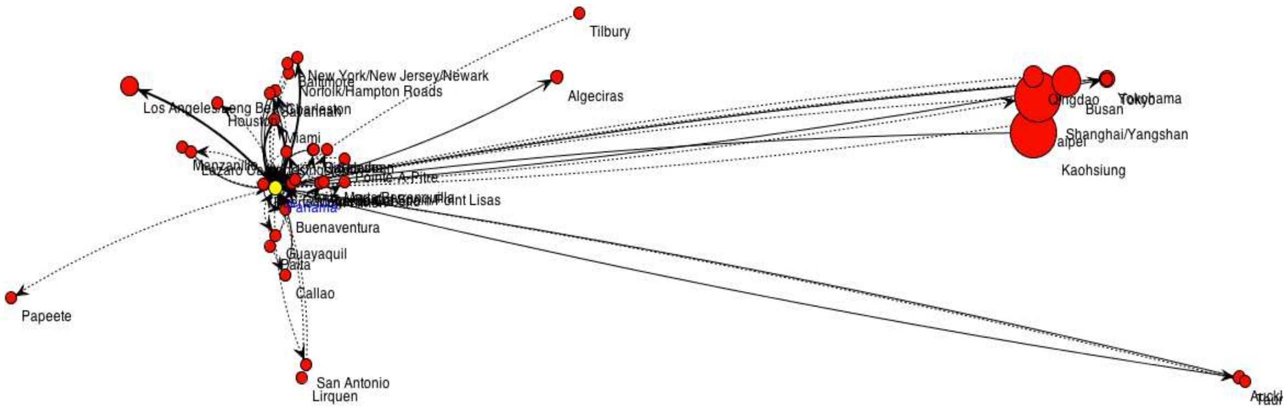
- Geographic position, for the reduction of freight cost and transit times
- Important port infrastructure and effective operation
- Important position within the Global Shipping Network, supported by the importance of the Panama Canal
- Railway and highways
- Port expansion projects and new developments such as the PSA Panama Terminal in the Pacific.

[10] Georgia Tech Deep Connectivity Index (July 2011)

- Great connectivity with the region with a variety of liner services
- Great connectivity with other important ports in North and South America, Asia and Europe.

This advantages brings opportunities not only to became a gateway to enter the region, but also a gateway from the outbound perspective, connecting local exporters with important high end markets as USA, Canada, Europe and Japan.

Figure 1: GTDCI – Visualization of Panamanian Ports Connections.



However, when the Panamanian Ports are not aggregated, only Balboa and Manzanillo remain dominant in the top two positions of the regional ranking given by the GTDCI (Table 7). It is important to that when these Panamanian Terminals are not aggregated. Cristobal becomes the least connected port of the region.

If we expand the scope of the selected region, we find that other regional ports receive significant scores by the GTDCI in terms of import and exports. One of the main examples of this is Lazaro Cardenas (Mexico), which receives higher scores than Panama (when the Panamanian ports are not aggregated).

Table 22: GTDCI - Regional Scores. Ports of Panama not aggregated[11]

Port	Import Score	Export Score
Manzanillo (Panama)	0.0401	0.0557
Balboa (Panama)	0.0399	0.0494
Kingston (Jamaica)	0.0222	0.0198
San Juan (Puerto Rico)	0.0006	0.0077
Cartagena (Colombia)	0.0071	0.0067
Freeport (Bahamas)	0.0024	0.0055
Colon (Panama)	0.0072	0.0033
Limon Moin (Costa Rica)	0.0057	0.0031
Puerto Cabello (Venezuela)	0.0056	0.0028
Puerto Cortes (Honduras)	0.0003	0.0026
Rio Haina (Dominican Republic)	0.0063	0.0003
Cristobal (Panama)	0.0042	0.0002

Lazaro Cardenas is a highly ranked port is related to outbound (export) connections. This is due to the exporting activities that Mexico manages through this port. Its history indicates that the port was previously created as an industrial port but with the development of commercial shipping routes and its strategic position for trade between Mexico and the US with Asia, it has been gaining importance through the years.

This port is considered as the gateway for inbound and outbound operations of Mexican market, and a very profitable option for the Southwest region of the United States. However, if we analyze the number and destination of its other connections within the region, they don't have the big variety of connections as Ports of Panama. This is another important characteristic necessary for any terminal that is trying to become the transshipment hub of the region.

[11] Georgia Tech Deep Connectivity Index (Jun 2011)

Panama as a single port

At this point, it is evident that Panama achieves the best regional connectivity when all the port terminals of the country operate as a single unit. To be fully integrated, it must be cheap and fast to move containers among ports. However, informal inquiries suggest that this is not currently the case because the market is not allowed to function freely and pressing needs such as adequate roads that connect the ports of Colon are not currently available.

In order address these issues, a high level of coordination between the government and local port operators is required to orchestrate improvements in customs procedures, security measures, technology and infrastructure. These improvements are necessary to achieve the required integration that will allow Panama compete as a single port unit.

Comparison: Georgia Tech Deep Connectivity Index and UNCTAD Liner Shipping Connectivity Index

Before trying to compare the results given by these indicators, we need to take in consideration that the GT Deep Connectivity index measure is made by the connections of individual ports. On the other hand, the liner shipping connectivity index measure is made by Country. So a level of aggregation of ports per country needs to be determined in order to make equivalent comparisons.

Is it worth to compare both indexes?

Depends on the type of information we are looking for. In our project we are interested in the actual connectivity of single ports as an advantage for world commercial trade. With the aggregation of ports at country levels, we are unable to identify the best strategically connected ports per region in order to address specific recommendations.

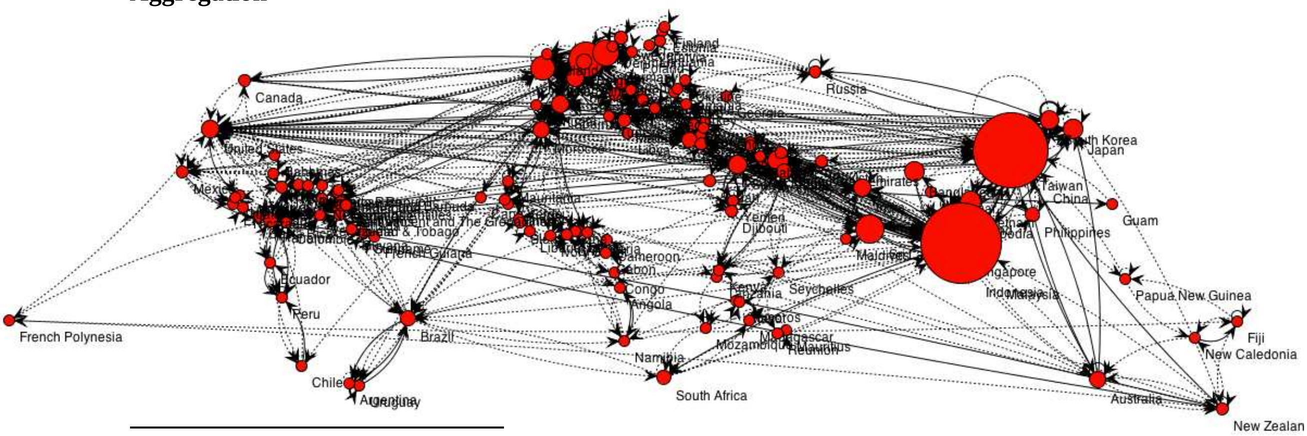
Gonzalez-Laxe (2011) indicates that the productivity of a specific port can be measured by how many container lines they attract – which is a direct measure of connectivity. Ports attract shipping services by being productive, flexible and by offering competitive costs.

Needless to say, some ports have more limitations than others based on space available, depth or other criteria. But if we compare two ports of about the same size, serving the same market and with the same available economic resources, they should have about the same productivity or attract the same number of carriers. If with the same available resources a port has significantly less connectivity than other, it could be a sign that something is not functioning properly. This could be of interest for governments or companies in charge of overseeing port performance.

Other indexes that aggregate port data in order to obtain a score for the entire country may not be applicable for organizations looking for this type of information. The scores provided by the Deep Connectivity index are unique because they give each port a separate score whereas other the UNCTAD's Liner Shipping Connectivity Index aggregate the "connectivity" of all ports in a country which limits the differentiation between each port's connectivity. For a company that is deciding where to base their operations in a specific region, this aggregation may not be beneficial because it assumes that regardless of which part of a country you establish your operations in a country, you will get the same connectivity. It is important to note that the UNCTAD approach is most useful when a country can be considered a single port such as Panama or the Bahamas.

In spite that these two indexes are calculated taking in consideration different perspectives, we can still analyze the differences in the results and address the possible causes by aggregating the ports on the GTDCI.

Figure 2: Global Containerized Shipping Network Generated Using the GTDCI – Country Level Aggregation[12]



[12] Georgia Tech Deep Connectivity Index (July 2011)

In order to calculate the aggregated connectivity scores of each country, the connections for each port are summed to obtain a total number of edges between countries. The GTDCI counts the number edges between the new nodes (countries) and computes the recursive connectivity score.

Figure 2 presents a visualization of the Global Containerized Shipping Network generated using the GTDCI (ports aggregated to country level). The size of the node and the type of edges (dotted or solid linest) depend on the number of connections between ports.

Table 8 and Table 9 presents the "best connected" countries per region using the GTDCI (country level analysis) in order to compare them with the results provided by the liner shipping connectivity index.

Table 23: GTDCI - Country Level Analysis. Best connected ports per region (import scores)[13]

Region	Country	Import Score
Asia	Malaysia	1.0000
North America	United States	0.0965
Europe	Netherlands	0.3464
Central America	Panama	0.0580
Africa	Morocco	0.0888
South America	Brazil	0.0728

Table 24: GTDCI - Country Level Analysis. Best Connected Ports per Region (export scores)[14]

Region	Country	Export Score
Asia	Singapore	1.0000
North America	United States	0.0904
Europe	Germany	0.1671
Central America	Panama	0.0464
Africa	Egypt	0.0734
South America	Brazil	0.0220

From the results presented on Table 8 and Table 9, it is interesting to note that even with different sets of data and computing algorithms, some countries stayed almost on the same rank within the Global Containerized Shipping Network.

[13] Georgia Tech Deep Connectivity Index (July 2011)
[14] Georgia Tech Deep Connectivity Index (July 2011)

The advantage of measuring at country level is that it allows the user to obtain a general idea of which are the most important countries for the global shipping connectivity index. Political and Economical analysis for the industry can be easily enriched with this type of information, and other topics related to world trade.

The disadvantage of this level of study is that it is impossible to analyze specific scenarios inside one country. For example, the user is unable to analyze the activities of US East Coast ports vs. US West Coast ports. Nevertheless, this analysis can be done using the GTDCI.

It is understandable that the GT Connectivity Index has weaknesses. For example, it cannot be used for pure comparison between countries, because when the ports of the country are aggregated, connections between ports of the same country are eliminated. This is why there are some differences in the ranking by country between these two indexes, especially large countries with several important and interconnected ports as China. In this case, China, a country with a significant amount of intra-national shipping, receives a reduced score because these intra-national connections are no longer considered. On the other hand, countries such as Singapore, a country not affected by the discard of intra-national connections, will appear stronger because of the weakening of the score of countries like China.

For Panama there is not much variation because the amount and importance of sea connections between Panamanian ports are not as critical as its connections between to rest of the network. However, a lower ranking for Panama it's perceived.

Comparison: Container throughput, UNCTAD Liner Shipping Connectivity Index, and Georgia Tech Deep Connectivity Index

When we compare the container throughput of the Top 10 Container Terminals in Latin America, the UNCTAD Liner Shipping Connectivity Index and the Georgia Tech Deep Connectivity index, the results indicate that even though both indexes measure connectivity using different computation methods and data, the GTDCI has a stronger correlation with the throughput levels.

Table 25: Container Throughput and Connectivity Tools Comparison[15]

Port	TEU Throughput 2010	LSCI	GTDCI Import Score	GTDCI Export Score
Colon-Balboa	5,569,163	41.09	0.0259	0.0145
Santos	2,715,568	31.65	0.0052	0.0038
Kingston	1,891,770	33.09	0.0008	0.0010
Buenos Aires	1,730,831	27.61	0.0008	0.0010
Cartagena	1,581,401	26.31	0.0007	0.0011
Manzanillo	1,509,378	36.35	0.0031	0.002
Callao	1,346,186	21.79	0.0001	0.0004
Guayaquil	1,093,349	18.73	0.0002	0.0002
Freeport	1,081,000	25.71	0.0002	0.0001

From the analysis of this sample of ports, the correlation between the 2010 container throughput and the GTDCI Import and export score was 0.974 and 0.985 respectively. On the other hand, the correlation of the throughput levels and the LSCI was 0.746.

Conclusion from Connectivity Indexes Comparison

We conclude that the Georgia Tech Deep Connectivity Index seems to be an appropriate tool.

[15] Generated by the authors from Table 2; Table 4; Table 6

CHAPTER 3: REGIONAL PORT COMPETITIVENESS

Overview

A high performance of container terminal connectivity is not the only necessary factor to achieve port leadership. Gomez (2010), indicates that the main determinants of port competitiveness are: freight costs; geographic position (distances to other ports); port productivity; container handling capacity; and the connectivity of the port in terms of access to the liner services.

Tongzon (2009) ranks these factors and indicates that, from the perspective of the freight forwarders, port efficiency is “the most important factor in the port selection process” followed by shipping frequency, adequate infrastructure and geographic location.

In this context, port efficiency depends on the container handling capacity of a terminal. For example, if a container terminal has an adequate number of quay cranes, it dedicates the appropriate number of cranes to the load and unload operations of a containership. This will provide a faster and more reliable service in which the cargo is delivered on the promised time.

Regarding geographic position, if a port has short distances to other major ports, the transportation costs is reduced because less fuel and transit time is required. If a port is in the route of trade flows, it is also benefited by the opportunity to provide a point for redistribution on a hub and spoke configuration.

Gomez (2010) developed the Regional Competitiveness Index to combine measures of port distances, port infrastructure and connectivity; and used this to rank the most competitive ports in the Atlantic Coast of Central America and the Northeast Coast of South America.

The result is a final indicator that helps to understand the comparative positioning of container terminals of this region. Because of lack of data and variability in the freight rates and port productivity, these two factors were not used to compute the regional competitive index.

Methodology

The ports of region that will be compared are: Colon - Balboa (aggregated ports of Panama), Kingston (Jamaica), San Juan (Puerto Rico), Freeport (Bahamas), Limon Moin (Costa Rica), Puerto Cabello (Venezuela), Cartagena (Colombia), Puerto Cortes (Honduras), Rio Haina (Dominican Republic).

i. **Geographic position:** In order to determine the port with the most competitive geographic position, distances in (nautical miles) from the major trade regions (Europe, Far East Asia, North and South America) to the nine ports of the study were calculated. Ports received a score based on how central they are in terms of the major trade regions. The procedure used to determine the competiveness of the nine ports is as follows:

   1. Using information from the liner services of the top five shipping companies[16], the main trade regions connected to the nine ports selected were indentified.
   2. The routes that connected our region of interest to the major trade blocks were examined looking for those ports that the shipping companies used most frequently.
   3. The distances from the ports of the major trade regions (e.g. Rotterdam in Northern Europe and Shanghai in China) to the nine ports of were obtained and the different combinations of origins/destinations using the nine ports as intermediary (transshipment) point were created analyzed.

   The results obtained from the distance analysis were:

   - The port of Colon-Balboa has the shortest distances in all the combinations of origin-intermediary-destination routes analyzed.
   - The port of Limon Moin has the second best position with a great relevance to the routes connecting the U.S. Gulf Coast and South America.
   - San Juan ranks third with an advantage in those connections with Europe.

[16] Alphaliner (October 2008) AXS Alphaliner Top 100: APM-Maersk; MSC; CMA CGM Group; Evergreen Line; and Happag Lloyd.

- Kingston has strong significance to the routes connecting the Far East and Europe with the U.S. East Coast.
- Freeport has a good position for routes connecting Far East and the U.S. East Coast.
- Cartagena, Puerto Cabello, Puerto Cortes, and Rio Haina are relative close to the ports previously described. However, in terms of distance, they do not seem to be more competitive. Consequently, Gomez (2010) suggests that these ports are oriented to domestic markets and transshipment within the Caribbean.

Table 26: Regional Port Competitive Distance Rank[17]

Port	Competitive Distance Rank
Colon and Balboa (Panama)	1
Limon Moin (Costa Rica)	2
San Juan (Puerto Rico)	3
Kingston (Jamaica)	4
Freeport (Bahamas)	5
Rio Haina (Dominican Republic)	6
Puerto Cortes (Honduras)	7
Cartagena (Colombia)	8
Puerto Cabello (Venezuela)	9

The breakdown of the ports and their relevance to specific trade regions is important because we can argue that a transshipment hub will depend not only on their number of connections but its relevance to specific regions. For Example, Freeport could be the best transshipment hub for cargo going to the U.S. East Coast whereas San Juan could be use as the transshipment hub for cargo going to Europe.

ii. **Capacity:** The cargo handling capacity of a port and, consequently, its container throughput, depend on its available infrastructure. The container throughput of a port is also a reflection of the behavior of demand and the necessity of having sufficient infrastructure to handle such demand (Gomez 2010).

[17] Gomez (2010)

In order to determine the infrastructure component that has the strongest impact on the cargo handling capacity of a port, the relationship between number of berths, quay cranes and container throughput were analyzed. The results demonstrated that ports with a larger number of quay cranes to have larger container throughputs. Therefore, the number of quay cranes is used as a measure of container handling capacity (Ibid).

Table 27: Regional Number of Quay Cranes and Container Throughput 2010 – Ports of Panama Aggregated[18]

Port	Number of Quay Cranes	Container Throughput
Colon and Balboa (Panama)	53	5,569,163
Kingston (Jamaica)	17	1,891,770
San Juan Puerto Rico	13	1,684,884
Freeport Bahamas	12	1,081,000
Limon Moin (Costa Rica)	2	858,176
Puerto Cabello (Venezuela)	7	790,000
Cartagena (Colombia)	6	1,581,401
Puerto Cortes (Honduras)	8	538,853
Rio Haina (Dominican Republic)	3	288,417

From the capacity information presented on Table 12 we conclude that the Port System of Panama (Colon-Balboa) has the largest number of quay cranes and port equipment when compared to other ports of Central America and the Caribbean. Similarly, it is the port with the largest throughput. However, it is important to note that on two instances the container throughput is not proportional to the number of quay cranes. These two exceptions are the port of Limon-Moin and Puerto Cortes (Honduras). The exact reasons for these exceptions will require a deep analysis of the operations of these two terminals. The exceptions demonstrate that there are other variables that affect the port throughput and not necessarily a large number of cranes will result in a large throughput (Gomez 2010). Examples of these types of

[18] Economic Commission for Latin America and the Caribbean (2010); Port Authorities websites; Georgia Tech Logistics & Innovation Research Center (Jul 2011). Does not include the gantry cranes of PSA Panama because the 2010 throughput data for Panama does not include movements performed by PSA Panama.

variables are: Crane operator skill level, crane type, Crane age, economic downturns, etc.

iii. **Connectivity:** The Regional Competitiveness Index uses the connectivity scores given by UNCTAD's Liner Shipping Connectivity Index.

The problem with using the LSCI for a port level analysis is that it may not give a good representation of the actual connectivity score for a single port (except when the port is the only major port of the country). Based on this, we propose to run two tests: The computation of the Regional Competitiveness Index using UNCTAD's Liner Shipping Connectivity Index score and the computation of the Regional Competitiveness Index using the Georgia Tech Deep Connectivity Index.

Test No.1: Regional Competitiveness Index using UNCTAD's Liner Shipping Connectivity Index scores.

The methodology used to compute the Regional competitive index combines the values of following competitiveness metrics for each port: rank of the ports in terms of geographic distances to major trade regions, the number of quay cranes of each ports, and a connectivity score for each port (in this case, the Liner Shipping Connectivity index).

Table 28: Regional Competitive Metrics Including UNCTAD Liner Shipping Connectivity Index – Ports of Panama Aggregated[19]

Port	Competitiveness Metrics		
	Distance	Capacity	Connectivity
Colon - Balboa (Panama)	1	53	41.09
Kingston (Jamaica)	4	17	33.09
San Juan (Puerto Rico)	3	13	10.92
Freeport (Bahamas)	5	12	25.71
Limon Moin (Costa Rica)	2	2	12.77
Puerto Cabello (Venezuela)	9	7	18.71
Cartagena (Colombia)	8	6	26.13
Puerto Cortes (Honduras)	7	8	9.09
Rio Haina (Dominican Republic)	6	3	22.25

[19] Generated by the authors using Table 4; Table 11; Table 12

Then, each competitive metric is standardized based on the port with the highest score. Once the metrics are standardized, the average of each of the metrics score is obtained resulting in a general regional competitiveness index for the port. Table 14 presents the standardizations and results for Test No 1.

Table 29: Regional Competitiveness Index Based on LSCI Scores – Ports of Panama Aggregated[20]

Port	Standardization			Regional Competitiveness Index
	Distance	**Capacity**	**Connectivity**	
Colon -Balboa (Panama)	1.000	1.000	1.000	1.000
Kingston (Jamaica)	0.250	0.321	0.031	0.201
San Juan (Puerto Rico)	0.333	0.245	0.012	0.197
Freeport (Bahamas)	0.200	0.226	0.008	0.145
Limon Moin (Costa Rica)	0.500	0.038	0.023	0.187
Puerto Cabello (Venezuela)	0.111	0.132	0.000	0.081
Cartagena (Colombia)	0.125	0.113	0.027	0.088
Puerto Cortes (Honduras)	0.143	0.151	0.004	0.099
Rio Haina (Dominican Republic)	0.167	0.057	0.000	0.074

The results from computing the Regional Competitiveness using the LSCI (Table 14) indicate that the port system of Colon-Balboa has the best scores in terms of geographic distances to major trade regions, the number of quay cranes of each ports, and a connectivity. As a result, it becomes the most competitive port of the region.

Since the computations of the Regional Competitiveness Index use the basic principles of standardization of variables used by the UNCTAD Liner Shipping Connectivity Index, it is the subject to similar critics as the LSCI.

Test No.2: Regional Competitiveness Index using Georgia Tech Deep Connectivity Index.

The methodology applied to compute the results of Test No.2 is the same used on Test No.1. However, the connectivity scores for each port are from the Georgia Tech Deep Connectivity Index.

[20] Generated by the authors using Gomez (2010) Regional Competitive Index principles and information from Table 13

Since the scores connectivity scores given by the GTDCI are presented separately in terms of imports (inbound connections) and exports (outbound connections), two subtests are presented: Test No.2A for the import connectivity scores and Test No.2B for the export connectivity scores.

Table 30: Regional Competitiveness Index Based on GTDCI Scores – Ports of Panama aggregated[21]

Port	Regional Competitiveness Index	
	Test No.2A	**Test No.2B**
Colon and Balboa (Panama)	1.000	1.000
Kingston (Jamaica)	0.201	0.213
San Juan (Puerto Rico)	0.197	0.193
Freeport (Bahamas)	0.145	0.144
Limon Moin (Costa Rica)	0.187	0.207
Puerto Cabello (Venezuela)	0.081	0.086
Cartagena (Colombia)	0.088	0.105
Puerto Cortes (Honduras)	0.099	0.098
Rio Haina (Dominican Republic)	0.074	0.079

Since the metrics for distances and quay cranes remain unchanged, the results of calculating the Regional Competitive Index using the scores from the GTDCI still rank Panama (Colon-Balboa) as the most competitive port of the region (Table 15). It is important to mention that even though the scores for imports and exports are computed individually, the Regional Competitiveness Index scores are very similar in Test No.2A and Test No.2B

From the results provided on Test No.1, Test No.2A and Test No.2B, a new question arises: If the ports of Panama are not combined as a one, would it still be the most competitive port of the region?

To answer this question we run Test No.3 where the ports of Balboa and Colon are consider independent ports.

[21] Generated by the authors using Gomez (2010) Regional Competitive Index principles and information from Table 6 and Table 13

Test No.3: Regional Competitiveness Index – Ports of Panama not aggregated.

For this test, the ports of Panama will be separated as follows:

- Colon: formed by Manzanillo International Terminal, Colon Container Terminal and the Panama Ports Cristobal Terminal.
- Balboa: formed by the Panama Ports Balboa Terminal.

Since we want to the determine the competitiveness score of two separate terminals within a country, the UNCTAD's Liner Shipping Connectivity Index will not serve our purpose because it gives a connectivity score at the country level. Therefore, we use the Import and Export scores provided by the Georgia Tech Deep Connectivity Index where the scores for two independent ports within a country can be obtained.

For the computations, the only metric that will change is the GTDCI scores for Panama that are replaced for independent scores for port of Colon and the port of Panama. The distance rank for the ports of Panama remain the unchanged because the distances between these ports (about 43 nautical miles) is not significant to make a difference in the ranking.

From Table 16 we can observe that the results for the Regional Competitiveness Index in terms of import and exports are very similar; in both scenarios, the Port of Colon ranks first followed by Balboa. It is also important to note that there is a significant difference between the scores of the ports Panamanian ports and the rest of the ports analyzed.

Table 31: Regional Competitiveness Index Based on GTDCI Scores – Ports of Balboa and Colon Treated independently

Port	Regional Competitiveness Index	
	Test No. 3A	Test No. 3B
Colon (Panama)	1.000	1.000
Balboa (Panama)	0.851	0.786
Kingston (Jamaica)	0.284	0.299
San Juan (Puerto Rico)	0.258	0.251
Freeport (Bahamas)	0.200	0.199
Limon Moin (Costa Rica)	0.202	0.227
Puerto Cabello (Venezuela)	0.112	0.119
Cartagena (Colombia)	0.122	0.142
Puerto Cortes (Honduras)	0.136	0.134
Rio Haina (Dominican Republic)	0.088	0.094

From these results, another question arises; would the Ports of Colon (Manzanillo, Cristobal and Colon) still be competitive if not aggregated? To answer this question we run Test No.4 where the Ports of Colon are not aggregated.

Test No.4: Regional Competitiveness Index Using GTDCI – Ports of Colon not aggregated.

The results for this test are presented on Table 17. From this table we can observe that for the import and export scenarios, the Port of Balboa is the new most competitive port of the region followed closely by Manzanillo. The third and fourth positions are held by Colon and Kingston respectively. Cristobal occupies the fifth position. It becomes the first test in which all the ports of Panama are not on the top competitiveness positions of the ranking.

Table 32: Regional Competitiveness Index Using GTDCI - Ports of Colon not Aggregated[22]

Ports	Regional Competitive Index - GTDCI Import Score	Regional Competitive Index - GTDCI Export Score
Balboa (Panama)	0.998	0.9623
Manzanillo (Panama)	0.879	0.8788
Colon (Panama)	0.545	0.5046
Kingston (Jamaica)	0.525	0.4594
Cristobal (Panama)	0.474	0.4406
San Juan (Puerto Rico)	0.313	0.3542
Freeport (Bahamas)	0.268	0.2814
Limon Moin (Costa Rica)	0.244	0.2155
Cartagena (Colombia)	0.192	0.1727
Puerto Cabello (Venezuela)	0.19	0.1599
Puerto Cortes (Honduras)	0.171	0.1844
Rio Haina (Dominican Republic)	0.153	0.1028

In an interview with Dr. Gomez to discuss our results we discussed that the geographic position metric will always favor Panama. The explanation for our results can be that the

[22] Generated by the authors using Gomez (2010) Regional Competitive Index principles and information from Table 7 and Table 13

geographic position is a factor of connectivity. Therefore, it repeats the measurement and adds more weight to geographic position than any other variables. Consequently, a port with good geographic position but low scores in terms of capacity and connectivity can still obtain a good score from the Regional Competitiveness Index.

Because of this, we decided to run a new set of tests for the Regional Competitiveness Index without including the geographic distance metric.

Test No.5A: Regional Competitiveness Index using GTDCI Export Scores - not including the geographic distance variable.

When we take out the geographic distance metric and run the computations for the Regional Competitiveness index (without any aggregation of ports) our results show a very significant difference; on Table 18, Colon falls to the 6^{th} position and Cristobal falls to the 10^{th} position in terms of regional competitiveness. These two Panamanian Terminals rank much below in competitiveness than many other regional ports for the first time. This test proves that the use of the geographic centrality measure artificially benefited the ports of Panama because it raised their scores significantly (even when their number of cranes and connectivity scores were lower than many other regional ports). The results of this test are similar to the ones presented on Table 7 in which the connectivity scores of the GTDCI for these regional ports is presented.

The results presented on Table 7 and Table 18 demonstrate the importance of investing in the necessary infrastructure, technology and processes required to developed an intermodal system that effectively ties the Panamanian port assets together as a single port.

The results for Test No.5B where the Import scores are used show similar results. However, for that set of data, Colon climbs to the 4^{th} position and Cristobal raises to the 9th position.

When we run the Regional Competitiveness Index without the geographic distance metric but aggregating the ports of Colon and subsequently the ports of Balboa, the Panamanian terminals still maintain their hegemony in the ranking. But with this new way of computing the Regional Competitiveness Index, the differences in the scores between the top ports and their competitors is reduced significantly.

Table 33: Regional Competitiveness Index Based on GTDCI Export Scores - Ports of Colon not Aggregated. Not Including Geographic Distance Metric[23]

Port	Regional Competitiveness Index - GTDCI Export Scores
Balboa (Panama)	0.9434
Manzanillo (Panama)	0.8182
Kingston (Jamaica)	0.5641
San Juan (Puerto Rico)	0.3646
Freeport (Bahamas)	0.3221
Colon (Panama)	0.2569
Puerto Cortes (Honduras)	0.2052
Cartagena (Colombia)	0.1965
Puerto Cabello (Venezuela)	0.1842
Cristobal (Panama)	0.1609
Limon Moin (Costa Rica)	0.0733
Rio Haina (Dominican Republic)	0.0709

Conclusions from Port Competitiveness Tests:

In order to obtain a fair set of results where ports are not artificially benefited from the metrics used, the geographic distance factor should be discarded when computing the Regional Competitiveness Index.

Similar to the results obtained from the evaluation of the connectivity tools, the Georgia Tech deep Connectivity Index seems to an appropriate tool to compute the connectivity part of the Regional Competitiveness Index. The combination of the Regional Competitiveness Index and the Georgia Tech Deep Connectivity allows compute results for individual ports as well as aggregated terminals to evaluate the benefits of improvements in local port interconnectivity.

[23] Generated by the authors using Gomez (2010) Regional Competitive Index principles and information from Table 7 and Table 13

The Panamanian Ports will achieve superior regional port performance if they manage to operate as a single unit. Competing as independent terminals many regional ports are more competitive than some of the Panamanian Ports.

CHAPTER 4: PROJECT CONCLUSIONS

As measured by several indices, Panama's competitiveness – when considered as a single port – dominates all the other ports in the region. This can attract companies that wish to reach multiple markets more directly.

To support this competitiveness, Panama should increase the interconnectivity between its Atlantic and Pacific ports.

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