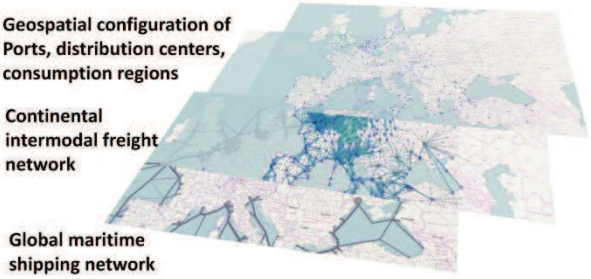
Strategic analysis of global intermodal freight transportation networks

The 3rd Erasmus Smart Port Rotterdam/Port Research Centre Poster Session, Rotterdam, 2nd October, 2014

Main research question: How can we systematically model global freight (container) intermodal transportation systems to deal with the uncertainties which lie therein?

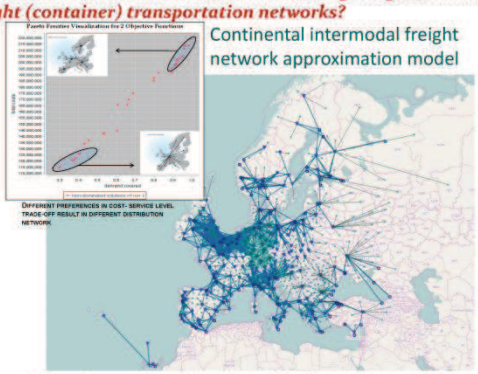
Answer: By structuring the global freight transportation system into sub-systems (as depicted by picture on the right) and model these sub-systems in an integrated manner.

Different sub-research questions were formulated to answer the main research question. The focus of the research is to develop an integrated model for hinterland and maritime freight transport networks. The model is used to estimate the impact of different plausible scenarios in the future on the performance of the global ports.



How can we take logistics considerations such as locations of distribution centers into account in modeling the global intermodal freight (container) transportation networks?

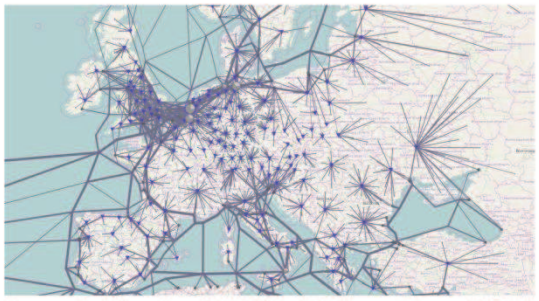
Continental intermodal freight network approximation model



The model produces estimated location of distribution centers in Europe, taking into account (container) trade flows between 1500 NUTS3 regions and the rest of the world, locations of 150 ports in Europe, and 309 potential DC locations in Europe (at NUTS2 level). Any future changes in the abovementioned factors can be simulated to estimate future distribution structures.

What are the impacts of changes in the locations of distribution centers on the global intermodal freight (container) flows?

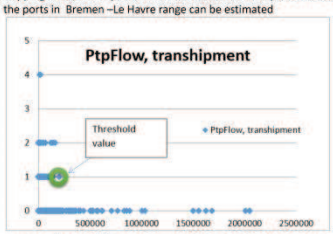
Integrated global freight intermodal logistics model



Integrated model consists of the WCM and the European Intermodal Freight Network Model. Using this model the impact of changes in distribution structure in Europe on Port choices can be simulated. Hence, the integrated model is capable of estimating the impact of changes in global trade pattern on continental distribution structure and eventually global freight(container) routing

What are the impacts of the emergence of direct shipping networks on the performance of the ports in Bremen- Le Havre range?

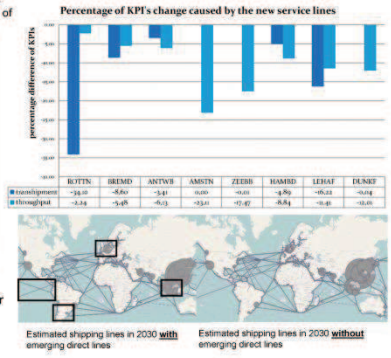
By simulating the new global maritime network which include direct shipping lines , the impact of this new network on the performance of the ports in Bremen –Le Havre range can be estimated



Using the World Container Model 160.000 port to port flows in 2030 scenario were observed.

The threshold value* is found at approx. 200.000 TEU/ yr

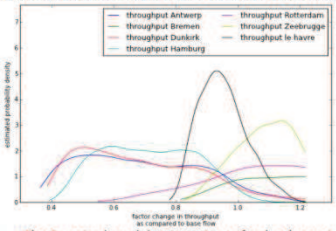
* the threshold value: a flow value above which the transshipment number becomes zero indicating direct shipment



How can we structurally investigate the uncertainties of the global intermodal container networks?

The Exploratory Modeling Analysis technique was used to analyze uncertainties which are inherently present in the freight transport network involving Ports in Bremen – Le Havre range. 10.000 Scenarios are evaluated and systematically analyzed.

Exploratory Modelling Analysis on the world container network



A value of 1 on the x-axis means that the flow has stayed the same compared to base case in 2006.

- The Gaussian kernel density estimate for the change in throughput for each of the ports in the Bremen- Le Havre range
- Port of Rotterdam has a range of throughput variation between 55-120 %

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1. CURRICULUM VITAE

Ronald Apriliyanto Halim (1986) is a PhD researcher at the transport and logistics group in TPM faculty under the supervision of Prof. Lóránt Tavasszy . He began his PhD research in 2011 soon after graduated as the first international Transport and Infrastructure Systems Engineer from Delft University of Technology. Ronald decided to study in the Netherlands after being offered a full scholarship from the Royal Dutch Shell in 2008.

Being fascinated with the application of mathematical sciences in many fields Ronald finds his passion in applying optimization techniques in both modeling the transport flows of goods at the global level and designing transport infrastructure networks. His main research area is in modelling the global flows of containers using transport models. The approach he develops makes use a combination of different models to explain the characteristics of intermodal freight transportation network globally. Using the models he develops Ronald helps stakeholders such as Port Authority of Rotterdam to gain a strategic insight on the future impacts of the changes in international trade and transportation system on their capacity and competence. His research findings are generally discussed with the Business Intelligence department of the Port Authority. Ronald also has done several projects together with the Indonesian ministry of transport to help providing policy recommendations in designing Indonesia's freight transport network.

2. MODELING GLOBAL INTERMODAL FREIGHT TRANSPORTATION NETWORK

Freight logistics is an important element of freight transportation system which determines the routing patterns of commodities. In a situation where there is a change in the magnitude of freight demands in different regions of a continent/ a nation, a change in logistic structure is expected. The adaptation effort of the companies to minimize the costs of supplying the demands would result in changes in their distribution networks. We can find this phenomenon in While the need to include logistics consideration in freight transportation models has been acknowledged for assessing the extent the spatial pattern of international intermodal freight logistics network would evolve, there haven't been, unfortunately, many models developed to serve this purpose.

One general problem that is addressed in this research is the integration of logistics considerations in freight modelling methods particularly those which are used in modelling global intermodal freight transportation networks. We further look into different sub-systems of the global freight intermodal network such as both hinterland distribution structures and global maritime shipping networks and investigate how logistics models can be used to explain the formation of intermodal freight transport networks and eventually intermodal global freight flows. Ultimately, the models which have been developed would be useful to help informing decision makers on the impacts of the uncertainties which come from changes in the global freight transportation system.

Given the limited time available and the focus of this research in relation to the interests of the port authority, several modeling exercises, and case studies have been performed throughout the research project:

1. Modeling the European freight intermodal distribution structures.

2. Developing an integrated model of the global container intermodal network. The model is going to be used to perform a case study on how changes in the European distribution structures will influence port choice.

3. Modeling the impact of the emergence of world's direct shipping lines on the European port's throughput.

4. Exploratory modeling analysis on the impacts of uncertainties in the global container networks on the European ports' throughput.

2.1 Research problem

The research problem can be defined based on the main and sub research questions described below:

Main research question:

- How can we systematically model global freight (container) intermodal transportation systems to deal with the uncertainties which lie therein?

Sub research questions:

- How can we take logistics considerations such as locations of distribution centers into account in modeling the global intermodal freight (container) transportation networks?

- What are the impacts of changes in the locations of distribution centers on the global intermodal freight flows?

- What are the impacts of the emergence of direct shipping networks on the performance of the ports in Bremen- Le Havre range?

- How can we structurally investigate the uncertainties of the global intermodal freight (container) networks?

2.2 Research Objective

The main research objective of this project is to answer the main and sub questions presented above by developing an integrated model of the global intermodal freight (i.e. container) transport systems. The model is designed to support the understanding and analyses of the impacts induced by the changes in global logistic drivers such as: changes in trade flow patterns, development of new infrastructure (ports, rails, and terminals), shift in economic growth and consumption patterns, and the increase of scale/capacity of shipping lines.

3. RESEARCH RELEVANCE: PORT OF ROTTERDAM AND REAL-WORLD PROBLEMS OF STRATEGIC DECISION MAKING

Looking at the important role that port of Rotterdam has been playing as a global hub during the past couple of decades, it is clear that strategic planning of the port authority is crucial in maintaining the competitiveness of the port. Especially, with the uncertainties in global trade, the necessity for Port of Rotterdam to be strategic in dealing with the competition in freight transshipment market in North Western Europe is unquestionable. Decisions relevant to the investments in infrastructure and capacity within the port would become key factors in determining the outcomes of the competition. However, such decisions possess inherent difficulties to be made due to the changes that can happen in the structure of freight distribution in Europe. Changes in logistic networks both in the maritime (such as shipping network) and land sides (such as hinterland supply network) will bring about change in the choice of ports in the north Western Europe and this may eventually impact the throughputs of these ports.

While there are many freight models that are developed to study the movements of freights within Europe, many of them don't incorporate logistic aspects as investigated in this research project. The models developed in this research would enable analyses on the impacts of structural changes in logistic networks to throughputs of ports in Europe including port of Rotterdam. Approximation of the locations of facilities and the flows from Port of Rotterdam to these facilities and eventually to the end consumption sites would give a picture of how freight supply chain network in Europe looks like. Furthermore, strategic uncertainty analyses through explorations of different scenarios which involve perturbations of the states of the logistics network can also be performed to investigate uncertainties which come from external factors which may influence port throughputs. Finally, results of such analyses should give Port of Rotterdam a better insight on future circumstances they need to anticipate in the planning for the development of their capacity and all the necessary investments which entails.