



Arctic shipping: A systematic literature review of comparative studies

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1. Introduction

Arctic routes could reshape maritime transport geography with respect to global container shipping networks and tramp shipping. The implications for liner shipping could be a possible reconfiguration of existing networks or the launch of new ones depending on the origin-destination (OD) pairs. For bulk and specialised shipping, this could mean the opening of new routes for transport of raw materials, refined products and refrigerated cargoes between ports in Northwest Europe, the Baltic and the Arctic to Northeast Asia. The gradual change in Arctic sea ice conditions could potentially open up opportunities for the more frequent use of polar routes. Increased accessibility could facilitate shorter transit times, lower fuel and overall costs, improve network connectivity and lower carbon dioxide (CO₂) and other greenhouse gas (GHG) emissions. According to recent studies projecting future accessibility to the Arctic, more routeing alternatives for both the Northern Sea Route (NSR) and the Northwest Passage (NWP) will become available by 2050 for non-ice class vessels. The Transpolar Sea Route (TSR) will also become accessible for Polar Class 6 (PC6) vessels by that time (Smith and Stephenson, 2013; Melia et al., 2016). The possibility of operating via the TSR increases by mid-century, even for non-ice class vessels (Melia et al., 2016).

According to Eguíluz et al. (2016), in 2014 shipping activity in Arctic waters accounted for 9.3% of global shipping traffic (including domestic, destination and transit traffic). This included 5.9% of dry bulk and general cargo and 4.2% of liquid bulk cargo. A steep increase in transit traffic (i.e. voyages between the Atlantic and the Pacific) through the NSR was recorded between 2011 and 2014 followed by a sharp decline in 2015. The average duration of the sailing season was between 4 and 5 months (Zhang et al., 2016b). To date domestic and destination shipping predominate with bulk and general cargo being the main drivers behind the emergence of this route (Zhang et al., 2016b).

Arctic shipping is an emerging topic within maritime transport research, demonstrating an exponential increase in publications during the last ten years. Lasserre (2014, 2015) identified 26 comparative studies between Arctic and traditional routes from 1991 to 2013. Meng et al. (2016) reviewed 25 studies regarding navigational and commercial perspectives. However, to date, there has not been any systematic literature review evaluating the economic feasibility of Arctic routes.

Moreover, no account has been taken of studies reporting on the environmental assessment of these routes. Further, the aforementioned studies focus on research aspects and do not discuss the research methodological characteristics. The large number of discrepancies and differing assumptions regarding the parameters and results of the studies identified by Lasserre (2014, 2015) stress the need to evaluate the literature in a systematic way in order to identify factors that affect the viability of Arctic routes and add complexity to the route choice decision-making process.

This study systematically reviews the extant literature regarding comparative studies between the Arctic and traditional routes from both economic (costs, profits) and environmental (emissions) perspectives between 1980 and 2017. The current state of Arctic shipping literature is evaluated in order to establish a new evidence base, and to suggest areas for future research, and various methodological approaches. This review also serves as the starting point for developing a conceptual framework of route choice decision-making factors which could be used in future research within the context of Arctic maritime routeing by including other sea and non-sea based routes.

The following research questions were formulated in order to address the objective of this study:

MAIN RQ: According to the extant literature, what is the cost effectiveness, and what is the likely impact on emissions, of using Arctic compared to traditional routes, between 1980 and 2017?

Two further sub-questions were developed for the purposes of this study:

RQ1. : Which research methods and data analysis techniques are employed to address the research questions in comparative studies on Arctic shipping literature?

RQ2. : What are the emerging issues that need to be addressed?

The remainder of this paper is organised as follows: First, the methodology used in the systematic review is explained. Subsequently, general statistics, methodological characteristics, and route choice decision-making factors are discussed and recommendations for future research made. Conclusions are drawn by reflecting on research gaps identified and methodological issues.

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2. Review methodology

This study adopted the review design for systematic literature reviews in the field of management and business studies proposed by Tranfield et al. (2003). A systematic review of the literature is based on comprehensive and unbiased searches of relevant studies by explicitly formulating review questions and using specific search terms and inclusion criteria for that purpose. The findings are synthesised through various approaches in order to identify emerging themes, key results or any links to theory or concepts (Tranfield et al., 2003). Traditional routes and oceanic canals dominate bulk shipping and determine connectivity in global liner networks. However, the emergence of new hubs (Notteboom, 2012), future canal development or expansion (Yip and Wong, 2016; Rodrigue and Ashar, 2016; Martinez et al., 2016) and the potential opening of polar routes (Tavasszy et al., 2011) could redefine the maritime transport geography landscape and increase maritime flows and network diversity (Ducruet, 2013). On the one hand, economic and environmental sustainability in shipping is achieved by employing vessels on traditional maritime routes and shipping canals. Different approaches to make shipping more cost-effective and greener include: slow steaming (e.g. Corbett et al., 2009; Notteboom and Vernimmen, 2009), scheduling optimisation (Lam, 2010), expansion of existing canals (De Marucci, 2012) or new ship sizes and designs (Knowles, 2006; Lindstad et al., 2013). On the other hand, Arctic routes could potentially become a viable alternative option to the classical shipping routes and canals so as to address both the economic and environmental sustainability in shipping, possibly by reducing the extent of the trade-offs involved between the latter two (Mansouri et al., 2015). All else being equal, the comparative advantage of Arctic routes stems from the fact that shorter geographical distances mean shorter transit times and operating costs, higher service frequency, potentially lower fuel consumption, which in turn means lower voyage costs, as well as lower CO₂ and GHG emissions.

2.1. Search strategy

Arctic shipping literature contains studies spanning a broad spectrum of issues including economics, legal, geopolitics, geo-economics, climatic and technical and is informed by various disciplinary bases. The research scope of this review was narrowed according to the research questions so as to include only papers reporting original results on the economic (costs, profits) or environmental (emissions) assessment of Arctic routes compared to traditional ones. According to David and Han (2004), quality control is increased only by restricting the searches to journal papers and therefore excluding unpublished studies or book chapters.

Scopus was used for the initial scoping searches. Title, abstract and keywords of a sample of papers were searched covering all subject areas (fields of study) without specifying the period. The initial keywords used in Scopus were “arctic shipping” OR “northern sea route” OR “northwest passage”, result in 512 documents across a large range of disciplines. Abstracts of a sample of relevant papers were subsequently read and keywords were refined according to the aim and review questions of the study. Major shipping canals and maritime routes were used as keywords, as well as variations of terms that have similar meanings. The final set of keywords employed in the searches is presented in Table 1.

Relevant publishers and databases were covered such as Elsevier, Emerald Insight, Taylor & Francis, Cambridge Journals and Springer/Palgrave Macmillan. Two additional journals were identified: the *Journal of Maritime Research* (JMR) and the *International Journal of Transport Economics* (IJTE) that were not found in these databases. To ensure that the extant literature from 1980 to 2017 was covered, the searches were extended to include Thomson Reuters' database Web of Science, as well as the reference lists of the retrieved papers.

A total of 33 unique papers were retrieved and analysed based on

Table 1

List of keywords used in the systematic review.

Arctic shipping	Nicaragua(n) Canal	Ship ^a canal(s)
Cape Horn	Northeast Passage	Ship ^a corridor(s)
Cape of Good Hope	Northwest Passage	Ship ^a lane(s)
Magellan Strait(s)	Northern Sea Route	Ship ^a passage(s)
Maritime canal(s)	Panama Canal	Ship ^a route(s)
Maritime corridor (s)	Sea canal(s)	Ship ^a strait(s)
Maritime lane(s)	Sea corridor(s)	Strait(s) of Magellan Suez Canal transpolar passage transpolar sea route
Maritime passage (s)	Sea lane(s)	
Maritime route(s)	Sea passage(s)	
Maritime strait(s)	Sea route(s) Sea strait(s)	

^a Ship or shipping.

their methodological and research considerations. Descriptive analysis is used to discuss the classification of the reviewed papers in publications per journal; total number of papers published per decade; total number of papers per country as well as the methodological considerations such as research methods and data analysis techniques reported in the data. Narrative synthesis is used for the analysis of the research considerations whilst the results are classified based on Stopford's cash flow model (Stopford, 2009).

3. Results

3.1. General statistics

Fig. 1 shows the number of papers published from 1980 to 2017 included in the review. It is noticeable that a small number of papers assessed the potential of Arctic routes during the 1980s and most importantly from 1991 to 2000. Nevertheless, the lack of research interest during that period could be attributed to the underutilisation of Arctic routes and the lack of interest from the shipping industry in general. Of the 33 papers reviewed, two were published in the 1990s, seven between 2001 and 2010 and 24 between 2011 and 2017.

This rising trend of publications appears to be consistent with the view that scholarly research followed the recent developments regarding the utilisation of Arctic routes. For instance, it was only in 2010 onwards that an increasing number of non-Russian flagged vessels started to use the Northern Sea Route (NSRIO, 2018). The 33 papers selected for this review were published in 22 journals. The *Journal of Transport Geography* and *Transportation Research Part A: Policy and Practice* have the most frequent publications followed by *Maritime Policy & Management* and *Maritime Economics & Logistics*, whereas the remaining journals each published one paper between 1992 and 2017 (Table 2).

Twelve countries have contributed to Arctic shipping research concerning the economic and environmental assessment of Arctic routes (Table 3). The selection of countries was based on the country of affiliation of the first author of each paper. Canada and China have the biggest contributions whereas Germany and Singapore have the lowest rate of contribution with one paper each.

3.2. Methodological considerations

The categorisation extended to include the methodological characteristics of the reviewed papers, such as research methods and data analysis techniques. Arctic shipping is a topic within maritime transport research rather than a discipline per se. However, the differing assumptions reported in the extant literature regarding the cost assessments and determinant factors influencing route choice decision-

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