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Study on China-EU container shipping network in the context of Northern Sea Route☆

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ABSTRACT

The emerging Northern Sea Route (NSR) represents change to the existing liner network for China-EU container shipping. It is necessary to re-examine the container network in this context and assist liner companies in decision-making. This paper assesses the potential of the NSR based on designing a multi-port multi-trip liner service by establishing a two-stage optimization model. Based on the estimated data of NSR shipping, ship routing schemes on both the NSR and conventional routes are proposed. It is determined that container service along the NSR is largely influenced by ice-breaking charge, seasonality, and cargo volume, which makes NSR more likely to act as a supplementary line of the liner network in the short or medium term. The results also indicate that use of NSR may drive the redeployment of shipping network and hub ports in the long term. This study's conclusions may prove useful for strategic planning by liner companies, port authorities, and governments to assess the operation of liner service via the NSR.

1. Introduction

Seaborne transport is an integral part of the international logistic network and facilitates the development of global trade and commerce. Industrial, tramp, and liner shipping are the three operational modes of sea transportation, among which liner shipping is the most commonly used because of punctuality and economies of scale. Since the 1960s, containers have been extensively utilized. As containerization continued, the past two decades saw the trend of further internationalization of trade and production. The world containerized cargo volume is 171 million of Twenty-Foot Equivalent Unit (TEU) in 2014 (UNCTAD, 2015; Verny 2007). The Asia–Europe shipping line, which transported 23 million TEU of containers in 2014, is one of the busiest liner routes in the global shipping network (UNCTAD, 2015). The Suez Canal Route (SCR) is the conventional and most important sea route linking the Asian and European markets. According to the statistics from the Suez Canal Authority, approximately 42 million TEU of containerized cargo, which represents 24.5% of the global cargo, were transported through the Suez Canal; nevertheless, the Suez Canal passage is already suffering from growth of trade volumes (Verny, 2007). The transit cargo volume more than doubled since 2000 with 368 million tons in 2000 and 822 million tons in 2014. Surging traffic may hit the capacity of the canal in the future and create a long queue of vessels waiting for passage (Brigham and Ellis, 2004; Notteboom, 2012). As most of the liner companies choose the Suez Canal to save time and cost, the congestion may undermine the advantages of conventional routes and lead ship owners to search for alternative passageways (Verny, 2007). To avoid the increasing waiting time for the Suez Canal, new sea routes and networks should be envisaged to serve the Asia–Europe market. Hence, the emerging polar sea route across the Arctic Ocean is attracting the attention of marine markets.

The Arctic Ocean is the vertex of the Americas, Europe, and Asia, which provides a shortcut for shipping among those areas. During the last several decades, global warming led to a rapid retreat of Arctic sea ice, thereby promoting the potential of Arctic Sea Routes (ASR) for commercial navigation. ASR is predicted to be ice-free in summer in the mid-21st century and will have improved marine access in the near future with the investment of ship technology and infrastructure construction (Stephenson et al., 2013). Marine navigation seasons keep increasing and attract ASR commercial transport compared to southern marine routes (Khon et al., 2010). ASR can be divided into two symmetric sea passages: the Northern Sea Route (NSR, also known as the North-East Passage) which extends along the northern Eurasian coast from Novaya Zemlya to the Bering Strait, and the Northwest Passage (NWP), which crosses the Canadian Arctic Archipelago along the northern North American coast. In Asia–Europe liner shipping, navigating on NSR avoids passing through the congested Suez Canal and enables a shorter voyage with approximately 7869 nautical miles from Shanghai to Rotterdam in comparison with the conventional SCR of 10,450 nautical miles (Fig. 1). Compared to the conventional lanes via

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Fig. 1. Northern Sea Route and conventional Suez Canal Route.

Suez Canal or Cape of Good Hope, shipping through the Arctic Sea Routes (ASR) clearly could save shipment distance and fuel costs, avoid geographical hotspots and congestion in canals, and contribute to more flexible and agile liner shipping (Schøyen and Bråthen, 2011).

Recently, tourism, fishing, Liquefied Natural Gas (LNG), oil, and bulk transport were among the main activities on the NSR (AMSA, 2009). According to the transit vessel data recorded by the NSR Information Office, only one container ship (Zapolyarniy, from Shanghai to Dudinka) passed through the NSR in 2014. Other container vessels were employed for regional transportation. Most of the ships using the NSR are tankers, bulkers, refrigerator vessels, general cargo vessels, and certain engineering ships. Currently, the NSR's potential for container shipping is relatively weak due to seasonality, high risks, and capital costs (Lasserre and Pelletier, 2011). However, approximately half of the cargoes transported through the SCR are containerized cargo which continues to be the main cargo type of Asia–Europe trade. It is reasonable to conclude that the NSR will share some of the overall volume in the future due to the enlarging demand of container transport between Asia and Europe. The increasing ice-free season and development of ice-strengthened ships and arctic seaports will also promote NSR container transport (Xia et al., 2013). The NSR may soon become the new lane in the international liner shipping network with the highest commercial potential.

The purpose of this paper is to study the NSR container shipping network design problem: structuring cost estimation, port selection, port sequence, and ship routing to obtain maximal annual profit from the full-year navigable NSR. We also evaluate the economic feasibility of the NSR from the aspect of the liner network under different ice-breaking charge levels and discuss the influence from seasonality, port selection, and, cargo volumes. Unlike other studies on the NSR container shipping, we estimate the potential of the NSR based on a more flexible network with multiple seaports and trips. It is expected that the proposed NSR-based ship routing scheme could assist stakeholders of liner transport to re-plan their service and to examine the economic benefits of the NSR in terms of regular liner shipping in the Arctic Sea.

The paper is organized as follows. The first part introduces background of this paper and the necessity of designing a NSR-based liner network. After reviewing the relevant literature on ASR and liner network design problem, the container shipping network design model is expounded in the third part. We then estimate the major parameters and data about NSR shipping, plan the liner network, and compare the economic efficiency of NSR under several scenarios. Finally, a discussion and the study's conclusions are presented.

2. Literature review

Many studies looked into NSR from the economic, political, legal, and technical aspects. The literature reviewed is categorized into four categories: economic assessment and simulation, discussions on attitude of shipping actors, navigation conditions, and political/economic environment. Studies of the ASR's economic potential remain a hot topic and raise many debates on whether the ASR is feasible. Lasserre (2014) reviewed the main models that simulate the economics of Arctic shipping. A majority of them display container traffic simulation (18 in 26 studies). Somanathan et al. (2009) evaluated the economic feasibility of the Northwest Passage (NWP) and found that this route is less advantageous versus the Panama Canal as a consequence of high capital and maintenance cost of ice-strengthened ships. Verny and Grigentin (2009) created a port-to-port shipping schedule by conceiving a NSR Express for container transport via NSR and compared unit cost of