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TRANSPORT AND CONNECTIVITY: PROBLEMS FACED BY SMALL ISLAND DEVELOPING STATES *

by

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1. INTRODUCTION

The background paper for this meeting makes it clear that containerization is a necessary condition for increasing trade in developing countries (UNCTAD Secretariat 2003, 9). Moreover, containerization has played the main role in the development of multimodal transport and logistic services. The efficient operation of the movement of containers requires the integration of several key players. Two of the most important are ports that enable intermodal transfer to occur, and carriers in the form of ships at sea and trucks and railroads on land. But the provision of transport infrastructure is no guarantee that efficient transportation will occur. The provision of logistics services in the form of management of cargo moves, warehousing, and information transfer is also a necessary condition for the efficient movement of containers.

This paper only concerns a part of the multimodal and logistics business. It focuses on ports and their connections provided by shipping lines, relating the properties of the networks which these infrastructures create with throughput at the ports. Although the geographical focus of the paper is the Caribbean basin, I suspect the comments are appropriate to other regions of the world where developing countries are depending more and more on containerization and multimodal transport to increase their trade in merchandise and intermediate goods.

In order for ports to prosper they must be well connected. The better connected the port the more opportunity that a port has to expand its throughput and the better off the area served by the port in terms of export and/or import volumes and opportunities to expand those volumes. But connectiveness is only one variable in the prosperity of the port. Many factors go into the development of a successful port – too many to discuss in this paper. I only wish to focus on connectiveness. Just how important is connectiveness to the throughput of ports? Can that importance be measured? For that matter, how is connectiveness expressed?

No port is isolated from other ports. All ports belong to a network of shipping connections. This network is made up of other ports and linkages between them. Shipping lines that make decisions about what ports to call, in what sequence, how often and using which vessels provide these linkages. Shipping lines may service the same port with different services depending on which other ports form part of that service. Also, a port may have more than one link between itself and another port because of different shipping lines providing competitive services or even the same shipping line providing different services at different times. Therefore, connectiveness of a port can be described in at least three ways: the number of shipping services it has, the number of port partners in its services' network, and the number of linkages provided by the shipping lines to these port partners. A fourth measure is a composite one taking into account both the linkages and the ports. The arithmetic division of the former by the latter gives the average number of links between that port and its port partners. We can call this measure a connectivity index of that port.

How well does port throughput measured by container volumes (in TEUs) relate to these measures of port connectiveness? It is implied above that there should be a positive relationship, but how strong is it?

In order to determine the answers to these questions a data set with accompanying maps of the Caribbean network of container shipping services for 1994 and 2002 has been created. It is the 2002 network that is the focus of the paper, but the attributes of both networks become important in the paper's discussion.

2. DATA AND METHODOLOGY

The data on container services in the Caribbean come from the *Containerisation International Yearbook*. As a commercial handbook, dependent upon the submission of information from the shipping lines themselves, its reliability and comprehensiveness may be questioned. There *are* errors in its reporting. It is, however, the only source of its type that provides the information required for this paper. Also, over its 35 years of existence it has built up a good record of credibility and usefulness.

Data were drawn for two years: 1994 and 2002. The former year predates major developments in container shipping. In terms of shipping lines and their services 1994 predates the formation of the major alliances: Maersk-Sealand, Grand, Global (later New World) and Hanjin Tricon (later United) which were all formed in 1996 (Midoro and Pitto 2000). These alliances have had a profound effect on global shipping patterns (Slack 2002 *et al*). 1994 also predates major port developments in the Caribbean at Puerto Manzanillo in Panama, Kingston, Jamaica and Freeport, Bahamas.

All the shipping line services operating in the Caribbean basin in those two years were recorded. For every service listed the shipping company, the ships assigned to the service, their capacity, the frequency of the service and the Caribbean ports of call of that service were recorded. By knowing the ports of call service networks could be constructed. The *Yearbook* is not clear on the actual routes ships use. In order to construct the service networks it was assumed that ships called at the ports in their geographical order of proximity. For each service a line was drawn connecting nearest neighbour ports but the line was not closed. For example, if a route included the ports of New Orleans, Houston, Veracruz and Kingston a line was drawn joining those ports in that order. Kingston and New Orleans were not joined. Some service routes just stopped at one port in the Caribbean e.g. Freeport, Bahamas or Puerto Manzanillo, Panama. In these cases the route is represented by a line joined to the port but not joined to any other port either in the Caribbean or beyond. A GIS was used to record the ports and the service routes.

3. THE NETWORKS AND PORT CONNECTIVENESS MEASURES

Figures 1 and 2 show the container shipping networks joining the ports of the Caribbean basin in 1994 and 2002 respectively. Table 1 summarizes the number of ports and their linkages. The connectivity index is an attempt to measure the complexity and redundancy in the total network. As explained above it is determined by dividing the number of links or edges of the network by the number of ports.

Table 1: 1994 and 2002 Networks Compared

	Links (l)	Ports (p)	Connectivity (l/p)
1994	677	90	7.36
2002	584	89	6.56

In the 8-year period the network has actually become simpler in structure. There are fewer linkages, fewer ports (marginally) and a lower connectivity index. What is remarkable about this simplification is the fact that the actual number of containers handled in Caribbean basin ports has more than doubled from around 5.5 million in 1994 to close to 13 million in 2002.

In terms of ports and their connections to other ports (herein called port partners) Table 2 presents a summary of the 20 most connected ports in 1994 and 2002 with an accompanying column showing change in terms of the rank of the 2002 ranked ports. Of the 20 ranked ports in 2002 14 have increased their rank since 1994 (this includes Puerto Manzanillo which was not listed as a port in

1994.) Of these the greatest gains in rank have been made at Fort-de-France (+19), Port Castries (+17), Veracruz (+14), and Pointe-a-Pitre (+11).

There have also been losses in status over the time period. Of those ports still in the top 20 of port partners in 2002, New Orleans (-7), Houston (-5) and San Juan (-4) are the big losers in rank. However, other ports in the top 20 in 1994 have suffered worse losses. Oranjestad, ranked 8 in 2002 is ranked 39 in terms of port partners in 2002 (not shown on Table 2) for a loss of -27 positions. Maracaibo lost 21 positions between the two years (it was ranked 7th in 1994, but it declined to 28th rank in 2002).

Table 2: Changes in Ports with the Most Port Partners, 1994 vs. 2002

1994	Port Partners	Rank		**2002**	Port Partners	Rank		**Change in Rank of the 2002 Ranked Ports**
Houston	51	1		***Rio Haina***	49	1		+9
New Orleans	49	2		**Port of Spain**	46	2		+2
San Juan	46	3		**Kingston**	44	3		+7
La Guaira	45	4		Puerto Cabello	43	4		+2
Port of Spain	45	4		La Guaira	42	5		-1
Puerto Cabello	44	6		Houston	37	6		-5
Maracaibo	42	7		**San Juan**	35	7		-4
Oranjestad	38	8		Cartagena	35	7		+6
Willemstad	37	9		New Orleans	32	9		-7
Kingston	35	10		Puerto Limon	32	9		+1
Puerto Limon	35	10		**Bridgetown**	32	9		+8
Rio Haina	35	10		**Pointe-a-Pitre**	32	9		+11
Cartagena	34	13		**Willemstad**	32	9		0
Guanta	33	14		**Port-au-Prince**	30	14		+3
Mobile	32	15		**Fort-de-France**	30	14		+19
S Tomas de Castilla	32	15		Veracruz	29	16		+14
Bridgetown	31	17		**Port Castries**	28	17		+17
Port-au-Prince	31	17		Puerto Cortes	27	18		-1
Puerto Cortes	31	17		**Basseterre**	27	18		+7
Santa Marta	30	20		Puerto Manzanillo	27	18		*

* Unable to determine since Puerto Manzanillo terminal did not exist in 1994.

In Table 2 Caribbean island ports have been highlighted. They form the focus of the rest of the paper. In total they number 12. Unfortunately, in what follows Basseterre is not included because the *Containerisation International Yearbook* does not provide TEU throughput values for the port.

As examples of how the networks are configured and how changes can be seen Figures 3 (Kingston) and 4 (Bridgetown) are presented. The 2002 statistical information for Kingston and Bridgetown is repeated in Table 3 which is a summary of the network characteristics of all of the 11 island ports in 2002. Also shown is the TEU throughput for the ports.

Table 3: Connectiveness Characteristics of Selected Caribbean Island Ports, 2002

	Services	Port Partners	Linkages	Connectivity (links/ports)	Throughput (TEUs)*
Rio Haina	27	**49**	**126**	2.57	460,18
Port of Spain	25	47	**126**	2.68	282,48
Kingston	**31**	44	118	2.68	765,97
San Juan	**31**	36	100	**2.78**	**2,392,749**
Bridgetown	13	32	71	2.22	68,6
Pointe-a-Pitre	17	33	77	2.33	129,99
Willemstad	11	33	68	2.06	71,0
Port-au-Prince	8	31	38	1.20	97,9
Fort-de-France	16	30	72	2.40	141,70
Port Castries	10	29	63	2.17	27,0
Oranjestad	6	17	28	1.64	71,5

* Source: *Containerization International Yearbook*, 2002. Values are for 2000, the latest year available.

4. ANALYSIS

As Table 3 shows there is a wide range of the number of services to each of the ports. As well the number of port partners, linkages and connectivity indices vary considerably. The greatest differences, both absolute and relative, are shown in TEU throughputs ranging from over 2.3 million TEUs for San Juan to 27,000 for Port Castries. The data contained in Table 3 allow us to measure the relationship between throughput (the dependent variable) and the individual port connectiveness measures. Simple linear regression was used to measure the relationships. The R^2 values are shown in Table 4. Graphs are presented in Figure 5.

Table 4: R^2 values for Simple Linear Regression Analysis between Port Throughput (Dependent Variable) and Individual Port Connectiveness Measures (Independent Variables)

Independent variable	**R^2**
Services	0.4944
Port Partners	0.0767
Linkages	0.1754
Connectivity	0.2739

The relationships shown are not strong. This is disappointing. The strongest relationship is between TEUs and services with close to 50% of the variation in TEU values explained by this one variable. For the other variables the explanatory value of the independent variables is very much less. A close appraisal of the graphs shows that one point, San Juan, is very far removed from the trend lines. San Juan is by far the largest port in the Caribbean islands. Much of the container tonnage is because of San Juan's special status with the United States, and because of this status San Juan could be considered an anomaly to the ports under study. Removing it from consideration improves the relationships between TEUs and the independent variables. Table 5 shows the new R^2 values.

Table 5: R^2 values for Simple Linear Regression Analysis between Port Throughput (Dependent Variable) and Individual Port Connectiveness Measures (Independent Variables) **without San Juan**

Independent variable	**R^2**
Services	0.8025
Port Partners	0.5193
Linkages	0.5678
Connectivity	0.3458

These results are much more encouraging. The number of services, the number of port partners and the number of linkages all independently explain over 50% of the variation in port throughput. The number of services alone explains over 80%. The connectivity index is not as powerful an explanatory variable, but it does explain on its own over 1/3 of the TEU throughput. Given all the variables that impact on the throughput of a port including port management, hinterland activities, port efficiency, port infrastructure and others it is remarkable that the port connectiveness variables acting individually explain as much of port throughput as they do.

5. DISCUSSION

The conclusion to draw from the analysis is that port connectiveness *is* important to port throughput, an assumption made at the start of this paper, but now shown to have validity. The difficulty with this conclusion and its application to the ports under study is that since 1994 some of the ports have been losing services, port partners, linkages and connectivity index values (Table 6). This does not bode well for these ports. Bridgetown, Willemstad, Port-au-Prince and Oranjestad show negative values under all four variables. Only Kingston has positive change values in the four variables.

Table 6: Changes in Port Connectiveness Measures, 1994-2002

	Services			Port Partners			Linkages			Connectivity Index		
	1994	2002	Change	1994	2002	Change	1994	2002	Change	1994	2002	Change
Rio Haina	25	27	2	38	49	11	106	126	20	2.79	2.57	**-0.22**
Port of Spain	25	25	0	46	47	1	157	126	**-31**	3.41	2.68	**-0.73**
Kingston	23	31	8	35	44	9	93	118	25	2.66	2.68	0.02
Bridgetown	15	13	**-2**	33	32	**-1**	99	71	**-28**	3.00	2.22	**-0.78**
Pointe-a-Pitre	15	17	2	29	33	4	81	77	**-4**	2.79	2.33	**-0.46**
Willemstad	13	11	**-2**	38	33	**-5**	84	68	**-16**	2.21	2.06	**-0.15**
Port-au-Prince	10	8	**-2**	32	31	**-1**	48	38	**-10**	1.50	1.20	**-0.30**
Fort-de-France	14	16	2	24	30	6	68	72	4	2.83	2.40	**-0.43**
Port Castries	7	10	3	23	29	6	56	63	7	2.43	2.17	**-0.26**
Oranjestad	11	6	**-5**	39	17	**-22**	75	28	**-47**	1.92	1.64	**-0.28**

It might be expected that with the decline in connectiveness values that ports would experience declines in throughput, but this is not the case. Only Willemstad handled fewer containers in 2000 than 1993. There are other factors at work to explain how throughput can continue to increase while port connectiveness declines. Remember that the explanatory values of the independent variables are not 100%. Two variables are particularly important, and they have not been considered up to now. They are: size of vessels servicing the ports and frequency of service. If either one or both of these variables increase then a port can experience a decline in port connectiveness, however measured, and still have an increase in throughput (Table 7).

Table 7: Changes in Throughput, Vessel Size and Frequency of Service, 1994-2002

	Throughput (TEUs)*			Average Vessel Size (TEUs)			Average Frequency of Service (per month)		
	1994	2002	Change	1994	2002	Change	1994	2002	Change
Rio Haina	107,042	460,184	353,142	499	661	162	2.8	4.1	1.3
Port of Spain	101,129	282,487	181,358	404	765	361	2.2	3.3	1.1
Kingston	265,011	765,977	**500,966**	365	1,146	**781**	2.3	3.3	1.0
Bridgetown	37,718	68,600	30,882	349	562	213	2.5	3.6	1.1
Pointe-a-Pitre	95,567	129,991	95,567	533	889	356	3.3	3.8	0.5
Willemstad	72,436	71,000	**-1,436**	526	807	281	2.8	3.7	0.9
Port-au-Prince	28,962	129,991	69,011	526	467	**-59**	2.7	4.5	**1.8**
Fort-de-France	95,303	141,700	46,397	528	779	251	3.0	3.6	0.6
Port Castries	21,295	27,050	5,5755	225	526	301	3.6	3.8	0.2
Oranjestad	48,702	71,500	22,798	460	856	396	3.4	3.8	0.4

* Source: *Containerization International Yearbook*, 2002. Values are for 2000, the latest year available.

As can be seen throughput changes are all positive (exception is Willemstad), average ship size has increased (exception is Port-au-Prince) and average frequency of service has increased for all ports. Of the 10 ports listed in Tables 6 and7 only Kingston has positive change values for all variables. It should be no surprise then that Kingston experienced the greatest increase in port throughput of the ports studied between the two years (excluding San Juan).

There is one other point about connectiveness that should be made. Not only is it important that ports be connected, but to whom is also important. This is particularly the case for the smallest ports that must rely on feeder services and small vessels for service. These ports depend on transshipment points, or hubs, as major conduits through which their goods must pass. In the Caribbean basin many ports compete as transshipment points. In the northern part of the basin Houston, Miami and Freeport, Bahamas act as such points. Within the islands Kingston, Rio Haina, San Juan and Port of Spain are major hubs. Along the South American coast, including Panama, Puerto Cabello, Cartagena and the terminals at Colon (Puerto Manzanillo, Colon and Cristobal) all act as transshipment ports. The more hub ports that small islands are connected to the more the chance that the island ports will benefit by increased throughput.

Table 8 shows the hub connections of the seven island ports that are not themselves major transshipment hubs. Four of the ports have all experienced net losses in hub connections. These four – Oranjestad (-11), Bridgetown (-5), Port-au-Prince (-5) and Willemstad (-3) – are the same ports that showed negative losses in all the port connectiveness measures from Table 6. Note the importance of Port of Spain as a transshipment center for these non-hub ports. Houston is the big loser as a transshipment center for four of the ports; Kingston, Cartagena and Rio Haina have become more important in the eight-year period.

Table 8: Hub Connections of Non-Hub Island Ports

	1994 Hubs	2002 Hubs	Net Change	Major Losses	Major Gains
Pointe-a-Pitre	Port of Spain 6 Houston 2 Rio Haina 1 San Juan 1 Puerto Cabello 1 TOTAL 11	Port of Spain 4 Kingston 3 Cartagena 3 Rio Haina 3 San Juan 3 Puerto Cabello 2 Puerto Manzanillo 1 TOTAL 19	+8	Houston 2	Kingston 3 Cartagena 3 Puerto Manzanillo 1
Willemstad	Port of Spain 9 Puerto Cabello 7 Cartagena 3 Kingston 3 Rio Haina 3 Houston 2 San Juan 2 Colon* 2 TOTAL 31	Puerto Cabello 9 Port of Spain 5 Cartagena 5 Kingston 3 Colon* 3 Rio Haina 2 Houston 1 TOTAL 28	-3	San Juan 2	
Port-au-Prince	Kingston 5 Rio Haina 3 Port of Spain 3 San Juan 3 Puerto Cabello 2 Houston 1 Cartagena 1 TOTAL 18	Kingston 5 Rio Haina 4 Port of Spain 1 Houston 1 Freeport, Ba. 1 TOTAL 13	-5	Puerto Cabello 2 Cartegena 1	Freeport, Ba. 1
Fort-de-France	Port of Spain 5 Houston 2 Rio Haina 1 Puerto Cabello 1 San Juan 1 TOTAL 10	Port of Spain 5 Cartagena 3 Rio Haina 3 Puerto Cabello 2 San Juan 1 Puerto Manzanillo 1 TOTAL 15	+5	Houston 2	Cartagena 3 Rio Haina 2 Puerto Manzanillo 1
Port Castries	Port of Spain 6 San Juan 1 TOTAL 7	Port of Spain 8 Kingston 3 San Juan 2 Rio Haina 2 TOTAL 15	+8		Kingston 3 Port of Spain 2 Rio Haina 2
Oranjestad	Puerto Cabello 6 Port of Spain 5 Rio Haina 4 Houston 3 Kingston 2 San Juan 2 TOTAL 22	Puerto Cabello 5 Port of Spain 2 Rio Haina 2 Kingston 2 TOTAL 11	-11	Port of Spain 3 Houston 3 San Juan 2	
Bridgetown	Port of Spain 9 Houston 5 Kingston 5 San Juan 3 Rio Haina 2 TOTAL 24	Port of Spain 9 Kingston 4 Rio Haina 3 San Juan 2 Houston 1 TOTAL 19	-5	Houston 4	

* Colon includes Cristobal and Puerto Manzanillo

6. CONCLUSION

Ports do need to be connected to prosper. The analysis shows this to be true to a varying degree depending on how connectiveness is measured. The most powerful explanatory measure is the number of services that shipping lines provide to the port. But the number of port partners and the number of linkages also explain individually more than half of the variability in port throughput.

But connectiveness is not everything in explaining port throughput. If it were then we would expect it to play a more powerful role in explaining the variation in throughput. Variables such as vessels size and frequency of service are also important in influencing throughput. Finally, as far as this analysis is concerned, the actual ports, especially transshipment ports, to which the port is connected is important.

Although there is no doubt that containerization is a necessary condition for increasing trade in developing countries, its very presence is not a guarantee that such improvement will occur. The actual dimensions of the shipping networks by which the country through its ports is connected are important factors in bringing about positive change.

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8. ACKNOWLEDGEMENT

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Figure 1: Caribbean Container Shipping Network, 1994
Ports = 90 Linkages = 677 Connectivity = 7.36

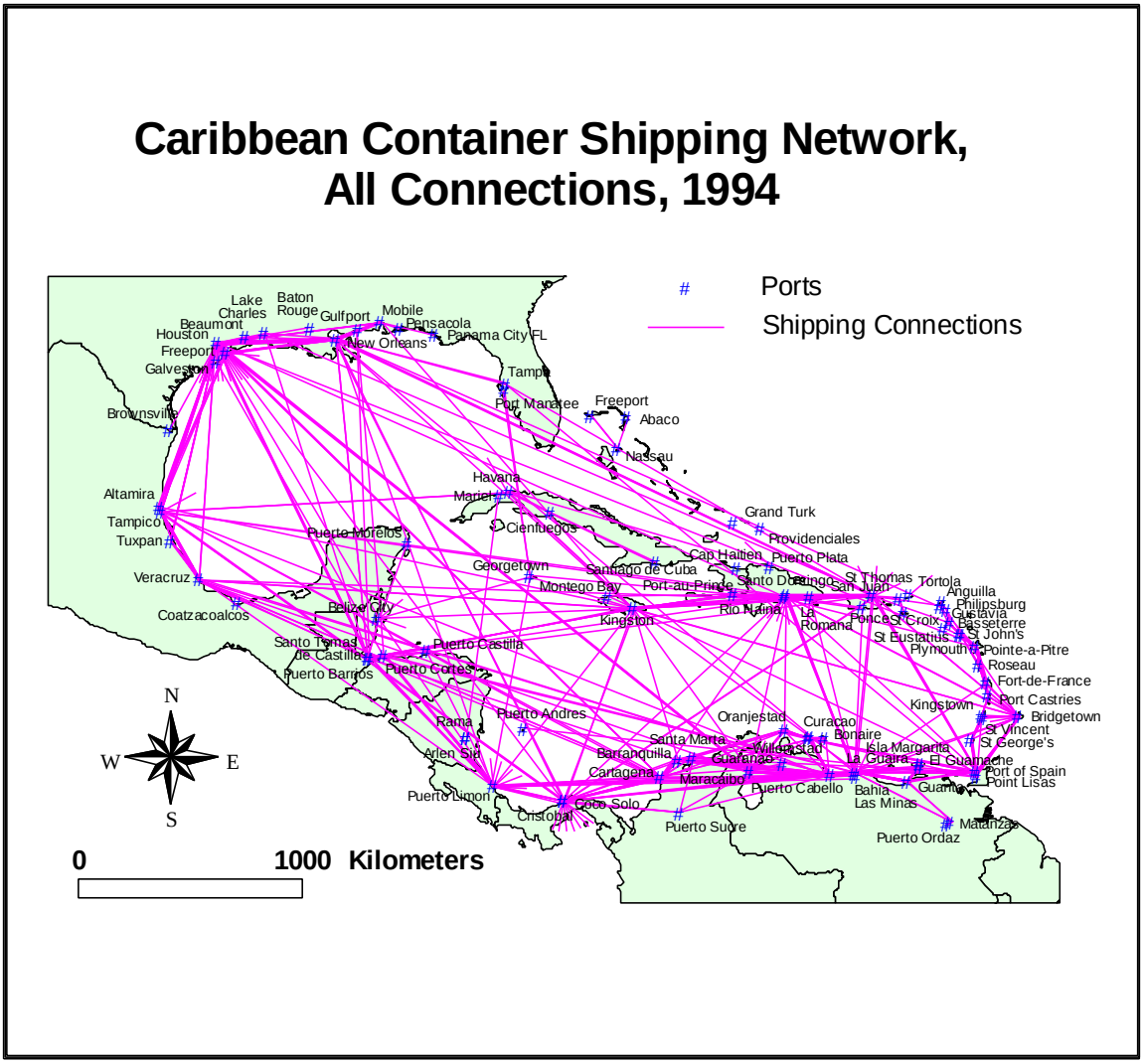


Figure 2: Caribbean Container Shipping Network, 2002
Ports = 89 Linkages = 584 Connectivity = 6.56

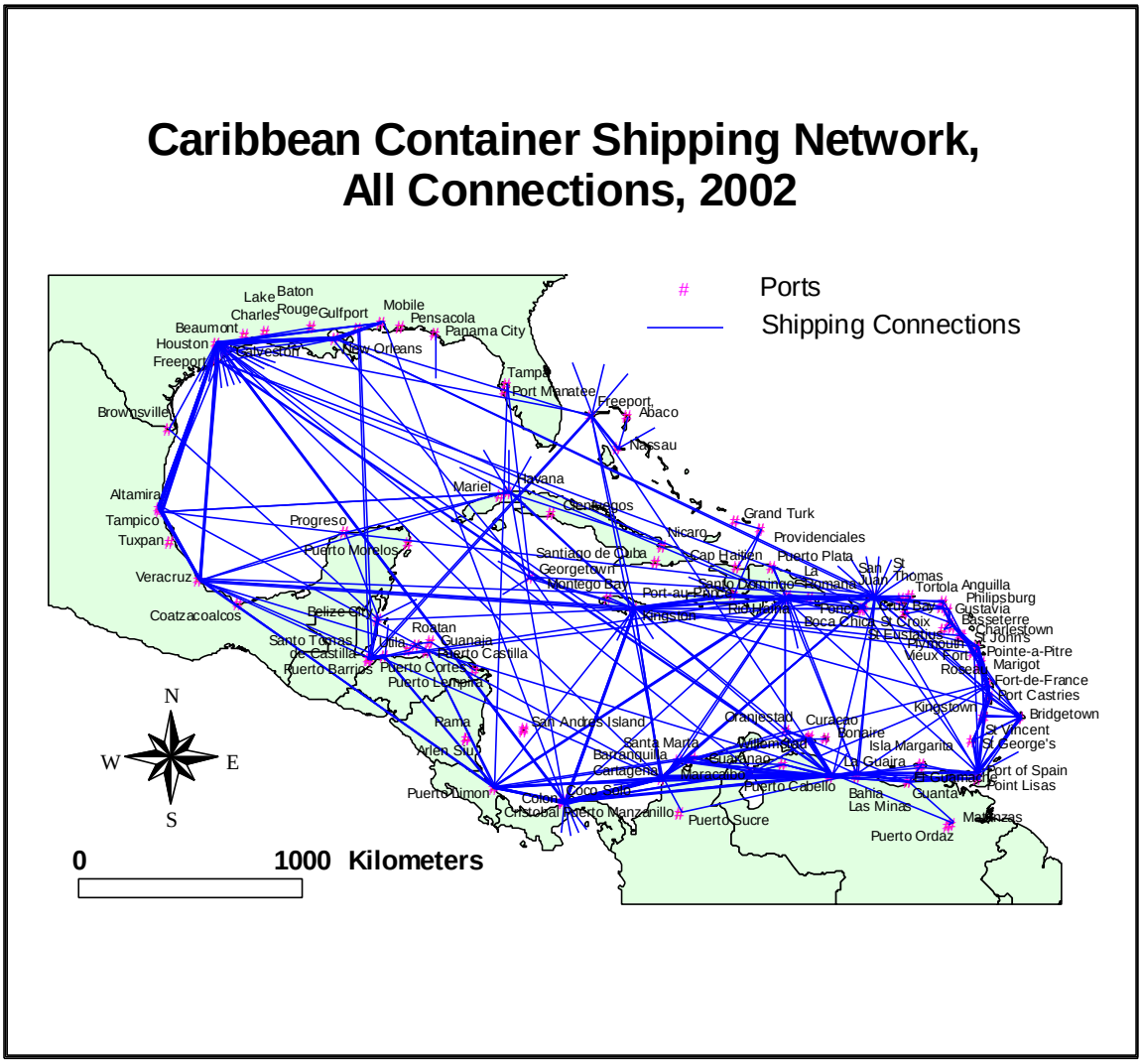
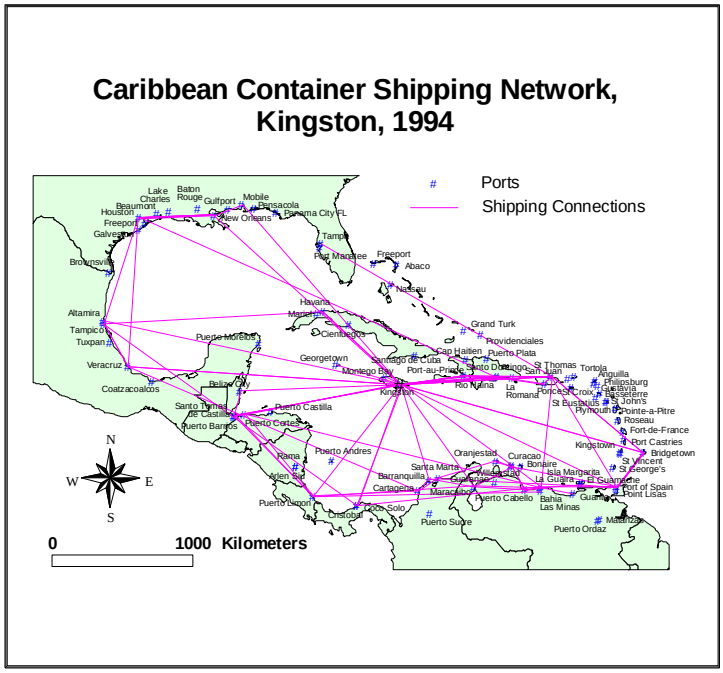


Figure 3: Kingston Connectivity Networks, 1994 and 2002



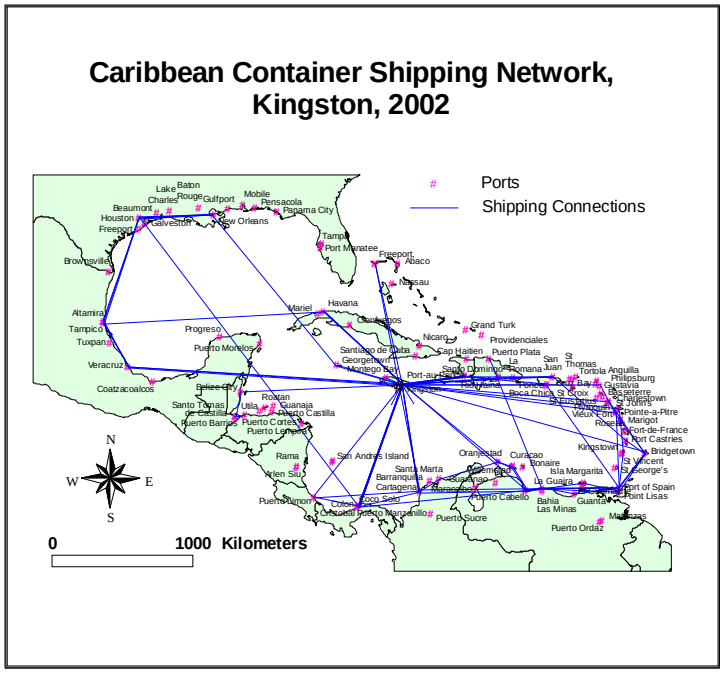
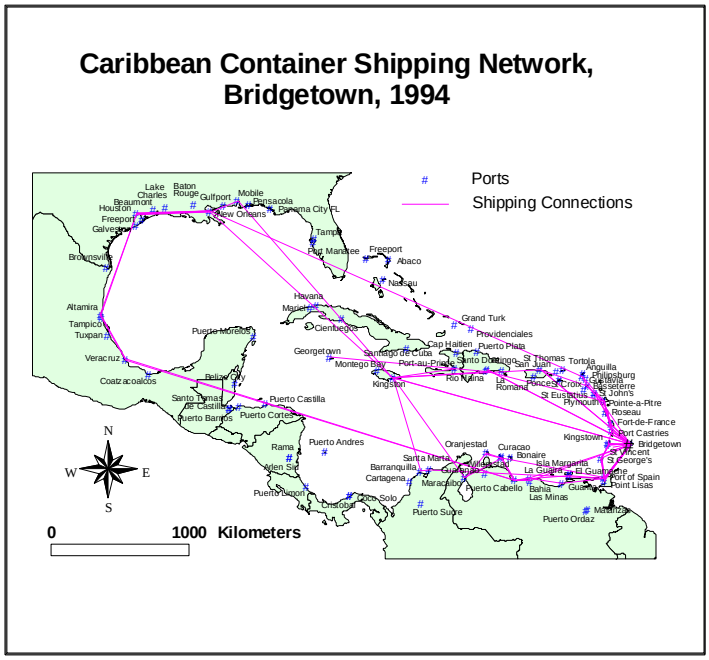


Figure 4: Bridgetown Connectivity Networks, 1994 and 2002



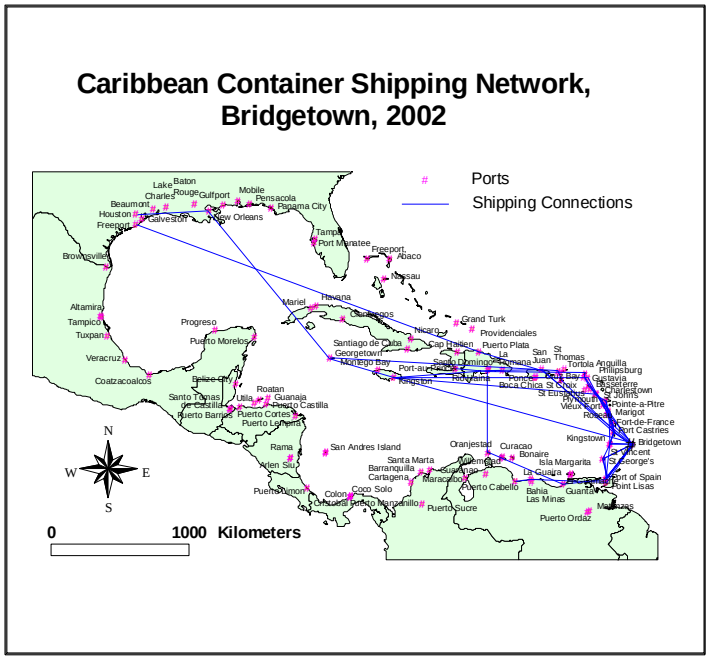


Figure 5: Relationships between TEUs and Port Connectiveness Measures