Dragan Čišić, Ph.D.
Pavao Komadina, Ph.D.

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Studentska 2
51000 Rijeka
Croatia

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Bojan Hlača, Ph.D.
Port of Rijeka Authority
Riva 1
51000 Rijeka
Croatia

NETWORK ANALYSIS OF THE MEDITERRANEAN PORT SUPPLY CHAIN STRUCTURES

With the recent advent of computer-based communication technologies, transportation networks have become an important factor in the global interaction, as a real part of a virtual business. The world in the transportation and supply chain view may be described as being connected by a lattice of networks.

As liner routes create a network, the authors are using the network analysis starting with the data that describ the set of relationships among the ports - members of a system. The goal of analysis is to obtain, from the low-level relational data, a higher-level description of the structure of the system. The higher-level description identifies various kinds of patterns in the set of relationships. These patterns will be based on the way individual organizations are related to other ports in the network.

The primary goal of this research is to identify the most important actor(s) in the network, and a couple of measures, designed to highlight the differences between important and marginal ports acting in liner network , are presented too. The definitions of importance and prominence are given along with the mathematical concepts generated by various definitions.

Key words: *transport networks, ports, social networks, Mediterranean transport system.*

1. INTRODUCTION

The supply chain management has carried the integration function concept out of the organization, since it comprises the chain of participants from suppliers to customers. A port, as an organisation itself, is a part of the whole process, which needs the interaction and contribution of all components. Such an external integration has highlighted the importance of network research of the system, focused on the individual view of the networked structural environment as providing opportunities for the actors in the chain.

Inter-organizational systems are essentially pairings of business organizations. Each port as an organization may develop links with more than one important partner, but each link is largely independent of the others. Over time, however, economies of scale have become important, and organizations have tended to develop an infrastructure that serves the needs of each of the links, conceiving new relationships in the network.

The analysis provided in this paper is based on the assumption of the importance of the relationships in the liner ports network chain. Relations defined by the linkages among units are a fundamental component of network theories. Ports in the liner network are viewed as interdependent rather than autonomous actors. Relational ties between them are liner routes, conceptualizing the structure as a lasting pattern of relationships. Employing the network perspective furthermore, one can also study the patterns of relational structures directly, without reference to attributes of an individual port involved.

2. PORTS IN MARITIME TRADE

Globalization, as a phenomenon, is defined as a substantial (exponential) "expansion of cross-border networks and flows." Such flows may include the creation of a global financial market, expansion of governance, or the increasing ubiquity of the Internet and other forms of communications via modern information technology. Frost, E (2000) describes globalization as a long-term process leading to "globality – a more interconnected world system in which interdependent networks and flows surmount traditional boundaries (or make them irrelevant)."

The maritime world can also be seen as a primary source of globalization because it is the medium by which 90% of the world trade (when measured by weight and volume) is transported.

In the past few decades many trade barriers have fallen. Key factors in the demand and supply have resulted in a burgeoning of trade relationships between nations and regions across the world. At a global level, the growth of the value of international trade since 1989 (up by 190%) has substantially outstripped the growth in production (up by 80%) (HIDC, 1998).

Complex trading networks have evolved primarily to exploit labour cost differentials and the availability of raw materials in particular countries.

Around 90% of goods are transported by sea. According to WTO data, the world seaborne trade amounted to 5.9 billion tons of loaded goods in 2002, up by 0.8% from the previous year. In 2002, the share of seaborne exports of the developing countries was equal to 49.4%, while that of the developed countries was 40.4% (the developed countries' share in seaborne imports was 60.3%, while that of the developing countries was 31.4%).

The global economy is expected to expand, but much will depend on the rate of industrial development in Asia, import and export growth in the United States and Europe, as well as on the price of oil

In line with the above developments, European ports showed a throughput of 60 million TEU in 2003, what is an average 10.5% increase as compared to 2002.

The most significant development in the transformation of ports has been the remarkable changes in the technology associated with the transportation and distribution of cargo, particularly the widespread introduction of containerization since the 1970s. The most dramatic effects of containerization have been the reduced ship turn-round time, which has massively reduced labour costs. The economy of scale and large container ships have introduced the concept of port concentration. Container lines have sought to minimize costs by limiting the number of port calls. In so doing they have re-emphasised the importance of regional hub ports. It is suggested that in the future there will be only 4 to 5 big hub ports serving leviathan vessels of 18 000 TEU. The feeder networks based on major hub ports will then expand geographically

3. NETWORK STRUCTURE RESEARCH

A considerable theory-based research on network structures has emerged over the last 25 years (Cook 1977; Burt 1980) (Boissevain J. and J.C 1973), (Monge P. and N.S. 1997). Monge and Contractor have given a brief overview of the network analysis and ten families of theories together with their respective theoretical mechanisms that have been used to explain the emergence of networks in organizational researches, including: theories of self-interest (social capital theory and transaction cost economics), theories of mutual self-interest and collective action, exchange and dependency theories (social exchange, resource dependency, and network organizational forms), contagion theories, social information processing, social cognitive theory, institutional theory, structural theory of action, cognitive theories (semantic networks, knowledge structures, cognitive social structures, cognitive consistency), theories of homophily (social comparison theory, social identity theory), theories of proximity (physical and electronic propinquity), uncertainty reduction and contingency theories, social support theories and evolutionary theories.

The study of organizational networks is an exciting practice because of the intuitive impression among numerous scholars that its true potential, as an explanatory framework, is yet to be harnessed.

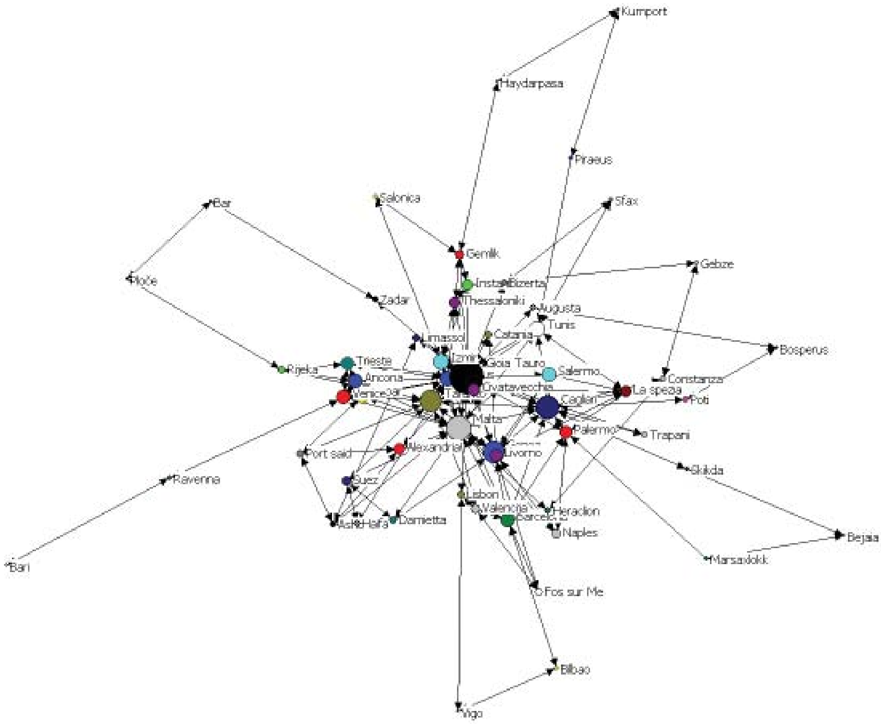
The framework of this research acts as a basis for the network analysis of the supply chain relationships for international transport. Taking this network perspective into consideration, rather than the individual dyadic relationships, offers significant insight into the cost of considerable complexity. To cope with the complexity, we defined our organization-set as a series of focal networks comprising the document, material and cash flow. The social network analysis is the founding theoretical approach into this research, and is used to study the communication structure variables measured on the companies in the supply chain network. The relational structure of a supply chain system consists of a communications relationship patterns among the companies in the chain.

4. THE MODEL

The model used in this research is fundamental, but, nevertheless, the authors will present a method for measuring the Mediterranean liner transport system.

As there is a significant problem to retrieve information about liner services in all Mediterranean ports, the authors have, in the first week of March, created a snapshot of data shown on Picture 1.

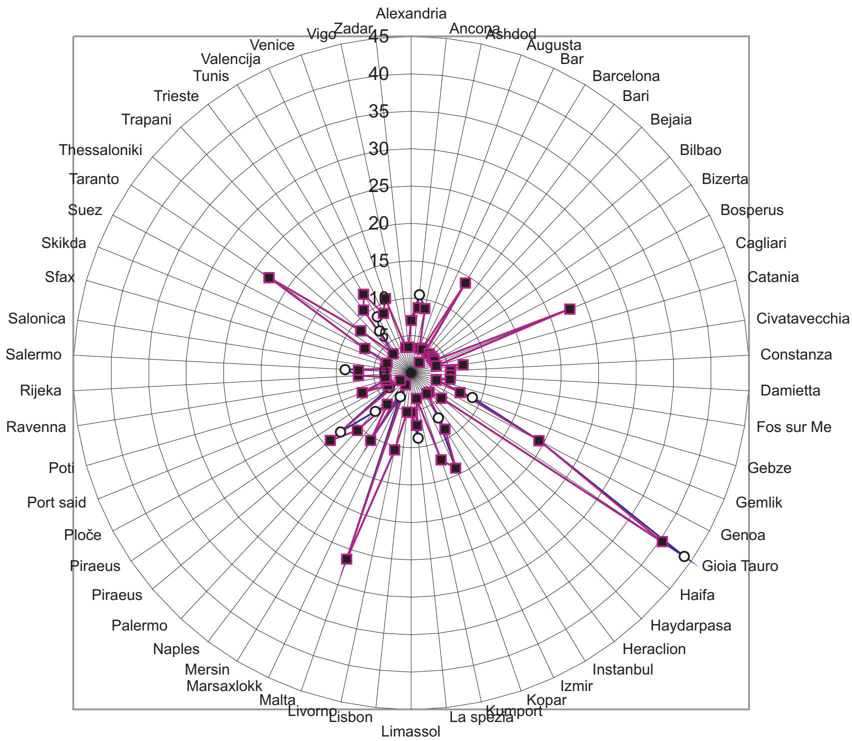
The model is created by adding links between ports in liner service. All ports outside the area of interest have been excluded together with their ties. This is a significant limitation to the model, but as this is an initial research, the authors do think that the results, obtained with this restricted model, are significant.



Picture1: The Mediterranean liner network.

5. THE RESULTS

The results of the research into these models have show that the transport system has 264 out of the 3304 possible connections between ports, or it has a mean value for density of 0.08 (8 %), with a standard deviation of 0.271, showing a loosely coupled system with a high variety. The network is totally reachable, meaning that there is always a route between any port in the network.



Picture 2: Centrality factors for the Mediterranean ports

The relevance as a factor is directly coupled to the degree centrality. The degree centrality could be separated into two parts, first calculating the in- and secondly the out-degree, depending on the incoming and outgoing paths. The in-degree centrality is known as prominence, while the out-degree centrality is usually tied with the idea of influence. As a transportation system is not directed, the in- and out-degrees are identical.

The mean value for the in- and out-degree centrality for the network is 7.76, with a standard deviation of 7.03 and 6.83 respectively. The network centralization is 36.5 % showing moderate centralization, with the most central ports of Gioia Tauro, Malta, Livorno, Taranto, Barcelona and Genoa.

The closeness centrality has been calculated for the models and shown on picture 3.

The average closeness centrality for a model is 46.5% with a 6.99 standard deviation, indicating that the ports in the transport system have a high closeness.

The in-between centrality is always connected with the terms of bridging-over, because it gives the measure of the importance of being the mediator between two actors. In the transport system this factor is connected with the term transshipment. The total in-between centrality for nodes in a model is 3.28% with a standard deviation of 6.8%, with the network centrality of 44.5 % defining that there are few central ports in the system. The network analysis has shown that the most central port is the port of Gioia Tauro, with the centrality factor of 47.02 %, followed by the ports of Cagliari, Malta and Taranto having the centrality factor higher than 10 %.

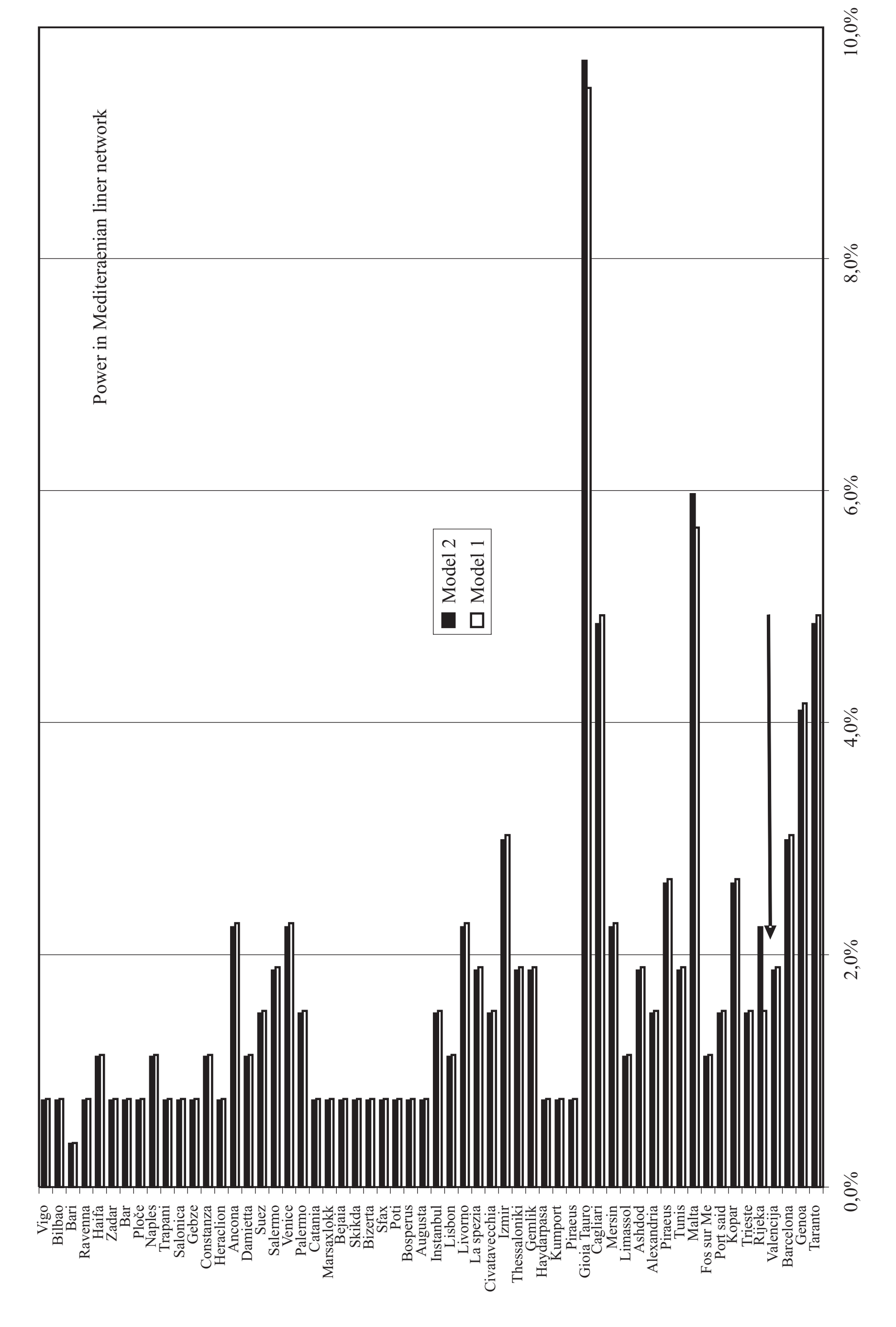
The calculation has been made by using the UCINET computer program, shown on picture 4.

The results have shown that the overall power of network is 2.339 with a standard deviation of 2.059.

The port of Gioia Tauro has a power of 12.5 or 9.06 % of all ports in the network, followed by Malta with 5.8%, Cagliari 5.07 %, Taranto 4.7 %, Genoa 3.99 %, as well as Piraeus, Izmir and Barcelona with 2.90%.

The power is spread unevenly and the first 10 ports have 42.3% of all the power within the whole 50 ports network.

In order to show the validity of the research for the port system, the authors have introduced a small change in the network. The port of Rijeka had a power of 1.05 % out of the total power, and was ranked as from 21st to 25th place, based on the power. After adding two lines connecting the port of Rijeka with Malta and Gioia Tauro, the power of the port of Rijeka has changed to 2.25 % of the total power in the system thus ranking from 11th to 14th place within the 50 ports in the Mediterranean (Picture 3).



Picture 3: Spread of power in the Mediterranean liner network

6. CONCLUSIONS

The network analysis focuses on the relations among companies, and not among individual companies and their attributes. This means that the companies are usually not sampled independently, as in many other types of studies. The results represent a clear view in the structure of the supply chain communications network, thus enabling to describe the contribution of the network position to the importance, influence, prominence and power of an actor in a network

The methods used in the social network analysis provide some useful tools for addressing one of the most important, but in the same way one of the most complex and difficult, aspects of the network structure: the sources and distribution of power. The network perspective suggests that the power of individual actors is not an individual attribute, but arises from their relations with others.

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Sažetak

ANALIZA STRUKTURE MREŽE LANACA DOPREME TERETA U LUKE MEDITERANA

Uvođenjem kompjuterski baziranihi novih tehnologija prometa tereta, prijevozne usluge,kao stvaran dio pravog posla, postale su važan čimbenik u globalnoj interakciji. Svi čimbenici unutar lanca prijevoza i prometa tereta mogu se opisati kao svijet međusobno umreženih lanaca.

Budući da brodovi linijske plovidbe čine jednu mrežu, autori ovog članka, koristeći se analizom mreže, prikazuju podatke kojima se opisuje odnos koji vlada među lukama – dijelovima jednog sustava. Cilj analize jest dobiti opis strukture sustava na jednoj višoj razini, koristeći pri tome odnosne podatke niže razine. Opisom više razine identificiraju se različite strukture unutar određenih odnosa. Ove će se strukture temeljiti na načinu na koji su individualne organizacije povezane s ostalim lukama unutar mreže.

Ovo istraživanje ima za primarni cilj identificirati najvažnije sudionike unutar mreže, kao i prikazati izvjestan broj mjera kojima bi se istaknula razlika između važnih i marginalnih luka unutar mreže brodova linijske plovidbe. Ponuđene su i definicije važnosti i zauzimanja istaknutog mjesta unutar mreže, kao i matematički pristup koji je proizašao iz različitih definicija.

Ključne riječi: *mreže prijevoza, luke, društvene mreže, sustav prijevoza na Mediteranu*

Dr. sc. Dragan Čišić
Dr. sc. Pavao Komadina
Pomorski fakultet u Rijeci
Studentska 2
51000 Rijeka

Dr. sc. Bojan Hlača
Lučka uprava Rijeka
Riva 1
51000 Rijeka