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UNIVERSITÉ DE NANTES

ASSESSING THE IMPORTANCE OF ASIAN PORTS BY APPLYING SOCIAL NETWORK ANALYSIS

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Day 2: Doctoral Schools in Cambodia

Lemna
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1. Introduction

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Containerized trade

- containerized cargo accounts for only 10% of the total volume, its value represents 52%.
- since 1990, the containerized trade has increased by more than 600% (Clarkson Research)
- Following the Subprime crisis, in 2009 container prices fell by 14% (UNCTAD, 2009).
- In last two years, freight rates have been very low, ship values have plummeted and competition on the various trade routes has intensified (Rec et al., 2016).
- UNCTAD highlighted the mismatch between supply and demand in the containerized trade.
- More alliances in order to deal with the empty containers and increase the economies of scale
- Recently, Hanjin Shipping declared bankruptcy
- In 2016, more than 20% of containerized seaborne trade was passing through the Chinese ports
- "*the success of the port is strongly affected by the ability of the port community to fully exploit synergies with other transport nodes*." (Notteboom, 2010)

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ASEAN Member States

- ASEAN member states have become more integrated in the world economy - also increased the trade between them – AEC;
- ASEAN integration - lower shipping cost and improved quality of shipping – improvement of trade performance and international competiveness (Tongzon and Lee, 2015); \
- The position of the ASEAN community in the maritime and global trade networks needs to be analyzed.

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Research questions:

- What are the characteristics of the maritime port network and the trade network?
- What is the effect of the container throughput on the country's main centrality indicators?
- What are the main differences between the maritime and the trade networks in the Asian and ASEAN regions?

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3. Methodology

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Social Network Analysis (SNA)

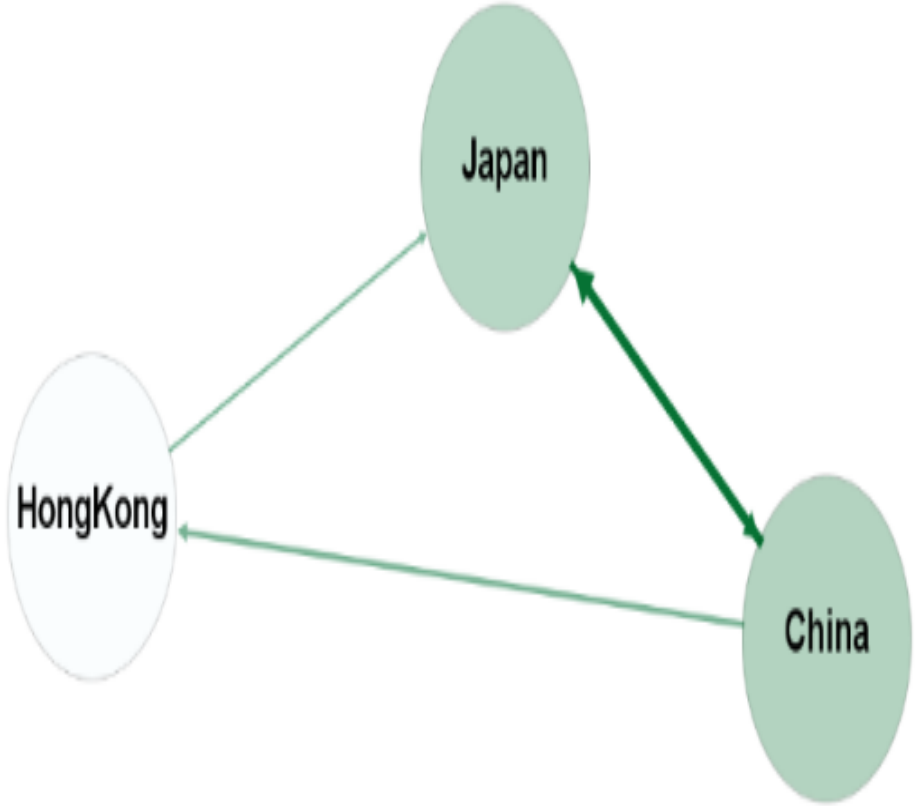
SNA is the process of investigating social structures through the use of networks and graph theory (Otte and Rousseau, 2002).

A network - collection of nodes, and links (or edges) between nodes.

Nodes – ports

Edges - flow of exports from one country to another country, or any maritime/ports indicators, as the average containerships size between the two ports. The importance of the flow depends on the link weight.

Network is directed - ship that moves from one port to another port.



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Social Network Analysis in the context of maritime trade

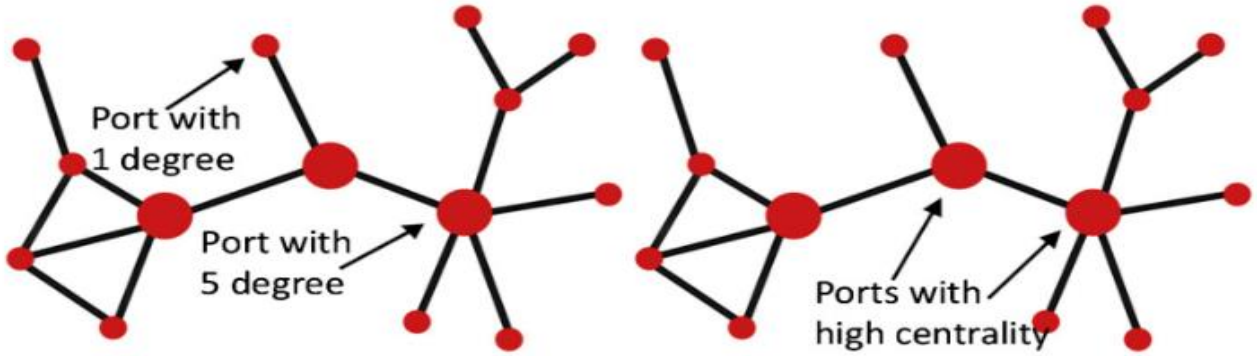
Jackson, (2010) classified centrality measures into four main groups:

i) degree centrality - assessing how a node is connected to others,

ii) closeness centrality - showing how easily a node can be reached by other nodes

iii) betweenness centrality - describing how important a node is in terms of connecting other nodes, and

iv) eigenvector centrality measure (or the Bonacich centrality) - referring to how important, central, influential, and tightly clustered a node's neighbors are.



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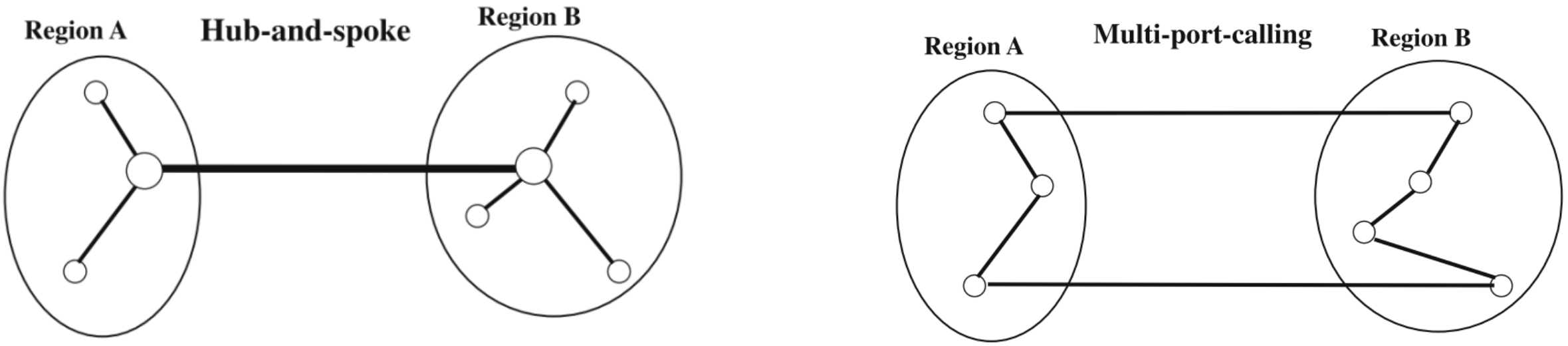

Figure 3: Hub and Spoke versus Multi-Port Calling configuration.
Source: (Imai et al., 2009)

Maritime database, obtained from Lloyd's Marine Intelligence Unit (LMIU), year 2014

153 ports and 51 countries

79 ports are located in Asia, 27 in North America, 20 in Europe, 19 in Africa and 8 in the Latin America and the Caribbean.

- Container port of departure (A)
- Container port of arrival (B)
- Average size of the ships in dead weight tonnage (DWT) going from port A to port B
- Average size of the ships in Twenty-Foot Equivalent Unit (TEU) going from port A to port B
- Number of ships going from port A to port B
- Number of operators transporting goods from port A to port B
- Number of trips from port A to port B

Export database (same countries) - UN ComTrade commodity databases in the Standard International Trade Classification (SITC) Revision 3.

- https://comtrade.un.org/

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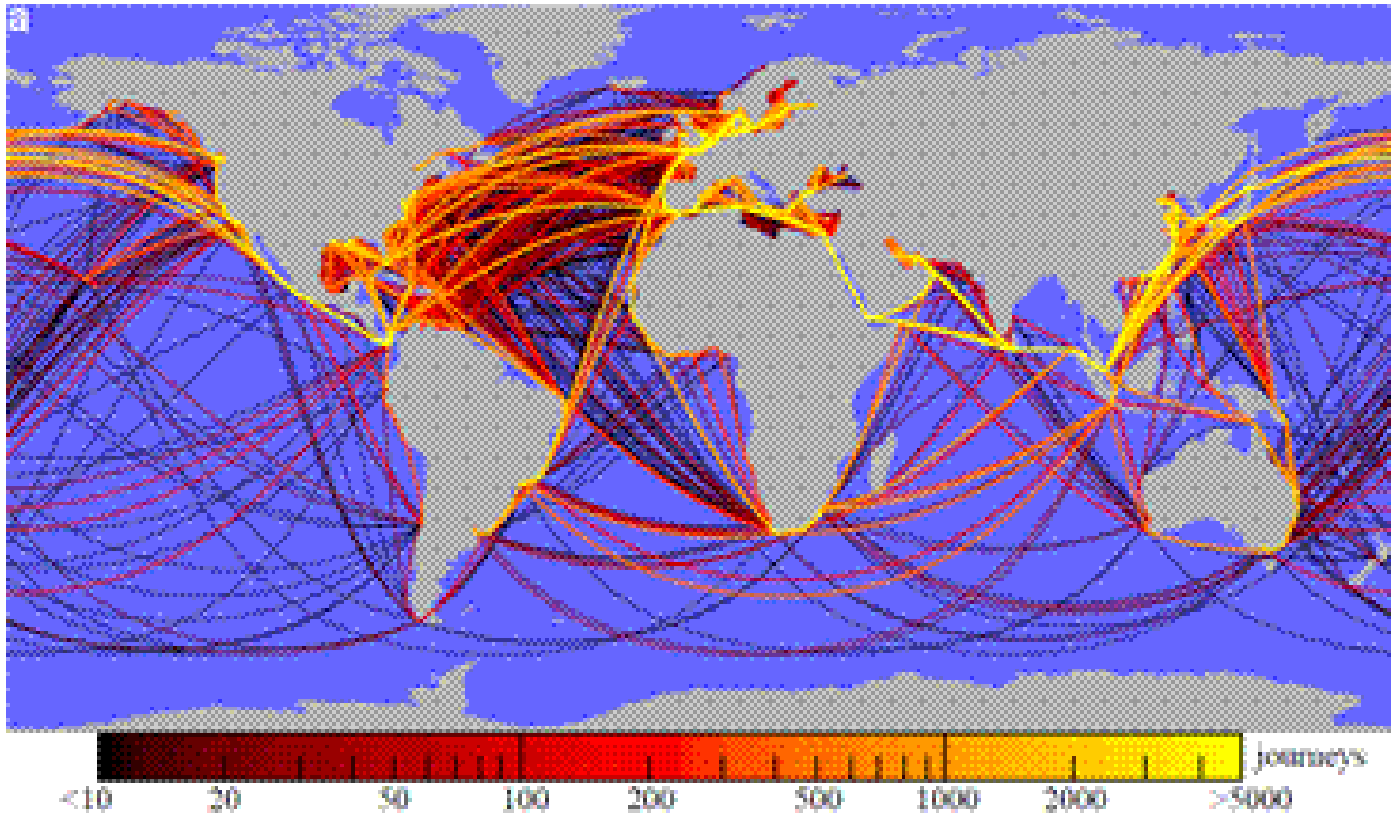
Types of networks in the current paper:

1) Maritime network which includes the ports in the sample
2) Trade network which takes into account all exported goods between the countries in the sample and gives the value of exports in thousands of dollars
3) Maritime network at a country leve



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4.1. Container Port Network

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Container Ports' network – Descriptive statistics

Nodes attributes						
Attribute	***Min.***	***1st Qu.***	***Median***	***Mean***	***3rd Qu***	***Max.***
Total TEU of arrived vessels at each port	0	581824	1351088	2633576	2969636	16303330
Total TEU of departed vessels at each port	0	474527	1219443	3194332	3653856	25770455
Links attributes						
Attribute	***Min.***	***1st Qu.***	***Median***	***Mean***	***3rd Qu***	***Max.***
Avg.TEU	80	1712	4082	4300	5867	18270
Avg.Dwt	2351	24278	51542	54885	73905	194335
No.of.Ships	1	2	9	25.2	27	1237
No.of.Trips	1	2	21	99.7	90	5510
Estimated TEU between ports	80	8412	57890	391681	361053	14386449
No.of.Operators	0	2	5	11.13	13	264

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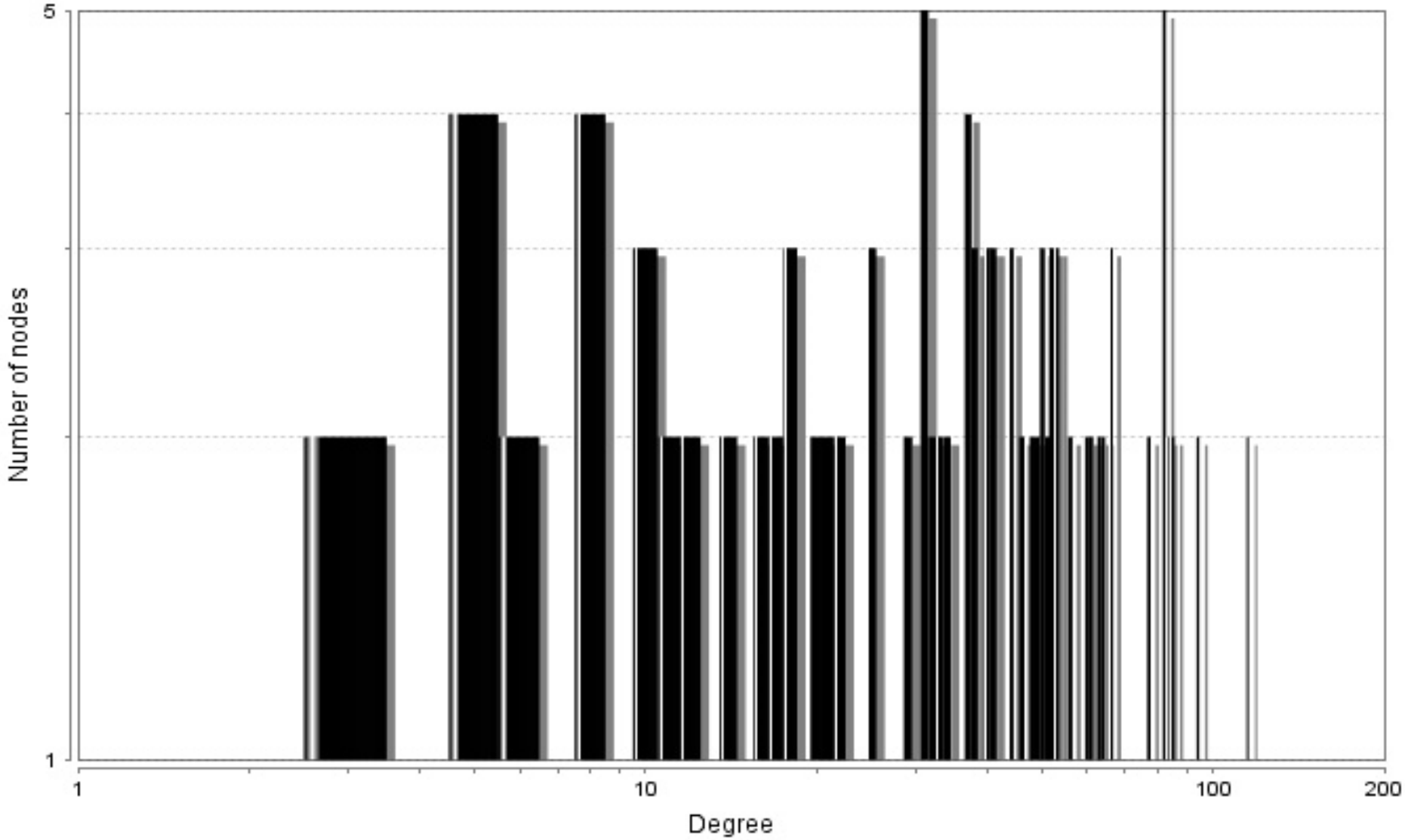

Degree distribution of maritime network - Port level data

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Network Statistics – Port level data

Clustering Coefficient	0.690409154
Connected Components	1
Diameter	4
Radius	2
Connected Pairs/Shortest Paths	23256
Average Short Path Length	1.808565531
Average Neighbors	47.81699346
Node Count	153
Number of edges (without self-loops)	6410
Density	0.2756

A scale-free configuration. characterized by a degree distribution that follows a power law with a few highly connected nodes and a majority of low-degree nodes.

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Port ranking by degree, closeness and betweenness centralities and container throughput in 2014 – Port level data

	Top 10 in port network file ranked by the Degree method		Top 10 in port network file ranked by the Closeness method		Top 10 in port network file ranked by the Betweenness method		Top 10 ports according to the Annual Container Throughput in 2014		
Rank	**Port**	**Score**	**Port**	**Score**	**Container Port**	**Score**	**Port**	**Country**	**TEUs**
1	Singapore	241	Singapore	138.50	Singapore	1873.04	Shanghai	China	35,300,000
2	Hong Kong	233	Shanghai	136.50	Shanghai	1257.84	Singapore	Singapore	33,900,000
3	Shanghai	229	Hong Kong	136	Hong Kong	1234.02	Shenzhen	China	24,037,000
4	Ningbo-Zhoushan	219	Shenzhen	133.50	Ningbo-Zhoushan	790.04	Hong Kong	Hong Kong	22,300,000
5	Shenzhen	217	Ningbo-Zhoushan	133.50	Shenzhen	769.07	Ningbo-Zhoushan	China	19,500,000
6	Port Klang	197	Port Klang	129	Port Klang	706.83	Busan	South Korea	18,700,000
7	Kaohsiung	197	Kaohsiung	127.50	Kaohsiung	665.08	Qingdao	China	16,660,000
8	Rotterdam	188	Rotterdam	126.67	Antwerp	479.87	Jebel Ali (Dubai)	United Arab Emirates	15,249,000
9	Antwerp	178	Port Said	126.50	Algeciras	477.63	Rotterdam	Netherlands	12,297,570
10	Tanjung Pelepas	172	Antwerp	124.33	Rotterdam	404.35	Port Klang	Malaysia	10,945,804

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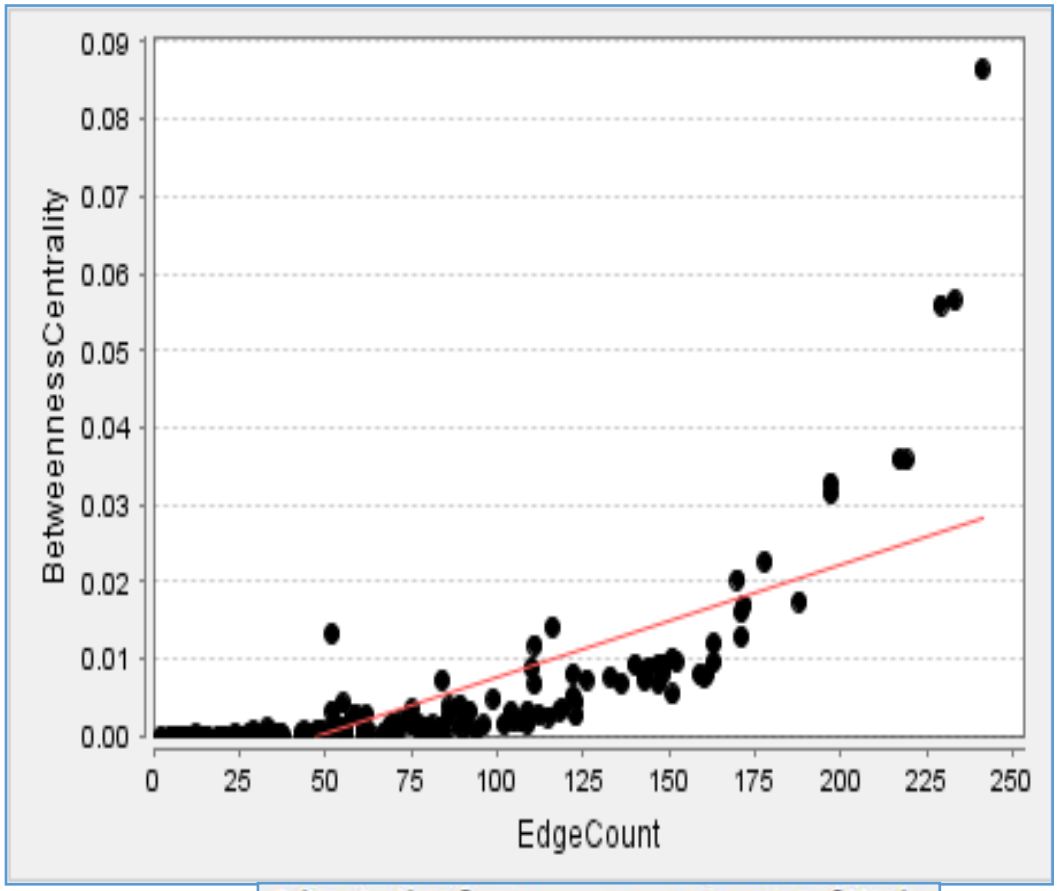
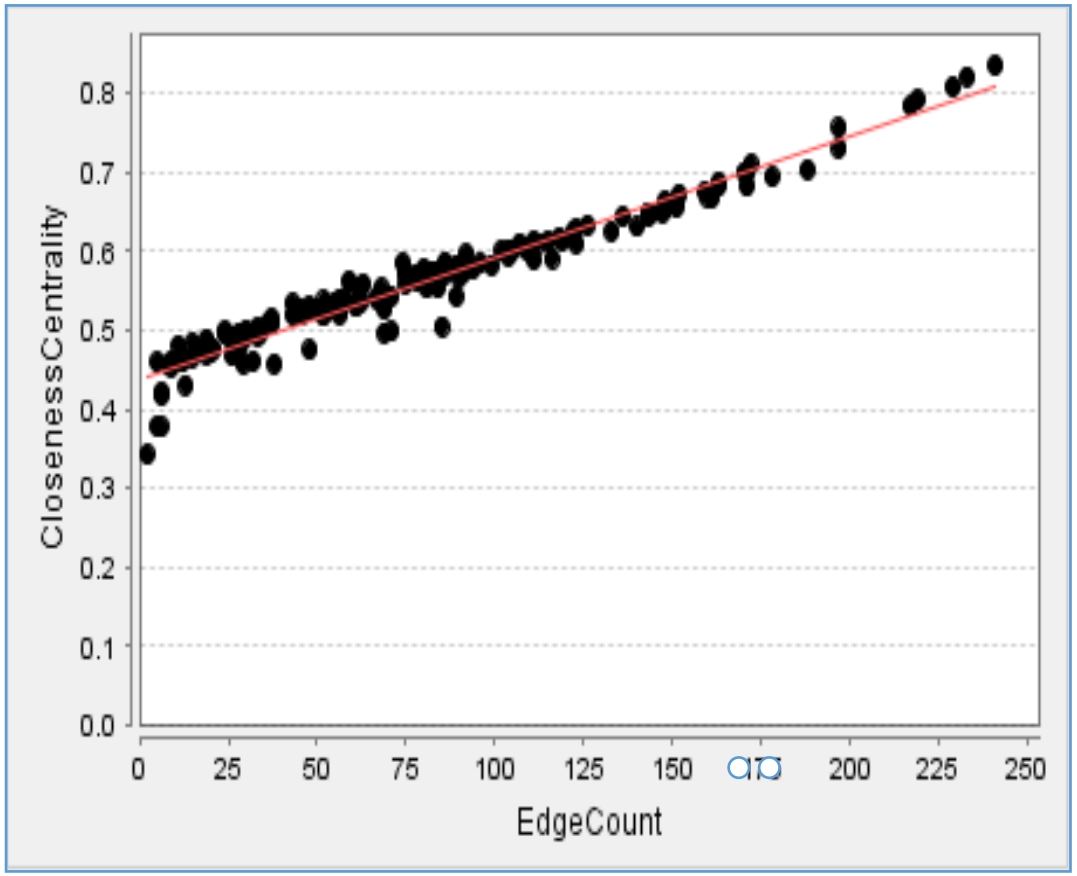
Correlation between degree, closeness and betweenness centralities – Port level data



A line in the form $y = a + bx$ was fitted.

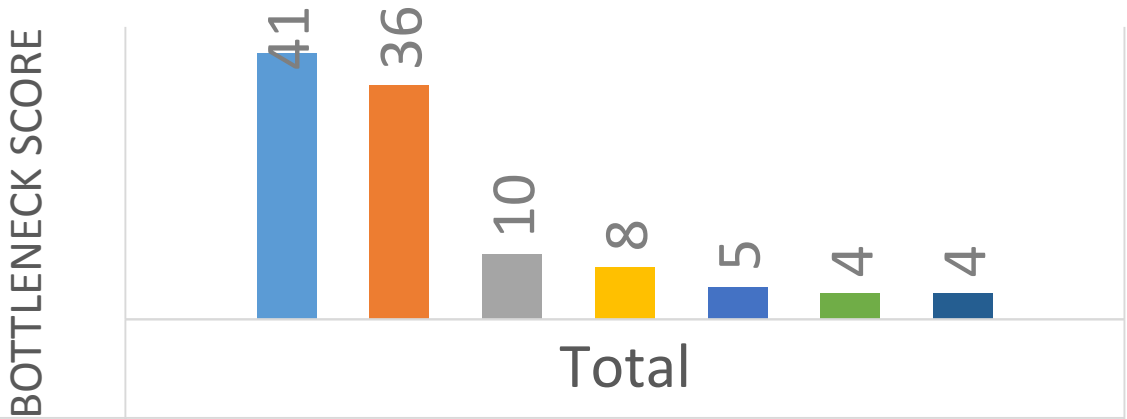
a:	-0.007
b:	0.000
Correlation:	0.739
R-squared:	0.545



A line in the form $y = a + bx$ was fitted.

a:	0.438
b:	0.002
Correlation:	0.975
R-squared:	0.950

Ranking of the ports with the highest scores for bottleneck



	Total
Antwerp	41
Ningbo-Zhoushan	36
Shanghai	10
Hong Kong	8
Algiers	5
Singapore	4
Port Said	4

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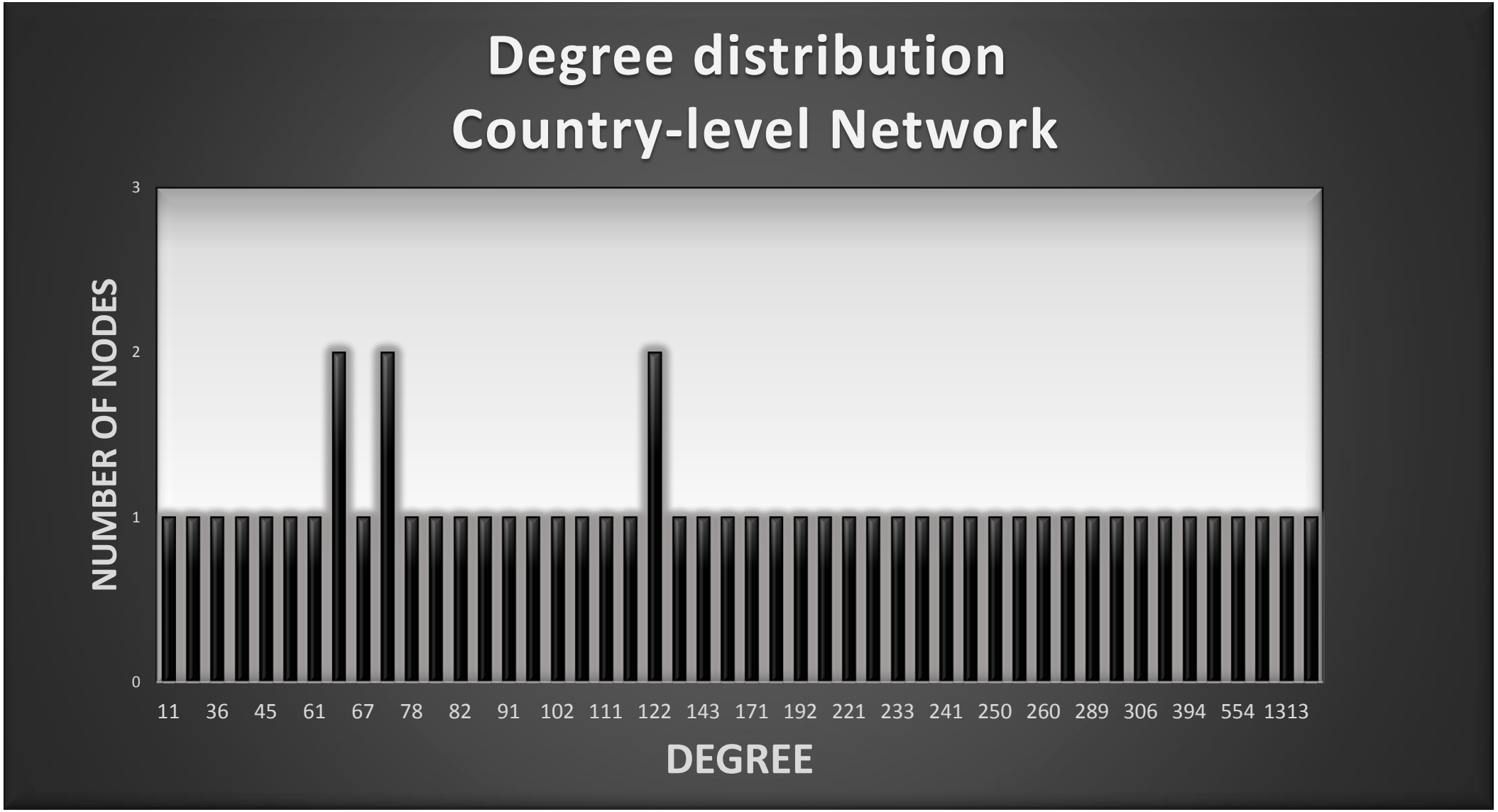
4.2. Container Port Network at Country level



Degree distribution of maritime network – Country level data

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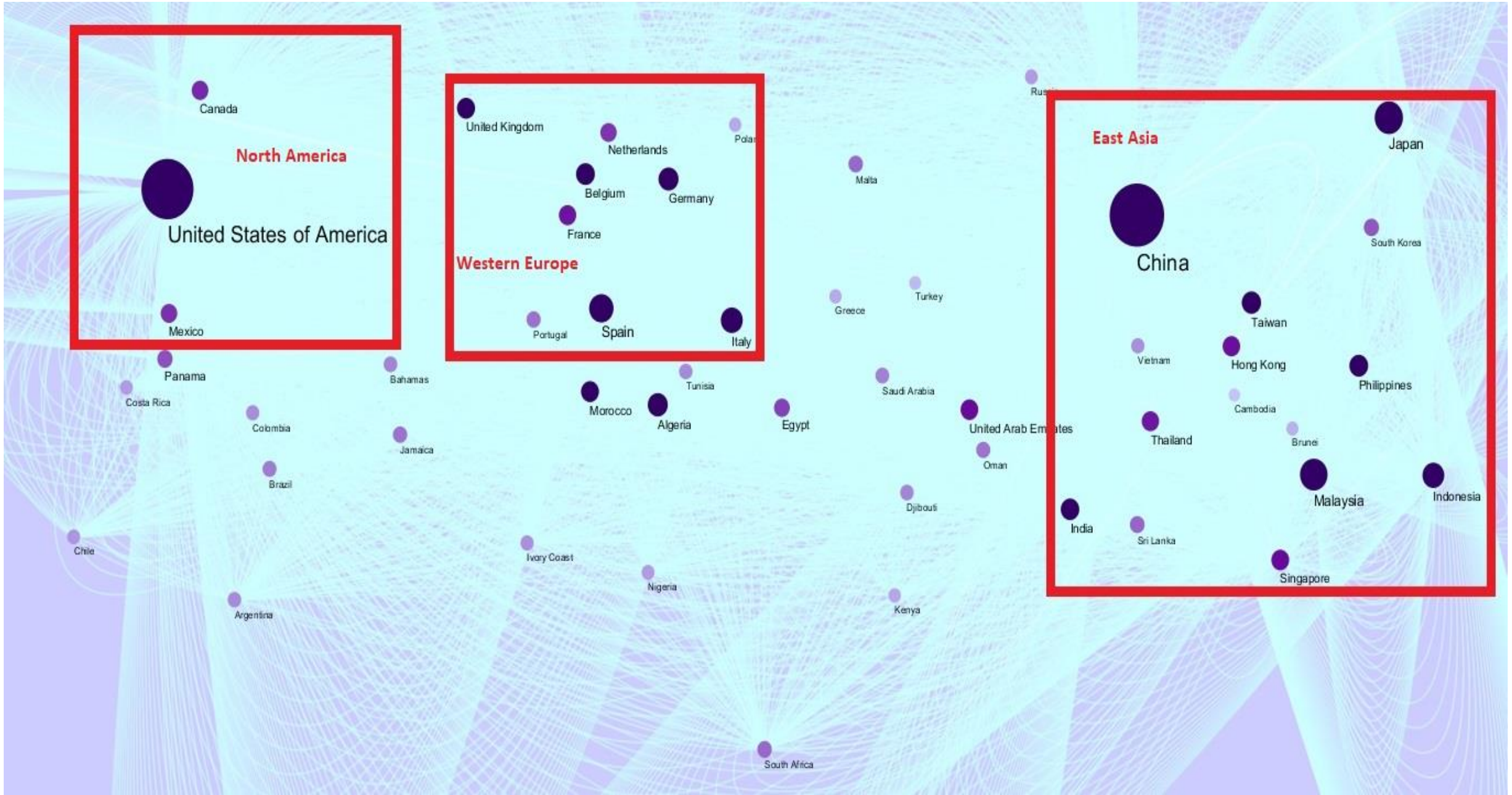
Maritime network visualization – Country level data



Maritime network clusters – Country level data

Cluster	Score (Density*#Nodes)	Nodes	Edges	Node IDs
1	31.515	34	520	Brazil, Germany, Saudi Arabia, Malaysia, Argentina, Portugal, France, India, Egypt, China, Belgium, Djibouti, Algeria, United States of America, United Kingdom, United Arab Emirates, Taiwan, Sri Lanka , Spain, Singapore , South Korea , Panama, Oman, Netherlands, Morocco, Jamaica, Mexico, Malta, Bahamas, Thailand, Japan, Italy, Hong Kong , South Africa
2	3	7	9	Nigeria, Ivory Coast, Philippines, Indonesia, Russia, Costa Rica, Poland

The countries' trade interactions are no longer defined by the geographical position of the ports as mentioned by (Ducruet et al., 2010)

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Maritime vs Trade Networks all countries

Maritime Network - Country level			Trade Network - Country level	
Clustering Coefficient	*0.7941876 4*		*Clustering Coefficient*	*0.978*
Connected Components	*1*		*Connected Components*	*1*
Diameter	*3*		*Diameter*	*2*
Radius	*2*		*Radius*	*1*
Connected Pairs/Shortest Paths	*2550*		*Connected Pairs/Shortest Paths*	*2550*
Average Short Path Length	*1.4047058 8*		*Average Short Path Length*	*1.024*
Average Neighbors	*32.431372 5*		*Average Neighbors*	*49.608*
Node Count	*51*		*Node Count*	*51*
Number of edges (without self-loops)	*5650*		*Number of edges (without self-loops)*	*2490*

Trade network: links were weighted according to the value of Exports in thousand USD.

Maritime network: links were weighted according to the Number of trips between the ports.

How does container throughput affect ports main centrality measurements?

An estimation using the OLS method was performed in the following form:

$$Log\ (Degree) = \beta_0 + \beta_1 * Neighborhood\_Connectivity + \beta_2 * Container\ Port\ Throughput + \varepsilon$$

```
lm(formula = log(Degree) ~ Neighborhood_Connectivity + CPT, data = DEGREE)
Residuals:
    Min      1Q      Median     3Q     Max
-1.9870 -0.1830  0.0232  0.2323  1.1741
Coefficients:
                            Estimate    Std. Error   t value  Pr(>|t|)
(Intercept)                 1.214e+01  1.424e+00    8.523    1.05e-10 ***
Neighborhood_Connectivity   -2.027e-01 3.681e-02   -5.507    2.03e-06 ***
CPT                          2.864e-08 1.402e-08    2.042      0.0475 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.4964 on 42 degrees of freedom

Multiple R-squared:  0.5949,          Adjusted R-squared:  0.5756
F-statistic: 30.84 on 2 and 42 DF, p-value: 5.745e-09
```

When a country has highly connected neighbors, it decreases its number of interactions. (hub and spoke structure)

High container throughput increases the connectivity of a country (degree centrality)

Asian and ASEAN Countries: maritime network

MARITIME NETWORK				
Network Stats - ASIA			Network Stats - ASEAN	
Clustering Coefficient	0.847987049		*Clustering Coefficient*	0.896428571
Connected Components	1		*Connected Components*	1
Diameter	3		*Diameter*	2
Radius	2		*Radius*	1
Connected Pairs/Shortest Paths	342		*Connected Pairs/Shortest Paths*	56
Average Short Path Length	1.257309942		*Average Short Path Length*	1.142857143
Average Neighbors	13.47368421		*Average Neighbors*	6
Node Count	19		*Node Count*	8
Network density	0.748538012		*Network density*	0.857142857
Number of edges (without self-loops)	1595		*Number of edges (without self-loops)*	272

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Asian and ASEAN countries: Trade network

TRADE NETWORK				
Network Stats - ASIA			**Network Stats - ASEAN**	
Clustering Coefficient	**1**		***Clustering Coefficient***	**1**
Connected Components	**1**		***Connected Components***	**1**
Diameter	**1**		***Diameter***	**1**
Radius	**1**		***Radius***	**1**
Connected Pairs/Shortest Paths	**342**		***Connected Pairs/Shortest Paths***	**56**
Average Short Path Length	**1**		***Average Short Path Length***	**1**
Average Neighbors	**18**		***Average Neighbors***	**8**
Node Count	**19**		***Node Count***	**8**
Network density	**1**		***Network density***	**1**
Number of edges (without self-loops)	**341**		***Number of edges (without self-loops)***	**56**

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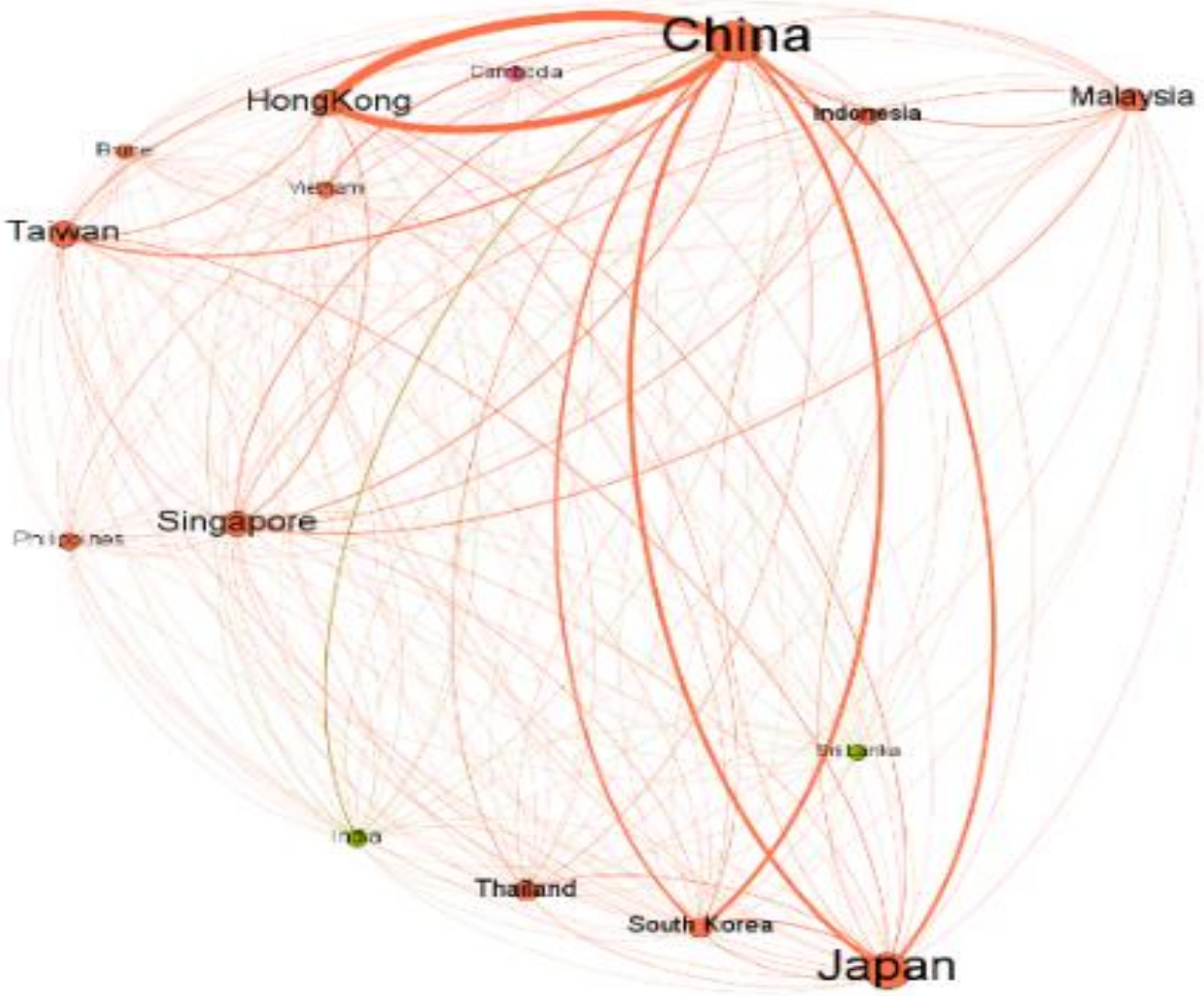
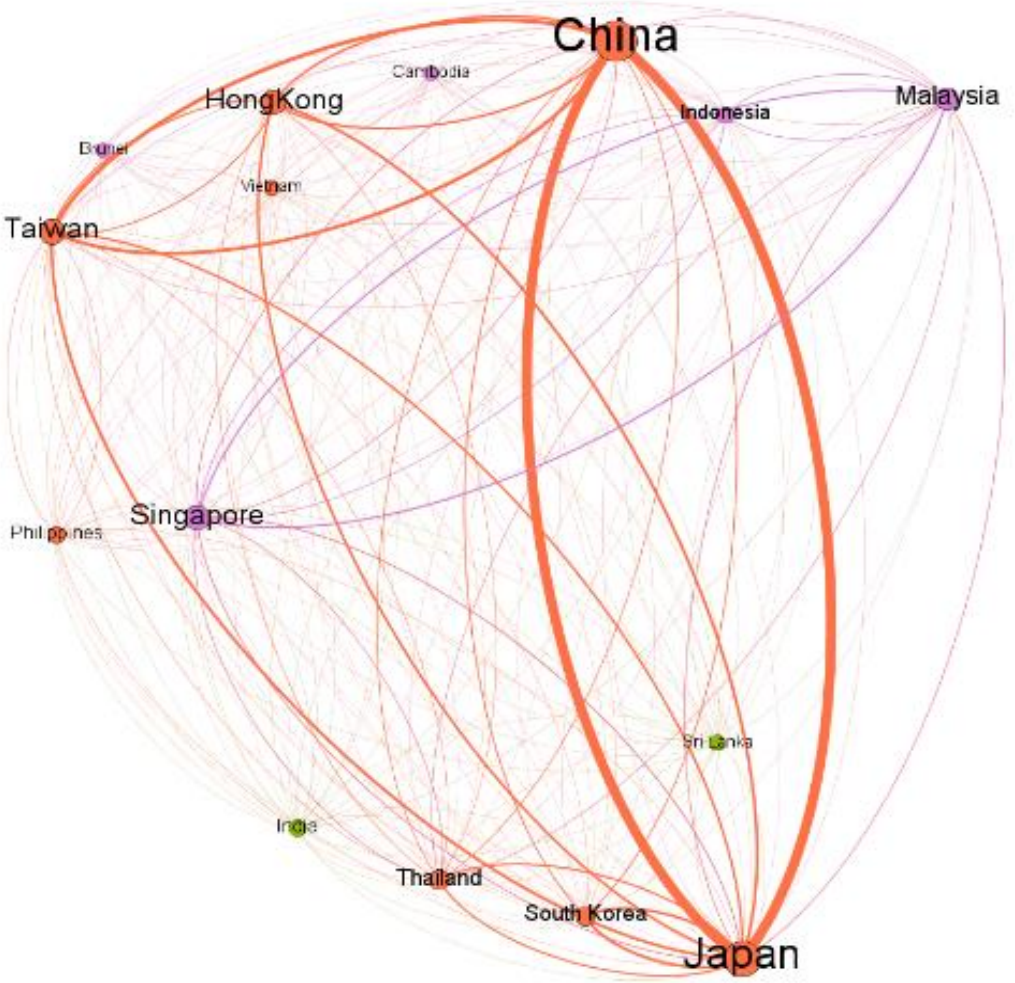
ASEAN Communities in the Trade network (left) and the Maritime network (right)





5. Conclusion

Maritime network

The maritime network is characterized by a core-periphery structure associated with scale-free networks and is guided by shipping carriers cost minimization incentives

The trade network is a small-world structure reflects the ongoing globalization process and regional integration.

The linkages have been found to be stronger within the trade network than in the maritime network.

States with very well connected neighbours have less interactions (number of containerships operating between the two countries).

The ports with high level of container throughput also have a high degree centrality. This confirms that the maritime network is a hub and spoke – high level of resilience.

The identification of a cluster of 34 states from different continents show that trade interactions between the states are no longer defined by their geographical positions

In Asia - mutually connected countries is composed by Singapore, Malaysia, Indonesia, Cambodia and Brunei.

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Thank you for your attention !!!

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