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Incorporating subjective elements into liners' seaport choice assessments

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ABSTRACT

This paper provides a broader understanding of seaport choice. There has been considerable expansion in international maritime container based trade that is requiring substantial investment in seaport capacity. The growth in demand for port services has, however, neither been even over time nor across ports making the defining of appropriate investment policies challenging. Most studies of port choice, a major factor in the demand for any individual port, focus on relatively easily quantified measures, such as financial costs, to the neglect of less tangible factors that also influence decision-making. Here we examine the role played by subjective factors, namely the preference rates in port choice, by focusing on the optimal port of call of shipping lines serving South-east Asian and European ports drawing upon trade-offs between generalized costs and preference rates. An analytic hierarchy process is employed to ascertain the subjective element. The findings confirm that subjectivity does matter in influencing port choice, and thus failure to incorporate it in policy-making can involve leaving out an important element in the management of port investment and financing.

1. Introduction

Inter-port competition has intensified as the volume of container trade has increased. The nature of the competition is far from perfect, not only because ports themselves are geographically specific and offer differing bundles of services, but ships are changing as larger vessels move into denser markets facilitated by both port developments and also re-engineering of other related maritime infrastructure such as the Panama Canal. This has been combined with the growth in Asian economies, and in particularly that of China, which has changed the demand patterns for maritime services. Overlapping this have been significant changes in policies towards the maritime sector, both at national levels and at the mega-regional levels, such as that of the European Union (European Commission, 2007). Within this dynamic, however, there are still core container networks that have to be served making uses of more traditional vessels and involving established as well as new markets. These are our focus.

In this context, ports need to be responsive to the demands of their users to remain competitive. We examine port choices of Panamax vessels in multiple port regions of the North Adriatic, North Mediterranean and East and Southeast Asia. We pay attention to the challenges of network design when using such ships, basically the workhorses of the ocean going container market, rather than looking at the mega carriers where route analysis, because of port constraints, is in many ways much easier. We also do not consider feeder services to the ports by smaller vessels because this is largely a derived demand determined by the Panamax fleets' port priorities.

Generally the decision to route cargo through a port lies with shippers, although there are cases where freight forwarders and receivers can influence choice, as with Walmart. Cargo source, port facilities, delivery distance, port location and operating cost have emerged in previous studies as major determinants of port choice, but much of the prior work implicitly assumes this choice involves minimizing total operation costs, or is made from a hinterland perspective. We widen this out to embrace more complex, less tangible objectives.

2. Background

The economic nature of ports makes reliable demand forecasting important. Seaports involve long-lived sunk costs; they have few other uses should adequate demand fail to materialize (Baumol and Willig, 1981). Given this, and a general tendency for risk aversion, or strictly the minimization of uncertainty, there is

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likely to be underinvestment in port facilities. More reliable demand forecasts act to reduce the uncertainty involved and, in turn, to reduce this downward bias.

Port choices are made in a network context involving at the very least the selection of an origin and a destination port, but with interconnectivity considerations when there are intermediate opportunities. Here we are not strictly concerned how the port's attributes may affect the choice of another. In other words, we do not dwell on the influence of port A as an origin influencing the selected destination port other than in terms of sailing times. We are interested more in the generic features that attract liners to a particular port.

Port choice modeling has traditionally employed linear programming with weight factor analysis incorporated to integrate quantitative data with qualitative ratings. More recently, fuzzy approaches have been used in solving the port selection problem. Overall, the problem of port choice within these frameworks has been viewed as a multiple criteria decision-making or a discrete optimization problem. Here, however, we model choice with respect to distance and weight, and focus on trade-offs between the overall operating cost and preferences. Within this context, there are three main strands to port choice analysis.[1]

There are studies that examine factors that influence categories of decision-makers regarding port choice. Tang et al. (2011), for example, uses a network-based integrated choice evaluation model that blends elements of a port service network with observed port attributes to identify quality factors influencing port choices. Tongzon (2009) specifically focuses on the freight forwarders' perspective to draw out policy implications for port authorities. He finds, for example, that efficiency in terms of cost-minimization, good location, and connectivity to other ports are important in the choice process. In contrast, Chang et al. (2008) focuses on how shipping lines view efficiency, making use of factor analyzes.

A second approach simulates the behaviors of shipping carriers' or shippers' port choices that minimize overall operation costs. Port choice is treated as a multiple criteria decision-making problem with carriers seeking to minimize direct financial costs while taking into account factors such as the volume of containers, port facility, port location, and port operation efficiency. A variety of technical approaches for doing this have been adopted, including a Stackelberg framework (Yang, 1995) and fuzzy multiple criteria decision-making models (Chou, 2007). Tran (2011), in looking at port selection on liner routes from a wider logistics perspective, deploys a nonlinear heuristic model to minimize the overall cost of a cargo's journey including seaside cost.

The third area builds decision support tools to help select the optimal container port taking cognizance of quantitative or qualitative criteria. To this end, Onut et al. (2011), deploy fuzzy analytic network process methods to compare seven container ports in a region, and Norbis and Meixell (2010) develop a multi-objective optimization model for port selection that accommodates not only costs and standard measures of quality, but also port security.

Changes in networks have external effects, both positive and negative, on other links and nodes that are difficult to foresee (Economides, 1996). These complexities combined with poor information flows can also lead to disjoints between what a customer perceives to be the desired qualities of, in our case, a seaport and what port management thinks shipping lines require (Miremadi et al., 2011). In addition, competitive shipping lines are likely to react to retain market share or revenue if there are changes in the relative economic characteristics of the ports they use. Finally, the commodities being moved and the requirements of customers, have changed in recent years as found in de Langen (2007) work on contestable hinterlands in Austria where door-to-door service has grown in importance. These factors combine to add to the uncertainties involved in making changes to port call patterns and, thus, to their frequency.

We limit ourselves, however, to a rather less complex world and consider neither network externalities nor game playing between rival lines, but rather at optimization for a single liner with multiple objectives that extend beyond conventional cost considerations. In doing so, however, we focus on the preferences rates of those using the ports to gain a wider insight into the priorities of the shipping lines when selecting ports, and in particular the role of any subjective forces in play.

3. Modeling framework

Maritime container networks vary in their complexity, as do their analyzes. The simplest network is linear and often reflects that of the largest vessels, (Fig. 1a). In this case P_i, $i=1.2.3\ldots l$ is the departure port, P_j, $j=1.2.3\ldots j$ the destination port, C_L, $L=1.2.3\ldots L$ are points of consumption, and S_k, $k=1.2.3\ldots K$ are production points. The path for moving goods from production to consumption can be divided into: Stage 1, from source to departure port (S_{Sk},P_i), Stage 2, from departure to destination port (P_i,P_j) and Stage 3, destination port to consumption point (P_j,C_l).

The situation becomes more complex when vessels are loaded with goods from multiple production points and, from destination ports, move to a variety of locations and distribution points (Fig. 1b).

From the shipper's perspective, the most effective port is that with the lowest costs. The costs of moving goods from S_k to C_L involve the sum of the land transport costs in moving goods from S_k to P_i, the costs of maritime transport from P_i to P_j, and the land transport cost from P_j to C_L. These cost elements can be expressed as a sum of the weights $\omega_{S_kP_i}$, $\omega_{P_iP_j}$ or $\omega_{P_jC_l}$ assigned to each stage. In developing the model, Fig. 1c also shows the case of multiple ports that allows P_j to receive goods from one or more ports P_i, P_{i+1}, P_{i+2}, etc.

The general cost outcomes in the case seen in Fig. 1c can be expressed as,

$$W=\sum_i\left(\sum_j \omega_{s_kp_i}+\omega_{p_ip_j}\right)+\sum_l \omega_{p_jc_l} \tag{1}$$

Costs, however, are not always the only thing that can influence port choice. We add a preference rate, (PR) using an analytic hierarchy process (AHP), with PR_{P_j} being the preference rate for the jth destination port.[2] We assume that PR_{P_j} has an impact on the weight in every stage connected to port P_j; i.e. weights are influenced by the performance rate. The first step is to deduce the weight for each stage. For instance, P_iP_j is influenced by the PR_{P_j}, producing

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[1] Woo et al. (2011) provide a more detailed survey.

[2] The AHP provides a rational framework for structuring a decision problem, for representing and quantifying its elements, relating those elements to overall goals, and evaluating alternative solutions. Decision problem are broken down into a hierarchy of more easily comprehended sub-problems, each then analyzed independently. Once the hierarchy is built, decision makers evaluate its elements by comparing them pairwise to one another, with respect to their impact on an element above them in the hierarchy using concrete data about the elements, but use their judgments about the elements' relative importance. The AHP converts these evaluations to numerical values that are compared over the range of the problem. A numerical weight is derived for each element of the hierarchy, allowing diverse elements to be compared in a consistent way. Finally, numerical priorities are calculated for each of the decision alternatives that represent the alternatives' relative ability to achieve the decision goal.