Architecture of the global container shipping network: a crucial structural core

Mengqiao Xu*†[1] and Haoxiang Xia[1]

[1]Faculty of Management and Economics, Dalian University of Technology – China

Abstract

Maritime transportation is of fundamental importance to the development of international trade and thus the world economy. Because about 90% of world trade is carried by the international shipping industry, and especially, container shipping takes up about 60% of the goods by value moved internationally by sea each year. However, structural dynamics of maritime shipping networks have been relatively less investigated than those of other transportation networks such as urban railway networks and airline networks.
Based on inter-port level of container flow data derived from the service information of world shipping companies, provided by a leading database in the maritime shipping industry, we constructed a weighted global container shipping network (GCSN) with 977 nodes (i.e. ports) and 16680 edges (i.e. inter-port connections). The weight of an edge is the container capacity deployed therein. Firstly, basic topological properties of the GCSN indicate that it is a heterogenous network with neutral assortativity and economic small-world properties. Secondly, the GCSN has a multiscale modular structure-each module can be further divided into a set of sub-modules. With the division of port communities, we defined three kinds of structural roles of individual ports in the GCSN based on the pattern of intra-community and inter-community links: provincial hubs, gateway hubs and connector hubs. In the GCSN there are only a few hub ports of each role, and there exist significant correlations between ports' roles of provincial hub and connector hub, and gateway hub. Thirdly, to address a general question of how the presence of specific roles affects the performance of complex networks, we quantified the possibly existent phenomena of structural-core organization of the GCSN. Indeed, we found a gateway-hub-based structural core of the GCSN. We proved that the detected structural-core ports were topologically central, individually and as a whole; and that core connections (i.e. edges between core ports) were significantly important in supporting long-distance maritime transportation in the world. These results suggest the crucial role of the structural core in the integration of the individually segregated parts in the GCSN. In addition, to assess which kind of structural roles is most related with port economic performance, we correlated each kind of structural role with port traffic for all the world ports, finding that port traffic shows a high correlation with the "gateway-hub" role, a relatively high correlation with the "provincial-hub" role, and a moderate correlation with the "connector-hub" role. Our work provides a deep understanding of the underlying topological structure of the GCSN and also how ports' structural roles are related with their economic performance.
Keywords: transportation network; maritime shipping; port development; topological structure; empirical analysis

*Speaker
†Corresponding author: stephanie1996@sina.com