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ROUTE SELECTION BEHAVIOR OF SHIPPING COMPANIES – AN ANALYSIS FOR ARCTIC SHIPPING ROUTES

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İZMİR – 2022

THESIS APPROVAL PAGE

DECLARATION

I hereby declare that this doctoral thesis titled “ROUTE SELECTION BEHAVIOR OF SHIPPING COMPANIES – ANALYSIS OF ARCTIC SHIPPING ROUTES” has been written by myself following the academic rules and ethical conduct. I also declare that all materials benefited in this thesis consist of the mentioned resources in the reference list. I verify all these with my honor.

…./…./…….

Kemal AKBAYIRLI

ABSTRACT

Doctoral Thesis

Doctor of Philosophy

Route Selection Behavior of Shipping Companies – An Analysis for Arctic Shipping Routes

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Trade routes, which are the keystone of international trade, have been maintaining their importance for centuries. The majority of international trade is transported by sea in terms of both value and tonnage. Thus, the main dynamics and components of trade routes are significant for companies. Soever multimodal transportation is a must for door-to-door service, it is positioned as supporting maritime trade. On one hand, a problem occurring on road or railway will affect a few companies, on the other hand, a problem occurring on seaway may corrupt the structure of supply chains. COVID-19 pandemic and Ever Given case are the epitomes of this situation. Therefore, it should be considered risks of a maritime trade route as well as its advantages. In establishing a route, new service design process steps in. New service design is a highly complicated and multidimensional process, where companies' internal factors and external factors such as demand, maritime connectivity of the hinterlands being served, political and legal dimensions, IMO regulations, etc. intercede alongside advantages and risks of the route. Consequently, today there are 16 main maritime shipping routes with around 500 services.

Route selection is the transaction of determining the most convenient one within alternatives. A route to be convenient, transit time, speed decision, service and schedule reliability, and security factors must be suitable to the service structure. However, the most important one is cost. Companies can survive by making a profit and they seek ways of decreasing costs. As a result of global warming, new maritime shipping routes have become visible after

intense ice melts in the Arctic Ocean. These four routes, called Arctic Shipping Routes (ASR), reduce the distance and transit time between big economies on average. Bunker expenditures compose almost half of the shipping operation costs. In this way, a shorter distance provides a fair sum of total costs while a shorter transit time maximizes the utility of a vessel by the increasing number of annual voyages. Nevertheless, besides their potential benefits, the environmental and social costs of the ASR are pretty much. There is no exact knowledge about the environment, navigation, search & rescue, technical aids, charts, etc. For instance, voyages in the Arctic Region may negatively affect the ecology of the region, a significantly less fuel consumption will diminish emissions release in other respects. In such situations, policies, behaviors, and perceptions of companies and expectations of stakeholders are effective in addition to route selection criteria.

Within this direction, the aim of this dissertation is to find out the route selection behavior of shipping companies against the potential benefits and threats of Arctic Routes and to illustrate the decision-making perspectives and priorities of shipping companies in route selection. Stakeholders openly express their opinions and feelings. Therefore, in order to reach the aims and objectives of the study, first, Sentiment Analysis and Thematic Analysis have been conducted on social media data; then DEMATEL and Best-Worst Method (BWM) have integratedly been used to test the criteria that have been determined in compliance with purpose and structure of the topic.

The results show that the majority of stakeholders are against Arctic shipping and this issue is positioned as an environmental dilemma on their minds. Moreover, the results show that ASR evoke the themes of environmental considerations, business attitudes & behaviors, and policy in stakeholders' minds. The results of DEMATEL method reveal that cost and service dimensions are the most important dimensions, hinterland and safety & security dimensions have causal effects over other dimensions. Influential Network Relation Maps also say time and cost are the most influential dimensions. According to the results obtained with the integration of DEMATEL and BWM, equipment availability, schedule reliability, door-to-door service, transit time, and energy efficiency come out as the criteria having the highest priorities. The findings indicate that Suez Canal outweighs ASR by 2030, and ASR will turn the scale when it comes to the 2050s. In any event, it will not be

wrong to state that it would be convenient for both routes to be interchangeably used in specific periods and for specific cargo types. This study was handled with an innovative approach on several counts compared to route selection and Arctic shipping literature; embodies many initiatives. For instance, it is the first paper that identifies the feelings and opinions of stakeholders towards ASR; conducts thematic analysis by using social media data in the supply chain discipline; hybridizes DEMATEL and BWM specific to route selection and Arctic shipping. Again, this study displays a premise approach in terms of determining criteria. Additionally, the findings have the potential for shipping companies to clarify first their Arctic policies and second their social media-based engagement strategies.

Keywords: Arctic Shipping Routes, International Trade Routes, Route Selection Behavior, Social Media, Sentiment Analysis, Thematic Analysis, Multiple Criteria Decision-Making Methods, DEMATEL, Best-Worst Method

ÖZET

Doktora Tezi

Denizcilik Şirketlerinin Rota Seçim Davranışları – Arktik Rota için Bir Analiz

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Uluslararası ticaretin temel taşlarından olan ticaret rotaları yüzyıllardır önemini korumaktadır. Uluslararası ticaretin hem değer hem de ağırlık bakımından çoğunluğu denizyolu ile taşınmaktadır. Bu nedenle deniz ticaret rotalarının dinamik ve bileşenleri şirketler için önem arz etmektedir. Her ne kadar multimodal taşımacılık kapıdan kapıya hizmet sağlamak için bir zorunluluk olsa da deniz ticaretini destekler pozisyondadır. Diğer yandan kara veya demiryolu rotasında yaşanacak bir sorun birkaç firmayı etkileyecek olmasında karşın deniz yolu rotasında yaşanacak bir sorun tedarik zincirinin yapısını tamamiyle etkileyebilir. Bu duruma en somut örnek COVID-19 pandemisi ve Ever Given vakasıdır. Bu nedenle, deniz yolu rotalarının sağladığı avantajlar kadar barındırdığı riskler de gözetilmelidir. Bir rota kurulurken, yeni hizmet tasarım süreci devreye girmektedir. Yeni hizmet tasarımı, rotanın avantaj ve risklerinin yanısıra, talep, rota kapsamındaki hinterlantların deniz bağlantısı, politik ve yasal boyutlar, IMO yönetmelikleri gibi dış etkenlerin ve şirketin iç etkenlerinin devreye girdiği oldukça karmaşık ve çok boyutlu bir süreçtir. Neticesinde günümüzde 16 temel deniz nakliye rotası ve 500 dolaylarında servis bulumaktadır.

Rota seçimi, bu mevcut alternatifler içerisinden en uygun olanının belirlenmesi işlemidir. Bir rotanın uygun olabilmesi için transit süre, hız kararı, hizmet ve planlama güvenilirliği ve güvenlik faktörleri hizmet yapısına uygun olmalıdır. Ancak en önemlisi maliyettir. Firmalar kar elde ederek varlıklarını sürdürürler ve maliyetleri azaltmanın yollarını ararlar. Küresel ısınmanın sonucunda kutup bölgesindeki yoğun erimelerle Arktik Okyanus'unda yeni deniz yolları belirmeye başlamıştır. Arktik nakliye rotaları şeklinde anılan bu dört rota büyük ekonomiler arasındaki mesafeyi ve transit süreyi ortalama %40

azaltmaktadır. Yakıt giderleri deniz operasyonlarının neredeyse yarısına tekabül etmektedir. Mesafenin kısalması giderlerde bir hayli azalma sağlarken, kısalan transit süre yıllık ortalama sefer sayısını arttırarak geminin sağladığı faydayı maksimize etmektedir. Ancak, Arktik rotaların potansiyel faydalarının yanı sıra, çevresel ve sosyal maliyeti de oldukça fazladır. Çevre, sefer, arama & kurtarma, teknik destek, haritalama vb. konularda mutlak bilgi mevcut değildir. Örneğin, Arktik bölgede gemi seferleri bölge ekolojisini olumsuz etkileyebileceği gibi, daha az yakıt tüketerek emisyon salınımını azaltacaktır. Bu gibi durumlarda rota seçim kriterlerinin yanı sıra, şirketlerin politika, tutum ve konuyu algılayışları ve paydaşların beklentileri rota seçiminde etkili olmaktadır.

Bu doğrultuda, bu tezin amacı denizcilik şirketlerinin Arktik rotaların potansiyel fayda ve tehditleri karşısında rota seçim tutumlarını keşfetmek ve denizcilik şirketlerinin rota seçimindeki karar alma perspektiflerini ve önceliklerini göstermektir. Paydaşlar sosyal medyada duygu ve düşüncelerini açıkça ifade edebilmektedirler. Bu nedenle, çalışmanın amaç ve hedeflerine ulaşmak için önce sosyal medya üzerinden Duygu Analizi ve Tematik Analiz yapılmıştır. Sonrasında konunun amaç ve yapısına uygun olarak belirlenen kriterleri test etmek için DEMATEL ve Best-Worst Yöntemleri (BWM) karma bir şekilde kullanılmıştır.

Sonuçlar, paydaşların büyük çoğunluğunun Arktik rotaların kullanımına karşı olduklarını ve bu konunun onların zihninde çevresel bir ikilem olarak konumlandığını göstermektedir. Ayrıca, bu rotaların paydaşların zihninde, çevresel hassasiyetler, şirketlerin tutum ve tavırları ve politika temalarını çağrıştırdığını göstermektedir. DEMATEL yönteminin sonuçları maliyet ve hizmetin en önemli boyutlar olduğunu, hinterlant ve emniyet & güvenlik boyutlarının diğer boyutlar üzerinde nedensel etkiye sahip olduğunu ortaya koymaktadır. Etkisel Bağlantı İlişkisi Haritaları ise zaman ve maliyetin en etkisel boyutlar olduğunu söylemektedir. DEMATEL ve BWM yöntemlerinin entegrasyonu ile elde edilen sonuçlara göre ise, ekipman uygunluğu, planlama güvenilirliği, kapıdan kapıya hizmet, transit süre ve enerji etkinliği en öncelikli kriterler olarak gözükmektedir. Sonuçlar, 2030'lara kadar Süveyş kanalının, 2050'lere gelindiğinde ise Arktik rotaların ağır bastığını göstermektedir. Ancak, belirli dönemlerde belirli yük tipleri için iki rotanın entegrasyonunun uygun olabileceğini ifade etmek yanlış olmayacaktır. Bu çalışma, rota seçimi ve Arktik nakliye yazınına kıyasla pek çok açıdan yenilikçi bir yaklaşımla ele alınmıştır ve

birçok ilki de bünyesinde barındırmaktadır. Örneğin, paydaşların Arktik rotalar karşısındaki hislerini ve düşüncelerini tanımlayan; Tedarik zinciri disiplininde sosyal medya verileriyle tematik analiz yapan; ve DEMATEL ve BWM yöntemlerini rota seçimi ve Arktik nakliye özelinde entegre eden ilk çalışmadır. Yine, bu çalışma kriterlerin belirlenmesi bakımından öncül bir yaklaşım sergilemektedir. Ek olarak, çalışmanın bulguları şirketlerin Arktik politikalarını ve sosyal medya stratejilerini açık bir şekilde anlatmaları noktasında çıkarımda bulunmaktadır.

Anahtar Kelimeler: Arktik Nakliye Rotaları, Uluslararası Ticaret Rotaları, Rota Seçim Tutumu, Sosyal Medya, Duygu Analizi, Tematik Analiz, Çok Kriterli Karar Verme Yöntemleri, DEMATEL, Best-Worst Yöntemi

ROUTE SELECTION BEHAVIOR OF SHIPPING COMPANIES – AN ANALYSIS OF ARCTIC SHIPPING ROUTES

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ABBREVIATIONS

3PL	Third Party Logistics Service Provider
ABR	Arctic Bridge Route
AHP	Analytical Hierarchy Process
ANP	Analytical Network Process
ASR	Arctic Shipping Routes
BCO	Beneficiary Cargo Owner
BDT	Behavioral Decision Theory
BERT	Bidirectional Encoder Representations from Transformers
BRI	Belt and Road Initiative
BWM	Best-Worst Method
B2B	Business-to-Business
CR	Consistency Ratio
CSR	Corporate Social Responsibility
DEMATEL	Decision Making Trial and Evaluation Laboratory
ED	Emotion Detection
EEZ	Exclusive Economic Zone
ESG	Environmental, Social and Governance Strategy
EQ	Equation
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GPS	Global Positioning System
HFO	Heavy Fuel Oil
HMM	Hyundai Merchant Marine
ICR	Intercoder Reliability
IMO	International Maritime Organization
INRM	Influential Network Relation Map
ISM	International Safety Code
ITF	International Transport Forum
K-LINE	Kawasaki Kisen Kaisha
LNG	Liquefied Natural Gas
MARPOL	International Convention for the Prevention of Pollution from Ships

MAUT	Multi Attribute Decision-Making
MCDM	Multiple Criteria Decision-Making
MOUT	Multi Objective Decision-Making
MOL	Mitsui O. S. K. Line
MoU	Memorandum of Understanding
MSC	Mediterranean Shipping Company
NGOs	Non-governmental Organizations
NM	Nautical Mile
NPD	New Product Development
NSD	New Service Development
NSR	Northern Sea Route
NSRA	Northern Sea Route Administration
NWP	Northwest Passage
NYK	Nippon Yusen Kabushiki
OECD	Organization for Economic Co-operation and Development
ONE LINE	Ocean Network Express
PLC	Product-Life Cycle
PSC	Port State Control
PSR	Polar Silk Road
R&D	Research and Development
SA	Sentiment Analysis
SAR	Search and Rescue
SCR	Suez Canal Route
SM	Social Media
SOLAS	Safety of Life at Sea
TA	Thematic Analysis
TEU	Twenty-foot Equivalent Unit
TSR	Transpolar Sea Route
UNCLOS	United Nations Convention on the Law of the Sea
USA	United States of America
VRP	Vehicle Routing Problem

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CHAPTER I
INTRODUCTION

1.1. MOTIVATION

World trade is one of the basic components of the global economy. According to the classical theory of economics, economic growth and the direction of economic activities are strongly related to foreign trade. There are several functions of international trade, and transportation is initially crucial one of them (www.transportgeography.org). Therefore, it has been proven several times in many types of academic research such as Campbell (2018), Ng and Tongzon (2010), Tikoudis et al. (2018), Pradhan and Baghci (2013) that transportation is an essential part of both global and regional economic development. Increasing foreign trade accompanies both national and international level competition. Because transportation is one of the major cost items (Tikoudis et al., 2018: 78) and the primary agent for quality perception for businesses, the competing firms, which are willing to have superior quality with lower prices, also check up on the transportation leg of their organization (Wilmsmeier and Notteboom, 2011: 215 – 217) in addition to other business functions. Therefore, trade activities direct both global and regional transportation demands.

Transportation has been an essential function of trade for centuries. Global transportation demand has evolved, and the competition between transportation operators has become fierce. As the nature, volume, and shape of trade have changed; many alternative transportation firms have appeared; and the need for different transport modes has become necessary (Rondinelli and Berry, 2000: 400). This competitive environment between nations, businesses, and transport operators has accelerated both infrastructure and superstructure investments (Janic, 2010: 481 – 483). In this way, hinterland and maritime connectivity of both mainlands and feeders have continuously been developing (Wilmsmeier and Notteboom, 2011: 221). The developing connectivity has increased the integration of regions via trade routes and gateways. The usage of different transport modes and ever-developing trade relations between countries have ruled trade routes for both maritime and land trade. As a result, major trade routes have been connecting major economies of the world for centuries. After several technological evolutions and innovations, world trade has

been standing on maritime transportation's legs. Therefore, maritime shipping routes have been becoming significantly important for trade activities.

The idea of maritime trade routes was born with increasing colonization activities in the 19th century (ICS, 2011:3). In time, the direction of the trade shifted. Asia, North Europe, and North America continents have been ruling over maritime trade, especially in the last four decades (Stopford, 2009: 348). Hereafter, eight major maritime shipping routes organizinhg global supply chain network have been described by World Shipping Council. These major routes comprise several sub-routes connecting trade centers through ports between Asia, North America, North Europe, Mediterranean, Middle East, and South America (Stopford, 2009: 524 - 528).

After globalization, liberalization, and deregulation of world trade, goods have become more reachable (Notteboom and Rodrigue, 2009: 15) because different trade routes and transportation are now able to substitute another one. Here, the basic questions are how to distribute cargoes from origin to destination; and which trade routes and transportation modes to be used. Within this perspective, Rodrigue (2020) says that route selection and transportation mode selection concepts have risen. The interchangeability of some shipping routes has caused being concerned with the decision-making perspectives of shipping companies. At first glance, ship owners seem to be the only decision-maker in route selection; but in today's maritime industry, freight forwarders, logistics companies, and foreign trade companies have a voice. Perhaps they cannot directly determine the routing of vehicles but, thanks to shipping alliances and due ever-fiercer competition between transport operators, many service alternatives are available within a variety of shipping routes. Thus, they can select liner services under their route selection behavior.

The route selection decisions may reflect both objectives of the companies and the behavior of decision-makers. From limited literature, a set of attributes can be found effective in route selection such as speed (Wen et al., 2019; Tsirimpa et al., 2019; Shibasaki et al., 2017), transit time (Park et al., 2019; Pham et al., 2018; Wang and Yeo, 2018; Wang et al., 2018), security (Wen et al., 2019; Tischler, 2017; Moon et al., 2015), reliability (Moon et al., 2015; Fagerholt et al., 2010; Teodorovic and Kalic, 1995), distance (Wen et al., 2019; Shibasaki et al., 2017; Kashiha et al., 2016), cost (Tsirimpa et al., 2019; Wen et al., 2019; Park et al., 2019; Pham et al., 2018). As is expected, the most attractive one is cost. Such that shipping lines have tried to find out ways for reducing costs for years. Lun et al. (2010) indicate that low-cost transportation options enabled new service designs for new shipping routes. In this

context, low-cost-seeking shipping companies have begun to be willing for using the North Pole which continuously melts. As a conclusion of global warming, the ice masses at the Polar Zone enormously melt, and it has become unavoidable International Maritime Organization (IMO) to introduce Arctic Shipping Routes (ASR). Hence, these new routes have gained great importance in recent years. However, there is still a sizeable gap in the literature about route selection and Arctic shipping. In another respect, increasing interest in the Arctic region also attracts academia, but the number of studies remains restricted. Because, due to the changing and developing structure of the Arctic Region, there are limited resources and data about the Arctic. The scholarly papers on Arctic shipping are mostly about the cost advantage of these routes (Liu and Kronbak, 2010; Xu et al., 2018; Lindstad et al., 2016, Furuichi and Otsuka, 2015), fuel consumption (Liu and Kronbak, 2010; Tseng and Cullinane, 2018; Pavlenko and Glukhareva, 2010), cost and sufficiency of ice-breaking vessels (Theocharis et al., 2019; Furuichi and Otsuka, 2015; Solakivi et al., 2018), navigability and sea ice conditions within Arctic (Shyu and Ding, 2016; Aksenov et al., 2017; Tseng and Cullinane, 2018), the feasibility of arctic shipping (Beveridge et al., 2016; Xu et al., 2018; Theocharis et al., 2019), political considerations of ASR (Hong, 2014; Shyu and Ding, 2016; Tseng and Cullinane, 2018), transportation of natural resources and environmental expectations of the region (Lindstad et al., 2016; Pavlenko and Glukhareva, 2010; Afenyo et al., 2019). Moreover, some of the selection-based transportation studies conduct social costs of transportation activities, selection of trade routes, and decision-making behavior in carrier selection, but no one is related to ASR. Last but not least, my initial motives are to touch on a globally important issue rather than a local one, to handle an amazing and rarely handled subject.

1.2. PROBLEM AND SIGNIFICANCE

It is crystal clear that the earth gradually warms, the environment is globally in danger (Trenberth, 2018: 5 – 7), and polar ice dwindles (Aksenov et al., 2017: 306). Arctic Region has no reliable infrastructure and intermodal connectivity to meet door-to-door transportation (Myllylä et al., 2016: 157 – 158) thus, the absolute tie of big countries and companies will make investments and infrastructure work press forward in the region. Theory of social cost proposes that transportation and infrastructure works are initial sources of environmental hazards (Kapp, 1971: 197 – 206), if ASRs

are used further, the growing infrastructure and superstructure investments in this region might speed up global warming. Therefore, social cost of using this route may be notably high. Moreover, a marine accident may cause an ungovernable spread of marine and air pollution within the pole (Ivanova, 2011: 1 – 2; Guy and Lasserre, 2016: 300). The cleaning procedures (Ivanova, 2011: 1), search and rescue operations, and salvage under ice conditions are too hard to handle (Hill et al., 2015: 73 – 74). And even, increasing emission levels in the Arctic may be several times more hazardous than trucks do within the global extent (Schröder et al., 2017: 406 – 408). Hence, it is a near-future problem for not only Arctic States but also the Mediterranean, Latin American, Australian, and African people (Peters et al., 2011: 5305). But, despite this negative picture, companies and countries have a great tendency to prioritize their profits and utilities; and this situation may conduce to disastrous results faster than expected. Indeed, having satisfactory profit instead of profit maximization is a more sustainable and long-reaching strategy for companies, as it is hypothesized by Mol (1997) in ecological modernization theory. For this reason, the decision-making behavior of people and companies, which are subjected to the behavioral decision theory of Becker and McClintock (1967), gains great importance.

Today, Arctic Region has become a focus of interest of big countries such as China, Russia, USA, Japan, EU countries, etc. in terms of natural resource reserves (Afenyo et al., 2019: 476 - 477), national policies, international law (Hong, 2014: 280), and transportation issues (Beveridge et al., 2016: 411). The USA, Russia, Canada, and some EU countries such as Norway, Denmark, Sweden, Finland, and Iceland have direct connections to the ASR and further. Also, because Beijing Strait has a major role in these routes China, Japan, and South Korea gaze upon the region. Even if transportation through the Arctic is supposed to be a novel paradigm, it has been used for a long while (Guy and Lasserre, 2016: 295; Meng et al., 2017: 16). For instance, COSCO Shipping has been performing regular voyages through the Arctic at the summer times of the North Pole since a few years. In the wake of China's trade and transportation policies, COSCO augments the number of vessels that sail in the Arctic day by day (Huang et al., 2015: 64 – 67). Further, some big Russian liquefied natural gas (LNG) companies use the North Russian coast for gas and petroleum transportation almost year-round (Myllylä et al., 2016: 158). However, the most aforementioned case for Arctic shipping was trial trip of Maersk Line via Northern Sea Route (NSR) in August 2018. It has been discussed internationally and has made ground in global news agencies and on social media. There is an unwritten rule of the

world that some big countries and big companies lead, and others follow. Many incidences that have happened for the last century make us think so. For example, the opening of the Suez Canal was not found realistic when it was only a project on paper; the Panama Canal has also been deemed as an environmental and humanitarian massacre and has not been expecting such a demand. But big players' decisions have changed the approach and attitudes of others.

Companies desire to be more profitable and countries look for new resources. In this way, the interest in Polar zones gradually increases. Although using Arctic routes have some pros with significant distance, travel time, and cost reduction, its usage has several cons in terms of emissions level, ecology, global warming, ice melts, etc. For this reason, the future of human beings would be in greater trouble than expected in climate change scenarios. For now, important liner operators like the Mediterranean Shipping Company (MSC), CMA-CGM, and Hapag Lloyd officially declared that they will not use ASR. On the other hand, Maersk stays in the gray area while Hyundai Merchant Marine (HMM), and COSCO have planned behavior over ASR. If and only, the nature of the world and trade structure changes and competitive positions of companies are strongly volatile. The question is, by the time intra-industry competition becomes fiercer and by the time their rivals begin to exploit the cost and transit time advantage of ASR a few years later, what will be the behavior of shipping companies when it is needed to decide environmental factors and profitability?

1.3. RESEARCH QUESTIONS AND OBJECTIVES

The purpose of this dissertation is to find out the route selection behavior of shipping companies against the potential benefits and threats of Arctic Routes and to illustrate the decision-making perspectives and priorities of shipping companies in route selection.

This study addresses several basic questions to support the problem. These are:

1) What are the priorities and behavior of shipping companies in route selection?
2) How do shipping companies perceive and see the establishment and usage of ASR?

Also, the following research objectives would contribute to the achievement of the aim of the study:

1) To understand attitudes of ship-owning companies in route establishment.

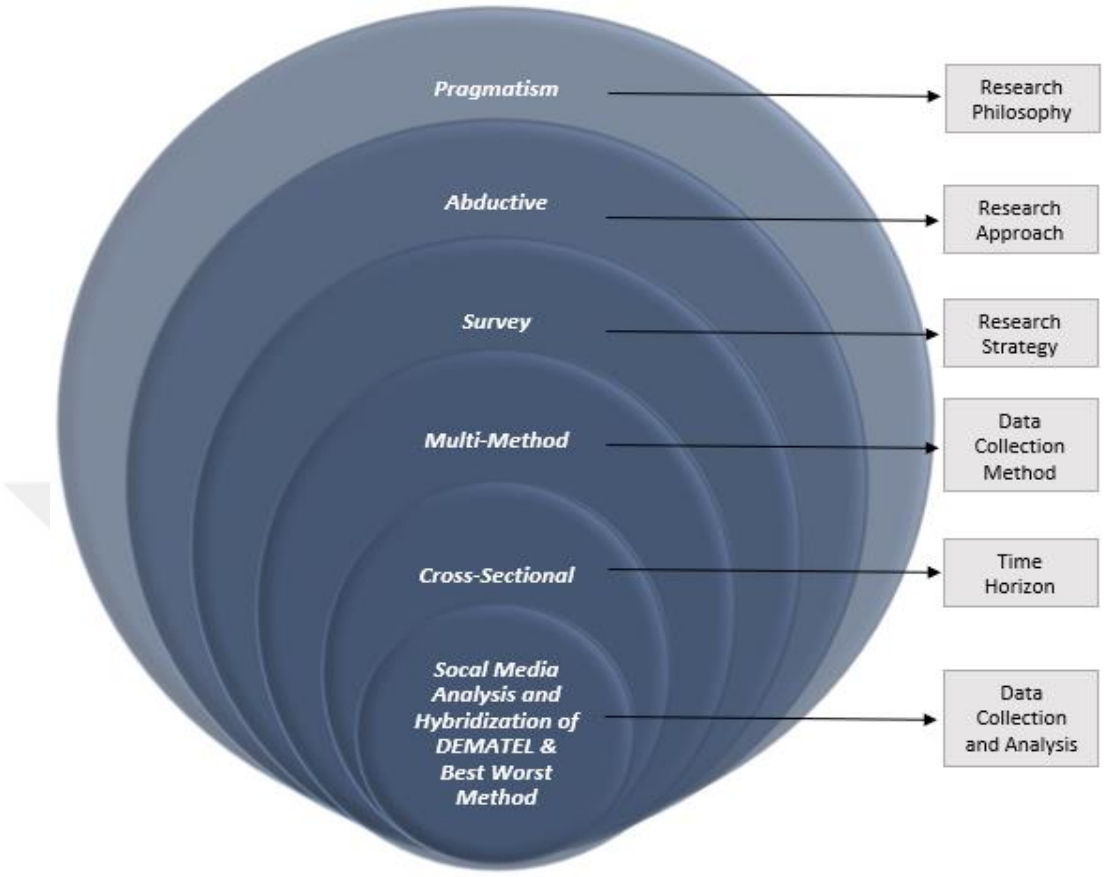
2) To clarify important factors affecting route selection of shipping companies.
3) To show interactions between route selection decision factors.
4) To explicate the perception and sentiments of stakeholders of shipping industry about ASR.
5) To identify ASR in all its parts by assessing economic returns and environmental, legal, and political bottlenecks of using ASR.

1.4. RESEARCH DESIGN AND MODEL

This section identifies the research onion of the study and research model that is clarified with a conceptual design of liner service.

The first layer of the research onion (Figure 1) indicates the ontological and epistemological approach to the study. The research cannot be degraded to a single philosophy. It is aimed to handle research from a more practical perspective because it is vital to use the best possible instruments. Information and knowledge are not constant, but rather must be queried and explicated; and these questions and interpretations have subjectivity a thought. In this way, pragmatism, which embodies deductive post-positivist research philosophy and inductive constructivist research philosophy, is a more appropriate approach for the research philosophy of this dissertation. Because the subjective judgments involving research questions are context specific. Hence most convenient research design and methodology are determined to scrutinize research questions. To find the answers right on the spot, the methodology is focused on the research questions directed. Thus, the methodological considerations should be concentrated on as a basic tool for connecting the researcher's judgments about the nature of knowledge, as it is more desirable to gain knowledge most directly and suitably. For the next layer, the abductive research approach is found suitable. Abductive reasoning as the primary approach of pragmatism provides the best probable explanation for the current situation. The abductive research approach accepts the researcher is boundedly rational. This concession supports the theoretical background of the study. There are uncertainties and idiosyncratic courses in Arctic Region. Therefore, it is hard to generalize for all conditions. Further, abductive reasoning is mostly fit for quantitative data and collocation of qualitative and quantitative data.

Figure 1: Research Onion



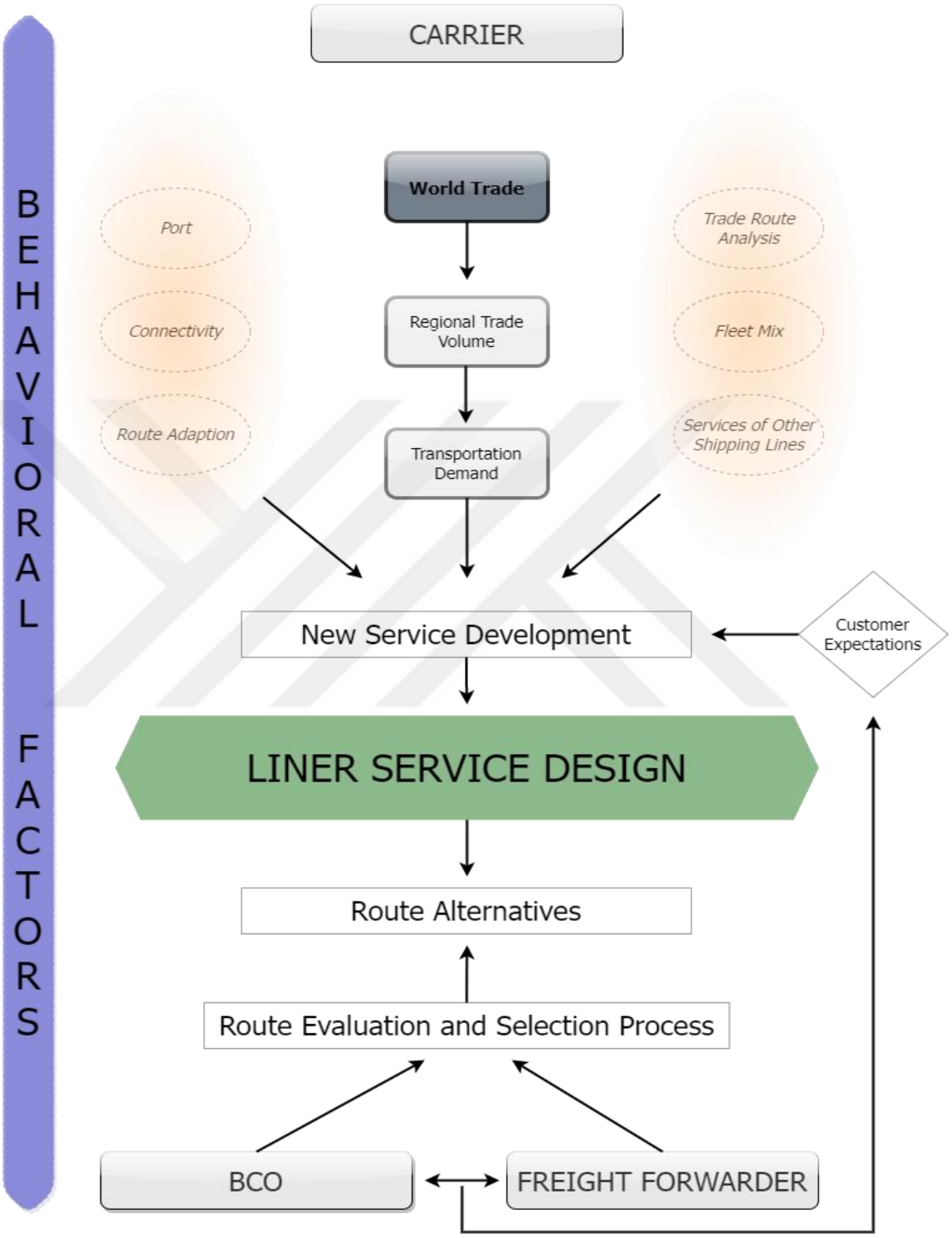
Source: Created by the author (Inspired by Saunders et al. 2007).

Quantitative data are prone to be analyzed empirically with a survey which is the research strategy of study. After the third layer is peeled, the data collection method is to be chosen. In this step, it is determined which types of data to be used. In the way of the main epistemological philosophy of study and previous layers, multi-method is selected. This method allows the researcher to use more than a qualitative and quantitative approach with a broader range of research methods. It is planned to collect these data in a cross-sectional time horizon. The last layer shows the data collection and analysis perspective of the research. This layer tells how data is collected and analyzed. To collect primary data, judgmental sampling is used to determine a more functional sample for the aim of the study. In liner shipping, there are few route alternatives, for this reason, route selection decision is an obvious example of a discrete problem. Also, there are trade-offs between variables and there are some conflicting variables such as cost, time, risk, reliability, and eco-friendliness.

These conflicting variables, directly and indirectly, affect each other. Therefore, for weighting and prioritizing criteria, it is more practicable to use Hybrid Multiple Criteria Decision-Making (MCDM) methods combining and integrating two or more analytic Multi-Attribute Decision-Making methods. To identify dimensions and criteria, social media analysis will be conducted, and the general structure of dimensions and criteria will be discussed with experts. After, the first DEMATEL will be used to determine the interaction and relationship between dimensions and criteria; then Best – Worst Method (BWM) will be used to reveal the priorities of criteria more realistically and more sensitively. And then, global influential weights will be obtained via hybridization of these methods. The hybrid construct of methods plays a proactive role in problem-solving because decision-makers transform information and experience into understandable and improvable decision forms.

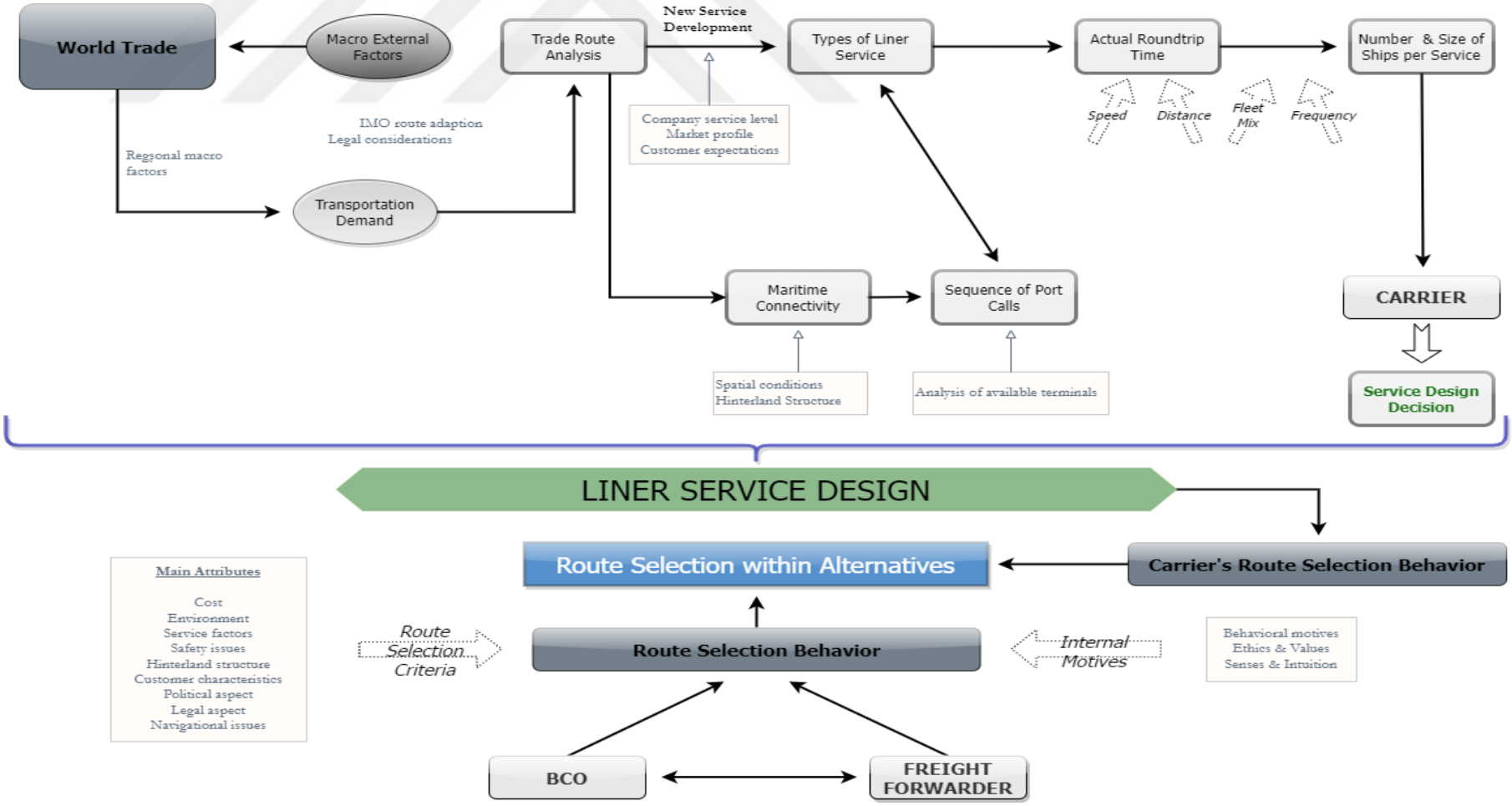
Figure 2 is a roughly illustrated version of the liner service design and route selection behavior of shipping companies. For a better understanding without any complications, research models are extended step by step. After examining the steps in the broad picture, the following figures can be scrutinized in more detail. In these figures, it is tried to use the same colors for the same items. Also, the thickness of the arrows tells whether connected factors are main or supportive.

Figure 2: A Broad Projection of Liner Service Design and Route Selection



Source: Created by the author.

Figure 3: General Overview of New Liner Service Design and Route Selection Attributes



Source: Created by the author.

Figure 3 gives a general overview of liner service design and route selection. Macro external factors are the base of world trade, and trade gives rise to shipping at both global and regional levels. In addition to macro factors, regional macro elements also affect regional demand. Demand patterns let the companies make analyses for developing new services and determining types of liner services. At the end of analysis, the actual roundtrip time becomes clear, and carrier decides on characteristics of the fleet to serve in the route given. In this flow, liner service is established by considering the carrier's route selection behavior. And last, BCOs and freight forwarders select the most convenient route within the alternatives in line with their behavior, motives, and policies.

Figure 4 shows the conceptual framework of the liner service design. This framework predominately reflects the demand-dependent maritime transportation because route establishment, design, and selection are the direct concern of carriers. Lai et al. (2019) indicate that the initial item is the global trade that leads to transportation demand (Lai et al., 2019: 1 – 2), and that is affected by the global economy (Stopford, 2009: 54), risks (Olufikayo and Grace, 2014: 103 – 104), political factors (Stopford, 2009: 147), and international trade relations (Kveiborg, 205: 2). World trade and global transportation demand contribute to the direction of regional transportation demand (De, 2014: 10) that is mainly based on the regional economy, demographic, industrialization level, regional risks, regulations, and restrictions (Fithra et al., 2018: 37 – 40). Again, national-level competition and regional transportation demand affect each other (www.hbr.org). The regional transportation demand concludes in infrastructure and superstructure investments of ports and all logistics facilities (OECD, 2002: 7 – 9) to improve both hinterland and maritime connectivity (Acciaro and McKinnon, 2013: 12 – 18). Hinterland connectivity also depends on spatial conditions and the industrialization level of the region while maritime connectivity is not only related to regional demand but also interacted with port efficiency level and is affected by hinterland connectivity (Merk and Notteboom, 2015: 8 – 19). In addition to maritime and hinterland connectivity, whether it is integrated with either existing or new routes, the new service must be adopted into IMO principal trade routes and must be anchored in IMO regulations (www.imo.org). With the new route announcements of IMO and after proper conditions have been actualized, the new service is adopted. Some factors related to new service such as expected cargo volume (Notteboom and Vernimmen, 2009: 329), volatility (Satta et al., 2013: 353), seasonality (Ducruet and Notteboom, 2015: 131; Polat and Günther,

2016: 44), routing problems (Hennig et al., 2015: 41), geographical service coverage of the company (Guericke, 2014: 135), the position of strategic partners (Ducruet and Notteboom, 2015: 132), actions of competitors (Bergantino and Veenstra, 2002: 232), and profitability (Ducruet et al., 2010: 18) are reviewed before a new service is adopted by ship-owners. If all commercial (Guo et al., 2022: 4 – 5), infrastructural, and superstructural conditions are met, navigational requirements like navigational infrastructure (Kiiski, 2017: 47; Tseng and Pilcher, 2017: 392 – 393), communication infrastructure (Ghosh and Ruby, 2015: 173), safety requirements (Guy and Lasserre, 2016: 301; Ghosh and Ruby, 2015: 177), navigational aids (Tseng and Cullinane, 2018: 426), etc. must be supplied by local and/or international authorities. Wilmsmeier and Notteboom (2011) and Ducruet and Notteboom (2015) discuss that such regions with commercial potential, suitable hinterland connections, and efficient port alternatives are required to be integrated into an existing route or a newly established one (Wilmsmeier and Notteboom, 2011: 214 – 216; Ducruet and Notteboom, 2015: 144 – 145). At the end of the first part of the cycle, the new liner service design is concluded and gets ready to be exploited.

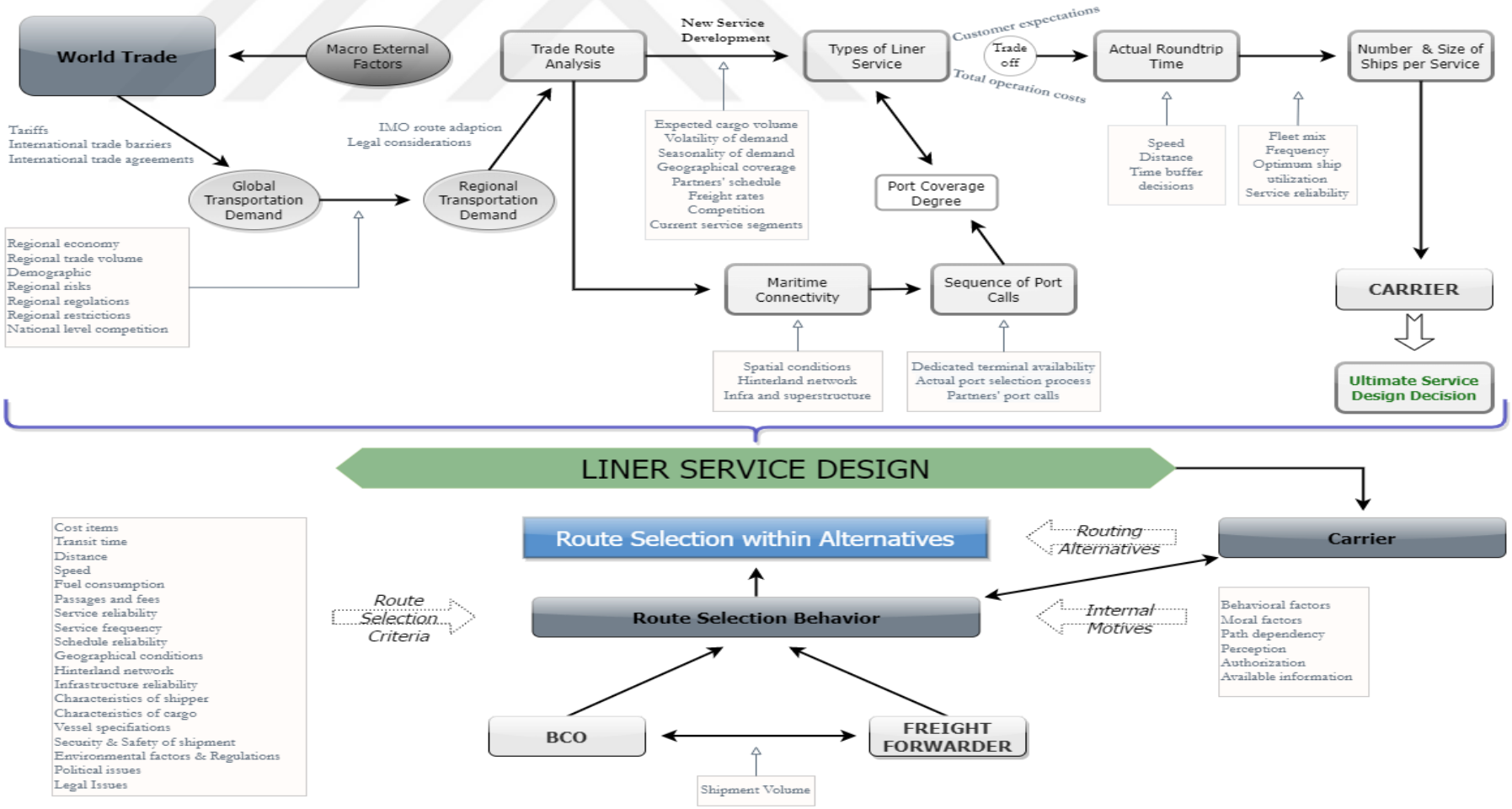
In the second part, a general overview of route selection decisions of carriers, BCOs, and freight forwarders are drawn. Although, BCOs and freight forwarders do not directly select routes and mainly consider prices, they indirectly select routes when selecting carriers and may consider routing alternatives in terms of sustainability and environmental issues. This is what is extracted from expert opinions and literature review, and what it is targeted to underline as an implication in this study.

Consequently, route alternatives are determined by carriers. These alternatives are evaluated in terms of main route selection criteria (cost, transit time, distance, speed, fuel consumption, service reliability, service frequency, schedule, hinterland network, infrastructure, characteristics of cargo, vessel specifications, safety and security of shipment, environmental factors, political issues, etc.), which are organized in accordance with route selection studies such as Tsirimpa et al. (2019), Wen et al. (2019), Park et al. (2019), Pham et al. (2018), Wang and Yeo (2018), Wang et al. (2018), Woo et al. (2017), Shibasaki et al. (2017), Tischler (2017), Kashiha et al. (2016), Moon et al. (2015), Fagerholt et al. (2010), and Teodorovic and Kalic (1995). Carriers are the bedrocks in shipping and ship routing by nature. However, shippers' needs shape their decisions (Fagerholt, 2004: 260; Tran et al., 2017: 670). Also, a shipper may select a carrier serving along an eco-efficient route instead of the carrier serving a cost-efficient route (Solakivi et al., 2017: 524 – 528).

The shipment volume determines whether BCO makes decisions or freight forwarders (Wong et al., 2008: 37). Even if BCOs authorize freight forwarders for the organization of shipment, they may demand that shipment is organized in line with their policies like sustainability (Kannan et al., 2011: 768 – 769).

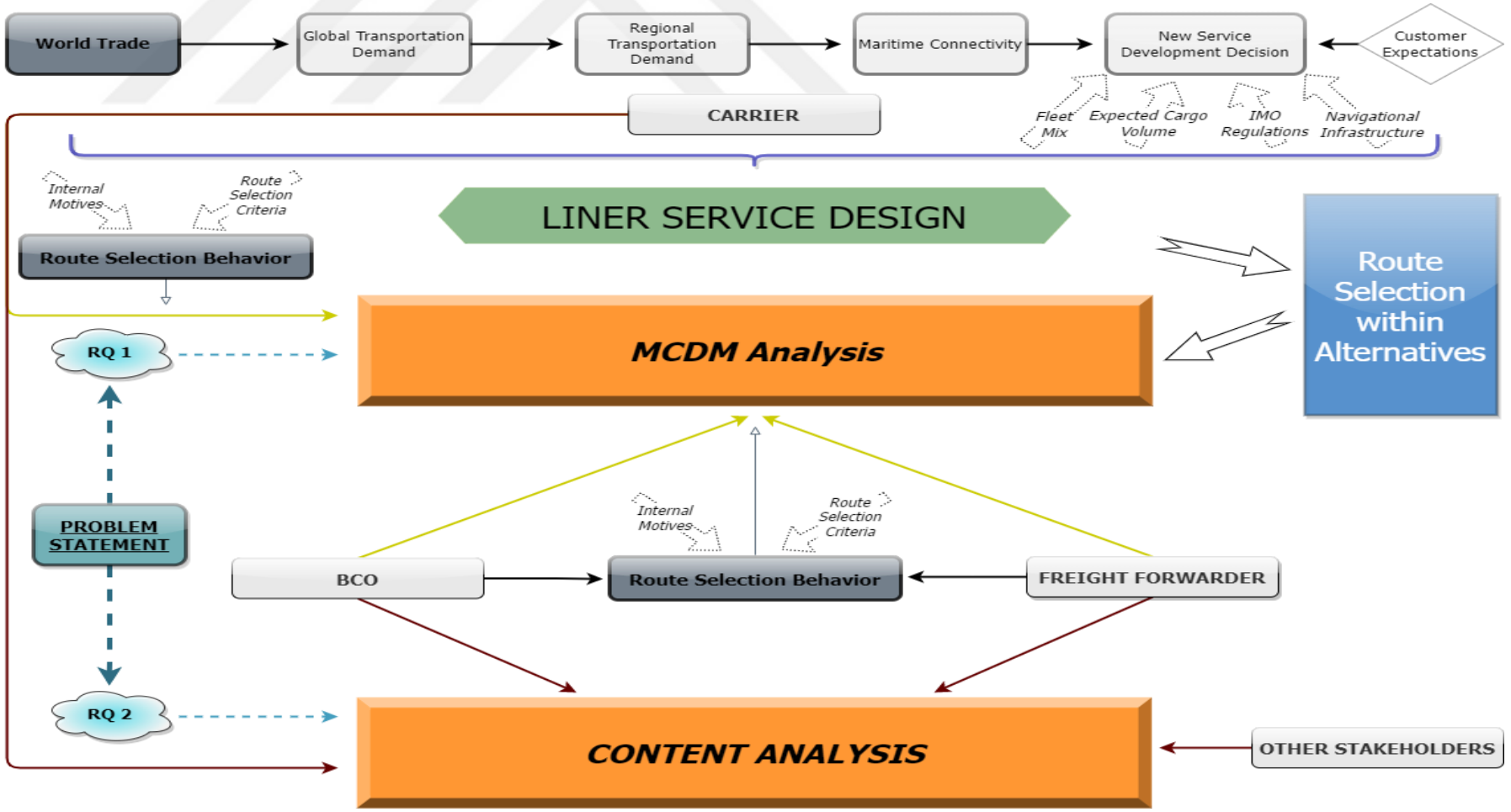
Besides, the decision-making process is an intellectual activity. The emotion, psychology, values, and even lifestyle of people are important in their decision as much as company policies. Robotic decisions, which do not contain internal judgments and comparisons, and that do not reflect behavior, cannot be feasible and satisfactory (Arslan, 2018: 9 – 10). In a decision process, decision-makers also have internal motives (Keren, 1996: 176) such as behavior (Takemura, 2017: 154), moral factors (Geva, 2000: 774), path dependence (Koch et al., 2009: 69 – 70), perception (Jerman et al., 1978: 30), available information (Holsapple, 1995: 5 – 6), knowledge (Holsapple, 1995: 5 – 6; Lau and Levy, 1998: 31 – 32), authorization level (Lau and Levy, 1998: 31 – 32), and external motives such as company policies, and organizational structure (Yaşar, 2016: 22). Besides, this decision mechanism links to customers' attitudes, behavior, and expectations. Ultimately, route alternatives are evaluated and then selected in light of the evaluation factors given.

Figure 4: Conceptual Framework of New Liner Service Design and Route Selection Procedure



Source: Created by author.

Figure 5: Methodological Overview of the Route Selection

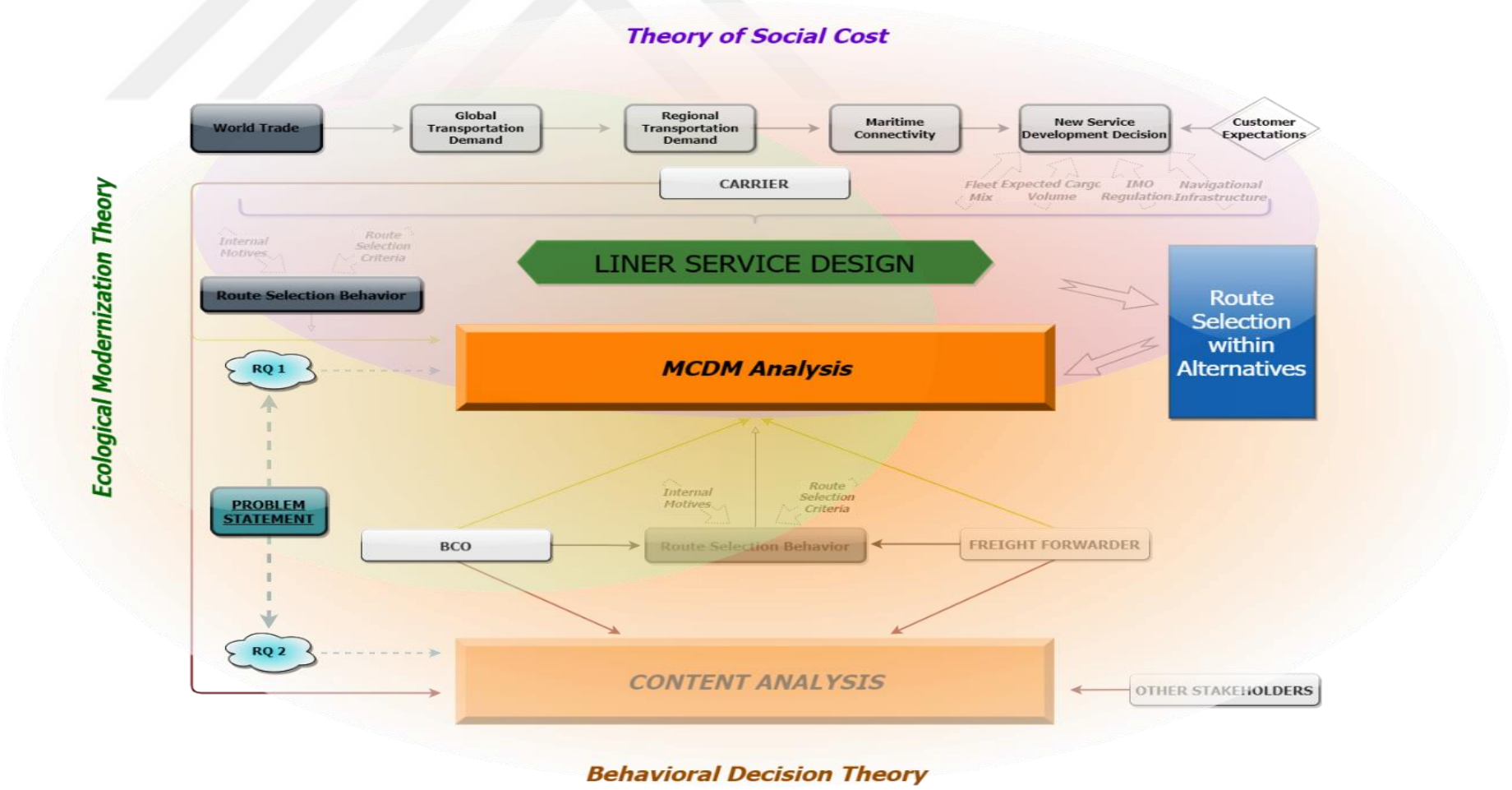


Source: Created by the author.

Figure 5 defines a methodological overview of the route selection used in this study. The liner service design process is comprehensively explained in Figure 4. At the end of the cycle, route selection within the alternatives, a hybrid Multi-Criteria Decision-Making (MCDM) analysis was used by addressing the problem statement through research question 1 (RQ1) and relevant research objectives; and a social media (SM) Content Analysis was conducted by addressing problem statement through research question 2 (RQ2) and relevant research objectives. Both methods were applied to carriers, BCOs, and freight forwarders in the global context. Additionally, other stakeholders in the shipping industry were also involved in Social Media Analysis to verify route selection dimensions with the help of their idea and perception. The ideas and perceptions were extracted from social media comments on Arctic-related posts on Twitter and LinkedIn platforms. The double-verified dimension and criteria were asked to the selected shipping companies' high-level managers via a hybrid MCDM survey. The hybrid model consists of DEMATEL and Best-Worst Method.

Figure 6 theoretical framework of the study is integrated into the methodological approach of this study. The world trade and its functions, transportation demand, connectivity, infrastructure investments, and finally new liner service are the social cost-generating activities. To avoid these costs companies' approaches are the indicator. As the ecological modernization theory proposes, the liner service design of carriers and route selections of BCO and freight forwarders should consider environmental factors while making a profit. This is only the way both profitability and ecology become sustainable. By considering social costs and sustainable development approaches, organizational behaviors and individual behaviors should shape the decisions of the companies, as suggested by behavioral decision theory. The behaviors including several internal and external factors direct decision-making processes. Within this scope, uncertainties of conditions and bounded rationality of decision-makers restrain the appropriateness of decisions. And thus, knowledge, personal judgment, perception, and path dependence direct the decision-making process.

Figure 6: Theoretical Overview of the Route Selection



Source: Created by the author.

1.5. DATA, SAMPLING, AND METHODOLOGY

This step explains how variables are determined, how sampling is picked, how data is collected under the data title; and how the methodology of research is designed, what are the basics and details of research methods under the methodology title.

1.5.1. Data

In literature, route selection of liner shipping companies was rarely handled. Most of the route selection studies are discussed from the point of cost, reliability, cargo demand, risk, and capacity. However, empty container and equipment availability, slow steam trend, sustainability, and environmental awareness are not mentioned; and risk and security considerations are not addressed in many research papers. In major shipping routes, especially cost, capacity, and service frequency may be viable determinants. Yet more different alternative perspectives must be discussed for infant routes because characteristics of the Arctic Shipping Routes are required to think more multi-dimensional. To determine variables, attributes used in route selection, transport mode selection, and carrier selection studies have been reviewed. The variables are tried to be standardized; some sub-variables and variables representing close meanings are gathered under the same categories (See Appendix 1). The variables in these studies are analog. For instance, carrier selection and transport mode selection studies are quite similar, while route selection studies differ from both because decision-makers should also consider technical factors in route selection. The attributes in route selection studies mainly rely on different concepts of time, cost, speed, security, and distance. Besides that, environment, port sequences, service frequency, shipment volume, infrastructure, hinterland connectivity, legal & political issues, shippers' decisions, and awareness of decision-makers are rarely tested in the literature. Transport mode selection literature also shows that time, shipment volume, service reliability, connectivity, service frequency, and damage are highly important; distance, characteristics of goods, environment, and price are important in average value; service quality, logistics facilities, flexibility, speed, scheduling, and security are used seldom. And the carrier selection studies mostly consider time, reliability, damage & loss performance, relationship, cost, service flexibility, and tracing. These studies normally practice price, service quality,

frequency, information supply, geographical coverage, reputation of carrier, and flexibility in pricing and payment. After all, equipment condition, fleet size, environment, employee, speed, security, annual TEU capacity, and website usefulness are discussed hardly ever. The fact remains that, especially transportation companies, which are deemed as a major source of social and environmental costs, concern with corporate social responsibility and social and environmental factors as it is proposed by the triple bottom line model.

Although many attributes have been revealed in past academic research, some attributes regarded as less important or non-important before became more important due to world economy's changing conditions, international trade, and global phenomena. The COVID-19 pandemic, one of these facts, has led to a global recession. The pandemic and recession have forced dynamics of the maritime industry, because COVID-19 procedures of countries and ports, slowdown of industries, diving service industries, and half capacity-running sectors have given rise to longer transit time, scheduling problems, lower cost-efficiency, and fluctuating prices. Also, world container circulation has been deranged because of uncontrolled shipments of medical masks, disinfectants, and drugs all around the world. These situations have ultimately led to errors in empty container positioning. Furthermore, as unrestrainedly transforming import-export balance cut down container availability. Lack of equipment and troubles in container flow increase costs, and port time; decrease the reliability of service. In light of this information, the above-mentioned attributes in the literature have partly been evaluated. When today's world trade situation is considered, maritime industry, basic characteristics of ASR, empty container availability and container circulation, congestion, uncertainties, sustainability of regular transportation, capabilities of ports in a sequence, competition, existence of logistics facilities, industry level of regions, the value of cargo, and suitability to slow steam application may highly – likely be of concern in route selection. To approve the gap relating to these attributes, an academician, a shipper, and two freight forwarders have been interviewed. They have also emphasized that under normal conditions, shippers and forwarders are already able to decide which route to be used when selecting a carrier because they check the most convenient schedule option in a different carrier and route alternatives. Especially empty containers, congestion, the existence of logistics facilities, and the value of cargo were found crucial. On the other hand, the shipper and forwarders said that degree of uncertainties, and the academician said that applicability of slow steam

may be regarded in route selection. The counselee emphasized that the sustainability of regular transportation also concludes in weekly schedules. Therefore, if there is no possible regular transportation, carriers do not probably establish a schedule in a route. Further, they remarked that industry level in regions is an important indicator to create a new route and organize weekly schedules for carriers, and to gather different transportation demands for forwarders. Industrialization determines the demand level in a region, and more demand guarantees permanent transportation services or increases transportation service frequency; therefore, it is also indirectly important for the shipper to overcome the high price and low service quality risk of monopoly or duopoly. On the other hand, forwarders and the shipper said that equipment unavailability of carriers causes sudden and enormous fluctuations in prices, in short, thus equipment availability and price reliability are initial factors in their selections.

In sum, at the end of the literature review variables that are in harmony with the aim and objectives of the study have been determined. It is harmonized route selection and carrier selection attributes by considering ASR-specific situations. Also, the results of social media analysis are benefited to make some additions and tricky arrangements. Some of the criteria were given with their direct meanings while some have more beyond their meanings. Further, especially Arctic-related criteria under environment dimensions were given with periphrases to create a better understanding of shipping companies' behavior towards ASR. However, those periphrases were not determined arbitrary, for instance, Lindstad et al. (2016) and Hansen et al. (2016) reveal that "Ozone layer spoil", which is the highly prominent consequence of increasing emissions and research activities in the Arctic area (www.ec.europa.eu), was given as second criteria of environment dimension. After a detailed examination of these variables and after having an expert opinion, twenty-nine criteria under seven dimensions have been found proper. These criteria are cost, time, service, hinterland, safety and security, and environment.

The categorization of sub-criteria is:

- Cost
    - C11 - Slow steam applicability
    - C12 - Energy efficiency
    - C13 - Mandatory assistance
    - C14 - Canals and passages
- Time
    - C21 - Distance

    - C22 - Transit time
    - C23 - Congestion
    - C24 - Berthing and cargo handling
- Service
    - C31 - Schedule reliability
    - C32 - Equipment availability
    - C33 - Competition
    - C34 - Shipping alliances
    - C35 - Loss potential
    - C36 - Brand image
- Hinterland
    - C41 - Port rotation
    - C42 – Door-to-door service
    - C43 - Industry level
    - C44 - Dry-port connections
- Environment
    - C51 - Damage to biodiversity
    - C52 - Ozone Layer Spoil
    - C53 - Air quality problems
    - C54 - Carbon footprint
- Safety and Security
    - C61 - Piracy
    - C62 - Accident and collision
    - C63 - Theft
    - C64 - Lashing, Stacking and Trimming
- Social
    - C71 - Public reaction
    - C72 - Health problems
    - C73 - Quadruple bottom line

For a more detailed explanation, see the dimension, criteria, and definition table in Appendix – 2.

1.5.2. Sampling and Data Collection

1.5.2.1. Social Media Content Analysis

In this paper, stakeholders' comments on ASR-related posts, reposts of these posts, and hashtags were investigated (All will be referred to as "comment" in the next sections). The official Twitter and LinkedIn accounts of the top ten liner shipping companies listed in Alphaliner (June 2021), and their CEOs were handled within the research scope. These companies are MAERSK, MSC, CMA-CGM, COSCO, HAPAG LLOYD AG, ONE LINE, EVERGREEN, HYUNDAI MERCHANT MARINE (HMM), YANG MING, and ZIM LINE. Although ONE LINE was established as a merger of MITSUI O.S.K. LINE (MOL), NIPPON YUSEN KABUSHIKI (NYK), and KAWASAKI KISEN KAISHA (K-LINE), the activities other than container shipping of these companies continue. Therefore, official accounts of them and their CEOs were scanned. Also, if there have been some changes in the organizational structure of samples within the time frame of the study, accounts of former CEOs were involved. Again, IMO and ShipsGo accounts were counted in because some sectoral discussions were found under their posts. Additionally, it was intended just for checking the perception of households via accounts of news agencies (Reuters, BBC, etc.) and Arctic corporations (Arctic Council, The Arctic Institute, etc.), but those were not included in the analysis.

On Twitter, quotations and comments on these quotations were also considered. From the acquired mass data, only analyzable comments containing opinions and sentiments of stakeholders related to ASR were included. Comments of peoples other than stakeholder were excluded. Same or similar comments of a stakeholder on both SM platforms were not included to avoid duplication. Data were manually collected. To clarify the proficiency of the sample, practitioners were stalked. Twitter data were squeezed with the help of search queries and filters, while LinkedIn was checked post by post due to a lack of advanced filtering.

The keywords are "Arctic", "Polar", "Northern", and "Pole" in scanning posts. These were picked up from the high-frequency sentence patterns of Arctic-related news and developments such as Arctic Shipping, Arctic Routes, Arctic Ocean, Northern Sea Route, Polar Silk Road, Polar Code, Polar Region, and North Pole. After all, some potential hashtags were dug, but all have been selected on purpose. These are:

- #VentaMaersk - the vessel that performs trial Arctic voyage of Maersk.
- #ArcticShipping - three highly used terms in literature and released news.
  #ArcticOcean
  #NorthernSeaRoute
- #PolarSilkRoad - is mentioned as an integrated part of the Belt and Road Initiative that directs China's investments and policies.

As search queries automatically find also #Arctic and #Polar hashtags, and as these hashtags were also included in the analysis phase, we did not add those hashtags into the data collection. Besides, because ASR are launched as an alternative to Suez Canal Route in literature #EverGiven, "#SuezCanal", "#SuezBlockage", "#SuezObstruction, #SuezCanalObstruction" hashtags were researched between 23 March 2021 and 15 June 2021.

For ASR, there are some critical dates. In 2016, Arctic Shipping was begun to be globally called out. Also, IMO circulated Polar Code in January 2017 and approved ASR in May 2018. Further, Maersk sent the first container vessel through NSR in August 2018. In March 2021, M/V Ever Given was grounded in Suez Canal. Therefore, the timeframe was limited to the period between June 2016 and June 2021.

1.5.2.2. Hybrid Multi-Criteria Decision-Making Methods

In the second part of the study, it has been preferred judgmental sampling. Because decision-maker position is required in this research, sampling has been determined as high-level managers of shipowner companies, third-party logistics service providers (3PL), BCOs, and experts in global context. The population is already highly limited for such a topic in maritime industry. From the population, 71 persons have been contacted and asked whether they share their knowledge and experience, 48 of them have accepted to contribute this study. In practice, a total 28 respondents have participated in the study. A detailed information about sectoral distribution of the participants is available in Table 1. According to table, the response rate is relatively high, compared to similar studies.

The share of the different sectors in both total request and sample are seemed almost proportional. The majority of the sampling (42,80%) has been determined from carriers because they are the initial actors of route selection mechanism. 3PLs and

BCOs have equal number of participants (21,45%). 3PLs and BCOs have been selected within the industry because they choose carriers, and they indirectly choose in routing. Hence, it is important to evaluate what customers of the carriers say. Experts (including academicians and consulting services), who have the lowest share, have been invited due to their wide-ranging knowledge and impartial perspective.

Table 1. Sectoral Distribution of Sampling

	Population 1	**Population 2**	**Sample**	**Share in Total Request**	**Share of Sample**
Carrier	28	16	12	39,40%	42,80%
3PL	17	12	6	23,90%	21,45%
BCO	14	11	6	19,70%	21,45%
Expert	12	9	4	17,00%	14,30%
Total	71	48	28	100,00%	100,00%

**Population 1: Total number or request*

***Population 2: Number of acceptances*

****Sample: Actual participants*

Source: Created by the author.

The participants around the world have been reached via mobile phone, e-mail, and LinkedIn platform. Some of the participants have conducted “Data Collection Form” (See Appendix 3) by aiding tutorial video and explanations given in the form. However, majority of the data have been collected via online meeting tools. A more detailed explanation of sampling is available in section 4.1.2.1.

1.5.3. Methodology

Considering the suitable selection within alternatives, decision-making should be associated with the priorities of companies. The decision on the best alternative is a crucial factor for acquiring augmented customer satisfaction and profitability. In Figure 5, a methodological overview of route selection is illustrated. The twenty-nine criteria related to the aim, objectives, and main framework of the study are fallen into seven dimensions. There might be further dimensions and criteria might be differentiated, but the variables are studiously picked to reflect route selection behavior of participants in the light of Arctic shipping characteristics.

The route selection decision model is shown in Figure 5. The process systematically illustrates how the research progresses and how research questions are addressed. The model starts with the main problem statement, the aim of the study, and research questions. These three trivets lead to directions of literature review. After a comprehensive review of literature on route selection, carrier selection, transport mode selection, Arctic Shipping Routes, and MCDM methods, a priori variables were found out. These findings were reconsidered and discussed with experts; then ultimate variables for route selection were picked in line with the purpose, objectives, and research philosophy of study. Following that, a Content Analysis based on Arctic shipping-related social media posts of shipping companies and their stakeholder was conducted. In this way, it was verified the consistency of theoretically determined criteria and dimensions with practice, and then the criteria and their dimensions were fine-tuned. In the beginning, it was evaluated to hybridize DEMATEL and Analytical Network Process (ANP) however in the pilot test, it was seen that ANP made the questionnaire longer and more complicated. The questionnaire form has already taken a long time. It would be moody and weary for participants. Moreover, the results of ANP had no significant contribution to the purpose and main objectives of the study. Therefore, ANP was excluded from the study. Ultimately, DEMATEL was used to determine the relationship and influence degree between dimensions, and Best-Worst Method was used to determine weights and priorities of criteria.

1.6. CONTRIBUTION TO LITERATURE

The results of this dissertation contribute to route selection, Arctic shipping, and liner shipping literature from several aspects. First, the current paper is the first that explores the feelings, opinions, and perspectives of stakeholders towards ASR by using social media data. The available studies have typically examined social media (SM) usage, interactions of SM posts, and advantages of SM within the business-to-business (B2B) context while a few relate SM with relationship and sentiment. Second, stakeholders' positions on a global issue are rarely considered by maritime and supply chain scholars. The results clearly state the standings and emotions of stakeholders on ASR. The majority of the limited literature is based on engagement level and messages of liner companies (Wang et al., 2021: 128 – 130; Bitiktaş and Tuna, 2021: 7 – 9), characteristics of SM posts (Sürücü-Balcı et al., 2020:

6 – 7; Baruönü and Sanrı, 2019: 172 – 174), stakeholders' sustainability considerations (Zhou et al., 2022: 5 – 7: Altuntaş-Vural et al., 2021: 8 – 10), and SM effects on corporate decisions (Orji et al., 2019: 1530 – 1532). Last, Arctic shipping literature is concerned with the viability of routes (Meng et al., 2017: 26 – 29), sustainability issues (Zhu et al., 2018: 465 – 467; Tseng and Pilcher, 2017: 396 – 398), political considerations (Xinmin, 2019: 269 – 271), and operational bottlenecks (Lee and Kim, 2015: 266 – 268). However, no study reflecting stakeholders' opinions about ASR has been found. Thus, this study fills these gaps by revealing sentiments, emotions, and cognitive approaches of stakeholders on ASR. Further, it is the first study that applies thematic analysis in shipping and supply chain disciplines, and it is one of a few studies that clarify the sentiments of stakeholders. Past research says that price and service quality-directed components are reasons for preference (Lancioni, 2005; Avlonitis et al., 2005; Olshavsky et al., 1995). Of course, economic factors are crucial, and firms normally prioritize economic factors. However, in such an industry where companies' services are very similar, and differentiation is hard economic factors are quite easily imitable by competitors. Therefore, companies may differentiate via their behaviors and attitudes to be perceived as inimitable. Our results show that environmental factors have considerable effects on the decisions of stakeholders. Hereafter, behavioral factors are noticed by customers.

On the other hand, this study is the first that harmonizes both carrier and route selection criteria. Those criteria were adopted for ASR and some of them were indirectly asked the participants to clarify their behavior. Different from traditional route selection studies, structure of the research model has been prepared to perform opinion mining rather than directing the participants to select a route within alternatives. By this means, it can be generated a route selection model to be used in future studies. This study is the most comprehensively conducted route selection study by this time with globally collected data from liner shipping companies, beneficiary cargo owners (BCO), third-party logistics service providers (3PL), and experts from different continents and trade zones. Moreover, this dissertation is the first study that models DEMATEL and BWM methods to reflect route selection perspectives of stakeholders of the shipping industry with a hybrid structure. Route selection literature is an underutilized research area. The available studies compare several attributes of different corridors or intermodal connections. However, maritime shipping route selection literature is scarce. Moon et al. (2015) determine competitiveness degree of transport routes from Korea to the EU by ranking priorities

of criteria with the TOPSIS method. The routes given involve seaway, railway, and a combination of sea and railway. Pham et al. (2018) researched the effects of Panama Canal expansion on route selection. They first consult an expert opinion to determine route selection criteria, and second, they assess those criteria with Fuzzy TOPSIS to determine competitiveness degree of alternative routes. Woo et al. (2017) aim to find a way to decrease total logistics costs of Korean automobile parts producers. In this direction, they compare transport costs, inventory carrying costs, and in-transit carrying costs of four route alternatives by relying on the inventory theoretic model. Kashiha et al. (2016) investigate impacts of the geographical location of countries on shipping route selection of shippers. They involve coastal and landlocked countries in their analyses. They reveal similarities and differences between shippers in both country types within the context of a conditional logit model. Wen et al. (2019) analyze the effects of Belt and Road Initiative on the route choice between China and Europe. They develop a route utility function assessing cost, reliability of transportation mode, security of shipment, environmental effects of the mode, transit time, and status of infrastructure. Shibasaki et al. (2017) model route selection of dry-bulk vessels by using vessel movement records. They compare the competitiveness of Suez Canal, Panama Canal, and Cape of Good Hope routes in terms of bunker costs, fuel consumption, operation day, and shipping risks. Wang and Yeo (2017) integrate Fuzzy Delphi and Fuzzy ELECTRE I techniques to obtain a structure for intermodal route selection for the shipments between Korea and central Asia. Fagerholt (2004) models optimal routes for real liner shipping problems via integer programming by incorporating costs and total transit time for the pre-determined routes. Tran et al. (2017) designed the optimal routes for container shipping. This paper's model targets to minimize shipping costs, inland and feeder transportation costs, inventory costs, and carbon dioxide costs for the shipments from Europe to the USA. There are many route selection papers including canal dues, transit time, distance, reliability, loss potential, port rotation, piracy, etc. as route selection criteria. Different from the literature, this study tests equipment availability, slow steam applicability, brand image, public reaction, and quadruple bottom line. The results also contribute that equipment availability and door-to-door service are found with the highest priority by respondents for the first time. Such outdated criteria such as canal dues, competition, theft, and accident were not rated indispensable as opposed to the available literature. Again, the criteria in this study were determined and expressed from a dissimilar perspective. It was aimed to touch on the behavioral decisions of shipping companies

and the criteria were prepared by adopting route selection criteria from available literature into the dynamics of Arctic shipping routes. Also, it is the first study, where the potential criteria are reduced with several steps including literature review, expert opinion, and social media analysis. Consequently, the theoretical framework of this study strongly differs from the literature. Although theory of social cost exceedingly creates bases for many papers in transportation and supply chain literature, it is the first study that underlines approaches of ecological modernization theory and behavioral decision theory.

1.7. ORGANIZATION OF THE DISSERTATION

The dissertation consists of five chapters. In the first chapter, it is explained some basics of the study such as motivation, problem statement, significance, research questions and objectives, data, and methodology.

Chapter two reveals the theoretical background of the study. This chapter also tells us route selection perspectives of ship-owners and the relationship between trade and shipping routes. Besides that, the specifications and macro external factors of Arctic shipping routes are mentioned.

Chapter three explains the methodological consideration of the study by defining the benefited research methods.

Chapter four reviews the result of data analysis.

And, in chapter five, the dissertation is concluded. It is summarized the literature review and main findings of the results. And the last chapter ends with limitations and implications of the thesis, and recommendations for future research.

CHAPTER II
LITERATURE REVIEW

2.1. THEORETICAL FRAMEWORK

As Rondinelli and Berry (2000) mention the multimodal transportation concept provides less costly and environmentally friendly service for global trade, and determination of routes and transport modes is the initial phase in establishing a multimodal transportation network (Southworth and Peterson, 2000: 162). But neither carriers nor shippers can decide by themselves (Friesz and Harker, 1985: 172). Therefore, even though shipowners' route selection plays a leading role in international trade, carrier selection and transport mode selection of shippers are important as well. The decisions in route, transport mode and carrier selection are determinant to institute economy, environment, transportation, and supply chains sustainably.

After social cost and social benefits concepts have come into international trade and transportation industries, the decision and behavior of both individuals and organizations have become more important for both disciplines. The social cost concept has first introduced in 1950 by Karl William Kapp (Berger, 2008: 245) and these concepts have been theorized as the theory of social cost. Hereunder, social costs are the costs that people are exposed to as internal and external results of business activities (Mateer and Coppock, 2018: 216). Social costs and benefits are simply concerned with the decisions of business enterprises (Kapp, 1978: 13). However, it has been understood that consumer buying behavior has a direct effect on business behavior and the decision process (Kotler et al., 1999: 279). Thus, not only companies' decisions and behaviors but also individuals' decisions and behaviors can create direct and indirect social costs. The decisions of persons are assumed they are rationally taken and are made toward the expected utility of decision-makers (Mankiw, 2017: 6). In this way, potential social costs and benefits are generally overlooked.

Many studies related to the analysis of selection criteria of companies and peoples are encountered in maritime business in just the same way as marketing, business, and international trade disciplines. Although attitude and perception-based decision studies are frequently performed in sociology and psychology disciplines, these concepts are growingly used in business and international trade in the last four-

five decades. In rational choice theory homo economicus, also known as a rational agent, evaluates all available information and makes robotic decisions between all available alternatives to obtain maximum utility from his/her choice (Mateer and Coppock, 2018: 540). Nevertheless, literal selection does not sound practical to explain the decision-making mechanism of humans. Besides available information, human behavior and psychology are directives in decision-making within alternatives. According to Herbert Simon, people do not always look for benefit maximization, and satisfying alternatives can also be a reasonable choice. Amos Tversky and Daniel Kahneman say that the cognitive installation of humans arises from current information and this situation causes heuristic biases in decision-making (Frank et al., 2018: 264 – 265). Because the knowledge of individuals is normally bounded, they take judgmental and heuristic actions.

The term decision-making – as a multiple-attribute problem (Takemura, 2014: 144) – is to choose the most appropriate option between several alternatives under the light of preferences (Yaşar, 2016: 5). The decision, which is taken in different forms such as under uncertainty (including under ambiguity and ignorance) and risk (Takemura, 2014: 7 – 8), mainly relies on the available information (Frank et al., 2018: 265), environmental factors, organizational factors, intelligence and expectations of decision-makers, social factors, and perception of utility (Yaşar, 2016: 22). Utility theory that represents a measurement of satisfaction suggests two decision parameters. These are subjective values reflecting the preferences of decision-maker and subjective anticipation of occurrence of possible results under different situations (Becker and McClintock, 1967: 241). Unlike utility theory, the decision-making strategy of people and organizations does not seek utility maximization or optimization (Simon, 1957: 92). This strategy is generally a heuristic that finds efficient and quick solutions to problems (Takemura, 2014: 129). For both managerial and individual decisions, brain algorithm automatically compares alternatives in terms of costs – benefits, utility, objectives, and perceived risks and returns as a basic decision strategy (Loewenstein, 1996: 214 – 215; Peter and Tarpey, 1975: 29) thereby considering various attributes such as cost, performance, service quality (Takemura, 2014: 147). As a result of the comparison, satisfying alternatives (Sramek et al., 2018: 3) are preferred instead of the best option because of some reasons such as price, time constraints, and the capacity of information processing (Simon, 1957: 93 – 94; Lau and Levy, 1998: 30), and information asymmetry (Slovic et al., 1977: 3).

In light of such information, after a comprehensive literature review of many selection studies in transportation are found being based on different versions of utility theory such as expected utility, random utility, and multi-attribute utility theory. Also, rational choice and decision theories are typically found convenient. Besides utility functions of decisions, social factors and behavioral background of decisions are begun to be investigated in up-to-date selection-based studies on transportation and international trade disciplines. In the end, twelve theories were found as convenient with this study: Prospect theory, bounded rationality theory, theory of social cost, theory of planned behavior, theory of expected utility, ecological modernization theory, multi-attribute utility theory, rational choice theory, decision theory, behavioral decision theory, behavioral theory of the firm, and theory of reasoned action. In the last two decades, global warming and ecological hazards gave rise to awareness among individuals, changes in policies and regulations of countries and non-governmental organizations (NGOs), and decisions of companies – particularly in transportation and international trade. Hereafter, service and production policies of many companies have favorably involved the triple bottom line model, which proposes firms should concern with social and environmental sustainability to make a sustainable profit. Within these contexts and according to the main philosophy and background of the study behavioral decision theory, theory of social cost, and ecological modernization theory are found more consistent among other relevant theories.

There are many theories relevant to decision-making in decision theory schools. These are classified as normative (based on rationality), descriptive (interested in actual human decisions) (www.oxfordre.com), and prescriptive (aiming to identify situation-based rational decisions) (Takemura, 2014: 12). Normative theories, different variations of utility theory, are highly theoretical and mostly overlook human judgment and comply with values of decision-maker. Normative models rely on value maximization while descriptive models allow identifying, values, beliefs, and judgments to address decisions (Shapira, 2008: 290: Slovic et al., 1977: 1 – 2; Lau and Levy, 1998: 30). The normative models assume non-cognitive behaviors directed by emotions, motivations, and moral issues, etc. do not affect decision. However, these factors shape preference reflecting decisions. Along with descriptive models consider reasonability of decision (Keren, 1996: 170). The theory and practice in decision-making differ from each other. These differences give rise to behavioral

decision theory within this school of thought by differing from decision theory (normative) with cognitive aspects (Takemura, 2014: 10; Keren, 1996: 169).

Behavioral decision theory (BDT) was described by Ward Edwards in 1961 (Keren, 1996: 169) as a descendent of Herbert Simon and Daniel Kahneman's thoughts (Takemura, 2014: 11). It involves some of the basic roots of several theories and hypothesis such as probability revision, clinical judgment, game theory, prospect theory, behavioral theory of the firm expected utility theory, and multi-attribute utility theory (Takemura, 2014: 154; Shapira, 2008: 287 – 288). In fact, BDT dates back to rational choice theory (the 1950s) that assumes decision-maker with computational skills estimate best alternative maximizing expected utility (Sramek et al., 2018: 3). In BDT, the center of research are decision, choice, and judgment (Shapira, 2008: 291). BDT, which is one of the overarching descriptive models, details how decisions are essentially taken. BDT has traditionally correlated with social psychology early on, latter it is quite accepted in behavioral economics, finance, organization, business (Takemura, 2014: 11 – 12), neuroeconomics, and neuromarketing (Takemura, 2014: 153). The theory interests in trade-offs between actions and options (Loewenstein, 1996: 214) with the objectives of establishing a descriptive structure for human judgment; developing better estimations, and eliminating biases (Shapira, 2008: 291). BDT assumes that principles of the decision process are transitivity of preferences, comparability of outcomes, sure thing, the inseparability of the preferences resulting in the same outcome, and independency of preferences to be optimistic, pessimistic, or realistic (Becker and McClintock, 1967: 241 – 243). Theory suggests that decisions are exceedingly conformable to the situation (Takemura, 2014: 157). According to the theory, humans are not enough skilled to take rational decisions; because they are deprived of cognition, knowledge, and accurate processing of information. People systematically combine available information of alternatives in their minds and select the most effective one by using heuristics. The decision does not solely appertain to the behavior of individuals and organizations. Knowledge and authority of decision-maker, available time to process information and to evaluate alternatives, and difficulty level of decision are unified in decision making (Lau and Levy, 1998: 31 – 32). To exemplify the arguments of Lau and Levy (1998), in business-level decisions such as supplier selection, the agents are conscious of potential negative outcomes of their decisions. Therefore, they are more likely to be rational and emotional senses do not have many influences on decisions (Kull et al., 2014: 472 – 473). Under uncertainty conditions, agents use heuristics in forecasting probabilities in proportion

to bias; and theory says that heuristics usage of agents includes judgments reflecting their actual behavior (Shapira, 2008: 289-290). Besides, these agents have bias, movement restrictions framed by business strategies, bounded rationality, and dominance structure (Kull et al., 2014: 473 – 474).

The forerunner contributors of theory implicate that in the marketplace, the need is acute more often, and alternatives with multi-attributes must be evaluated (Einhorn and Hogarth, 1981: 16) multidimensionally (Becker and McClintock, 1967: 247). To examine multi-attributes, multi-criteria must systematically be perused by decision-makers. After these multi-attributes are put on the decision table, seats will be booked for decision-making speed, computational ability, value judgment, deterministic estimation, stochastic decision-making, possibility to make false steps and chance of correction, monomania (i.e., higher quality is believed to be acquired higher price, or value can only be obtained with higher costs), utility perception including cost-benefit scale, mnemonic codes (Slovic et al., 1977: 2 – 3; Einhorn and Hogarth, 1981: 16-17). Although utility perception is the honored guest of this table, alternatives in the maritime industry are not enough different to create distinct utility dissimilarities. Thus, differences between trade routes may not or hard to be perceived (Woo et al., 2017: 12; Pham et al., 2018: 13; Chen et al., 2014: 398). In such cases, mnemonic codes intercede, and the decisions are taken path-dependently. Outcomes of previous decisions establish a path, and following decisions are prone to be influenced by past decisions with good or bad grace (Koch et al., 2009: 69 – 70). Else, even if there is no tunnel vision about future dates or there may be blind spots, businesses may be aware of several aspects of situations. Hinz et al. (2019) indicate that blind spots cannot be illuminated in short run for business and blind spots cause misleading decisions under highly uncertain conditions like providing regular service on Arctic shipping routes (Meng et al., 2017: 30). The uncertainties may be eliminated in time or needs of customer force companies to develop new services (Hayhtiö et al., 2017: 89) such as increasing demands for tanker and container shipments via Northern Sea Route (Lee and Kim, 2015: 267). Nevertheless, these need and demand signals may not be conceptualized by the company (Stevens and Dimitriadis, 2005: 193). Even though the light at the end of the tunnel can be seen and blind spots may be removed, there may be a paradigmic blindness because of the strongly convoluted process of a subject to be decided on or because of the perception that the option is unlikely to occur. Under these circumstances, both individuals and businesses either theoretically follow their path

and stereotype steps or make behavioral strides with the combination of weighing pros and cons, heuristics, beliefs, and ethical judgments.

The second theory – theory of social cost as a guiding spirit of ecological economics – (Kapp, 1978: 5), is simply social damages of all primary and secondary consequences of such economic activities that are endured by all communities (Berger, 2008: 245; Kapp, 1978: 13) and future generations (Kapp, 1978: 5). These negative social results, which are deemed as externalities in the classical theory of economics (Berger, 2008: 245), may fundamentally be a dangerous phenomenon for human-being and all habitats such as health damages, the devastation of human living space, destruction of species, and even cultural life (Kapp, 1972: 93; Kapp, 1978: 5). However, these losses must be evitable to name them as social cost (Berger, 2008: 245). According to the assumptions of the theory, negative social effects may originate at the source of some industries, within the production process, and/or in time after the process has been completed. Because an open system characterized economy is in the ecological system and its openness has an enhancing solid structure with society and nature (Valentinov, 2013: 29-31), the social losses become an expected conclusion of business activities (Kapp, 1978: 8). The firms are prone to reflect these increasing distinct and hidden costs to the consumer, thereby externalizing their internal costs (Kapp, 1971: 15; Kapp, 1978: 76). However, consumers that seek for paying lower prices force companies to bear total costs (Kapp, 1978: 15). Therefore, to identify social cost, willingness-to-pay, minimum social standards, tolerance degree, and ecological environment of people must be analyzed with value in exchange, not the market value (Kapp, 1978: 5-6; Berger, 2008: 246).

The nature of the economy ignores what is occurring in the social and ecological environment, and social costs ultimately embank sustainable development (Valentinov, 2013: 31) and sustainable transportation (Starostka-Patyk and Grabara, 2010: 704). For example, the complex mutual effects of technological advances, cost minimization techniques, ever-increasing population, and growth in production-consumption levels in the last five decades have caused waste-based water pollution and emissions-based air pollution that are flag carriers of social costs in the more industrialized world (Kapp, 1972: 93-94; Kapp, 1978: 47). All these items create some social losses for human, animal, plant, microorganisms, and soil (Kapp, 1978: 60) such as changing topography (Kapp, 1972: 94) and air movements (Kapp, 1978: 50), augmenting temperatures, and inversions in water temperatures. And the cumulative

effects of these social costs are changing climate and melting Arctic region (Kapp, 1972: 95; Kapp, 1978: 48; Berger, 2008: 248). All these negative effects cause melting ice in the polar areas and lead the Arctic Shipping Routes to appear (Peters et al., 2011: 5305). Besides that, polluted air diminishes clean visibility, hence accident risk upsurges for air and sea transportation (Kapp, 1978: 63) particularly in the Arctic zone where sailing is too hard, and risks are too high (Lee and Kim, 2015: 267).

On the other hand, the social cost of distribution is an opportunity cost because of people cannot reach any product and services without transportation and cannot have a social cost-free world with transportation unless construct greener logistics chains. Transportation-sourced social costs are not the only vehicle and engine-based wastes but all facilities in the transportation industry (Kapp, 1971: 197-199). Because transportation is not just transportation of goods between two points. Kapp (1971) says that transportation of a good from origin to destination requires complementary transportation infrastructure and superstructure investments on both sides; because the competitiveness of the transportation firms accelerates via establishment of terminals and adequate rail and road transportation facilities (Maciulis et al., 2009: 96). All these activities create some environmental and social hazards, therefore many governmental and non-governmental actions, such as minimum standards, productive efficiency, air pollution and water pollution prevention, are assigned to overcome social cost problems and repairing of social losses for especially highly competitive industries (Kapp, 1978: 15). Nevertheless, efficiency and productivity of transportation, which are key elements of green supply chain, and which augments mutual benefits of firms and communities, anchor in intermodal transportation with integrating modes and facilities (Vachon, 2007: 4372; Kapp, 1971: 198-199; Sakalys and Palsaitis, 2006: 148). Considering all of these, besides marine transportation activities, Arctic Region is not suitable for intermodal transportation because there are big infrastructure gaps to perform door-to-door transportation. Establishing these networks are substantial social cost items that accelerate Polar warming and ecological hazards. Even if transportation through this region is logical, there will be social costs-based internal costs of the carrier. It is obvious that carriers will externalize these costs such as navigational standards, fuel with lower sulfur levels, emission regulation, and speed limits. The shippers to bear externalized costs of carrier depend on the value, perishability, and characteristics of goods to be carried. Dompere (1995) and Berger (2008) argue that for all kinds of costs, the utility concept is crucial for producers, service providers, and consumers. In the theory of social

costs, the utility function is finalized with a decision process after evaluation of alternatives that increase or decrease social costs. In modern life, an economy must pay regard to environmental conditions, air and water pollution, renewable energy usage, and optimum resource utilization while growing sustainably (Valentinov, 2013: 29; Kapp, 1978: 61). In this way, technological capabilities must be exploited to get over market failures like environmental hazards, and profit margin can be eco-friendly increased (Kapp, 1972: 96-97) as it is mooted in ecological modernization theory.

Ecological modernization theory is a series of strategies and policies that create contemporary solutions for environmental problems (Orhan, 2004: 16). Ecological modernization can be identified as the reshaping industrial capitalist world in way of considering environmental concerns in the modern world. It makes the distribution of roles between people, states, capital, and technology; and shows how companies and social communities combine environmental issues into their business activities and their daily routines (Mol et al., 2013: 15-16; Pepper, 1998: 2; Buttel, 2000: 60). According to the classical capitalist style development does not have a long life due to scarce resources (Pepper, 1998: 1) and environmental wastes, that are unearned profits (Carolan, 2004: 249). The initial reasons for environmental disorders in this century and next years are modernization and industrialization (Buttel, 2000: 61). Therefore, key idea of ecological modernization is to repair important design deficiencies of modernity (Mol et al., 2013: 22-23). This theory deals with behaviors against environmental disruption, global consumption level, governmental failures, and technological and industrial advances (Mol et al., 2013: 15). Ecological modernization is simply used to clarify companies' behavior (Buttel, 2000: 58) in building environmental economics (Jorgensen, 2016: 2). Mol (1997) offers two strategies to overcome system failures. First, environmental policies must be adopted from therapeutic to preventive by governmental bodies and NGOs; and must directly touch on the behavior of producers and consumers. Second, a market can act more efficiently and effectively against environmental bottlenecks, thus responsibilities must be transferred to the companies, and incentive mechanisms must be taken into action by governments. In this way, a self-regulatory economic system would have been established; eco-industrialization and rationalization of environmental restoration can crucially fix system faults (Buttel, 2000: 61).

The environment should be economized by favor of increasing social gains with acceptable environmental losses. This theory contributes to establishing green economics (Pepper, 1998: 5), innovative reforms, and additional considerations for

global environmental policies (Mol et al., 2013: 17). The “ecologizing of the economics” term, which dwindles ecological impacts of nations, must be located into the heart of government and business activities to boost sustainability (Spaargaren, 2000: 325-326; Jorgensen, 2016: 3). With this perspective, industrial developments and innovations that ensure a protected environment may sustain economic growth (Buttel, 2000: 58). Under an appropriate economic and political situation, it gives chance firms to ecologically differentiate in the competitive arena through eco-industrialization, superior efficiency levels, and minimized pollution (Mol et al., 2013: 18; Carolan, 2004: 250; Buttel, 2000: 59). Ecological modernization is a kind of voluntary political modernization to be adopted for new conditions of the world and environmental challenges (Pepper, 1998: 2; Mol et al., 2013: 18).

Ecological modernization says that aggregation of individual consumption decisions expresses social preferences (Carolan, 2004: 256). Thus, environmental governance has a broader framework that begins from choices of individuals to decisions of manufacturers, service providers, and governments (Mol et al., 2013: 19). The theory hypothesizes that production and service industries are deemed as the source of environmental hazards (Carolan, 2004: 248). Therefore, social externalities must be internalized for eco-valuation of products and services (Mol et al., 2013: 19) in as much as these industries are major waste sources (Carolan, 2004: 256). Moreover, all actors in supply chains must form a social and technological network to incorporate green products and services (Spaargaren, 2000: 328). As it is proposed in the triple bottom line model, with this environmental movement, sustainable development and social responsibilities of companies have become decision-making criteria for upgrading competitiveness levels (Buttel, 2000: 61; Pepper, 1998: 2; Orhan, 2004: 16). And besides that, companies, who adjust their technological developments and innovations in accordance with environmental factors and efficiency, will be more profitable thereunder polluter pays principle (Pepper, 1998: 2-3). In today’s world, at first glance many firms accept these activities as a cost item, but a wider perspective shows that greening principles create more sustainable profits, but renewable energy resource utilization, recycling, greenhouse gas (GHG) prevention are the conclusions of cost reduction strategies indeed (Spaargaren, 2000: 325).

In the transportation industry, one of the basic rules of creating sustainable profit is to reduce fuel costs (Bergqvist, 2008: 186) and intermodal availability in trade routes (Lirn et al., 2012: 429). Especially in liner shipping, which is based on door-to-

door transportation, intermodal integration is required for route establishment and route selection (Santos and Soares, 2016: 702). Another respect in diminishing both fuel costs and emissions levels is slow steam application in the maritime industry (Zacharioudakis et al., 2011: 295). In this way, eco-friendly service is to be provided, costs are lowered, and a sustainable supply chain approach is to be contributed (Nagurney, 2007: 36-37). Modernization and classical industrialization processes generate risky impacts, especially global warming (Pepper, 1998: 3). To be insistent on this so-called modernity maintains to change climate and make thinner continuously melting polar ice (Afenyo et al., 2019: 476). The quadruple bottom line model (extension of triple bottom line) says that future generations must be considered for sustainable prosperity. This model enables companies to be future-oriented and to assess the future outcomes of their decisions. As companies do not play along with the quadruple bottom line model, the earth has already reached a boiling point (www.palgrave.com). If carbon release and massive resource usage are pursued to expand the economy by businesses, the global ecology and atmosphere will accelerate to decay a lot more than (Jorgensen, 2016: 1) it is projected in emissions scenarios for the next decades (Liu and Kronbak, 2010: 436); and Arctic routes would be open in longer seasons (Trenberth, 2018: 6) because environmental damages are not visible, they appear indirectly or in the long run. Hence emissions must be reduced at their source (Orhan, 2004: 16) such as slowing down ongoing vessels, using less hazardous fuels, optimizing vehicle numbers in transit, and diminishing road transportation. Kjeldsen (2011) reveals that liner shipping is the core of a supply chain, and the augmenting awareness makes carbon emissions and environmental disruption a direct objective in handling routing problems and transport route selection. After all, these decisions hinge on the behaviors of the firms. The companies' attitudes towards sustainable development, satisfying profit philosophy (instead of maximum profit), and socio-ecological selection (instead of fully rational decisions) determine the condition of the environment and future trends in the world.

2.2. INTERNATIONAL TRADE THEORY AND EVOLUTION OF TRADE ROUTES

International trade is handled in three main stages by Thomas Friedman. In Globalization 1.0 (1492 – 1800), states dominated international trade; in Globalization 2.0 (1800 – 2000) multinational firms rapidly augmented commercial development, and in Globalization 3.0 (After 200) technology has been directing the way of trade

(www.coursera.org). Even if many components of trade have changed and/or transformed, importance of trade routes has been staying stable for international trade. Trade routes have provided a connection between countries in commercial relationships. Although Spice Road and Silk Road have been the most famous and important trade routes (Stopford, 2009: 6 – 7), because navigability and speed of vessels have derived better accessibility, humanity has explored oceans. Hereafter, nowadays maritime trade routes dominantly control international trade (www.transportgeography.org).

International trade can be traced from centuries B.C. Each period has had unique characteristics and has shown different development compatible with a technological change from hackney-coach to steamships. However, after the production ability of countries and the volume of trade have changed and developed, new directory theories have come to light. Despite trade-related ideas going back many centuries, international trade theories are broadly categorized as classics (Country-based theories – after the 16th century) and modern (Firm-based theories – after the 1950s). Classical theories are Mercantilism, Absolute Advantage, Comparative Advantage, and Heckscher-Ohlin while modern theories are Skilled Labor, Technology Gap, Product-Life Cycle, Similarity in Preferences, and New Trade Theory.

2.2.1. Classical International Trade Theories

The oldest classical theory, Mercantilism, says that the wealth of a nation directly depends on gold and silver stocks, and these stocks can be enlarged thereby restricting imports and promoting export with protectionist behavior. In this situation, the principal objective of countries is not to have a foreign trade deficit. Today, even though some countries use Mercantilism in the form of Neo-mercantilism to protect domestic and key industries, free trade gains favor initially for consumers and other industries.

Within this context, the first trade theory advocating free trade is Absolute Advantage Theory. Adam Smith focused on the wealth of humans instead of the silver and gold stocks of countries. Smith assumed that there are two countries, and they produced only two products. A country should specialize and trade in the good that can be produced more efficiently than other countries and should import the other good that can be produced more ineffectively than another one. So then, there should

not be any restrictions and regulations in international trade (Robbins, 1998: 210 – 211). The specialization depends on production rate, production costs, and labor capabilities, which are key factors for effectiveness. And increasing effectiveness may create more benefits for countries and their citizens (Clayton, 2000: 496).

The major deficiency of Absolute Advantage is that there is no advantage for those countries that can be produced efficiently both goods. Hence, David Ricardo presented Comparative Advantage Theory as a response to this deficiency. According to Frank et al. (2018), in this theory, a country should be specialized in goods whose production process is relatively efficient. In this way, although a country is more efficient than another country for both goods, the country should export the good that can be produced more efficiently and should import the other good. In other words, trade between two countries relies on comparative costs instead of absolute cost differences. Even though assumptions of the theory are notional, Ricardo has revealed the most basic form of modern international trade (Gondolfo, 1987: 7 – 8).

Theories of Smith and Ricardo ground on the free and open market hypothesis (Robbins,1992: 213). However, a country concentrates on the abundance of production factors, thus it can clarify which production factor creates an advantage as it is proposed by the Factor Proportion Theory of Heckscher-Ohlin (Bayraktutan, 20013: 178). The theory says that production factors are land, labor, and capital (Verter, 2015: 211), and costs of these factors are determined in compliance with the classical supply-demand mechanism. For this reason, for instance, if the supply of labor is more than the others, that country should export labor-intensive goods and expensive and scarce factor-intensive goods should be imported on the contrary (Gondolfo, 1987: 76). Despite these theories generates the primary source of international trade, that phenomenon is too complex and sophisticated to be explained by a single theory and old mechanisms. Particularly, the technology-based acceleration of globalization has caused classical theories to be evolved into contemporary modern theories.

2.2.2. Modern International Trade Theories

In contrast with country-based classical theories, firm-based theories are suggested by business schools rather than economists. Global dispersion of multinational companies, global supply chains, and facilitation of trade are the most effective factors in the appearance of firm-based theories. There is no doubt that the

main sources of accelerating multinational companies are growing trade volume, a decrease in international trade barriers, and rapidly establishing transportation networks. With these new theories, global competition, brand, quality, innovation, and customer-oriented approaches have been to be used to explain international trade.

Skilled-labor Theory as the first modern theory reveals that trade between industrial countries originated from the differences in the skilled labor force. This Neo-Factor Proportion Theory tells us labor-intensive and capital-intensive goods are deemed equivalent (Seyidoğlu, 2003: 81).

According to the Technology Gap Theory, trade between industrial countries is based on innovative firms. New products, new production processes, and new idea-generating firms become the monopoly of innovation, and innovation is to be preserved via patent law (Gondolfo, 1987: 266 – 267). If there is no legal protection, the production process of the innovation is easily imitated and shifted to the countries which have cheaper production resources through free trade. As a result, the first exporter country of goods transforms into an importer because of non-competitive costs (Posner, 1961: 323 – 325).

Reymond Vernon who introduced Technology Gap Theory says that some countries should be specialized in existing goods, while some of them are specialized in new goods (Verter, 2015: 212). A new good can turn into old good when it is imitated and shifts to another geography. This process is called as Product-Life Cycle (PLC). According to PLC Theory, technological innovation and new goods are introduced in industrial countries because new goods or services development is required high research and development (R&D) expenditure (Iamarino and McCann, 2013: 43). In this theory, a new product is produced close to the market and for domestic consumption in first stage. In this stage, product development is aspired to. In second stage, production increases and is exported, but still, it cannot be copied. Then, production technology is standardized because issuing product license to both internal and external markets become more profitable than sustaining production in third stage. Product development falters, and if to produce in different geography is cheaper, it is acceptable to produce abroad and import goods for the domestic market (Bayraktutan, 2003: 181; Gondolfo, 1987: 268 – 269). PLC theory has played a key role in defining the dominant effects of multinational companies in international trade (Iamarino and McCann, 2013: 40 – 41).

Similarity in Preferences Theory relies upon economies of scale, decreasing costs (Gondolfo, 1987: 270 – 271), and product and service differentiation concepts

that have not been considered by Heckscher-Ohlin (Verter, 2015: 213). This theory tries to detail intra-industry trade (Bayraktutan, 2003: 181) and suggests that countries with similar per capita income should merchandise each other. Because per capita income major factor in determining preferences (Linder, 1961: 93) and preferences of countries' citizens with similar development levels are also similar (Verter, 2015: 213). More profit is possible with more production and wider markets (Bayraktutan, 2003: 182). Therefore, producers should initially consider domestic consumption and specialized in goods in great local demand, and after should export to equipotent countries (Gondolfo, 1987: 270 – 271).

The New Trade Theory is a combination of economic models in international trade. The theory that works with return to scale (Sen, 2005: 1017), network (Verter, 2015: 213), and protecting infant industry principles sticks up for necessity to create path dependence in industries (Alam, 1994: 8 – 9). At this point, Krugman was the flagman (Ahmed, 2012: 1557). According to Krugman's theory, which explains the effort of multinational companies to gain competitiveness against other international firms within the industry (Ahmed, 2012: 1561), the global competitiveness of companies depends on strategic commercial decisions (Sen, 2010: 9). To achieve and protect first-mover advantage (Verter, 2015: 213) provides sustainable competitiveness and constitutes a natural market entry barrier for other companies (Wangwe, 1993:22). To strengthen this barrier, firms should (1) regularly perform R&D, (2) exploit economies of scale in production, and (3) render ease of accessibility to raw materials (Wangwe, 1993: 12; Alam, 1994: 19 – 20). Later, Krugman modified the theory several times. In one of the modified versions of the theory Krugman and Lancaster state that mergers, strategic alliances, and learning organizations are outstanding parameters to gain sustainable competitive advantage (Wnagwe, 1993: 19 – 21). Krugman, as the inspirer theoretician of modern-day international trade, tells us that countries with similar factor proportions, technology, and product costs can also perform free trade (Bayraktutan, 2003: 182; Ahmed, 2012: 1561). Krugman integrates a contemporary form of product differentiation (Verter, 2015: 213) and optimum economies of scale, and highlights the importance of transportation costs in global competitiveness (Sen, 2015: 1019 – 1020).

Whatever theory is more applicable, locations of trading countries and spatial connectivity of nations into the main trade routes have been crucial in the ancient Silk Road time (Fehlings and Melkumyan, 2018: 8), and it still stays important for today's major maritime trade routes (Kim et al., 2018: 147) because one of the main cost

items for industries are transportation and transit time (Salandha et al., 2009: 176). As the world has become globalized, the need for more sophisticated transportation has increased. A regular origin-to-destination international trade has turned into a comprehensive transport chain, which includes different stops between origin and destination. All transport modes must be integrated into the chain to conduct cost and time-effective international trade (Rodrigue et al., 2009: 197 – 199). Integrating different countries (Fehlings and Melkumyan, 2018: 10) and commodity chains (Rodrigue et al., 2009: 202) into international trade major trade routes have been growing day by day and establishing new services has become unavoidable for transport operators (Stopford, 2009: 38 – 39), especially in the liner shipping industry (Yercan and Yıldız, 2012:35).

2.3. NEW SERVICE DEVELOPMENT AND SERVICE INNOVATION

The commodity trade and product innovation have been accepted as the only way for the growth of trade volume. For many firms, new product development (NPD) and product innovation are better growth strategies than any types of partnerships (Papastathopolou and Hultink, 2012: 705).

Although service-like intangible profit items have not been included in trade components of countries for many years, it has been understood that service would be exported, and the service industry creates an enormous job opportunity to fulfill aimed wealth rate (Menor et al., 2002: 135; Papastathopolou and Hultink, 2012: 705). Because service industry occupies more than half of the gross domestic product (GDP) of developed countries (De Jong and Vermelun, 2003: 844; Menor et al., 2002: 135), size and types of new services have progressively been initiated and differentiated (Kitsios et al., 2015: 36). Since characteristics of service and product are different, new service development (NSD) and NPD patterns distinctly progress (Oduori, 2017: 11). Service developments face more difficulties than products (Shekar, 2007: 2). Service is produced and used simultaneously and for this reason, resources of a firm, business activities, technological requirements, managerial considerations, and customer relationship must be integrated into the service system (Papastathopolou and Hultink, 2012: 706; Gebremeskel, 2011: 18). Service that cannot be evaluated before it is consumed has four fundamental characteristics – perishability, intangibility, variability, and inseparability (Shekar, 2007: 2). Service user' perception is a key success factor (Papastathopoulou et al., 2012: 849), and

these characteristics determine the level of perception (Shekar, 2007: 2). On one hand, inseparability characteristics make customer interaction and customer perception indivisible; on the other hand, perishability makes service delivery process and service outcome levels effective methods to pin loyal customers and to overcome excess capacity problems (Papastathopolou and Hultink, 2012: 706). Thusly, despite there being some similarities between NPD and NSD, innovating and positioning the services is harder than a product (Gebremeskel, 2011: 15).

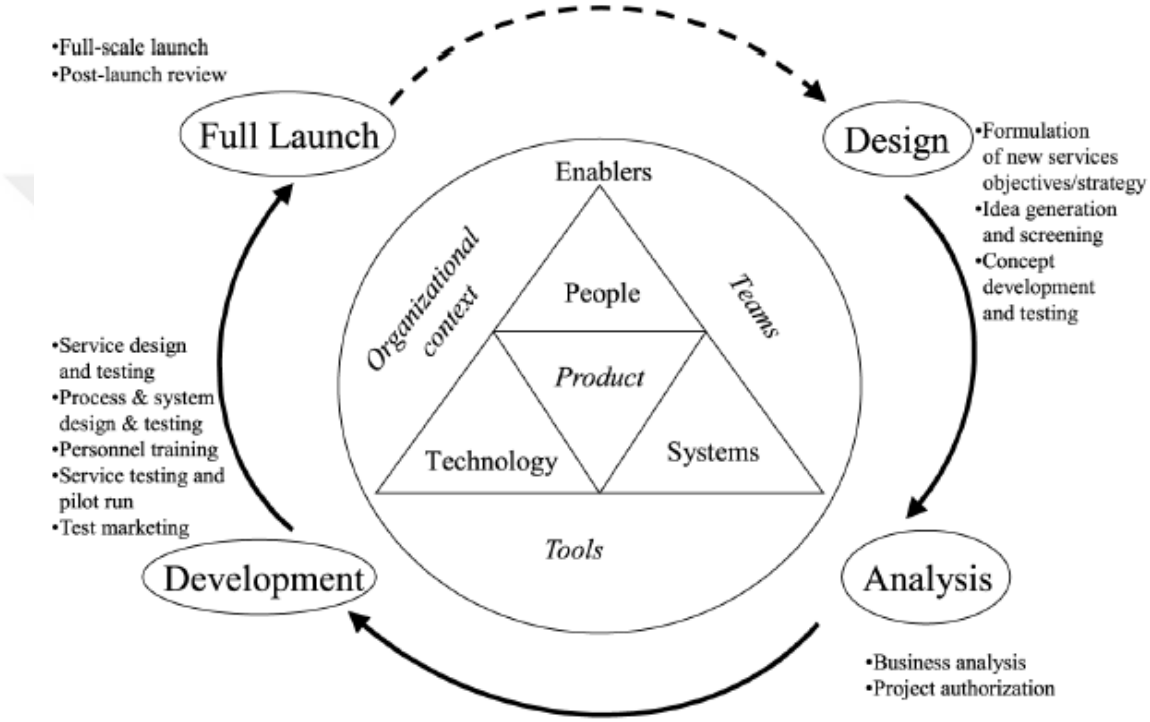
The global competitive environment (Stevens and Dimitriadis, 2005: 175) and technological improvements force companies to offer innovative services (Menor et al., 2002: 136). As an interdisciplinary process, NSD tries to originate novel services to increase the company's profits thereby meeting existing customers' expectations and engaging the attention of new ones during service delivery (Hayhtiö et al., 2017: 79 – 80). With the new market opportunities, NSD provides a worldwide competitive advantage against rivals (Menor et al., 2002: 136; Stevens and Dimitriadis, 2005: 175). The innovative offerings of a company can be concentrated on the development of core services, value-creating, changes in the company's offers, and new services. The term "new" is widely used to attract consumers in marketing, but to say "new" for a service requires major innovations and/or style change (Oduori, 2017: 11 – 12).

The NSD is the process that comprises the development of a concept, system, and process (Stevens and Dimitriadis, 2005: 177). Concept development is a reproduction of ideas and strategies concerned with meeting customers' expectations (Johnson et al., 2000: 18). Hence it starts with the determination of customer needs and monitoring the ways new services can satisfy customers (Shekar, 2007: 4). System development is related to service delivery, in this way not only the physical and technical ability of company but also managerial support is vital to establish proper infrastructure for effective service delivery (Menor et al., 2000: 139; Oduori, 2017: 13 – 14). The process development involves reviewing overall process. As well as all other elements of business, planning, screening, and fulfillment of business activities are progressively required to commence new services for developing overall process (Stevens and Dimitriadis, 2005: 178; Johnson et al., 2000: 18).

Figure 7 shows revolving process that is the sum of NSD phases. When service becomes in obsolescence, NSD circle cycles to obtain sustainable service development (Menor et al., 2002: 140; Oduori, 2017: 15). The flow starts with design of the new service. The design involves formulation, generation, and testing of the new idea. After completion of the newly designed service analysis, the development

step is practiced with pilot tests of the whole service system and market environment. Finally, if a developed new service is capable to meet customers' needs and catching new clients, it can be launched into the market until sustainable innovations are needed to ensure loyal customers (Johnson et al., 2000: 18; Menor et al., 2002: 140 – 141; Stevens and Dimitriadis, 2005: 178).

Figure 7: The NSD Cycle



Source: Stevens and Dimitriadis, 2005: 178.

Innovation, which is firstly defined by Schumpeter with the name of invention and is the dynamo of economic development (Wagner, 2008: 215), is one of the effective tools for gaining competitiveness and value creation. Because innovative attempts of businesses analyze expectations and changes; process new ideas; and find corresponding solutions (De Jong and Vermeulen, 2003: 844; Calcerrada, 2011: 6).

In literature, there are several innovation classifications (Table 2), but mostly they gather around nine common types: Radical and incremental innovation; regular, architectural, and modular innovation; niche and revolutionary innovation; and

autonomous and systematic innovation (Coccia, 2006: 9-12; De Jong and Vermeulen, 2003: 844).

Table 2: Classification of Innovations

Type	Definition
Radical	It is required in the obsolescence of current technological knowledge. New technologies must be sharply and discontinuously adopted into processes.
Incremental	Product or service that exploits existing technologies. New technology is continuously adopted over time.
Regular	Change thereby preserving market and technical abilities.
Architectural	Change thereby ruining market and technical abilities.
Modular	Structural knowledge of product/service is raised, knowledge related to components is destroyed.
Niche	Technical abilities do not change, market abilities and customers are ruined.
Revolutionary	Technical abilities are ruined, market abilities and customers do not change.
Autonomous	Develops freely from other innovations but relies on artificial intelligence and robotic machines.
Systematic	Subsidiary innovation, which is a methodological process to solve distinct problems.

Source: Adopted from Perunovic and Vidic-Perunovic, 2011 and Coccia, 2006.

In the last decades, innovation-based studies have attracted researchers (Table 3). The oldest version of classification was described in 1994 by Rothwell's model, which is accepted as a standard for classification of innovation models, and which consists of five generations. It can be seen in Table 2 that the following authors have derived their models from Rothwell (Taferner, 2017: 50 – 51; Zizlavsky, 2013: 2 – 3). Between 1950-60, first-generation suggested technological push into the market with extensive R&D and new products for industrial development. From the 60s to 70s, because competitiveness in the local marketplace is accelerated, new or highly differentiated products/services are developed toward market needs in 2G. In the next decade, world faced many bottlenecks and financial troubles. R&D and new technology expenses might not correspond. For this reason, 3G proposed that technology must be pushed in harmonization with market pull. 4G has shown up with the globalization and technological booms from 1980 to the mid- '90s. The economic recovery of the world has brought the heat to R&D activities, and an organizational learning-based integrated model of innovations from suppliers to consumers has been

focused on. Then, increasing global competition after the 90s led 5G to be created. Network, strategic decisions, and technical capabilities of companies have become generators to gain more market share. Besides that, flexible, adaptive, and fast production ability conclude in sustainable strategic networking, easy access to the markets, and enhanced technology-driven production strategies. In this way, the fifth generation of innovation became the core component of the value chain (Rothwell, 1994: 7 – 13; Taferner, 2017: 50 – 52; Barbieri and Alvares; 2016: 90 – 93; Perunovic and Vidic-Perunovic, 2011: 8 – 9; Zizlavsky, 2013: 3 – 4).

Table 3: Innovation Generations

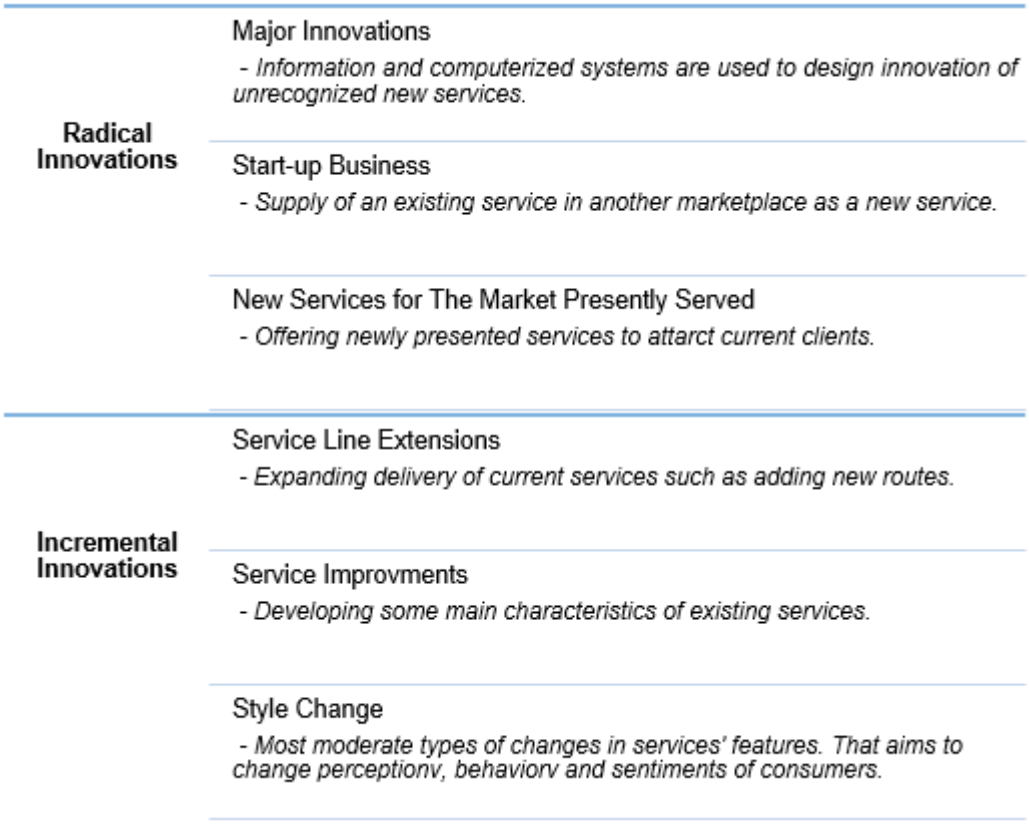
	Rothwell (1994)	**Marinova and Phillimore (2003)**	**Tidd (2006)**	**Berkhout; Duin; and Ortt (2006)**	**Bochm; Frederick (2010)**
1st	Technology push	The black box model	The linear models that involve technology push and market pull	Technology push	Technology push
2nd	Market pull	Linear models that involve technology push and market pull		Market pull	Demand pull
3rd	Coupling model	Interactive model that involves coupling and integrated models	The coupling model	Combination of technology push and market pull	Portfolio management
4th	Integrated model	Systems model	The parallel lines model	Cyclic innovation model	Integrated management
5th	Parallel and integrated model	Evolutionary model	Systems integrations an extensive networking		Systems integrations
6th		Innovative milieu			Integration in network

Source: Barbieri and Alvares, 2016: 90; Taferner 2017: 50.

However, innovation of service greatly differs from product innovation (De Jong and Vermeulen, 2003: 844). The existing service is imitable by far (Gebremeskel, 2011: 20). It is incrementally and slowly changed without any remarkable amount of R&D (De Jong and Vermeulen, 2003: 844). Technological support was unnecessary for service innovation once because service experience of users is a driver of development. Yet, technology is a practical and essential part of

service innovation in today's world (Czarnota, 2015: 34; Stevens and Dimitriadis, 2005: 178; De Jong and Vermeulen, 2003: 846) for clients to correctly discern the value of differentiated and innovative service (Gebremeskel, 2011: 20).New service development can be categorized as radical innovations and incremental innovations (see Figure 8). The radical development of services suggests quite different innovations, while incremental development is a pace for service extension. A radical extension may be either new to the firm or new to the external world. In fact, the innovation level from high to low ascertains the new service is whether radical or incremental respectively (Menor et al., 2002: 137 – 138; Oduori, 2017: 11 – 12; Gebremeskel, 2019: 19). In the development of new services, lack of proficient staff and orthodoxy customers create essential barriers, for this reason, the adaption of the employee into the mechanisms of new service and the satisfaction of users' needs is a prerequisite for development (Shekar, 2007: 5 – 6).

Figure 8: New Service Classification



Source: Adapted from Menor et al., 2000 and Oduori 2017.

Although innovation is mostly defined as developing something new, it cannot be accepted as innovation unless it provides any benefit for users (Calcerrada, 2011: 9; De Jong and Vermeulen, 2003: 844). Innovation of service concerns the adoption of service formats such as delivery systems, technological alternatives, new concepts of existing services (Czarnota, 2015: 33; Calcerrada, 2011: 10; De Jong and Vermeulen, 2003: 845), knowledge, capability, and interaction degree of employees, and physical environment (Czarnota, 2015: 33). As opposed to products, services are produced more customer-oriented, and thusly innovative adjustments of services must be performed customer-specific (De Jong and Vermeulen, 2003: 845). Customer-centric service innovation plays a critical role in companies' competitive resources when the change is supported by human resources factors and organizational behavior (Czarnota, 2015: 32). The degree of innovation provides a major competitive advantage in line with how users understand this change. The more deregulated and globalized service industry in the last decades make competition excessively keener between international service providers (Oduori, 2017: 16 – 17). Accordingly, even NSD and innovative changes are moderately narrow in the specific environment of the logistics and transportation sector (Albracht, 2012: 21 – 22). Service innovations for the transportation industry would be core service innovation, market innovation, process innovation, and organization innovation (Wagner, 2008: 221 – 222). In another respect, Chapman et al. (2002), De Jong and Vermeulen (2003), Wagner (2008) and Flint et al. (2005) suggest technology (i.e. information and communication technology, electronic data transmission, scheduling and routing, monitoring and tracking, etc.), knowledge (i.e. comprehensive inclusion of clients into strategic knowledge to establish knowledge network, multi-solution for transportation networks, etc.), and relationship network (i.e. value chain creation, strategic alliances, and co-operations, etc.) as a service innovation for transportation and logistics.

The logistics sector, just like the transportation sector, is required the customers' expectations to be regularly examined and the organization to be progressively adjusted. Hence the NSD and innovation are required to contain direct customer-specific outcomes (Wagner, 2008: 222). In this way, proactive service development (Albracht, 2012: 47) in transportation are highly value-based and information-based innovations thereby exploiting culture, knowledge, and capabilities acquired via organizational learning (Albracht, 2012: 23 – 24; Flint et al., 2005: 118). Thus, transportation service providers, who are the fundamental intermediary of global trade (Chapman et al., 2002: 365), have always to be ready and open for

changes like offering new service types, launching new services for new destinations and new routes, adapting their systems into novel technologies, providing up-to-date infrastructure adequate to customer requirements, and transforming the infrastructure, services, and vehicles into eco-friendly.

2.3.1. Innovations in Maritime Industry

The shipping industry has indirect contact with the needs of end-users by the name of a structured supply chain flow. Because innovation is a key component of competitiveness, to achieve sustainable competitiveness, the shipping industry must yield to the innovation demands of stakeholders in the whole chain (Acciaro and Sys, 2020: 2; Lighthouse, 2015: 7). Not only technical and operational innovations but also to be receptive to cooperative changes is a driver for building a sustainable network through intra-industry and inter-industry. Furthermore, to increase firm performance, a new service must gain ground in the value chain, and value must properly be perceived by customers (Perunovic and Vidic-Perunovic, 2011: 3).

The maritime industry has centralized decision-making mechanisms, high capital costs for development, and non-flexible regulations. Thus, the industry is traditionally less sensitive to novelties and radical changes. Also, industry improves by learning and experiencing; ordinarily, incremental innovation permanently succeeds in the maritime industry (Perunovic and Vidic-Perunovic, 2011: 2 – 3). The invention of containers and the adoption of vessels for container carriage -as a type of radical innovation- (Acciaro and Sys, 2020: 3) is the milestone in maritime innovation. It was difficult to adjust the capabilities of ships and ports. Therefore, the industry has resisted containers for a while. However, in the favor of containers, global trade accelerated after the 80s (Talley, 2009: 9 – 10). After containerization, double hull tankers could be accepted as the second considerable innovation. The industry is constrained by the conversion of tanker design after Exxon Valdez accident. The new design of tankers has led to a change in the size and capacity of tankers in addition to the double side and bottom of structural design (Perunovic and Vidic-Perunovic, 2011: 11 – 12). As in transportation and logistics, in maritime industry, innovation is not excessively demanded by customers compared to other service sectors (Acciaro and Sys, 2020: 3). Maritime industry's routine competitive bases are still quality, reliability, cost, service frequency, and flexibility (Panayides and Cullinane, 2002: 195 – 196). However, so long as competition within the industry is

keener day by day (Stopford, 2009: 52), factors influencing competitiveness are recognized to be gained via innovative changes (Perunovic and Vidic-Perunovic, 2011: 3). Especially the pressure of environmental regulations (Lai et al., 2011: 636; Hermann, 2017: 144) and customer awareness force shipping companies to innovate efficiently and ecologically (Perunovic and Vidic-Perunovic, 2011: 3; Brooks et al., 2016: 778). After all, the hearth of the ecological modernization theory, eco-innovation concept, (Mol et al., 2013: 15) concerns transportation industries on a global scale (Hermann, 2017: 140 – 141). As an example of environmental innovation, ship-owners incorporate foot-print tracking of shipments into door-to-door service (Acciaro and Sys, 2020: 1).

Indeed, the basic innovation that shapes the industry's current situation is digitalization (Acciaro and Sys, 2020: 4). The conservationist maritime industry does not run enough fast to catch the edge of digitalization. They must undertake radical digital transformation (KPMG, 2018: 18). Digitalization of processes enables automation, sustainable competitiveness, big data processing, simulation, sophisticated software, and advanced safety (Acciaro and Sys, 2020: 4). Computer-aid systems have been increasing (KPMG, 2018: 18), accordingly, e-navigation and remote pilotage have been developed as digitalization-based navigational innovations. E-navigation, which has been described by IMO, needs some legal, technical, and architectural requirements to ensure safety at sea and protect environment. Besides the application of remote pilotage has different dimensions (Brooks et al., 2016: 787). Another innovation, autonomous vessels have not been found applicable on one hand, on the other hand, Rolls-Royce introduced an autonomous ship that is locally operated (KPMG, 2018: 10). Until June 2017, blockchain was usually associated with the finance sector. After Maersk's cyber-attack case, which hae global effect because Maersk transport one five of world trade, the idea of using a secure digital platform for negotiable instruments in the shipping industry was ranked first. Only Maersk lost almost US$300 m., and then investments in non-centralized computer systems having multiple servers were expedited. This digital innovation allows for virtual exchange of all documents with minimum risk (www.reuters.com.; Jovic, 2019: 142 – 143). Yet, the next innovation to be mentioned is 3D printer technology, which is expected to replace some of the manufacturing industries. In the middle of this century, 3D printers will probably have a major role in replacing manufacturing. Almost 40% of the TEU capacity will be destroyed because import volumes will diminish (KPMG, 2018: 19).

Environmental burdens are persistently increasing (Lighthouse, 2015: 9). Hence, transportation industry and all other related actors such as governments, associations, the manufacturing industry, and even households are responsible for climate change. They all must take measures relevant to eco-innovation. These measures should begin with ideas and behavior that are followed by products and processes (Hermann, 2017: 142 – 143). The investments in new and cleaner technologies in shipping and transportation provide sustainable and ecological development possibilities (Maleky, 2015: 84; Lighthouse, 2015: 9). However, the cost-oriented industry is selective while investing in cleaner technologies. An environmental action is not undertaken unless it provides effective returns (Zis et al., 2015: 172 – 173) and/or unless clients extremely demond eco-innovation (Hermann, 2017:144). A good example is a new ship propulsion technology (EU FP7). This technology admits a ship to be operated efficiently and diminish CO2 levels. In this way, it will probably generate cost reduction and loyal customers by being perceived corporate social responsibility (CSR) However, its usage has barely become extensive after strict emission regulations of EU ports (MESA, 2014: 15; Lighthouse, 2015: 11). Another example is also slow-steam applications, which enormously reduce carbon emissions. Nevertheless, the primary reason for slow steam to be chosen is not environmental awareness but cost efficiency (Zis et al., 2015: 162). The highly cost-oriented decision mechanism of the shipping industry takes hold of shipping companies' behavior in investments, network bundling, and route establishment and selection. In conclusion, the design of trade routes and new services are unsurprisingly shaped by cost-benefit logic.

2.3.2. Process of New Service Design in the Maritime Industry

In container shipping, the aim is to create an optimum service design that covers weekly routes for a definite fleet mix. Vessels in the fleet mix have a certain capacity and speed (Fagerholt, 2004: 261; Msakni et al., 2020: 2). On the contrary, liner companies are pushed to offer new services and to update vessel capacity because of increasing traffic like Asia-North Europe and Intra-Asian trade. This situation corrupts the balance of deployed fleet (Notteboom and Vernimmen, 2009: 336).

The new service of liner companies includes various decisions among several variables such as service type, speed, number of calling ports, type and size of

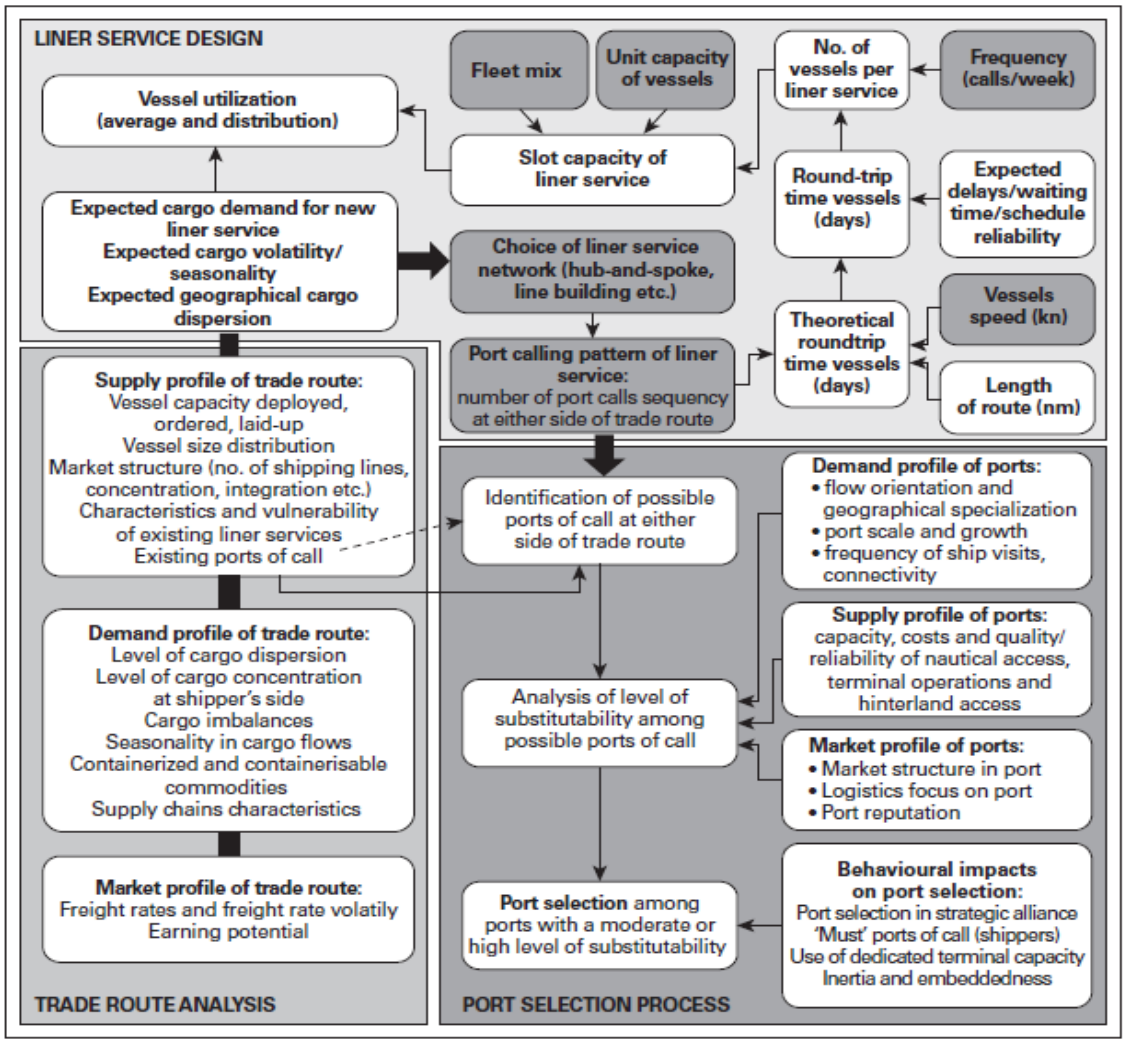
vessels, and frequency (Ducruet and Notteboom, 2015: 131 – 132). The speed decision is interrelated with bunker prices (Wang et al., 2019: 364), the vessel's technical capabilities, and environmental factors such as slow steam (Ducruet and Notteboom, 2015: 131; Cariou and Cheaitou, 2014: 322 – 323). The number of calling ports is determined and ordered by considering speed decision and total round-trip sailing distance (Wang et al., 2019: 346); but besides that, estimated round-trip time creates a lack of reliability in schedules because optimally calculated round-trip time is not practically applicable by virtue of weather sourced delays and congestion at ports, canals, and passages. To increase service reliability, an additional time can be added as a buffer to calculate round-trip time. This new round-trip time and service frequency affect the decisions on the number and size of vessels (Ducruet and Notteboom, 2015: 131 – 132).

Figure 9 explains a typical liner service design process. As liner networks are principally demand-dependent (Wilmsmeier and Notteboom, 2011: 214), the process should begin with analyzing market conditions and supply-demand characteristics of the selected route. The vessel-related items are included in supply sides such as ship size, utilized capacity, market profile, port calls, and existing services. And then, shipping lines center features of serving market, geographical dispersion of cargoes, instability of trade, and seasonality on the demand side. The supply and demand functions of the market to be served, which result in freight rate oscillations, aim to calculate the potential volatility and seasonality of demand. In this way, the economic viability and potential of the new service are estimated (Wang et al., 2019: 364; Wilmsmeier and Notteboom, 2011: 214 – 217; Ducruet and Notteboom, 2015: 131 – 132). In designing new service, scope of vessel sharing agreements and alliances, transit time, and empty container repositioning are as vital as demand, cost-revenue function, and fluctuating bunker prices (Tran et al., 2017: 670). Shipping alliances and vessel sharing agreements give rise to avoiding competition-related risks. Alliances increase market presence while decreasing the number of calling ports in port sequence (Wilmsmeier and Notteboom, 2011: 224).

Transit time is the initial factor to determine the direction of the liner service network. Liner operators prefer putting short transit times on the center of service design to get schedule reliability. For an ideal service, the timeline in announced schedules must be conformed to. Along with reducing reliability, shippers face extra logistics costs and shipping lines face extra costs of idle time and rescheduling. With these extra costs, perception of customers and the competitiveness of a liner

company are directly and indirectly affected (Notteboom, 2006: 24 – 25). Despite that, broadly, transit time is the maximum span between two nodes. Logistics service providers calculate transit time in door-to-door principle while for liner operators, it is total spending days from port A to port B. Hence, as well as speed, the arrangement of port sequences, such as proximity of last port of the first trip and the first port of next trip, crucially touch on transit time in a bundled line.

Figure 9: The Process of Liner Service Design



Source: Ducruet and Notteboom, 2015: 132.

The other factor is duration spent at the port, which is highly affected by congestion and port operations (Guericke, 2014: 20 – 21). Transit time is the key determinant of liner service reliability (Notteboom, 2006: 33), and high schedule and

transit time reliability of service have a price (Ehmke et al., 2015: 28). Maersk is a case in point in offering reliable services at higher prices while MSC uses as possible as low buffers to be positioned as a low-cost carrier (Notteboom, 2006: 34). There are schedule and transit time reliability, and even if schedule is unreliable, transit time may be reliable (Notteboom, 2006: 33). In this respect, shipping lines add time buffers in designing schedules (Ehmke et al., 2015: 7). In a highly competitive environment, schedule unreliability is the main tightness for liner service design (Notteboom, 2006: 19). To redress unreliability, shipping lines probably augment speed and incur an extra bunker cost (Notteboom and Vernimmen, 2009: 335). Because liner service is core of supply chains (Tran et al., 2017: 669), unreliability results in planning fails of all actors throughout the chains. In that, a delay in Port-A leads to new delays and unreliable service in growing size (Notteboom and Vernimmen, 2009: 329). Again, port efficiency is anchored in schedule reliability (Talley, 2009: 62 – 63). According to PSA Antwerp, to reach the planned efficiency level 90% schedule reliability of vessels is needed, but at most, 30% of ships rely on the schedule in practice while the rest confront late arrivals (Notteboom, 2006: 35). The importance of empty containers in a service design is that repositioning costs can reach up to 30% of running costs (Guericke, 2014: 28). Furthermore, optimization of liner service network is calculated under the light of empty container repositioning (Cariou and Cheaitou, 2014: 333 – 334) in which trade balance is the major influencer because import and export container movements should be in harmony to undertake optimum planning (Talley, 2009: 196). If not, empty container flows in port hinterlands sometimes generate an unavoidable extra cost because empty containers may occupy vessel slots higher than planned (Guericke, 2014: 28).

2.3.2.1. Designing New Shipping Routes

As market structure progresses and changes, new services are developed to meet rising demand. The new services may involve new schedules, new calling ports, and even new routes (Wang et al., 2019: 344). Sustainable reliability for new services can be achieved with an exact estimation of demand and optimum fleet mix with different vessel sizes. In fact, all these service design factors address slot capacity to be offered in a new network (Ducruet and Notteboom, 2015: 131 – 132). Originally, IMO official announcements are essential for new routes of the maritime transportation. In route establishment, several questions are brought to the agenda:

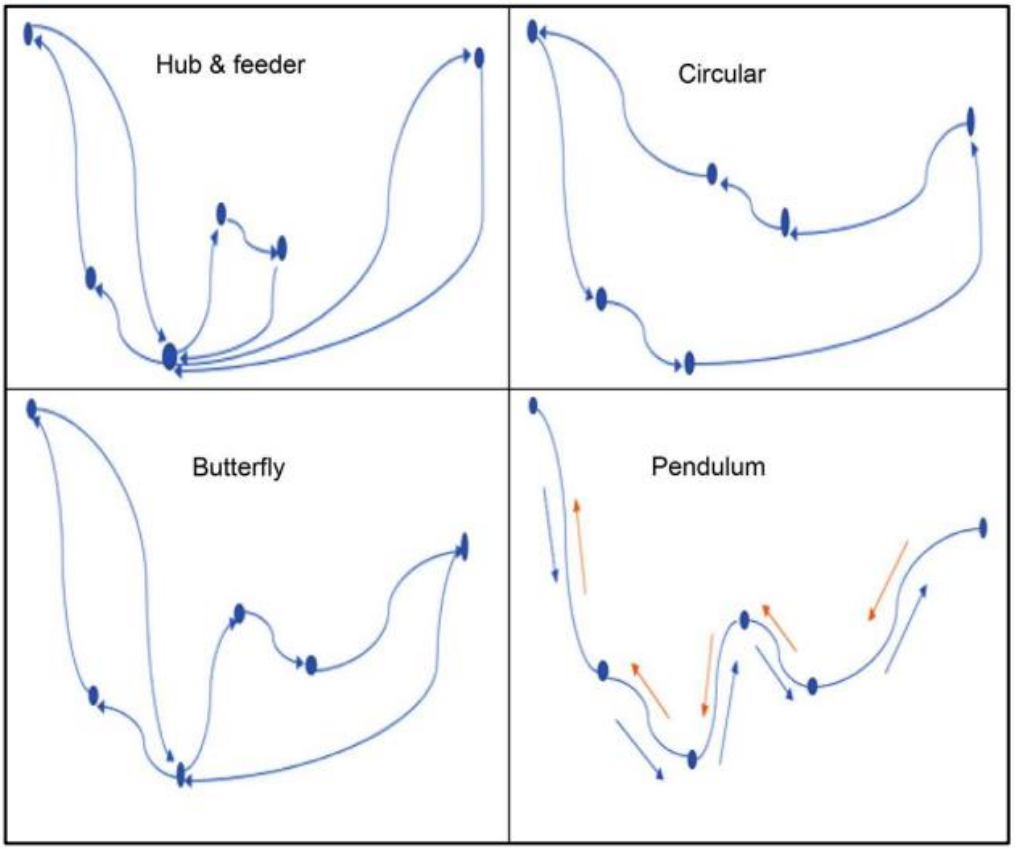
What are the characteristics of demand in continents to be visited? Which ports are capable in port sequences? What would be the optimal port rotation in this route? What is the optimum speed for reducing fuel consumption without extending transit time? (Wang et al., 2019: 344 – 345).

Shipping companies are disposed to find and use new alternatives within the regular routes to gain a competitive advantage. Nonetheless, new routes containing many uncertainties and risks are dark to plan on (Shyu and Ding, 2016: 1261). Ship routing is to deploy some ships in the fleet for available cargoes in tramp and industrial shipping. Both are time-sensitive and aim to minimize costs. Tramp shipments rely on maximizing profit, and tramp shipping companies plan routings to be able to find cargo in return paths. Also, lay-can is another consideration and, not to waste time, ship operators should arrange arrival time (Fagerholt and Lindstad, 2007: 216 – 218). However, due to the idiosyncratic nature of tramp and industrial shipping, route design is highly associated with liner shipping (Fagerholt, 2004: 260), in which routing is hinged upon strategies of liner companies (Wilmsmeier and Notteboom, 2011: 214). Route establishment that may either be new or modification and/or integration of current routes is one of the key functions of liner shipping (Ting and Tzeng, 2003: 379). First, shipping companies must analyze market potential of the planned route in detail on a weekly basis by bearing in mind operating costs (Zhao et al., 2016: 52). In establishing a route, which begins from and concludes in a hub or depot, minimization of transportation costs is the main consideration. Optimum weekly service for the fleet given must be organized between origin and destination (Fagerholt, 2004: 261).

Shipping routes can be mother or daughter routes. Huge vessels navigate on mother routes while feeders sail on daughter routes. There are four new route variations: (1) mother routes only, (2) combination of mother and daughter routes through a hub-and-spoke system, (3) daughter routes with simple cycles, and (4) daughter routes with simple and butterfly cycles (Msakni et al., 2020: 3 – 5). It must basically be decided whether topologic design of the route will be in hub-and-feeder, circular, butterfly, and pendulum cyclic forms (Figure 10). In hub-and-feeder, which is economical by virtue of economies of scale, feeders undertake shipments of cargo from hubs to smaller ultimate destinations. In circular form, ships call at all ports a single time and first port is the last port of the cycle while they call a port twice in butterfly form. Ships that sail in pendulum visit each port apart from last one twice (Kingsley, 2019: 801 – 802; Wang et al., 2019: 345-346). To establish only mother routes, need to use mother vessels, and capacity planning must be performed

properly. For instance, if a trip takes over seven days, a service may not be able to guarantee weekly service. To add second mother vessel may overcome this unreliability but then a low occupancy rate generates a profitability problem. Then again, a daughter vessel-based fleet on a route may also increase total costs and decrease the effectiveness of service. Therefore, planning of new route variation must finickily be handled (Kingsley, 2019: 800; Msakni et al., 2020: 3 – 4).

Figure 10: Topologic Structures of Shipping Routes



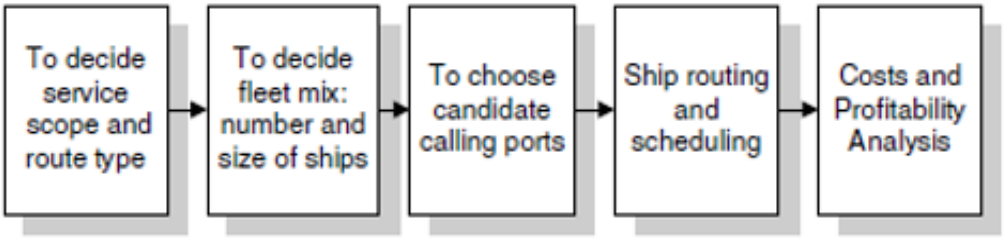
Source: Kingsley, 2019: 802.

The tactical, operational, and strategic decisions of liner companies are three stages of new route design. The first stage consists of advancing different routes and schedules of available fleets. The next stage includes determining the most convenient route to deliver cargo. And in the last stage size and number of vessels to be used in a route are optimized (Kingsley, 2019: 800). There are four evaluation criteria in these decisions: technology, safety, supply chain, and cost and service. The technology involves information circulation related to navigation, navigation ability in

the context of geographic position, experience level of crew, and required shipbuilding technology. Safety contains both environmental safety and safety & security of navigation. The supply chain factor points out transport infrastructure of the hinterland including capable ports and cargo potential. Last, cost and service indicate total distance of navigation, total cost of using a new route, and service quality (Syhu and Ding, 2016: 1263 – 1265).

At the first step of route planning process illustrated in Figure 11, the scope of services and route type are chosen suitably with cargo flow. Then in the second step number and size of vessels to be used are determined. Here, the most important decision is whether to use equities, charter, or new order. A vessel sharing strategy may be discussed additionally (Ting and Tzeng, 2003: 379 – 380) to obtain a better market penetration (Rau and Spinler, 2017: 159). As hub-and-spoke system is widely used, feeder services become more critical. Route design with heterogeneous vessels is harder (Kingsley, 2019: 799). The type of vessel complies with the duration of the voyage and service frequency needed (Cho and Perakis, 1996: 258 – 259). Bigger vessels are more suitable for longer trips meanwhile feeders are used in short-sea shipping (Kingsley, 2019: 801). Another crucial cost item is the capital cost of a vessel that would be affected by an appointed fleet mix. Moreover, fleet sizes are determinant of port time, thus planning of fleet size in a fleet mix must be considered in route establishment (Christiansen et al., 2004: 3; Kingsley, 2019: 803; Hsu and Hsieh, 2007: 900).

Figure 11: Liner Shipping Route Planning Process



Source: Ting and Tzeng, 2003: 379.

Third, the most convenient transshipment facilities and port sequences (Zhao et al., 2016: 52; Kingsley, 2019: 804), which are near-final markets (Tran et al., 2017: 669), are decided in accordance with the shipment potential of hinterlands and technical capabilities of ports (Ting and Tzeng, 2003: 379 – 380). The technical

infrastructure including communication, real-time information flow, navigational aids, radar and satellite systems, and expressly port & hinterland infrastructure is a sine qua non for the designed route (Tseng and Cullinane, 2018: 426). In terms of cost minimization, insufficient rail infrastructure and rail access are general restrictions. Other usual restrictions are environmental considerations against depth and size enlargement of terminals (Fan et al., 2012: 480). At this point, another important decision is to merge with a port with the highest connectivity or to establish an alliance with some ports for them to be dedicated terminals (Talley, 2009: 66). According to the route generation algorithm in Fagerholt (2004) to originate feasible new routes, new ports should be added to the trip without sailing twice in a line, extending time constraints, and exceeding vessel capacity. After introducing a new route, in the long run, the emerging demand in new markets leads to a change of transshipment hubs on a network similar to the history of Suez and Panama Canals openings (Zhao et al., 2016: 58 – 59). Further, feeder connections, port charges, and berth availability are to be monitored (Vaferi et al., 2018: 120).

The fourth step includes detailed scheduling plans incorporated with sailing speed, and arrival and departure time of vessels (Christiansen et al., 2004: 4). An optimal vessel deployment and schedules must be incorporated with route design (Tran et al., 2017: 689). Ship scheduling, which can briefly be expressed as the timing of vessels' different actions on their routes (Christiansen et al., 2004: 5), is multifaceted in liner shipping. It requires detailed planning of arrival – departure times, sailing speed between ports, buffer decisions, etc. (Ting and Tzeng, 2003: 382). The schedule and networks are almost constant for a few decades, and any changes in network design or route design need to have an acute switch in cargo volume, safety concerns, IMO announcements of novelty, and sharp downsizing of distance, cost, and transit time (Zhao et al., 2016 52 – 53). Port time makes up a majority of the idle time because mooring and handling operations continue for several days, particularly at congested ports. Hence, so as to abstain from extra costs of late arrivals, schedule must be organized fitly thereby considering the working hours of port and weekdays. The robustness of the schedule affected by speed decisions has a close relationship with transportation costs (Christiansen et al., 2004: 7). On the other hand, the speed decision of vessels directly influences transit time and fuel costs constituting up to 70% of total operating costs; and indirectly influences the number of vessels to be assigned for rendering a stable service frequency (Wang et al., 2019: 346). Transit time calculation is a knife-edge factor to be well-planned in establishing a route.

Longer transit time also considerably lowers fuel costs while diminishing the competitiveness degree (Kingsley, 2019: 803).

The last, process is concluded by analyzing profitability and cost-effectiveness of a new route (Ting and Tzeng, 2003: 381), which are basics of ship-owners for use of a new route like ASR (Tseng and Cullinane, 2018: 425). The daily cost of a ship is too high, and slight development of route and schedule planning may lead to a significant amount of savings (Fagerholt, 2004: 259). Therefore, shipping companies should regard cost and income considerations to determine the optimal route (Fagerholt and Lindstad, 2007: 217). Modeling shipping routes and schedules target decreasing the costs (Hsu and Hsieh, 2007: 905). A cost-efficient vessel operation necessitates tactical route planning. Because optimized speed level and decreased port time produce high-level cost and operational efficiency, cruising speed and port time are essential in strategic route planning (Kingsley, 2019: 802). New route establishment decision broadly resides on economic factors that can be categorized as bunker, crew, insurance, other costs, and transit time (Tseng and Cullinane, 2018: 425). Faster cruising probably satisfies customers (Hsu and Hsieh, 2007: 900) – particularly for time-sensitive good shippers – but higher service prices absolutely dissatisfy them. Therefore, route designs must be dynamic and flexible to solve this dilemma in the planning phase (Kingsley, 2019: 802). In a new route, voyage costs are already steady, and these are vessel costs (crew, maintenance, insurance, depreciation, and fleet management fee), port dues (pilotage, towage, wharfage, tonnage fees, inspection, electricity, garbage removal, mooring – unmooring, light fees, and oil pollution levy), bunker costs (diesel and heavy fuel oil), and equipment costs. The variable costs proportionately change with cargo volume, feeder service, cargo handling, terminal stowage, trailer and railway, tallying, container repositioning (Ting and Tzeng, 2003: 389 – 390; Tran et al., 2017: 669), brokerage dues, cleaning of containers, cargo tanks, and hatches (Fagerholt and Lindstad, 2007: 217). In addition to the fleet mix, calling ports, scheduling, and transportation costs, the cost of supply chain, safety, and environmental factors are determinants in the decision phase of route planning.

Overall transportation costs are the highest portion of supply chain costs (Tran et al., 2017: 669). Inventory cost that occurred through shipping process directly touches on the perception of shippers (Hsu and Hsieh, 2007: 900) because the direction of transportation costs is in accordance with selected ports on a route. However, low transportation costs do not always result in decreasing total supply

chain costs. Using mega-ships and an increasing number of calling ports possibly lower total cost but, these vessels probably lead to high inventory costs. A higher inventory cost and port time are the hidden costs to be considered in route establishment (Tran et al., 2017: 669).

Safety of both vessels and environment are other indicators in new route establishment. The safety of vessels mainly consists of visibility, geographical conditions, temperature of the region, and security concerns. The environmental factors mainly are wildlife, ecosystem, potential environmental risks of collision, grounding and leakage, and environmental regulations of countries (Tseng and Cullinane, 2018: 427 – 428). End users highly query the footprint tracking of products and services they consume. For this reason, CSR has become a necessary strategy for companies in supply chains because all steps from the supply of raw materials to the consumption point may significantly raise footprint level of a product or service. In this way, liner shipping industry (Schøyen and Bråthen, 2011: 979), coordinating supply chains (Ducruet and Notteboom, 2015: 145), should attend social and environmental sustainability in addition to economic factors. Within this context, a liner company – as an example – has decided to use a fuel that contains 1.5% sulfur and to abide by extra costs even though regulations oblige to use fuel with a maximum of 4.5% sulfur (Schøyen and Bråthen, 2011: 979).

2.3.2.2. Types of Liner Service

Transportation networks are the spatial design of potential routes established by taking into consideration physical conditions in general. However, maritime networks, which does not face physical constraints unlike road and rail transportation, have locational dependence on many interconnected terminals in different coasts and continents (Ducruet and Lugo, 2013: 349 – 351). Among three main operation types of maritime transportation – industrial, tramp, and liner – network designs arbitrarily occur in tramp and industrial shipping for the sake of following available cargoes (Fagerholt, 2004: 259). Different from those, liner shipping service design and development have many factors to be considered because it carries thousands of scheduled containers.

The history of the container shipping industry, which dated from the late ‘50s after the invention of container by McLean, is newer compared to general and bulk cargo transportation (Stopford, 2009: 508 – 509). According to UNCTAD (2019),

today, with the advantage of cost reduction and a wide range of goods to be carried, carriage capacity of container ships in the world fleet is 13,5% with almost a 5% increase. This share was 1.6% in the 80s, 3.9% in the 90s, 8% in the 00s, and 13,3% in the 2010 (UNCTAD, 2018: 25). In 2017, total container vessels economically transported almost 60% of all seaborne trade (www.statista.com). Therefore, because sea transportation handles up to 90% of world trade (UNCTAD, 2019: 89) service configuration of container shipping is shaped in line with world trade (Hu and Zhu, 2009: 2061), and the route design of shipping lines dominate decisions and selections of other actors in global supply chains (Wilmsmeier and Notteboom, 2011: 214 – 215).

The global supply chain is highly sensitive to accessibility and transit time. The liner shipping industry establishes networks to encounter these requirements of chain (Ducruet and Notteboom, 2015: 126; Fagerholt, 2004: 260). In this way, service frequency of shipping lines has to be improved thereby using bigger vessels and/or enhancing the number of nodes to be served, because customers expect direct service from origin to destination (Hsu and Hsieh, 2007: 900). This situation forces ship-owners for expansion of feeder services to perform better port rotations. Increasing service frequency and carriage capacity in TEU provide a wider range of cargo availability. The extension of cargoes and nodes forces schedules and service structure of shipping lines. But a change of service structure contains a trade-off between customers' needs and an increase in operating costs (Ducruet and Notteboom, 2015: 126 – 127). Even though meeting shippers' demands are remarkable, service networks and route designs of shipping lines must be handled to optimize the employment of ever-growing ships (Hsu and Hsieh, 2007: 900 – 901; Cariou and Cheaitou, 2014: 323). Within this objective, shipping lines must rationally determine shipping networks, ports of call, and routes.

Liner services are roughly categorized as deep and short sea transportation. The ocean-crossing deep-sea transportation handles Trans-Pacific, Intra-Asian, and Trans-Atlantic trade. Feeder services also connect small ports to transshipment centers through short-sea transportation. Between small ports and huge hubs, liner operators establish routes, namely line or service bundling that are described according to port rotation (Guericke, 2014: 15) and principle for liner shipping network dynamics (Wilmsmeier and Notteboom, 2011: 215). Bundling can simply be summarized as cyclic roundtrips of a ship between ports that has identical calling characteristics (Msakni et al., 2020: 2; Notteboom, 2006: 22). In the meantime, vessels may be called by the same ports (symmetric) or by different ports

(asymmetric) in the return path of round-trip (Hu and Zhu, 2009: 2061 – 2062). Also, service bundling may either be a singular liner service or a service conjoining two or more liner services (Ducruet and Notteboom, 2015: 128). First, a singular liner service bundling focuses on end-to-end service that calls at several ports between two continents (Msakni et al., 2020: 2) through the selected route. The other patterns of line bundling are round-the-world and pendulum services that link two-five scheduled ports within the strongest markets such as the Far East and North Europe. In a pendulum service, vessels navigate at several ports between three continents four times on the same trip. One continent plays a pulley role while the other two coasts are shafts (Ting and Tzeng, 2003: 379 – 380; Wilmsmeier and Notteboom, 2011: 215; Hu and Zhu, 2009: 2061). Second, conjunction of two or more liner services extremely relies on hub ports located on the mainstream global network (Ducruet and Notteboom, 2015: 128 – 129). These intermediary hubs develop connectivity and accessibility to various hinterlands on different continents (Fagerholt, 2004: 260). The transshipment hubs may be integrated with many feeder ports or may be interlined with another hub (Hu and Zhu, 2009: 2061). Hub-and-spoke provides an opportunity for shipping along with long-distance and exploiting economies of scale enormously (Guericke, 2014: 11). Contrarily, extra costs of increasing feeder traffic may suddenly transform mega-ships into insufficient, and cost inefficiency may result in that cargo may shift to other lines which serve within different networks (Cariou and Cheaitou, 2014: 323; Ducruet and Notteboom, 2015: 130). For this reason, the determination of sizes and numbers of vessels to be deployed in a network is another important factor in the liner service configuration. Liner operators are usually obliged to utilize high-service frequency availability of small ships in line with customers' needs or to employ bigger ships as far as possible in pursuit of scale economy. The other trade-off related to ship size is transit time. Small ships offer lower transit time while mega-ships provide an enormous cost advantage, but port time, total transit, and distance are lengthened (Wilmsmeier and Notteboom, 2011: 216; Ducruet and Notteboom, 2015: 130).

There are three main directions for liner shipping networks: East/west, north/south, and regional services. These global transportation grids would give liner companies chance to overcome trade fluctuations because it helps them in aggregating different shipping routes in a single network (Ducruet and Notteboom, 2015: 130). Maersk, MSC, and CMA-CGM are dominantly active in both major and secondary trade routes. Maersk stably covers whole global liner networks meantime

MSC and CMA-CGM focus on specific networks involving several big hub ports, and they do not walk blindly into secondary routes. Regardless of the global demand-pull of powerful players, individual carriers rule regional markets. Asian carriers are a good example of this regional allocation because they mainly concentrate on intra-Asian, East-North Europe, and Trans-Pacific trade routes (Notteboom, 2006: 22; Wilmsmeier and Notteboom, 2011: 216). Particularly after mergers, acquisitions, and cooperation agreements within liner shipping companies (Ting and Tzeng, 2003: 380), Asian companies such as COSCO, Evergreen, ONE, Yang-Ming, OOCL, traffic circulation, and regional coverage of Asian liners have become aggressively sensate (Ducruet and Notteboom, 2015: 130).

2.3.2.3. Routing Problems in Shipping

The volatile and intensively uncertain nature of maritime transportation (Cho and Perakis, 1996: 249) makes routing problems dissimilar to other modes of transport. Maritime shipping has operational differences from other modes: (1) vessels are mostly allocated for international trade, (2) maritime transportation takes almost weeks, (3) technical specifications of the vessels are the function of vessel-port suitability, and (4) vessels pay charges to load/unload cargoes while trucks do not face any remarkable fee for loading/unloading container (Christiansen et al., 2004: 2 – 3).

A vehicle calling on one or more nodes in a trip has time and capacity constraints. Hence, one of the main Vehicle Routing Problem (VRP) can be described as the optimization of routes for vessels. In a fleet, each vessel has different characteristics regarding capacity, cost, and speed. An optimal route should minimize costs within the frame of these characteristics (Fagerholt, 2004: 260 – 261). The backhaul is the principal cost item and routing problem in tramp shipping (Christiansen et al., 2004: 6). In tanker shipping, crude oil is largely shipped from Gulf countries to three biggest crude oil exporter regions. As a routing problem of tankers, the sailing time takes five weeks on average owing to long distances between these regions and high-volume shipments, thus either the transit time of using Cape of Good Hope or canal dues of Suez is to be chosen (Christiansen et al., 2004: 6 – 7; Henning et al., 2015: 41).

The liner routes are not flexible enough for any changes. Thus, cargo demand must studiously be estimated that may lead to major routing problems in case of

misestimation (Cho and Perakis, 1996: 251). The network configuration of liner shipping that is shaped by demand is a VRP in itself. Two main components of the network are vessels and terminals. When it is needed new vessels or terminals to overcome a VRP, the fulfillment time of new orders creates additional VRPs. If a company decides to close the gap with vessels from other networks, new planning process of both networks also originates VRPs. This case may become a vicious cycle. Furthermore, a new terminal establishment may produce VRP for other transportation modes because door-to-door transportation is a key element of liner shipping (Rieck, 2014: 863 – 864; Kjeldsen, 2011: 139 – 141). The timetables are arranged in harmony with integrated modes and terminals. To plan a schedule for each shipment in a fleet given has to be flexible and robust. The inventory management problems and robust scheduling problems are resolved in sub-problems of routing problems (Christiansen et al., 2004: 7 – 8).

A weekly designed route time contains navigation, port time, and unexpected situation-based idle time. The initial VRP in liner shipping is multi-trip where each ship is granted for several routes and trips within route time that does not transcend one week (Christiansen et al., 2004: 7; Fagerholt, 2004: 261 – 262). The problem of multi-trip and time-constraint of weekly designed routes generates the logistics infrastructure design and decision of fleet size as other strategic routing problems (Christiansen et al., 2004: 3). Another routing problem of liner shipping is to calculate optimal cargo-ship combination and to arrange container stowage plans. It is needed complex planning, which has a huge number of different cargo-ship assignments and cannot be easily organized the sequencing of containers in this puzzle. It must be clear, resolvable, traceable, and consistent with the information provided. Moreover, this sophisticated structure is needed to be embodied with the most feasible port sequences. It is simply called as the combination problem of cargoes, vessels, and ports (Fagerholt and Lindstad, 2007: 216 – 217). Yet, empty container positions direct vessel routing. Due to the capacity constraint and necessity of bringing empty containers, the number of empty containers to be discharged in a port is generally similar to full containers to be loaded. Hence, problem of weekly planned liner routes comes close to time-restricted VRP (Fagerholt, 2004: 262). The last, because of global warming, there is an increasing awareness about environmental subjects. Air and water pollution, as accelerators of ecological disasters, have become crucial VRPs. Especially environmental effects of vessel carbon emissions force shipping companies to find out the way to decrease emissions while resolving VRPs. Fuel

consumption is an initial factor for GHG, and speed is the steer of fuel consumption; but although speed is one of the solutions for VRP, its environmental hazard generates another routing problem (Kramer et al., 2015: 523).

One of the best ways to overcome VRP (Vaferi et al., 2018: 121) such as multi-trip, fleet size decision, and cargo-ship combination (Christiansen et al., 2004: 7; Fagerholt, 2004: 261; Fagerholt and Lindstad, 2007: 216) is the minimization of total distance for container vessels in liner shipping. Minimum distance creates an opportunity to minimize problem of selecting consolidation locations and problem of feeder allocation (Vaferi et al., 2018: 121). Some other perspectives suggest an increase in speed. When speed and distance are compared, increasing speed reduces total duration but augments bunker costs while distance minimization may be a more efficient solution because it decreases both VRPs and total costs (Kramer et al., 2015: 523 – 524). Both sub-problems and main problems are tried to be defeated via using optimization systems to find the best option, developing company-based software portals, employing planners who are masters of their domain, establishing systems that flow simultaneous information, and enlarging the scope and size of shipping alliances (Christiansen et al., 2004: 12 – 14).

2.4. MAJOR TRADE ROUTES

This part of chapter two starts with a general overview of trade routes of liquid bulk, dry bulk, and container trade routes. All canals and passages are introduced briefly, and finally, eight major container shipping routes and Arctic routes are referred to in detail.

2.4.1. General Overview of Maritime Trade Routes

Industrialization is a regional activity. Many of the economic geographies that have been the trade centers for centuries still pursue their positions. The strong positions have been shaped around the countries and regions, which did not miss the train of industrialization after industrial revolution. In this way, commercial activities and investments have been gathered around the newly industrialized countries. Because shifting a completely industrialized region to another one is highly costly and means that all global trade systems are to be changed, the enormous investments and developing trade have created a path for these economic geographies. The path

dependence has generated uneven development of countries and regions. With the effect of globalization, uneven development between regions has begun to be experienced more deeply. To vitiate the negative competitive effects of this situation, governments and local authorities have enlisted to actualize decentralization and deregulation. Transportation has undertaken critical status. When decentralization and deregulation have been promoted with technological advances, the connections between modes of transport, infrastructure capabilities, and service quality have augmented (Combes et al., 2008:15-16; Sokol, 2011: 38 – 42), while costs were diminishing (Krugman, 2000: 51).

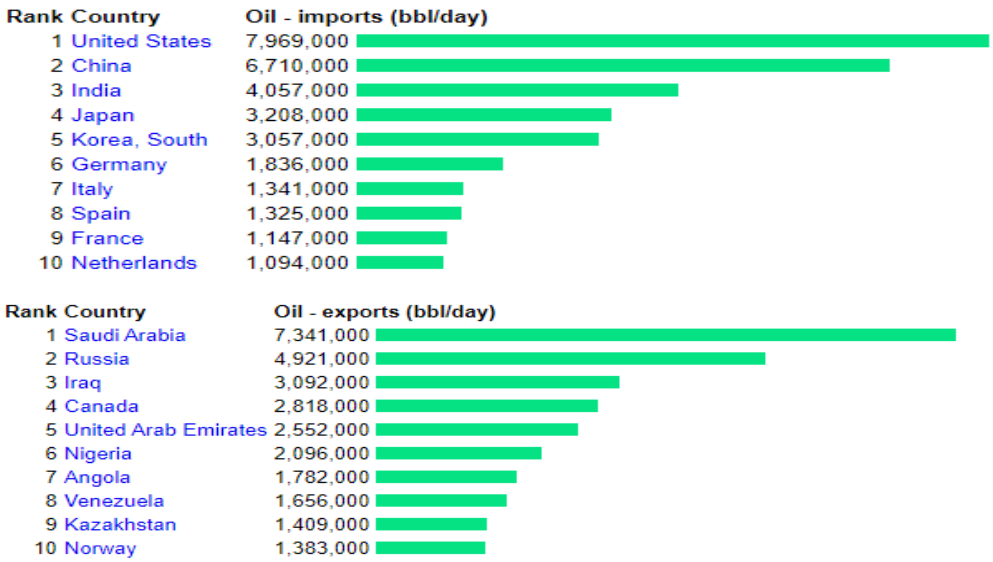
Soever international trade theory accepts that means of production are immobile while economic geography says capital and labor among production factors are highly mobile to catch opportunities at other regions that differ from homeland (Krugman, 2000: 49 – 53). There are fundamental distinctions between regions with regards to geography, transportation integration, and raw materials (Combes et al., 2008:16). When it is considered the agglomeration effects and velocity of the investments in trade centers (Combes et al., 2008:17), production systems have systematically shifted into Asia (Pham et al, 2018: 1), and trade systems of the globalized modern economy have been modeled nearly within this direction. As a result of aggressive expansion strategies of multinational enterprises in global trade (Shatz and Venables, 2000: 125-126), outsourcing has become widespread, foreign direct investments (FDI) have swelled (Rodrigue, 2017: 3), and world GDP level has started to increase gradually in last 30 years (Shatz and Venables, 2000: 126). In the wake of demographic effect of Asia, FDI's have unevenly been distributed between regions and developing countries, thus economic growth, trade circulation, and flows of trade routes have become Asia-oriented (Shatz and Venables, 2000: 128-129). The trade routes in east-west direction remain noticeable since re-organization of world trade has been completed (Rodrigue, 2017: 1). Maritime trade routes linking Asia, North America, and Europe have a dominant position in seaborne merchandise trade (Stopford, 2009: 348; Rodrigue, 2017: 1).

Shipping routes are corridors connecting trade hubs and defeating land transport discontinuities (www.porteconomicsmanagement.org). For instance, transportation costs of landlocked countries are almost 50% higher in general. Because transportation is the costliest part of the supply chain, it impedes economic growth. Therefore, if it is also regarded the maritime transportation being a highly deregulated industry, world trade proceeds on the focus of maritime transportation,

which is most advantageous mode with respect to cost and volume. That is the initial importance of maritime shipping routes. The seawater occupies 70% of the earth's surface. It is not surprising that Atlantic, Pacific, and Indian Oceans have major shipping routes in the world. Particularly Transpacific and Transatlantic routes link economic geography of production and technology. These regions are deemed as major markets which are connected via major or core routes, and the others known as secondary routes are bridges connecting secondary markets to majors (Rodrigue, 2017: 1 – 5).

In bulk cargo, trade is executed between raw material and main production centers (Stopford, 2009: 419). Even though each country requires petroleum products, main shipping routes for petroleum trade comprise top exporters and importers countries (Figure 12). The baseline for petroleum shipments is Arabian Gulf, Russia, North America, and some parts of Africa, while destinations are production and population-intensive regions such as USA, China, India, Japan, Korea, and EU. The critical nodes within these routes are the Strait of Hormuz, the Strait of Malacca, the Turkish Straits, and the Suez Canal. The cycle between these 20 countries approximately corresponds to 80% of total value of petroleum trade. Although Russia uses its spatial advantage and delivers some of its cargo through pipelines to China and EU, shipping routes between Russia-EU and Russia-China carry a fair sum of traffic (www.reuters.com).

Figure 12: Top Oil Importing and Exporting Countries in 2020

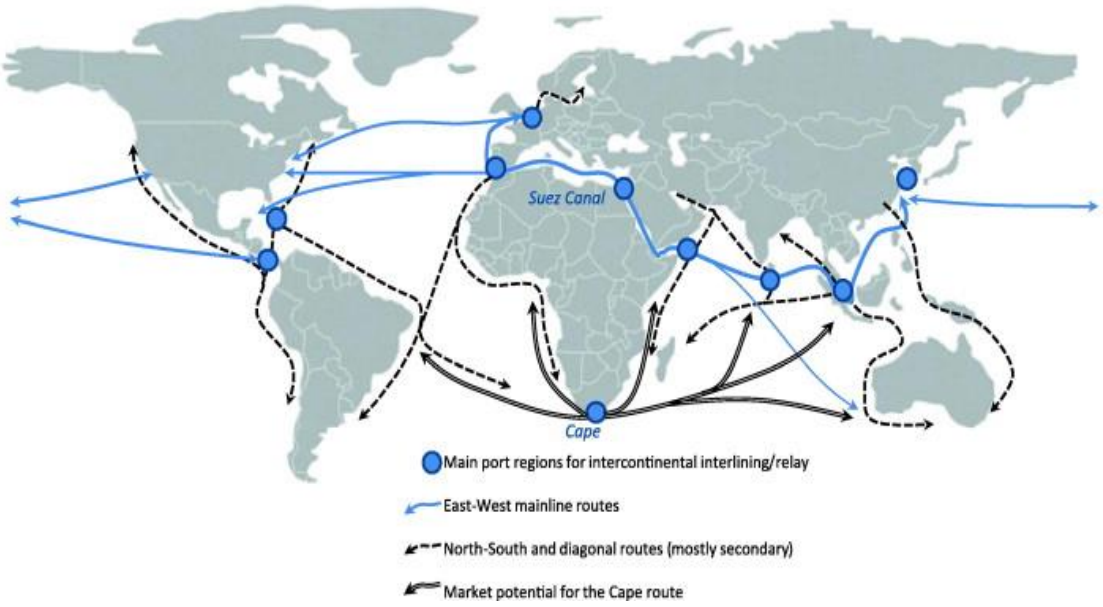


Source: www.indexmundi.com.

Trade patterns in dry bulk cargo routes are not different from liquid cargo routes. Bulk cargo transportation follows cargo by nature, and shipping routes are shaped between major exporter and importer countries. The five major bulks compose mass of the transportation in terms of tonnage. The coal, iron ore, and grain from five major bulk shine out in average haul in dry cargo shipping routes (UNCTAD, 2020: 10 – 11; Stopford, 2009: 419 – 420).

The nature of liner shipping is quite different. It has pre-determined port calls and weekly service frequency to be provided is officially announced on web sites of liner operators. Therefore, their routes are also fixed, pre-determined, highly planned, and tight knit to their schedules. These fixed services are also called as ship routes. These routes create a liner shipping network that generates a loop within a port rotation given (Yercan and Yıldız, 2012: 35; Wang and Liu, 2015: 362 – 365; Abioye et al., 2019: 1 – 2). More than 400 liner services are listed by World Shipping Council (Abioye et al., 2019: 1), which are organized with the purpose of reaching major markets through shortest routes with shorter transit times (Rodrigue, 2017: 5). But in practice, weather conditions, congestion, mechanical failures, strike, piracy, etc. cause late port arrivals. The delays affect the entire network, gradually reflect on all segments within liner shipping routes, and total costs of chain increase (Abioye et al., 2019: 1 – 2).

Figure 13: Mainline Routes in Container Shipping



Source: Notteboom, 2012: 177.

In container shipping, there are three principal routes (Figure 13) connecting main port regions of Europe, East Asia, and North America. These port regions have dominant positions with majority of container shipments (Jansson and Shneerson, 1998: 31). The ship routes are split up east-west and south-north directions (Wang and Liu, 2015: 365). Despite Suez Canal having a major role and competitive position for Asia-Europe shipments, while Cape of Good Hope surpasses the traffic between Oceania, East and West Coast of Africa, and East Coast of South America (Notteboom, 2012: 177).

Figure 14: Domains of Maritime Circulation by Vessel Type



Source: www.shipmag.org.

Figure 14 shows density of traffic on shipping lanes by vessel types. In figure, yellow lines represent container ships, blue lines are dry bulkers, reds are liquid bulk carriers, green ones are gas carriers, and purple lines are ro-ro ships. In line with this figure, Rodrigue (2017) says that container vessels navigate through main equatorial maritime trade routes that are linked within a wide range of routes and host many large ports, especially on Transatlantic and Transpacific traffic. The dry bulk traffic is between the biggest raw material suppliers and importers in South America, South

Africa, Australia, and South-East Asia. The liquid bulkers carriers are seemed to be dispersed around the world but, red lines thicken on the routes connecting Hormuz, North America, and Eastern Asia. LNG shipments are broadly directed from Iran and Nordic countries such as Russia, Norway, Canada, Alaska of USA to world, particularly industrialized regions. Ro-ro vessels prolong within Asia, North Europe, North and South America, and Mediterranean bi-directionally on the north-south and east-west trade routes.

2.4.2. Strategic Chokepoints in Maritime Trade Routes

With effect of path dependency theory of economic geography (Iammarino and McCann, 2013: 147 – 149), specific location notion has had ground in maritime trade. These specific locations are strategic chokepoints of global trade such as canals, passages, and straits. These locations that are flag carriers of transportation with respect to cargo volume and value are also classified as primary (cornerstone of main routes) and secondary (supportive of main routes). The growing volume and value have revitalized piracy in addition to closure risks of canals and passages by reason of accidents, strikes, and geopolitical problems (Rodrigue, 2017: 1 – 2). The chokepoints of transport geography (Rodrigue, 2004: 359) and maritime trade are principal straits, canals, and passages with high traffic volume (www.sealaw.com) forming world trade circulation (www.ship-technology.com) despite their geographical constraints (Rodrigue, 2004: 359). Some of them such as Turkish Straits and Strait of Hormuz intrinsically have natural constraints while some of them like Suez and Panama canals have interruption of depth and width, and closure constraints because they are artificially established (Rodrigue, 2004: 359; www.marineinsihght.com).

These points (Figure 15) are forcibly pinned to international shipping routes that unsurprisingly serve for any kind of raw materials, semi-finished goods, and finished goods between Asia, North America, and Europe. The non-traditional chokepoints may substitute primary chokepoints with the help of other means of transport. Of the chokepoints, the Suez Canal (15% of world trade / with daily 100 transit capacity), the Panama Canal (5% of world trade / with daily 50-60 transit capacity), and the Straits of Malacca (30% of world trade / with daily 800 transit capacity) are the most critical ones and heart of shipping and trade activities (www.porteconomicsmanagement.org). Further, Hormuz (30% of liquid shipments) is another important place that is active for liquid-bulk cargoes (www.eia.gov). Although

they have enormous shipment circulation, in the general sense, these chokepoints are risky positions. Due to geopolitical risks, piracy, and terrorism alternative routes with higher distances may be more feasible, especially for high-value cargoes (Wellesley et al., 2017: 16; www.selaw.com).

Strait of Hormuz links Persian Gulf to Arabian Peninsula and disjoins the gulf from Indian Ocean. The strait has a major role in oil supply with $1.2 billion in daily shipments (www.businessinsider.com). Besides, Hormuz has daily traffic of 17 m. barrels and hosts world's 10th busiest container port Jebel Ali that handled 18 m. TEU in 2018 (www.worldshipping.org). Therefore, Hormuz has also become a strategic network of Asia, East Africa, and Middle East container shipping routes alongside oil shipments. Strait of Hormuz have no depth problem for large vessels' passages, but it has navigational limits because respectable amount of tankers and container ships are constrained to a pair of 3 km wide channels. As likely as, most critical limitation is security that is sourced by geopolitical tensions and terrorism (Rodrigue, 2004: 366 – 367).

Figure 15: Strategic Maritime Chokepoints



Source: Wellesley et al., 2017: 18.

The *Malacca Strait* prolongs between Malaysian west coast and Sumatra Island of Indonesia. The strait that links Indian Ocean to China Sea is under the responsibility of Malaysia, Indonesia, and Singapore (Evers and Gerke, 2006: 3). This path gathers main and sub-shipping routes adherent to Southeast Asia that accounts for 25% of global transit of dry bulk, liquid bulk, and general cargo fleets (Rodrigue, 2004: 370). The Malacca is the longest, busiest, and most important chokepoint for maritime transportation. Such that, the strait is home to more than 50,000 vessels per year. This shortest path for the route from East Asia to Middle East and Europe accommodates strategic and large transshipment hubs namely PSA Singapore and Port Kelang. It has a minimum of 2.5 km in width, and a minimum of 23 meters in depth (Evers and Gerke, 2006: 3 – 5; www.porteconomicsmanagement.org). In any case, Malacca needs dredging as its draft is not fit for vessels bigger than 300,000 DWT, and distribution of dredging costs is not easy to agree on by right holder countries. The three-legged decision mechanism creates political instability, and the last but the major bottleneck of Malacca is piracy attacks (Rodrigue, 2004: 369 – 370).

The *Suez Canal,* which is an artificial man-made maritime passage (www.porttechnology.org), lies between Suez Gulf and Port Said and connects Mediterranean Sea to Aden Gulf. It offers a great shortcut for both East Asian countries and Organization of Petroleum Exporting Countries to reach developed markets (Stopford, 209: 364 – 365). The shortcut represents almost 9,000 km and 10 days' savings on average from North Europe to Arabian Gulf compared to Cape of Good Hope route. It reduces the distances of routes between Asia and North Europe by 40% to 45% (www.worldshipping.org). The canal allows passage of ships with 64 meters beam and 16.2 meters' draft in maximal (Stopford, 2009: 365). After Suez was built at the end of 19th century (www.worldshipping.org), dredging and extension works have been performed several times, but the most meaningful development of the canal was executed at the 80s (Rodrigue, 2004: 367). In this way, Suez has become able to host very large crude carriers (www.porttechnology.org), and today ultra large crude carriers that have less than 300,000 tons of full-loaded capacity can pass through Suez. Before widening, in 2015, transits were performed with roughly 17 hours of transit time as unidirectional organized convoys that involve up to 15 vessels (Rodrigue, 2004: 367 – 368). The extra dredging and expanding activities in 2019 resulted in more than 55 transit capacity per day and 25,000 per year on average. As a result, two transit convoys per day can navigate bi-directionally and simultaneously (www.porteconomicsmanagement.org). The expansion has let the

opportunity of handling mega-vessels within canal, but on the other hand, growing size of transit vessels carries the risk of grounding and accidents. It creates closure risk (i.e., Ever Given Case) in addition to piracy, geopolitical tensions, and closure risks originating from wars and terrorist attacks (Rodrigue, 2004: 368).

Figure 16 shows tonnage and number of transit passage trends between 1975 – 2000. There are two trends emphasized in the figure. Between beginning of the 80s and mid of 2000-2005, number of total passages reflected a sensible decline while net tons carried were consistently raising. It shows that fewer but bigger vessels provide economies of scale opportunity. After the 2000s, world trade, markedly between Asia and Europe, accelerated with the Chinese effect. The tonnage carried was doubled while transit vessel numbers were reaching almost ever-higher levels. In the second trend, after the global economic crisis in 2008, Suez faced 20 to 25% traffic cuts. After 2013, traffic completed the recovery session and reached pre-crisis volume.

Figure 16: Tonnage and Number of Transits in Suez Canal (1975 – 2020)

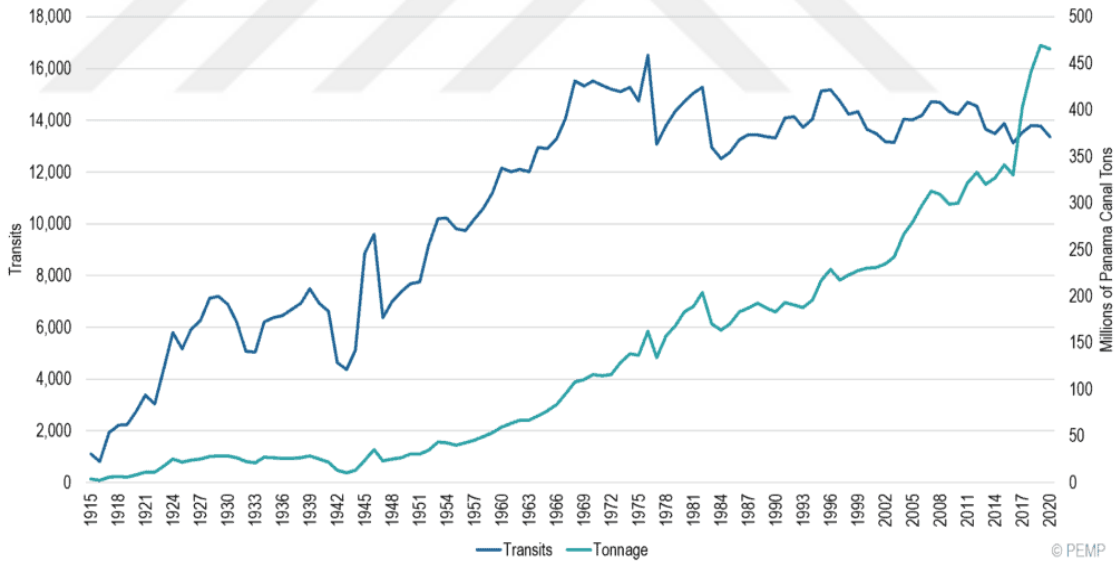


Source: www.statista.com.

The *Panama Canal* connects Pacific and Atlantic Oceans. It is the main and shortest connection from East Coast of North America to West Coast and Asia (Stopford, 2009: 365). The first stage of the construction of artificial canal was handled between 1881 and 1888, and the next one started in 1904. In 1904 canal began to operate (Abdulhafedh, 2017: 318). This passage offers shorter transit between Pacific

and Atlantic up to 9,000 miles. The system works thereby lifting ships up to 26 meters high via Lock Gates for balancing sea level differences within the canal (Stopford, 2009: 365; Abdulhafedh, 2017: 318 – 319). The Panamax vessels less than 65,000 DWT could pass through Panama Canal but, growing global trade and ship size forced the canal authority to start canal expansion works. Also, extra earning potential allure the authority because canal dues are based on tariffs per net ton. In conclusion, canal began to be expanded in 2007, and lifts are able to New-Panamax up to 12,500 TEU, with 430 meters in length, 55 meters in width, and 18.3 meters draft (www.porteconomicsmanagement.org; Stopford, 2009: 365). However, after expansion in 2016, economies of scale and tangible increase in passages were rapidly realized. 70% of the total traffic of Panama belongs to USA trade (Rodrigue, 2004: 370 – 371). Thus, the movements in Figure 17 are in harmony with trade patterns of the USA. With the widening works in 2007 and particularly in 2016 tonnage line face a sharp jump while transit numbers were staying steady.

Figure 17: Tonnage and Number of Transits in Panama Canal (1915 – 2020)



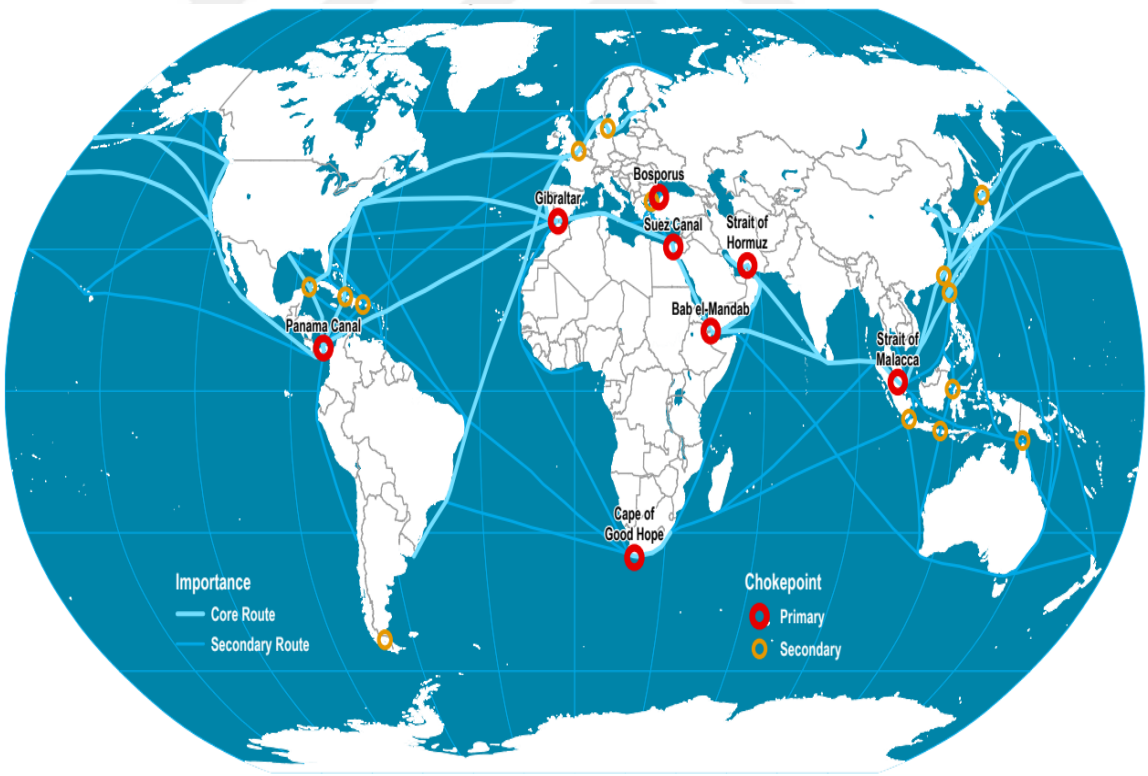
Source: www.pancanal.com.

The other strategic chokepoints are (1) *Strait of Bab El-Mandab*, which connects Indian Ocean to Red Sea and provides access to Suez Canal; (2) *Turkish Straits* links Black Sea Region to Mediterranean and have strategic importance for Russian entity; (3) *Danish Strait* is the passage between Sweden and Denmark and connects Baltic countries, Germany, Russia, and Poland to international shipping

thereby tying Baltic Sea to the North Sea; (4) *Strait of Gibraltar* is the Atlantic gateway of Mediterranean Sea, South Europe, and North Africa; (5) *Strait of Magellan* stays between Chile and Tierra del Fuego. It is the ultimate water mass of South America before Antarctic glaciers appear; (6) and *Cape of Good Hope* is the link between Atlantic and Indian oceans at the endmost node of Africa (Rodrigue, 2004: 368).

Figure 18 illustrates distribution of primary and secondary chokepoints over primary and secondary shipping routes. Theoretically, the number of maritime trade routes are unlimited, but trade flow, economic geography, and global economy lead the most feasible shipping routes to be created. The primary chokepoints locate on the way of core routes sure enough, while secondaries locate on supportive and complementary routes. The secondary routes also contain coastal shipping routes. The initial equatorial network connects main markets through primary chokepoints such as Suez, Panama, and the Strait of Malacca.

Figure 18: Maritime Shipping Routes with Primary and Secondary Chokepoints



Source: Rodrigue, 2017: 1.

The primary and secondary shipping routes and their TEU volumes have been introduced in Table 4 and Table 5. According to the table below, Eastbound

Transpacific trade shows a steady increase between 2014-2018, but trade wars and COVID-19 gave rise to a 10% decrease in containerized trade, while America-originated cargoes slightly increased within these years. The reason would be westbound shipments of pharmacological and sanitary products. Total Asia-Europe trade expanded from 21.3 m TEU to 24.7 m. in four years but fell by 7% in last year. Although the eastbound trade lane did not face a perceivable change, the westbound flow had a 1.5 m TEU negative change.

Table 4: Containerized Trade on Major East-West Trade Routes, 2016-2020 (Million TEU)

	Trans-Pacific			Asia-Europe			Trans-Atlantic		
	Eastbound	Westbound		Eastbound	Westbound		Eastbound	Westbound	
Year	East Asia-North America	North America-East Asia	*Trans-Pacific*	Northern Europe and Mediterranean-East Asia	East Asia-Northern Europe and Mediterranean	*Total Asia-Europe*	North America-Northern Europe and Mediterranean	Northern Europe and Mediterranean-North America	*Trans-Atlantic*
2014	**16.2**	**7.0**	*23.0*	**6.3**	**15.5**	*21.8*	**2.8**	**3.9**	*6.7*
2015	**17.4**	**6.9**	*24.3*	**6.4**	**15.0**	*21.3*	**2.7**	**4.1**	*6.8*
2016	**18.2**	**7.3**	*25.5*	**6.8**	**15.3**	*22.1*	**2.7**	**4.3**	*7.0*
2017	**19.4**	**7.3**	*26.7*	**7.1**	**16.4**	*23.4*	**3.0**	**4.6**	*7.5*
2018	**20.8**	**7.4**	*28.2*	**7.0**	**17.3**	*24.3*	**3.1**	**4.9**	*8.0*
2019	**20.0**	**6.8**	*26.8*	**7.2**	**17.5**	*24.7*	**2.9**	**4.9**	*7.9*
2020	**18.1**	**7.0**	*25.1*	**6.9**	**16.1**	*23.0*	**2.8**	**4.7**	*7.4*

Source: UNCTAD, 2020, 15.

Table 5 illustrates container trade flow carried through major shipping routes between 2016 and 2020. The table shows that East – West mainlane routes constitute 60 m. TEU in 2018 while it was 54 m. TEU in 2016. The shipment volume displayed a sharp decrease from 2019 to 2020. The direction of the maritime trade through other routes strongly were interregional. Opposed to mainlane, interregional trade flow stayed almost constant thanks to Intra-Asia trade. The routes on non-mainlane East – West and South – South trades cruised at similar capacity while North – South routes have had lowest TEU capacity.

Table 5: Containerized Trade on Major East-West Trade Routes, 2016-2020 (TEU)

	2016	2017	2018	2019	2020
Mainlane East-West routes	54 610 793	57 695 035	60 512 411	59 451 778	55 529 706
Other routes	81 973 339	87 152 831	89 796 992	92 439 115	87 733 977
of which:					
Non-mainlane East-West	17 928 632	18 977 780	18 961 472	19 869 413	18 099 717
North-South	11 108 989	11 753 235	11 963 148	12 018 424	11 576 259
South-South	16 251 689	17 619 241	18 898 303	19 433 908	18 007 289
Interregional	36 684 030	38 802 575	39 974 069	41 117 369	40 050 711
World Total	**135 584 133**	**144 847 866**	**150 309 403**	**151 890 894**	**143 263 682**

Source: UNCTAD, 2020: 14.

Table 6: Serving the Trade Routes (2018)

Route	Services
Asia-East Coast North America	19
Asia-West Coast North America	54
Asia-North Europe	20
Asia-Mediterranean	29
North Europe-North America	32
Mediterranean-North America	17
Asia-Middle East	43
Asia-South Asia	53
North America-Middle East/South Asia	10
South Asia-Europe	20
Middle East-Eastern Europe	36
Oceania	46
East Coast South America	14
West Coast South America	31
South Africa	19
West Africa	46
Total	***487***

Source: www.worldshipping.org.

The volume, characteristics, and needs of these routes determine the number and nature of services to be deployed. The World Shipping Council lists total of 16 main and feeding routes (Table 6). The total number of services to be offered was 487 in 2018. The number of services in a route cannot be a sign for a high volume of the shipment. It is probably related with the size of deployed vessels and competition level in a route.

2.4.3. Primary Maritime Trade Routes

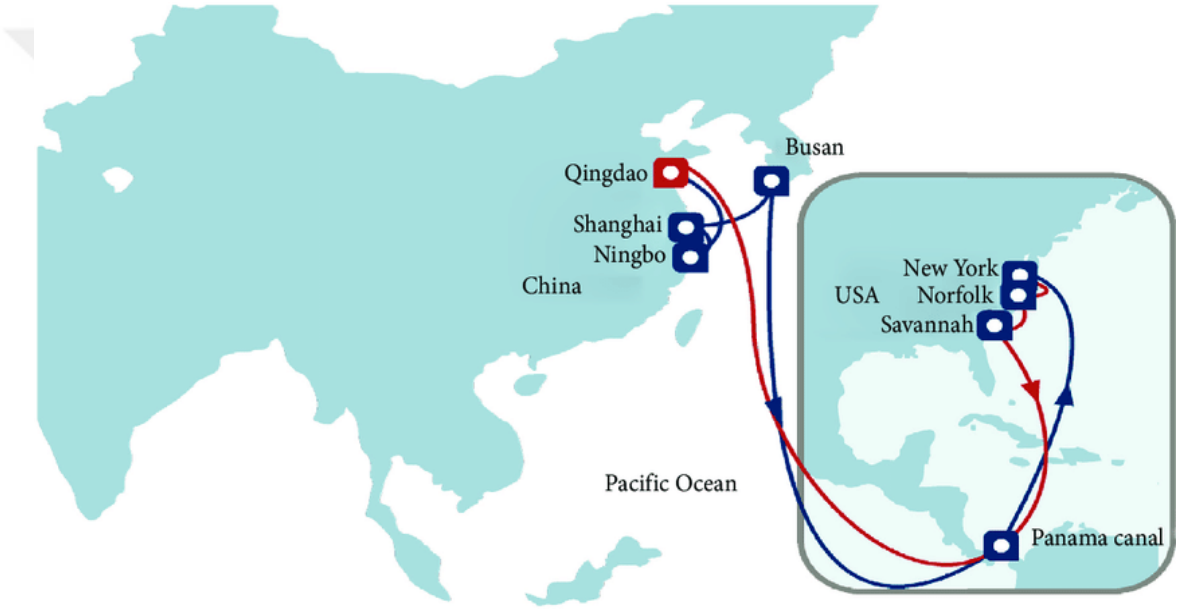
These routes are named differently in references. Some of the resources use names of continents, some of them use names of the ocean and/or sea within lanes while some may use names of critical straits or passages to indicate a particular shipping route. However, it is more reasonable to use the name of Transpacific, Transatlantic, and Asia-Europe, which are well-accepted definitions of the World Shipping Council.

Transpacific route is the network between North America and Asia (ICS, 2011: 11). The characteristics of this route are quite different than others forwhy it links the largest exporter and importer continents, and so it is the busiest shipping route. More than 25 m. TEU container cargoes are transported through Transpacific (UNCTAD, 2020: 15), and liner companies show due diligence to this transit with 54 services, which is the highest one (www.worldshipping.org). Transpacific shipments correspond to 40 percent of the East-West flow and 20 percent of global trade (UNESCAP, 2015: 44).

The figure below is a typification of Transpacific service provided by COSCO. Although the majority of liner services are occupied by Chinese ports (Zhou et al., 2020: 3 – 4), other Asian countries from Singapore to Japan have remarkable shipments (ICS, 2011: 11). This is because, Asian countries have inbound maritime flow of raw materials, semi-finished goods, energy, and food while outbound flow is general cargo shipments that mainly rely on manufactured goods (Stopford, 2009: 143). The distance from Singapore PSA to Panama Canal is 10,300 nm. while from Chinese gateways to Panama is 8,600 nm with 13 knots speed (Stopford, 2009: 359 – 360). In Transpacific, Panama Canal, which let the 8,000 nm and 21 days savings (www.safety4sea.com), is crucially important for transit time, total cost, overall accessibility, and schedule reliability. Another important chokepoint is the Malacca Strait, which accommodates transhipment hubs.

Far East-Europe route, where production centers in Asia allow the westbound traffic doubles North European origin cargo movements (UNCTAD, 2020: 15) and mega-ships are dominantly utilized, covers Northwest Europe, Eastern Asia, and Southeast Asia. This route bi-directionally and intensively consumer goods rather than raw materials and semi-finished goods (ICS, 2011: 12). It is the second busiest route with 40 services between Far East-Europe and 29 services between Far East-Mediterranean (www.worldshipping.org) with 23 m. TEU (2020) container flows (UNCTAD, 2020: 15).

Figure 19: An Example of Service in Transpacific Route

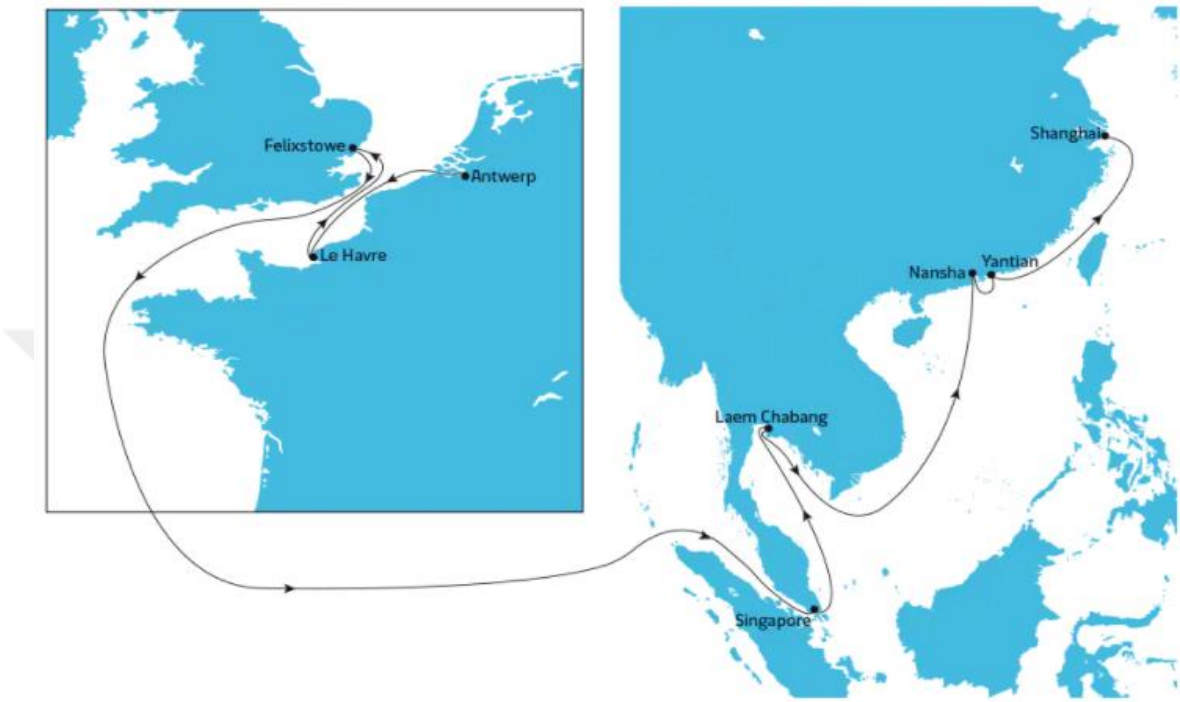


Source: Zhou et al., 2020: 4.

Rodrigue (2017) indicates pendulum services are ordinary in Asia-Europe traffic, as can be seen in Figure 20. It is an illustration of the eastbound Europe-Far East service of Maersk, which is planned totake 44 days within eight ports from Antwerp to Shanghai (www.maersk.com). This figure is a classic example of this route and characteristics of services are fairly similar. Therefore, Gibraltar, Suez, and Malacca are to be used in Europe-Asia traffic in both directions. Alternatively, closure of Suez proved that Cape of Good Hope is still usable and away from today's maritime risks although its usage concludes in high time and fuel consumption. *Transatlantic route*, which has massive vessel traffic (Stopford, 2009: 368), is between North Europe and North America (ICS, 2011: 11). The westbound dominant route had 7.4

m. TEU traffic in 2020 (UNCTAD, 2020: 15) with 49 (17 services between North America and Mediterranean) direct services (www.worldshipping.org).

Figure 20: An Example of Service in Far East-Europe Route



Source: www.maersk.com.

The figure below is one of the actual services of MSC. This route provides high-degree coverage of Northwest coast ports of America. The shortest network of this service is between Charleston and Antwerp (10 days). However, due to a number of port calls, transit time from Veracruz to Le Havre takes 32 days (www.msc.com) with 13 knots speed (Stopford, 2009: 357). Transatlantic not only provides maritime accessibility for Northwest coast of Europe but almost midcontinent is reachable via ships by courtesy of Rhine and Elbe rivers. Furthermore, Northeast coast of Europe, Russia, and Scandinavia have accessibility to Transatlantic routes through Nordic Seas, Baltic Sea, and Danish Strait (Stopford, 2020: 358 – 359). The other primary routes are listed by World Shipping Council in 2017 as Asia-Middle East (4.7m. TEU), Asia-East Coast South America (2m. TEU), North Europe/Mediterranean-East Coast South America (1,7 m. TEU), and North America-East Coast South America (1,25 m. TEU).

Figure 21: An Example of Service in Transatlantic



Source: www.msc.com.

2.4.4. Secondary Maritime Trade Routes

The secondary routes, which carry 60% of container cargo (UNCTAD, 2019: 12) are the networks linking secondary markets that have smaller sizes (www.porteconomicsmanagement.org). Secondary routes are served with relatively small size ships owing to their limited trade flows. These routes are demand-dependent and highly competitive. Thus, freight rates must quickly be adopted to the volatile and vulnerable environment (Kutin et al, 2018: 3 – 5). Secondary routes comprise non-mainlane East-West, North-South, South-South, and interregional traffic (UNCTAD, 2020: 15). The circulation also involves Intra-Asia trade that accounts as big as Transpacific because economies of Asian countries are driven by both raw materials and consumer goods exchanging Intra-Asia (ICS, 2011: 12). Together with, developing economies are included in secondary routes (UNCTAD, 2019: 12). In this way, investments on these countries, decisions on which sectors to be developed in these countries, financial power of these countries, and regional

political tension are indicators for cargo traffic within secondary routes (UNCTAD, 2020: 14 – 15).

2.4.5. Future of Maritime Trade Routes

The world has encountered several political, commercial, and social troubles i.e., Brexit, trade wars, COVID-19, and the container crisis whose results of each decelerate global trade. As a cumulative result of these cases, global trade has decelerated. Nevertheless, global trade is expected to show quick recovery and continue growing, containerized cargo flows are naturally expected to expand as well (www.helenicshippingnews.com). On the other hand, environmental regulations about mandatory lower sulfur levels in bunkers dictated by IMO will let the shipping industry become decarbonized (Rodrigue in OECD/ITF, 2019). Possible saturation of globalization will oblige trade pattern to be remolded although during these political, commercial, and social troubles it was reshaped. The novel patterns will require shipping industry to supply big data-oriented operational value (www.helenicshippingnews.com). The shipowner considers absolute demand instead of anticipation. The pure demand centricity cause vessels to create value for shipping companies within just 36 percent of her voyage time averagely. The coboundary ratio is spent at the port and in ballast navigation, which means a monumental inefficiency (KPMH, 2018: 10). In addition, there is an overcapacity problem in the sector, hence companies have no chance to transfer the extra costs of using fuel oil with lower sulfur level. These enormous additional costs of huge fleets remind Hanjin-like ends for some liner operators (Rodrigue in OECD/ITF, 2019). Along with the profitability of route, optimal solution for voyage and fleet within a route will be vital ever before as it produces energy efficiency and lowers GHG (www.helenicshippingnews.com). A convincible clarification is to benefit from big data analytics and artificial intelligence in anticipating most profitable and feasible shipping routes. Within this context, blockchain technology that embodies all data and system information plays main stem role in finding remunerative shipping routes thereby using all available information related to routes and customers (KPMH, 2018: 10).

In other respect, digitalization that will probably mutate shipping industry (Rodrigue in OECD/ITF, 2019) expedites robot usage in every step of life in exactly same way as manufacturing. As long as robots substitute labor, the popularity of labor-intensive low-cost countries will fractionally diminish in manufacturing. The

production will be desired to handle closer to end-users. This situation will hit shipping because the demand for long-haul trans-ocean routes will decrease. In this way, the digitally changed trade patterns will indicate the flow, shape, and direction of shipping routes to change sharply (www.helenicshippingnews.com). The shrinking demand for long distances will likely force shipping companies to enlarge operation extents and change operation characteristics. These extents may even cover customer-to-customer services on land to contest for company's position in the global supply chain because shipping companies will probably act as logistics service providers (KPMG, 2018: 22). Liner companies rarely have direct contact with their actual customers. The outsourced logistics service providers were contributing to economies of scale dramatically. In near future, it is probable that the shipping lines understand the needs and requirements to create and deliver value for their actual customers (Rodrigue in OECD/ITF, 2019).

Another critical issue about future of trade routes is Arctic Shipping Routes. Despite some finds ASR unrealistic and inapplicable, after IMO sulfur emissions regulation and after increasing number of investments on the region, ASR came to the agenda. Because shipping lines must decrease fuel consumption for both reasons of bunker costs and GHG. The distance, which is much shorter via ASR in comparison with other alternatives, is the initial item for reducing costs and pollution.

2.4.6. Arctic Shipping Routes

Arctic Region is the junction of three continents in the north hemisphere. These continents are connected to each other via icebound Arctic Ocean (Zhao et al., 2016: 50). However, due to global warming Arctic ice has been becoming water for several years (Shyu and Ding, 2016: 1262; Zhao et al., 2016: 50; Wan et al., 2021: 1.). Because overall temperature of the Arctic Region increases faster than rest of the world, ASR (Boylan, 2021: 1), which is the shortcut for maritime transportation, have become open for commercial shipping. Nowadays, some sections of ASR are seasonally open, but, except in wintertime, it is expected ASR to be ice-free before mid-century (Zhao et al., 2016: 50).

Arctic region has big commercial potential (Beveridge et al., 2016: 404) for energy resources, tourism, and shipping. Those routes are still a table project for three-four of a year in terms of hinterland-based shipping, ASR may strongly be able to provide destinational shipping and inter-regional transits in years (Boylan, 2021: 1).

Even though new and non-well-constructed mold have risks and uncertainties, being first out of the box create competitive advantage (Shyu and Ding, 2016: 1261 – 1262). In spite of that, ASR are far away from a standard infrastructure, investment, cooperation, and predictability concern. In the next sections, ASR are explained in detail with all their parts.

2.4.6.1. Main Characteristics of Arctic Shipping Routes

Suez Canal Route (SCR) connecting main trade centers of Asia and Europe (Shyu and Ding, 2016: 1262) through Red Sea and Mediterranean Sea. SCR carries 12% of total cargo and 30% of containerized cargo. It hosted a total of 19.000 vessels, corresponding to 50 vessels/day, in 2020. In March 2021, it was seen that this huge capacity would not be hung by a hair. Hence, in Ever Given Case, total loss of world trade was more than $60 b. This was only a measurable part of damage. What's more, supply chains and networks are disrupted due to lack of a B plan. The only alternative is to make a circuit on Cape of Good Hope with an extra $500.000 costs on average per vessel (Guo et al., 2022: 1 – 2). In this exact situation, Russian and Chinese authorities highlighted NSR's viability as an alternative to SCR.

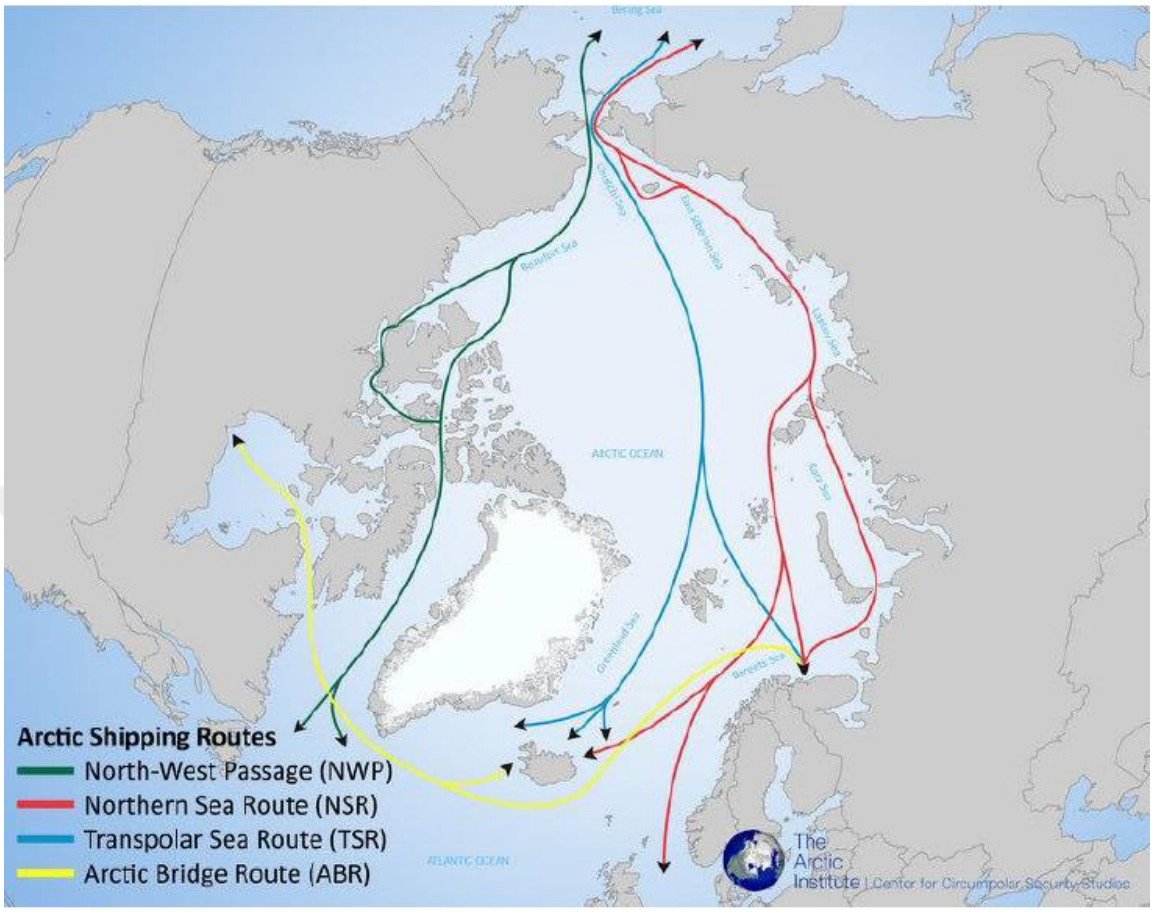
ASR generate enormous savings in terms of distance, fuel costs, and transit time; provide a chance to bypass congestion and piracy risks in comparison with Suez, Panama, and Cape of Good Hope. Besides, more than liner shipping, bulk shipping, tourism, and fishing are active in ASR (Zhao et al., 2016: 50). There are some other examples for the vessels navigating through Arctic. Although Russian vessels have employed NSR during the last century, a Finnish tanker is the first international commercial vessel completing its voyage using the route between Murmansk to Bering Strait in 1997 (Guo et al., 2022: 2 – 3; Meng et al., 2017: 16 – 17; Wan et al., 2021: 1). In 2009, two German cargo ships navigated between Korea and Rotterdam. Then, transits between 2010 and 2014 gradually increased and reached 50-70 commercial shipments (Guo et al., 2022: 2 – 3; Meng et al., 2017: 16 – 17) with 10 m. tons total shipments according to Russian Authorities (Guo et al., 2022: 2 – 3). Most of the recorded vessels were tankers, bulk carriers, reefer vessels, general cargo vessels, ferries, and research vessels (Zhao et al., 2016: 51). Next year a Norwegian vessel arrived in China. COSCO, by starting to send its first vessel in 2013, planned to have 36 transits by end of the 2018 (Meng et al., 2017: 16 – 17). Nevertheless, the year-round navigability of Arctic Ocean is still unpredictable due to

unstable ice conditions (Hansen et al., 2016: 14). The shipment volume through NSR has been gradually increasing (Ho, 2010: 714) but ice-condition in the Canadian Arctic remains volatile. The straights and passages on the north coasts of Canada stay being ice-covered most of the year (Hansen et al., 2016: 14). The estimations show that completely ice-free navigation on NSR can realize by the summer season of 2025 while Trans-polar navigation is expected to be open for transits by summer seasons of the 2040s (Kiiski, 2017: 77; Ho, 2010: 714).

ASR consists of four major routes: Northern Sea Routes (NSR), Northwest Passage (NWP), Arctic Bridge, and Transpolar Sea Route (TSR) (Figure 22). First two routes are accepted as main passages because they have enormous ice melts and have higher commercial shipping opportunities compared to other parts of the Arctic Ocean (Zhao et al., 2016: 50; Wan et al., 2021: 1).

NSR is represented with the red line in the figure below. As an alternative way of escaping from Suez Canal congestion with a shorter distance, it prolongs along the Siberian coast from Bering Strait to North-East Europe coast (Hansen et al., 2016: 10; Zhao et al., 2016: 50). In NSR, there are five major seas as Barents, Kara, Laptev, East Siberian, and Chukchi seas between north coasts of Russia and Europe (Liu and Kronbak, 2010: 435; Hansen et al., 2016: 11). For these days, NSR's competitiveness is ambiguous and unsustainable because of seasonality, uncertainties, and risks. Also, NSR's alternative, Suez, connects two main centers of trade. In this way, mega-vessels are employed for shipments from and to Asia and North Europe. Hence, NSR will take large and small pieces from the enormous shipment volume. That is the major factor for NSR being a viable alternative (Zhao et al., 2016: 51). Another reason for NSR to be on the scene, Russia has absolute sovereignty, and provides navigational support and short-term estimations of ice thickness. Moreover, Russia established a strategy of constructing NSR-connected railway infrastructure by 2030 (Wan et al., 2021: 1). NWP, which is illustrated with the green line in the figure, covers the northern coast of Canada and Alaska (Zhao et al., 2016: 50). NWP, which decease 20-30% of the distance, is also considered as a substitute of the Panama Canal (Hansen et al., 2016: 14 – 15). In NWP, first commercial vessel is a bulk carrier passing through in 2008 (Meng et al., 2017: 17). Although NWP is the second Arctic route with high potential to be settled, NWP faces fewer commercial shipping activities because waterways, weather conditions, and disputes of countries are not as clear as NSR (Wan et al., 2021: 1). In this way, NWP provides less steady status than NSR for shipping industry (Hansen et al., 2016: 14 – 15).

Figure 22: Four Main Arctic Shipping Routes



Source: Humpert and Raspotnik, 2012: 11.

TSR is the shortest diagonal line (Kiiski, 2017: 36) and a hypothetic route passing through the center of the Arctic Ocean by Greenland (Guo et al., 2022: 2), where China has huge infrastructure and iron ore pit investments. It is expected to be opened maybe several decades later. However, it is well-known that the routing of TSR has major hydrocarbon resources, and this situation will make economic activities increase (Humpert and Raspotnik, 2012:10). Last, Arctic Bridge Route (ABR), which is represented with the yellow line in the figure and connects North-Easetern Europe to Canadian industrial zones, is still questioned.

NSR significantly reduces the total distances for the shipments between Asia and Europe. The decrease in distance saves approximately 40% fuel and 50-80% emissions levels (Aksenov et al., 2017: 300). In tests, NSR, compared to Cape of Good Hope, provides almost an 8000 nm. shorter distance (Aksenov et al., 2017: 301; Zhao et al., 2016: 50) while compared to Suez, 4200 nm. shorter distance from

Yokohama to London (Figure 23) (Shyu and Ding, 2016: 1262; Aksenov et al., 2017: 301; Zhao et al., 2016: 50).

Table 7: Yearly Accessibility Expectation of Arctic Shipping Routes on Summer Period

Route	Length (km)	Accessibility (2000-2014)	Accessibility (2045-2059)
NWP	9,324	63%	82%
NSR	5,169	86%	100%
TSR	6,960	64%	100%
ABR	7,135	100%	100%

Source: Humpert and Raspotnik, 2012: 288.

Figure 23: Comparison of NSR and Suez Canal Route for Liner Shipping



Source: Wan et al., 2021: 3.

Table 8 shows distance comparisons of different shipping routes (in nm) for the shipments from several ports of origin located in Asia to North Europe. Alternative routes include the Cape of Good Hope, the Suez Canal Route, and Arctic Shipping Routes. Arctic routes have a spectacular advantage for the shipments from Japan such as Yokohama Port, Tokyo Port, etc., and Korean ports. In addition, Eastern Chinese ports like Shanghai and Taiwanese ports have exact distance savings when

NSR is used. Even though southern China provides less advantage than eastern side, the ports located in south give rise to a 15-20% distance reduction. However, ports around the Strait of Malacca point out Suez Canal Route for the shipments from Asia to North Europe.

Table 8: Distance between Asia and Europe by Different Routes

Port of Origin	**Port of Destination**	**Distance (nm)**			**Savings compared to Cape**	**Savings compared to Suez**
		via Cape	*via Suez*	*via ASR*		
Tokyo	Rotterdam	14,442	11,122	6,600	-54%	-39%
Busan	Rotterdam	14,084	10,827	7,248	-48%	-33%
Shanghai	Rotterdam	13,796	10,532	7,688	-44%	-27%
Hong-Kong	Rotterdam	13,014	9,748	8,390	-35%	-14%
Singapore	Rotterdam	11543	8,343	9,731	-15%	+16%

Source: www.sea-distances.org; Hansen et al., 2016: 27; Humpert and Raspotnik, 2012: 291 – 292.

In another test calculating per container costs, it was compared five alternatives. Those alternatives include shipment by SCR, NSR, Trans-Siberian railway, air, and combinations of sea and air. Results show that, by neglecting unexpected cases and congestion, SCR still exploits the advantage of economies of scale while NSR shares the second-best option pot with the railway (Shyu and Ding, 2016: 1262 – 1263). Shorter distance means having the chance to make more trips per year, increase efficiency, and exploit slow steam. Synonymously, it means ASR raise revenue and reduce costs (Humpert and Raspotnik, 2012:10).

Even if ASR have become integrated into global trade, regional development requires huge investments and a time horizon. Therefore, ASR take additional capacities of other routes, rather than being a direct rival (Humpert and Raspotnik, 2012:10). An icebreaker escort is still a must for Arctic voyages, but the reality shows that global warming in the region is acceleratedly continuing higher than environmental projections. Therefore, in summer periods from 4 to 6 months, escort

requirements seem will not be a matter of the NSR by the 2030s and of the NWP by the 2040s (Boylan, 2021: 1).

2.4.6.2. Environmental Perspective of Using Arctic Shipping Routes and Future Scenarios

The Arctic environment's warming rate doubles other areas and conceding to a dramatic decrease in ice surface and volume (Hansen et al., 2016: 22). Normally, most ice melts have occurred during summertime. The decrease in ice covers in September is two times higher than in March. Even if ice covers do not disappear, their thicknesses become thinner (Kiiski, 2017: 76 – 77). Besides, the region growingly takes solar radiation. The absorption of radiation increases Arctic temperature and ice losses (Hansen et al., 2016: 22).

2.4.6.2.1. Air, Water, and Noise Pollution in the Arctic Region

Carbon emissions are the initial factor of warming (Ghosh and Ruby, 2015: 177). Air and sea emissions are produced from vessel engines in the form of exhaust gas. The combustion engines work by mixing air and fuel. In mixing, engines take a huge amount of air, burn fuel, and release emissions as almost the same amount of air taken (Lindstad et al., 2016: 25). Growing transportation activities in the Arctic region trigger more emissions; and in addition to carbon dioxide and black carbon, Arctic atmosphere is expected to be exposed to other hazardous gases such carbon monoxide, organic carbon, sulfur oxides, and nitrogen oxides (Lindstad et al., 2016: 25; Hansen et al., 2016: 16; Ghosh and Ruby, 2015: 177). Among these gases, carbon dioxide holds on to the atmosphere for a few centuries while black carbon stays for a few weeks, Black carbon is a more powerful pollutant than carbon dioxide. Although it stays in the atmosphere short time, it is the second crucial cause of global warming (Ghosh and Ruby, 2015: 177; Kiiski, 2017: 79 – 80). The released carbon dioxide and sulfur oxide depend on fuel type. Nitrogen oxide is the function of fuel content and engine technology while black carbon is related to defective burning of fuel at low power. A misintelligence is that vessels will produce fewer emissions at lowest power. The fact that combustion engines release the lowest emissions at an optimum point between medium and highest power. In the International Convention for the Prevention of Pollution from Ships (MARPOL), carbon dioxide, nitrogen oxide,

and sulfur dioxide are regulated but black carbon and engine power-based emissions classification are neglected (Lindstad et al., 2016: 25 – 26). Nonetheless, the novel heavy fuel oil (HFO) ban is not only a matter of oil spill and sludge but also an effective way of fighting black carbon, because black carbon emissions can be filtered in low-sulfur fuels with an additional kit (Ghosh and Ruby, 2015: 177). The albedo directly reflects sunlight to the atmosphere. However, harmful gases keep the light within the region and decrease strength of the reflection. Hence, emissions in the Arctic are tremendously hazardous compared to emissions in other places (Hansen et al., 2016: 16). The exposed emissions levels differ region by region in the Arctic. The sea ice conditions, radiation, and optical cover of the atmosphere thusly differ. The difference creates imbalances in stocked black carbon within the Arctic. The more stocks imply the more fragile atmospheric opticity and higher temperature (Lindstad et al., 2016: 25 – 26).

Oil pollution is the presider risk for Arctic nature (Ghosh and Ruby, 2015: 174). The Arctic has a vulnerable environment and awkward recovery structure for oil spills (Ivanova, 2016: 1). Increasing traffic has the meaning of transporting million tons of petroleum and its derivatives. In case of oil spill, support and procedures for clean-up are quite limited. The environment is harsh, ecosystem is fragile, equipment to be working in the ice is riddle, and visibility is dusky for six months. Under these circumstances, the chance of performing successful operation is 1-5% utmost (Ghosh and Ruby, 2015: 174). That was experienced on 11 November 2007. A storm hit the region, several ships were damaged and sank, an HFO-loaded ship was fallen apart, oil was spilled into the water and coast, and numerous birds, fish, and species were lost (Ivanova, 2016: 1 – 2). Another example is the Exxon Valdez accident near Alaska in 1989. Millions of species died, and oil residuals were still detected around accident area even after fourteen years (Hansen et al., 2016: 16). These show risk of oil spills, difficulties of eliminating spilled oil, and the requirement of a functional oil spill recovery system. Even if oil spill risk cannot be fully extinguished, can be minimized with preventive actions (Ivanova, 2016: 1 – 2). Vessels' ballast operations lead millions of species' transfer from one region to another. Although it is regulated by Ballast Water Management Convention, even in regular waters it is hard to avoid damaging or transferring the habitats such as bacteria, eggs, microbes, larvae, etc. Aside from ballast waters, vessel fouling is found as a substantial reason for non-indigenous species replacements. Each passage may conclude in transferring countless of species. Imagine that equatorial species are transferred to icy waters or

vice versa. This situation either destroys or misbalances the ecology (Kiiski, 2017: 79 – 80; Ghosh and Ruby, 2015: 175 – 176). Panama and Suez Canals taught that moving from cold to warm waters cause species in ballast waters cannot survive due to osmotic trauma and sudden change in temperature. Nonetheless, waters of NSR and NWP lack salinity, that's why species in ballast water are more likely to survive. In this way, management systems and rules must be mandatory for Arctic ballast (Ghosh and Ruby, 2015: 176).

The Arctic region has an idiosyncratic noise type. A few sources of underwater noise are a movement of icecaps and marine mammals. These animals are highly responsive to noise, and the noise of commercial vessels and icebreakers may cause these mammals to displace from their homeland. Also, these mammals have practices to communicate with each other and map attacks of predators. The growing strange voices make the mammals lose their abilities (Ghosh and Ruby, 2015: 176 – 177).

2.4.6.2.2. Preventive Actions against Arctic Pollution

It is clear that Arctic environment has extremely risky conditions for vessels and ecology. Shyu and Ding (2016) indicate that because climate-suffering Arctic region is subjected not only to scientists but also policymakers, Arctic countries, and observer countries try to establish a ground. In this situation, IMO attempted to put the first brick with Polar Code in January 2017. The code coordinates and systematically imposes standard measures for companies to sail in Arctic. Polar Code, of course, has objectives to generate an environmentally friendly shipping ecosystem in the Arctic, but it is mainly to prevent risks of disastrous collisions and accidents (Shyu and Ding, 2016: 1262). The Polar Code concerning protection of vessels and environment strictly regulates oil pollution threats and safety issues in the Arctic waters. The Polar Code brought a mandatory standard for structure and machinery of vessels, operational and navigational safety, communication, and manning procedures (Ghosh and Ruby, 2015: 174). The code banning HFO usage for the vessels to sail through Arctic is a significant measure, but the code does not create a restriction or standard for the vessels carrying HFO through the Arctic (Theocharis et al., 2019: 128; Ghosh and Ruby, 2015: 174 – 175). The dilemma is whether the oil spill potential of HFO-burning vessels is higher than low-sulfur fuel burning but HFO-carrying vessels. Last, Polar Code only gives recommendations for the vessels to implement standard ballast water management. The code also neglects

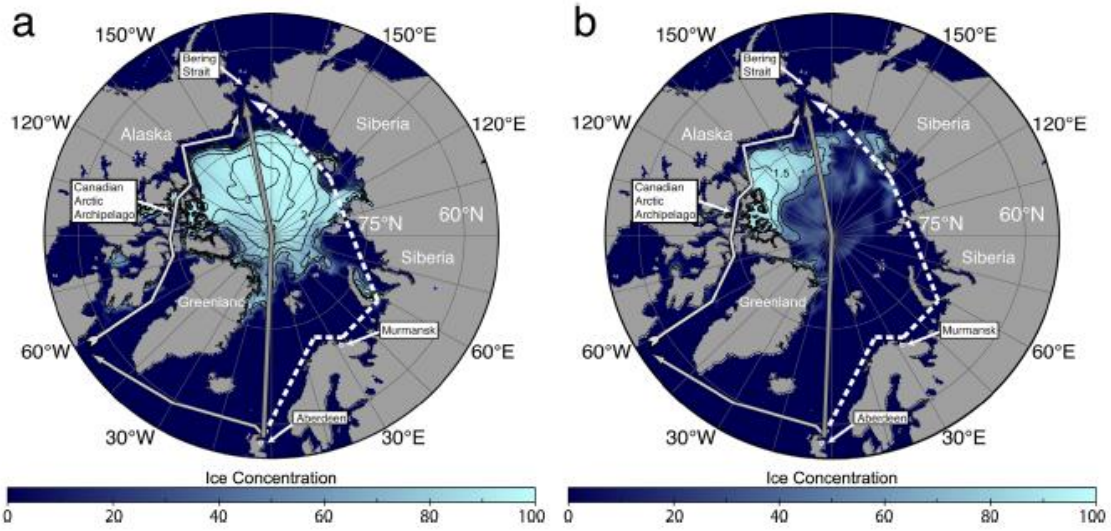
invasive microorganisms to be carried through ballast water and vessel board. It is not known how Arctic species will respond to invasive, but possibly they may not be enough immune to fight unknown items. Moreover, invasive species may damage glaciers and may accelerate the warming (Ghosh and Ruby, 2015: 176).

2.4.6.2.3. Future Scenarios

Future climate scenarios calculate the optimistic scenarios in harmony with Paris agreements and accept a global average temperature of less than 2˚C. Arctic ice will significantly decrease by the mid-century (Melia et al., 2017: 10). NASA also predicts that Arctic ice will have completely melted by 2035 in some areas and Arctic navigation will have materialized (Guo et al., 2022: 2). Another project concerning the 21st-century scenario for Arctic region foresees global temperature and rate of ice melts augment (Hansen et al., 2016: 23 – 24). According to the projections for the following decades, open water vessels can navigate at 30 to 40% of September through NSR, and Polar Class 6 vessels, which are qualified in ice with a thickness of 1.2 m and more, can navigate 90% of September. In a comparison of these two vessels, open water vessels arrive from North Europe to Yokohama in 20 days along NSR, while polar class 6 is 18 days. Otherwise, SCR takes 30 days excluding delays and congestion. Even under the best scenario (Melia et al., 2017: 10), on February, 8-34% of icecaps will diminish at the end of the century. In September, Arctic sails will probably be ice-free and open for all vessels by mid-century in the worst scenario (Hansen et al., 2016: 23 – 24). Despite that, TSR's applicability is still questioned because distributions of glaciers vary in the center of the ocean (Melia et al., 2017: 10).

Figure 24 explains sea ice thickness and concentration within years. A represents the period between 2010 and 2019, and B represents 2030 and 2039. In the figure, NSR is the dash line, NWP is the direct white line, TSR is a central dark gray arrow, and Arctic Bridge is the light gray at the bottom. The ice thickness is drawn with contours while ice concentration is with the blue tints. Also, it is indicated to create a better understanding of future navigability of ASR.

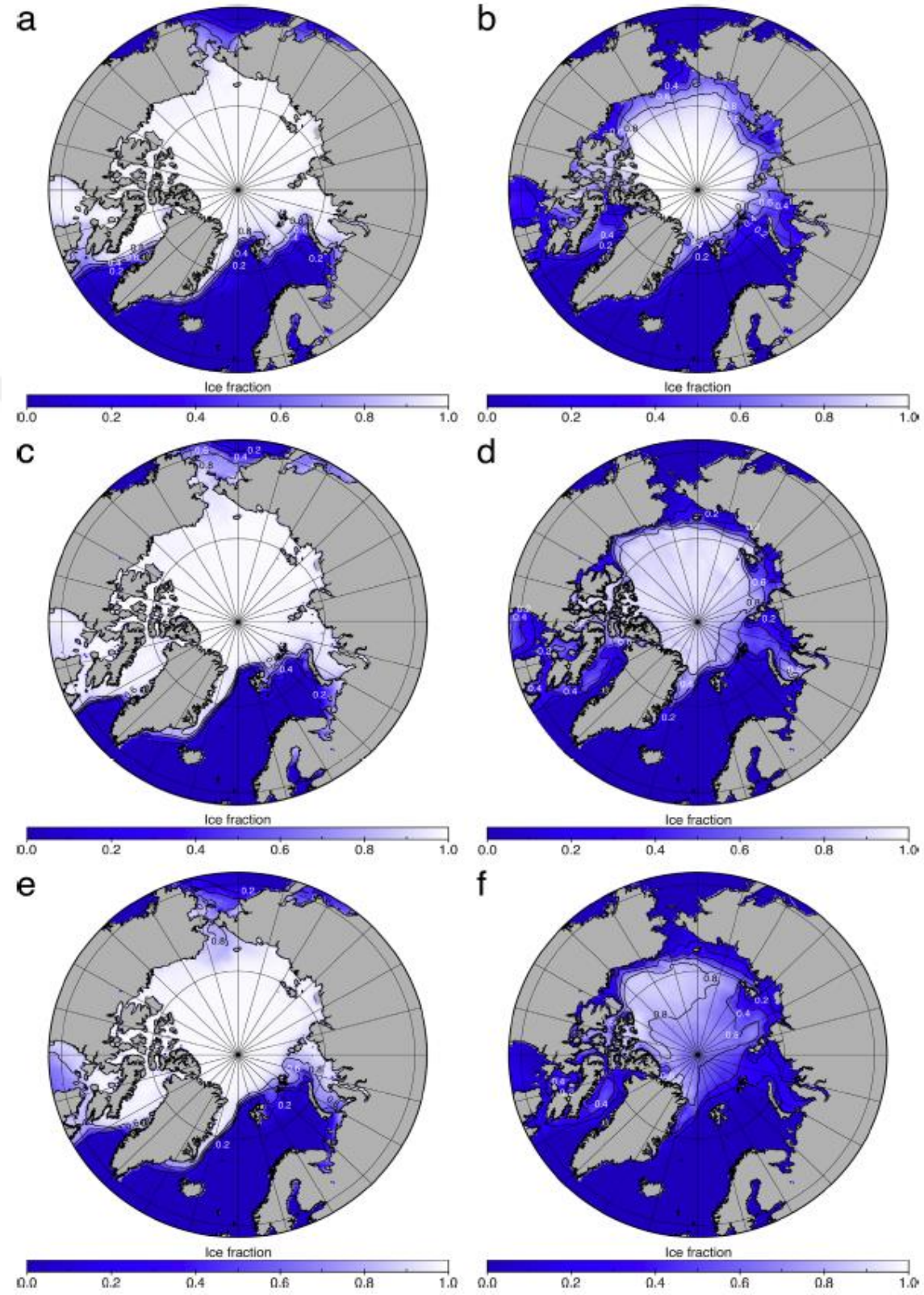
Figure 24: Sea Ice Fraction Scenarios



Source: Aksenov et al., 2017: 308.

Figure 25 models the change of sea ice in years by using past data and estimations. In the figure, the left maps represent winter from December to February and the right maps are summer season from June to August. A-B and C-D draw an average of the years between 1978 and 2005. E and F model the period between 2030 and 2039. In 1978, although there was an enormous ice cover in the Arctic, ice fraction occurred in summer period. However, after 2005 the difference between winter and summer ice levels pretty much increase. And at the period of 2030 and 2039, summer ice is expected almost completely to be disappeared. The albedo sources such as Polar regions are substantial trimmers of Earth's temperature (Lindstad et al., 2016: 26) and weather conditions and volatile ice cover is an initial problem for Arctic transits (Liu and Kronbak, 2010: 436). The observations from past data showed that from 1979 to 2012 3.8% of the glaciers melted on average, but after 2000 nearly a 10% decrease per decade has recorded (Hansen et al., 2016: 22). In 2012, Arctic faced notable resolution and 49% of the icecaps has disappeared in summertime compared to past a few years.

Figure 25. Sea Ice Fraction Scenarios



Source: Aksenov et al., 2017: 304.

It was recorded as 3.6 million km^2. Although next year ice covers slightly increased, the trend especially in summer periods indicated Arctic Ocean is irrecoverably melting. Due to thinning of the ozone layer, solar resistance of Arctic ice falters day by day and the region absorbs more heat (Lindstad et al., 2016: 25 – 26; Hansen et al., 2016: 22). Furthermore, the melting ice releases several gases caged under ice to the atmosphere. This situation creates a vicious circle for Arctic Region, and even Paris Agreement-style acts and preventions will only have postponed the wake-up alarm (Morozov, 2012: 22; Schröder et al., 2017: 400).

2.4.6.3. Potential and Viability of Arctic Shipping Routes

Liner shipping, which produces the highest potential and value for a region (UNCTAD, 2021: 13), is the busiest segment of shipping industry. It makes a major contribution to global economy along with regional ones. Container vessels navigate faster than their peers and their primary concern is to find out new methods such as economies of scale, slow steam, and structural design to diminish fuel consumption. The acceleration of ice erosion in the Arctic is deemed and perceived as an opportunity to serve with lower costs and lower transit time (Hansen et al., 2016: 26). Hence, it is excessively discussed the pros, potentials, and viability of ASR.

ASR generates higher economic benefits and flexibility in altering obligatory choices (Guo et al., 2022: 4 – 5). Distance and seasonal low-speed navigation are the most mentioned pros of ASR (Meng et al., 2017: 25; Hansen et al., 2016: 53 – 55). Slow steam obviously increases transit times. For instance, transit time between Asia and Europe is about 4 days higher than regular duration when speed is decreased from 24 to 20 km. Liner shipping companies perpetually evaluate trade-offs between higher fuel costs of fast delivery and slow steam. Faster transits provide higher service levels but higher costs while slow steam diminishes customer service but lower costs (Notteboom and Vernimmen, 2009: 335-336). When demand is not high, low-speed navigation through Arctic may be a profitable alternative. Otherwise, it must be examined, in a normal demand pattern, whether a decrease in speed leads to cost reduction for ice-strength vessels navigating through icy waters. If a vessel, even ice-classes, navigates with super slow steaming (from 12 to 15 knots) on ice-free zones of NSR, the voyage from Asia to Europe takes around 35 days. This drastically diminishes bunker costs (around 20% compared to SCR) but eliminates transit time advantage of those routes. This creates an attraction for companies to

invest in ice-strength vessels (Hansen et al., 2016: 53 – 55). On the other hand, faster vessels increase their chance of increasing annual total shipments (Guo et al., 2022: 4; Hansen et al., 2016: 55); effects are irrevocable, and renewal of effects is tremendous. Also, ASR will require re-organization and new construction of hub ports and hinterland networks (Guo et al., 2022: 4 – 5).

Sea-ice level (Tseng and Pilcher, 2017: 392) and length of navigation season are primary, and speed of Arctic navigation is the following determinants for the feasibility of ASR. These three specify the level of uncertainty, transit times, and costs. Out of those factors, the cost that is composed of higher capital cost, fuel consumption, operating cost, and fees for passages is the ultimate indicator of NSR's competitiveness. Competitiveness is further dependent to revenue elements such as dwt utilization, vessel size, and shipment volume (Meng et al., 2017: 25 – 26; Theocharis et al., 2019: 112). A viable route must be feasible first. The feasibility of ASR broadly covers the matters of bunker (Melia et al., 2017: 16 – 17), insurance premiums, passage fees, and crew costs. For NSR, insurance premiums are fully unstable (Tseng and Pilcher, 2017: 394 – 395; Theocharis et al., 2019: 119). Hull and machinery premiums are expected to increase (Ghosh and Ruby, 2015: 177) higher than protection and indemnity owing to the high damage potential of icy waters (Pruyn, 2016: 666; Meng et al., 2017: 26 – 27). Fuel costs, as a significant contributor to total costs (Melia et al., 2017: 16 – 17; Zhang et al., 2016: 244), vary from 25% to 55% depending on speed, distance, oil prices, and vessel size and type. Due to speed dependency of liner shipping, container vessels' fuel costs fill a larger portion of total costs. For ice-class vessels, higher capacity means extra weight and extra need for engine power (Meng et al., 2017: 26 – 27). Therefore, ice-strength vessels have higher bunker costs and capital costs. Navigation needs to be performed at slower speed because of additional icebreaker assistance costs (Tseng and Cullinane, 2018: 423 – 424). Icebreaker is advisable for safety and insurance issues. Icebreaker fees are arranged at maximum rates but are negotiable (Zhang et al., 2016: 246; Meng et al., 2017: 26 – 27). These rely on the ship's hull strength, gross tonnage, total escorted zones, and season. Also, ice pilots' fees are arranged as $1000 per assisted day plus to $5000 fixed price. Suez fees are also formatted according to ship type, direction, Suez tonnage of the ship, whether the vessel is cargo-loaded or not, draft, and beam by using specific drawing rights rates (Theocharis et al., 2019: 119 – 120; Meng et al., 2017: 26 – 27). In 2018, maximum rate of icebreakers was 530 rubles ($8,5 with a

USD/Ruble average of 62.9135 in 2018) per tonnage for liquid cargo (Theocharis et al., 2019: 128).

Ships are supposed to statically move into a path but zigzag around glaciers cause distance and transit time to be uncertain in fact (Meng et al., 2017: 25). Ice thickness is uncertain and that also makes average speed uncertain. From the record, product tankers' speeds on ASR vary between 5.8 and 14.4 knots from 2011 to 2018 summer periods. In this way, average speed is 10.5 knots for a tanker's Arctic voyage whereas simulations found it 11.25 knots. Both real data and simulations imply that in the conditions of 2018 summer period maximum speed of a vessel to navigate through NSR is between 14-15 knots (Theocharis et al., 2019: 119 – 120). Moreover, companies should mind communication, manning, oceanographic and ice maps, insurance, maintenance costs, and vessel supplies (Tseng and Cullinane, 2018: 424).

Literature is mainly related to the comparison of NSR and SCR in terms of commercial feasibility, distance, and transit time (Xu et al., 2018: 515). Liner shipping companies try to maximize customer service level by providing various transportation options such as door-to-door transportation, lower transit time at higher price, etc. (Notteboom, 2006: 25 – 26). Liner shipping companies strive to serve their clients with low transit time (Notteboom and Vernimmen, 2009: 335). For instance, shippers of valuable and perishable goods are ready to incur higher freight rates for minimizing transit time. Shorter transit time brings liner shipping companies a more competitive position as the sooner the ship is ready for the next shipment, the greater the opportunity cost. On the opposite way round, a delay may cause a higher cost than daily charter rate of a post-Panamax vessel. And in a worse scenario, it may even lead to supply chain disruptions (Notteboom, 2006: 26 – 28). Even though NSR provides significant distance and transit time opportunities, annually ongoing SCR is still advantageous despite navigation season lengthens from 84 days to 129 days between 1979 – 2006 (Lee and Kim, 2015: 265). Several analyses on bulk carriers, LNG and product carriers, reefer vessels, and container vessels find that ASR are not capable of container shipment in their current positions (Xu et al., 2018: 515). Total costs of ice-reinforced ships are almost 6% higher than ordinary container carriers (Hansen et al., 2016: 55) and capital costs of ice-strength vessels decrease advantage level of ASR. (Meng et al., 2017: 26; Hansen et al., 2016: 53). As mentioned before, two vessels belonging to Beluga Company passed through NSR. They were escorted with an icebreaker. The company reported it saved €300,000 per vessel compared to traditional route. Despite the apparent distance and time savings

given by NSR and NWP, there are still a number of variables to consider (Tseng and Cullinane, 2018: 423 – 424). Further, Hansen et al. (2016) reveal that an 8000 TEU open water vessel consumes 0.192 ton/nm fuel on traditional service while an ice strength 8000 TEU vessel consumes 0.118 ton/nm fuel on Arctic service with same speed level.

NSR decreases by 40% and NWP decreases by 30% distance compared to SCR. Also, NWP decreases by 20% compared to Panama route. However, analyses neglect network deficiency of ASR (Fan et al., 2012: 481). NSR is a potential alternative to SCR that hosts the largest container vessels and 13-15 m. TEU containerized cargo. NSR provides major distance reduction for the shipments from or to Tokyo, Busan, Shanghai, and Hong Kong. However, the alternativeness of NSR is not for all Asian zones. The break-even point is around South coast of Vietnam. For Singapore, distance via NSR is 1,400 nm. higher than SCR (Hansen et al., 2016: 26 – 27).

Not only distance reduction but also scheduling and accessibility should be associated to the feasibility of ASR (Hansen et al., 2016: 28). Additionally, success of a transportation operation relies on reliability, decreasing cost per unit, and eliminating uncertainties. ASR still have progresses to be made. Lack of punctuality and varying transit times are barriers for ASR to be introduced as a liner service. Size of shipment and having stable and measurable circumstances is the cornerstone for a profitable liner service (Humpert and Raspotnik, 2012: 12). Besides, bulkers can be more profitable (Wan et al., 2021: 1) because dry and liquid bulkers that pursue cargoes rather than a schedule are not time sensitive (Kiiski, 2017: 42). Even if container shipping on Arctic seems to be dependent on climate scenarios in the long run, port-to-port services between Asia and Europe, Trans-Arctic voyages for bulkers, and cabotage were overjumped for 3-4 months. In this way, ASR, somehow or other, become an alternative for global trade (Humpert and Raspotnik, 2012: 12).

Gulf of Aden and Strait of Malacca as the requisite passages for SCR face piracy threats (Tseng and Pilcher, 2017: 393), which cause extra insurance premiums. Despite the piracy peaked between 2009 – 2014, in 2015 risk reduces with the decline in oil prices. However, there are permanent risks in those regions (Theocharis et al., 2019: 113). After 2022 Russia – Ukraine war, prices of oil-related products jumped, hence it is not difficult to assume piracy risk may increase again. Meng et al. (2017) indicate Arctic voyage generates significant savings on both fuel and asset use compared to conventional voyages. From those voyages, NSR is

overrated because the characteristics of vessels using SCR do not fit into NSR (Hansen et al., 2016: 28) and draft restrictions are compelling (Meng et al., 2017: 24). However, Panama Canal has dimensional restrictions, thus those vessels passing Panama are highly likely convenient for NWP voyages that decrease distance about 15% (Hansen et al., 2016: 28).

The economic potential of ASR is not a fillet ready to eat. Geographical conditions and political issues are the hidden considerations that should be appropriately evaluated (Tseng and Cullinane, 2018: 426). Also, the advantage of these routes can be literally employed with higher demand that let the number of voyages augment. The ice level of Arctic region is critical for the demand pattern. Schedule reliability is a desired attribute for shippers as fix schedule is an indicator for the competitiveness of liner shipping companies. In open waters, there are a few natural obstacles but in the Arctic Ocean has volatile and handicapped conditions to maintain a fixed schedule. Icebreakers assist a line of vessels and vessels must abide the convoy. For that reason, uncertain conditions may originate delays (Hansen et al., 2016: 28).

Due to carbon the emission advantage of sea transportation, Norway authorities support shipping between Norwegian ports and European ports (Guo et al., 2022: 4 – 5). The second-largest economy of the world, China, whose economy is strongly dependent to international trade (Hansen et al., 2016: 29), normally seeks for more efficient ways of delivering of goods. It is estimated that 5-15% of China's shipments would navigate through NSR after 2020 and Asia – Europe traffic through NSR can reach a quarter of total traffic by increasing 6.5% per year (Beveridge et al., 2016: 404). For instance, Belt and Road Initiative (BRI) is an enormous project to connect Asia to Europe including Caucasia and Middle East. With the increasing Arctic melts (Hansen et al., 2016: 29) China adapts the BRI according to ASR, with the name of Polar Silk Road (Tillman et al., 2018: 346 – 349). China's interest is welcomed by Russia, and they improved energy and trade agreements in consideration of China's cooperation in developing transport infrastructure in the Russian Arctic (Hansen et al., 2016: 29).

2.4.6.4. Barriers for Arctic Shipping Routes

There are almost 60 straits at NSR. This number is more at NWP because Canadian north coast has a unique coastline and many islands around north coast

(Wan et al., 2021: 2). The natural prolongation of the Nordic coasts and especially ice covers restrict commercial shipping activities (Wan et al., 2021: 2). The weather conditions are not static and generate complicated navigational conditions. Ice cover in those routes implies the window of navigational season, safety, vessel speed (Wan et al., 2021: 2; Guo et al., 2022: 4 – 5), and ecological balance (Guo et al., 2022: 4 – 5), as the initial challenges of Arctic navigation. The ASR are associated with several opportunities for shipping, but harsh and blurred Arctic Ocean has some barriers for shipping (Hansen et al., 2016: 15). These are economic, technical, and legal-political barriers roughly.

2.4.6.4.1. Economic Barriers

New building prices of ice-class ships are 10 to 30% higher than those non-equipped ships (Solakivi et al., 2018: 533; Furuichi and Otsuka, 2015: 14; Lee and Kim, 2015: 265; Hansen et al., 2016: 45). Also, the difference between voyage costs of both vessel types can vary from 6.5–30% (Wan et al., 2021: 3). Ice-class vessels have different structural standards that occupy cargo capacity of vessel and diminish potential earnings of a company. This loss may reach up to 25% in (Solakivi et al., 2018: 533). One of the hidden costs, depreciation costs, which represent about 6.7% of capital investment would be huge (Furuichi and Otsuka, 2015: 13 – 14). Navigational season is limited for companies to exploit distance advantage of those routes (Lee and Kim, 2015: 266). Nonetheless, it is not cost-friendly to invest in short-order running vessels (Guy and Lasserre, 2016: 298; Lee and Kim, 2015: 266).

Operating costs of shipping in risky environments incrementally enlarge for each risk factor. Primary risks are physical, and secondaries are market risks. The physical risks translate into costs in the form of ice-reinforced vessels, cost of preparation for winter, and additional fuel consumption. The market risk for liner shipping, which tries to work in accordance with just-in-time approach, is the disruption of supply chain and profit-making qualms. A liner shipping company does not only book some slots for customers, but it also promises to provide timely delivery based on pre-determined schedules. The shipping cost per TEU, therefore becomes meaningful (Guy and Lasserre, 2016: 298 – 299) with a satisfactory shipment size (Lee and Kim, 2015: 266 – 267) by assisting with transit time, reliability, and value factors. However, skiing on the unforeseeable ocean and frozen straits behind a convoy are not schedulable. That may lead to gigantic delays that result in penalties

and a negative reputation (Guy and Lasserre, 2016: 298 – 299). Arctic freights must cover operating costs (wages, repair, and maintenance, insurance payments, administration), voyage costs (fuel costs, supplies, charges for ports, pilots, icebreakers), and capital costs (capital recovery, interest, depreciation). The way ASR becoming profitable relies on discounted icebreaker tariffs, super slow steaming applications (Tseng and Pilcher, 2017: 393 – 394; Solakivi et al., 2018: 533), and high fuel prices scenarios (Lee and Kim, 2015: 266 – 267).

An ice-class vessel's repair and maintenance expenditures such as spare parts, and lubricant costs (Furuichi and Otsuka, 2015: 15 – 16) are higher (Lee and Kim, 2015: 265), nearly 20%, than open water vessels. A regular vessel maintenance period is subjected to age of ship. For ice class ships maintenance periods are stricter and number of repair and maintenance augments according to characteristics of shipment (Hansen et al., 2016: 45). Sea ice levels vary but are a permanent component of Arctic (Guy and Lasserre, 2016: 297). Uncertain conditions of the region keep the insurer distant from assuring the vessel. To make insurers not hesitate, premiums are required to be significant. Besides, several performed transits prove Arctic navigations are insurable. In this way, insurance companies try to help development of safety issues in Arctic (Hansen et al., 2016: 45 – 46). Arctic shipping requires ice-reinforced hull structure, powerful night lights and radars, practiced crew, and equipment for frost fighting. All are the cost increasing elements and are demanded by insurance companies. Premiums are already high for Arctic shipping (Tseng and Pilcher, 2017: 393 – 394; Lee and Kim, 2015: 265) and vessels not complying with these demands are exposed to extra insurance premiums above usual fees (Guy and Lasserre, 2016: 297). For H&M and P&I, a regular insurance premium corresponds to 0.343% of the new building price per year. In Arctic navigation, it is charged $10 for each gross ton per year (Furuichi and Otsuka, 2015: 15 – 16; Hansen et al., 2016: 45 – 46). Moreover, drifting on ice requires specific manning dynamics. Experienced and skilled crews working under these hard conditions are costlier (Tseng and Pilcher, 2017: 393 – 394) and annual salary expenditure of a vessel navigating through Arctic is estimated to reach $1.2 m. on average (Hansen et al., 2016: 46). Training procedures and certification of crew require special interests and extra spendings (Lee and Kim, 2015: 267).

Fuel costs account for 30-50% of total voyage cost (Wan et al., 2021: 3). Heavy polar class vessels with larger engines and machineries need more energy to activate propulsion systems (Furuichi and Otsuka, 2015: 21 – 22; Wan et al., 2021: 3;

Tseng and Pilcher, 2017: 393), and harsh weather conditions influence consumption of polar class vessels. HFO ban within Arctic region obliges vessels to use expensive low-sulfur oil. Such that new regulation diminishes economic attraction of ASR as fuel costs may reach 50% higher than HFO (Wan et al., 2021: 3). As an extra voyage cost, there is an Arctic toll, which however does not surely exceed that of SCR toll (Guy and Lasserre, 2016: 298 – 299). ASR provide significant distance reduction (Lee and Kim, 2015: 265), but the reduction cannot be completely actualized as cost saving because icebreaker fees have substantial impact on profitability (Wan et al., 2021: 1). Icebreaker fees increase in line with tonnage of assisted vessels (Furuichi and Otsuka, 2015: 14). The capacity of vessels to navigate through ASR may grow but this situation will bring extras for voyage costs. Unless fees face a significant decrease, ASR will not be feasible (Wan et al., 2021: 3). Although icebreaker assistance is not mandatory in NSR, ice pilots are made obligatory, and icebreakers are promoted by Russia for Arctic navigations (Guy and Lasserre, 2016: 298). The vessel officers have limited experience and navigational knowledge of updated ice conditions. The ice pilots are a necessity (Furuichi and Otsuka, 2015: 14 – 15).

2.4.6.4.2. Technical Barriers

Technical barriers broadly cover navigational and vessel-specific factors, infrastructure gaps, natural factors such as weather, ice, geography, etc., and safety & security issues.

2.4.6.4.2.1. Navigational and Vessel-specific Factors

The decreasing sea ice level in the Arctic must not lead to navigational difficulties being overlooked. Environment is still cruel. Navigation, communication, and vessel-specific conditions such as ice conditions, abnormal cold, visual bottlenecks, storms (Tseng and Cullinane, 2018: 426), darkness (Ghosh and Ruby, 2015: 173; Hansen et al., 2016: 15), and mirage caused by refractions (Ghosh and Ruby, 2015: 173) must be scrutinized. Likewise, a competent draft, weather conditions, contemporary communication tools, satisfactory charts, and visibility are the key elements for sea transportation (Meng et al., 2017: 18).

Global satellite system and global positioning system (GPS) providing navigational aids and real-time information are requisite for safe and correct routing

(Tseng and Cullinane, 2018: 426). GPS cannot be widely used in Arctic due to a lack of satellite coverage (Hill et al., 2015: 71). Ice detection radar and on-time communication of the radar is vital for Arctic voyages (Tseng and Cullinane, 2018: 426). Nevertheless, communication tools such as radio and satellite in the Arctic are not reliable (Ghosh and Ruby, 2015: 173) and may not be within the global coverage completely (Tseng and Cullinane, 2018: 426). Even if satellite and radar systems are definite, there may be some technical troubles. Gyrocompass failures and losing north on the magnetic compass are obvious possibilities (Ghosh and Ruby, 2015: 173; Hill et al., 2015: 71). Failures in radar, aerial insulators, and navigational tools, malfunctioning of systems, frosty tanks and vents, limited bridge vision, and safety of crew who working on the icy ground are other potential dangers for Arctic voyages (Ghosh and Ruby, 2015: 173 – 174). Also, the technology and search and rescue (SAR) components for Arctic are considerably expensive (Tseng and Pilcher, 2017: 392 – 393). Thus, those cannot be equally provided in whole Arctic. Even though there is an agreement on developing cooperation between members of Arctic Council for SAR operations in Arctic, SAR operations are uneven within NSR. SAR along the eastern coasts is not well-regulated while in the west more than 2000 navigational supports are available in each 15 nm (Wan et al., 2021: 4).

Hydrographic charts and data are not sufficient yet (Hill et al., 2015: 71; Tseng and Cullinane, 2018: 426). Less than 10% of Arctic Ocean is charted and less than 20% is mapped to IMO standards (Ghosh and Ruby, 2015: 173 – 174; Guy and Lasserre, 2016: 297 – 298). Unmapped Arctic waters are the dangerous environments for shipping operations (Hansen et al., 2016: 15). The ever-changing nature of the region complicates establishing proper maps and charts. Lack of route maps and bathymetric maps could be eliminated by crews of vessels by processing real-time ice information, especially for floating ices. But delivering information and images cannot be possible because of weak satellite systems. This diminishes routing options within NSR (Hill et al., 2015: 72). However, Russia tries to create maps via hydrographic research, also Polar Code agrees on conveying maps and charts in the same manner as the notices (Hill et al., 2015: 72).

For NSR, in these days, regular services cannot be applied without a definite and stable ground, and icebreakers are required due to lack of appropriate ice mapping (Liu and Kronbak, 2010: 436). Apart from sea ice conditions, NSR provides beam and draft limitations (Humpert and Raspotnik, 2012: 11). Draft is limited to 13 m. along the coast, but open waters within NSR have deeper sections (Tseng and

Pilcher, 2017: 393). up to 200 m. draft (Hill et al., 2015: 72). There are a variety of serious straits and channels that are too narrow in Kara and Laptev Seas (Humpert and Raspotnik, 2012: 11; Hill et al., 2015: 72), where draft fluctuates from 12 m. to 30 m. (Humpert and Raspotnik, 2012: 11).

Figure 26: Ice Class Notations

Baltic		Polar Class	
		PC1	Year-round operation in all Polar waters
		PC2	Year-round operation in moderate multi-year ice conditions
		PC3	Year-round operation in second-year ice which may include multi-year inclusions
		PC4	Year-round operation in thick first-year ice which may include old ice inclusions
		PC5	Year-round operation in medium first-year ice which may include old ice inclusions
1.0 m first year ice	ICE-1A*	PC6	Summer/autumn operation in medium first-year ice which may include old ice inclusions
0.8 m first year ice	ICE-1A	PC7	Summer/autumn operation in thin first-year ice which may include old ice inclusions
0.6 m first year ice	ICE-1B	-PC1 to PC6 may be assigned additional notation ICEBREAKER	
0.4 m first year ice	ICE-1C		

Source: www.iacs.org.uk.

Sea ice level changes in line with climate conditions of current year. There are seven polar class vessels for different ice levels (Wan et al., 2021: 2 – 3). Although International Association of Classification Societies brought a standard for icy waters such as Baltic Sea and Arctic Ocean in 2006 (Ghosh and Ruby, 2015: 178 – 179), Polar Code brought a range of more comprehensive and mandatory standards for Arctic voyages. A vessel to be navigate through Arctic must have a Polar Ship certificate and an operational manual (Solakivi et al., 2018: 532). In Figure 26, classification of ice-resistant vessels is given. The left column is ice-class vessels, and the right is Polar Class. ICE-1A*, known as superclass, can run in heavy conditions and does not need icebreaking escort while ICE-1A needs assistance when necessary. ICE-1B can sail in moderate ice and ICE-1C does in light ice covers. In Polar Class, strength of hull is represented by numbers. PC1 means being the most

resistant vessel and PC7 is the lightest Polar Class but almost equivalent to ICE-1A*. Ice class and Polar class vessels that are invented for icy voyages (Solakivi et al., 2018: 532) have thicker structures providing an immense endurance and region-specific propulsion system (Ghosh and Ruby, 2015: 173 – 174; Liu and Kronback, 2010: 437; Tseng and Cullinane, 2018: 426) and have more powerful engines (Tseng and Pilcher, 2017: 393). Those vessels are 4-16% heavier than regular commercial vessels and can be even more than their design weight with the effect of ice in lower temperatures (Solakivi et al., 2018: 532). Icy voyage affects overall vessel design (Liu and Kronback, 2010: 437; Solakivi et al., 2018: 532). For instance, bulbed bow design is replaced with a unique bow shape. To obtain maximum maneuverability and endurance, azimuth thrusters and pitch design differ (Solakivi et al., 2018: 532). Again, more powerful vessels need protection of rudder and propeller. The insulation of bulkheads, fuel tanks, and ballast tanks is strengthened (Liu and Kronback, 2010: 437; Tseng and Pilcher, 2017: 393).

Vessels passing through ASR are needed to be ready against risky conditions, hence, they are fully equipped to struggle with them (Wan et al., 2021: 4). Alongside being ice reinforced, vessels in Arctic waters should be equipped with improved stability, enhanced communication equipment, state of art survival instruments and should be winterized. Winterization renders it possible for the ships to work in extremely cold temperatures without any failure of engine and gears, loss of equipment, and unsafe conditions for the crew (Ghosh and Ruby, 2015: 177). Open water vessels' engines are arranged in line with vessel type by considering hydrodynamic and resistance factors. The friction already infests 70-90% of total resistance, residual resistance is 10-15%, and air is about 2%. For Arctic voyages, additionally buoyancy in fresh water and ice resistance has the majority of share. Thus, operational capacity and power requirements must be strictly configured as well as hull design (Solakivi et al., 2018: 532). Further, Polar class vessels must contain protective covers for machinery, ice removal instruments and extra heaters for mooring equipment, bridge, under-deck, stairs, walkways, tanks, cargo manifolds, and hatch covers (Ghosh and Ruby, 2015: 177).

2.4.6.4.2.2. Infrastructure Gap

Polar zones are components of the earth's oceans. Vessels navigating on Polar waters need crucial navigational aids and information, hence development of

navigational and meteorological infrastructures is indispensable (Ho, 2010: 714) as well as logistical infrastructure. Shyu and Ding (2016) indicate that uncertain conditions are risky even in ice-free periods and suitable support for sea transportation can be reached with proper infrastructure.

A proper infrastructure supports commercial attraction of a hinterland (Kiiski, 2017: 47). To create commercial attraction for NSR is becoming a transportation destination, transit demands must be backed up by local markets with enough and timely shipments (Tseng and Pilcher, 2017: 392 – 393). Lack of logistics and shipping infrastructure is a substantial challenge for Arctic shipping (Hansen et al., 2016: 15). To enable Arctic shipping, a suitable infrastructure that satisfies the logistical requirements of liner companies is needed (Wan et al., 2021: 3). Shipping companies ask for infrastructure, but Kiiski (2017) says that infrastructure investments also desire mass demand (around 40 m. tons/year) to create a sustainable and both financially and operationally efficient ground (Kiiski, 2017: 46 – 47).

Transportation and port infrastructures are scarcely any, and investments for them are needed in ASR. The requirement for huge investments can be expedited with international cooperation of both Arctic countries and stakeholder countries (Melia et al., 2017: 16 – 17). The way of investments relies on the economic strength of countries and international investments. For instance, China augmented its economic relationship with Iceland and Faroe Islands. China has specified role of those countries in Arctic shipping by investing in transportation and commercial infrastructure of those countries (Humpert and Raspotnik, 2012: 11). In 2011, Putin declared a ten-year national transport plan projecting interest of Russia in NSR. He stated that Russia will establish emergency and rescue services; increase capacity of ports by 50% in 5 years; and invest around €3.4 b. to develop maritime transportation (Humpert and Raspotnik, 2012: 11).

Rail and road transportation infrastructure that support door-to-door transportation in hinterlands are inadequate in the Arctic (Wan et al., 2021: 4). Also, current Arctic ports' infrastructures and capacities pose a reliability problem for global supply chains (Hill et al., 2015: 72 – 73). As large vessels operating between east-west routes principally call at hub ports (Ducruet and Notteboom, 2015: 130), Arctic region may be a profitable transit after completing port investments. Humpert and Raspotnik (2012) define that when it is accounted the factors such as draft, spatial location, and development capacity, two ports have potential to be the future hubs in the Arctic region. First, Vopnafjörður is the entrance of the Arctic Ocean and a

strategic area of Iceland. Second is Kirkenes port of Norway (Humpert and Raspotnik, 2012: 11). On the Russian coast along NSR there are 41 ports (Wan et al., 2021: 3). However, quantity does not refer to quality (Tseng and Pilcher, 2017: 392). They are too old; their infrastructures and superstructure are not sufficient. Their capacities and handling efficiency are the main challenges for the competitiveness of the route. Water depths of manies are not fit for large ships. A few of them, like Murmansk, Tiksi, Pevek, Dudinka, etc. are relatively well equipped and have distribution systems (Hill et al., 2015: 73; Wan et al., 2021: 3 – 4; Humpert and Raspotnik, 2012: 11).

As well as transportation infrastructure, technological infrastructure is to progress, and technologies of navigation aids and positioning must be developed (Hansen et al., 2016: 16; Wan et al., 2021: 3 – 4). Although USA, Russia, Finland, Norway, Canada, and Denmark try to establish navigational infrastructure and information systems in their coastal zones to overcome technical and technological defects of ASR (Meng et al., 2017: 22), this is only hurdled with enormous investments. The absence of navigational information is a prevalent issue for shipowners and communication infrastructure is required to develop information flow and quality of navigation in NSR (Hansen et al., 2016: 16; Wan et al., 2021: 3 – 4). In addition to the aforementioned deficiencies such as navigational aids, information technologies, radars, etc., geostationary – connection systems of navigating vessels – does not work stably in ASR and at 70°N signal level falls. Hence, a novel communication method should be developed for vessels to navigate on ASR (Meng et al., 2017: 23). Voice communication is critical for ship-to-ship and shore communication (Hill et al., 2015: 73; Meng et al., 2017: 22 – 23). Considering nature of the Arctic region, an adequate communication system must contain radio transmissions and iridium satellites for voice transmission (Meng et al., 2017: 22 – 23).

2.4.6.4.2.3. Natural Factors

Some of the natural barriers are roughly clarified in previous sections. Within them, characteristics and situations of Arctic geography, Arctic ice, and weather conditions are found as main natural factors of Arctic region. In previous parts of Arctic Routes section, it is revealed that ASR stays uncertain in terms of ice condition and future navigability. Ice levels remain a major obstacle to the viability of ASR.

Arctic transits are discussed as a seasonal alternative by researchers and shipping companies (Meng et al., 2017: 20). A mutual understanding is that worsening climate conditions will cause Arctic multiyear ice to disappear during summer seasons by mid-century. This reduction creates a ground for maritime transportation to increase along ASR by diminishing risks and uncertainties (Hansen et al., 2016: 15**).** Ice erosion has been observed since the last four decades, but in last three decades, notable ice melts put the spotlight on Arctic region (Polyak et al., 2010: 1758). Also, it was recorded that summer temperature in Arctic went beyond its normal high between 2007 and 2014. This situation meant ice melts increased day by day, and at the end of 2012 summer, sea ice level in Arctic Ocean shrank to the ever-lowest rate. Cumulated effects of ice are linked to thickness (Meng et al., 2017: 18 – 21). First-year ice constitutes less threatening for navigation, compared to multiyear ice. According to the measurements of multiyear ice thickness, thickness of average Arctic ice level was 3.64 m. four decades ago and it diminished to 1.89 m. In the center of Arctic Ocean, half of the ice cap was 5 years old minimum, and a quarter of the ice cap was 9 years old minimum in 1987. More dramatically, in last two decades, less than 7% of the glaciers were 5 years old minimum and there was no ice more than 9 years old (Polyak et al., 2010: 1758; Meng et al., 2017: 18 – 21; Bourbonnais and Lasserre, 2015: 73).

Ice covers and ice conditions are essential for voyages (Meng et al., 2017: 18), becauses ea ice levels generate stopovers for ships in winter (Bourbonnais and Lasserre, 2015: 71), and in summer, floating ices are critical dangers for navigation owing to difficulties to detect them (Guy and Lasserre, 2016: 297; Tseng and Cullinane, 2018: 427). Even if those are detected, it may be late to take action (Meng et al., 2017: 23). Meltings may encourage shipping activities, but fewer ice will probably cause hull damages due to higher floating ices (Polyak et al., 2010: 1761; Meng et al., 2017: 21) with wind effect (Guy and Lasserre, 2016: 297). On Canadian coasts, annual volatility of ice covers is extraordinary (Meng et al., 2017: 18 – 19; Guy and Lasserre, 2016: 297) while Russian coasts face inter-yearly fluctuations. Because of warmer neighboring oceans, east and west sides of Russian coasts are affected more; on the contrary, center points are relatively quite colder. This uneven diffusion of ice along NSR makes navigational issues more unpredictable (Hill et al., 2015: 74; Meng et al., 2017: 18 – 19).

Apart from ice level, impractical weather conditions eventuate in more sophisticated ice conditions and unsuitable visibility (Meng et al., 2017: 23; Tseng and

Cullinane, 2018: 427). Weather conditions determine predictability of transportation in terms of transit time and operational safety. Marine transportation has the most insuperable transportation ecosystem and the most notorious one is the Arctic (Hill et al., 2015: 74). Arctic region is associated with exceptional colds (Tseng and Cullinane, 2018: 427) varying from −5°C to −35°C and even fewer (Meng et al., 2017: 21), and even summer seasons are still cold, particularly at the center of the Arctic. Further, the eastern part of NSR is fully open to effects of Pacific weather systems in winter. Hence, in the North Ease Siberia, temperature is warmer; winds are stronger; and summer periods are able to be stormier (Hill et al., 2015: 74 – 75).

In icy waters, with the effects of storms (Bourbonnais and Lasserre, 2015: 78) and deep waves, structure of vessels face abnormal icings and imbalanced ice masses (Meng et al., 2017: 21; Bourbonnais and Lasserre, 2015: 78). The snow attacks and gale force acutely accelerate in the Polar zones. In such remote and risky areas, navigation must be well-structured for independently moving vessels (Hill et al., 2015: 75; Meng et al., 2017: 21). The nights of North Pole are absolutely dark in semi-annual period (Tseng and Cullinane, 2018: 427). Although the length of darkness periods changes, the regions along ASR are dark for more than five months (Meng et al., 2017: 21). Besides, icy weather has potential for the intense fog to come down suddenly (Bourbonnais and Lasserre, 2015: 78; Guy and Lasserre, 2016: 297 – 298). The cumulative effects of darkness and fog increase risks by reducing visibility (Hill et al., 2015: 74 – 75; Meng et al., 2017: 21; Tseng and Cullinane, 2018: 427). And last, Polar areas have, moreover, low atmospheric pressure. All those factors define the Arctic as unhospitable (Hill et al., 2015: 75). The fact remains that Arctic geography is complex (Wan et al., 2021: 2; Meng et al., 2017: 23) and limits size of the navigating ships (Meng et al., 2017: 23) because of the narrow and shallow waters (Wan et al., 2021: 2). There are substantial draft limitations in the NWP (Guy and Lasserre, 2016: 298) and NSR (Ghosh and Ruby, 2015: 173; Guy and Lasserre, 2016: 298) despite Eastern NSR provides 50 m. depth and more (Wan et al., 2021: 2 – 3). Some of the straits along ASR allow for only around 13 m. draft levels (Meng et al., 2017: 21 – 22; Guy and Lasserre, 2016: 298; Wan et al., 2021: 2 – 3).

2.4.6.4.2.4. Safety and Security

To establish a safer shipping environment within the Arctic, the tools of international standards must be integrated. From those standards, International

Safety Management Code (ISM) of the SOLAS (Safety of Life at Sea) reflects IMO's perspective on safety. Human stays at the heart of ISM, which emphasizes the necessity of risk assessment, communication, readiness, and crew inclusion for establishing a safety culture (Guy and Lasserre, 2016: 301). By considering ISM's viewpoint, crews must also be well-trained against extraordinary coldness for both operational safety (Ghosh and Ruby, 2015: 173 – 174; Ma et al., 2021: 857; Wan et al., 2021: 3) and self-health protection (Ghosh and Ruby, 2015: 173 – 174; Tseng and Cullinane, 2018: 427). On the operation side, crews must be proficient (Ma et al., 2021: 849) with hull stress in ice, ice pilot and escort operations, stability in icy waters, and maneuvering on ice. On the health protection side, cold-fighting clothes, nutrition, and application against and in case of hypothermia must be adequate (Ghosh and Ruby, 2015: 173 – 174).

Risk assessment and management of potential risks must be disciplined via Port State Controls (PSC) (Guy and Lasserre, 2016: 301 – 302). PSC inspectors share information about a survey (Ma et al.., 2021: 856) on a common platform such as Paris memorandum of understanding (MoU), where inspectors can internationally find reports. It is practical for Arctic countries to cooperate with other MoUs to access appropriate information about a vessel before she arrives at the territorial waters. These safety standards are dictated to shipping companies through insurance companies' policies, which conform to ISM (Guy and Lasserre, 2016: 301 – 302). Insurers believe that the salvage operations cannot be handled properly, and a total loss probably happens in case of marine accidents in Arctic (Ghosh and Ruby, 2015: 177 – 178), where support services are a long way off (Hansen et al., 2016: 16; Ghosh and Ruby, 2015: 177 – 178).

Arctic challenges constitute machinery breakdowns, ice and weather damage, firefighting systems being out of order (Bourbonnais and Lasserre, 2015: 79; Ghosh and Ruby, 2015: 177), and groundings (Tseng and Cullinane, 2018: 427 – 428; Ghosh and Ruby, 2015: 177). The initial reasons of accidents are mechanical and electronic breakdowns of navigational equipment, propulsion default, and miscommunication. In other respects, polar type vessels are the best way of reducing those failures and damage possibilities (Tseng and Cullinane, 2018: 428). Weather conditions are already harsh, and before summer season ends salvage operations must be driven (Hill et al., 2015: 73). In the winter period, it may be impossible to perform not only surface but also sub-marine operations in darkness and icy conditions (Ghosh and Ruby, 2015: 177 – 178).

SAR is vital in Arctic routes (Lee and Kim, 2015: 265; Tseng and Cullinane, 2018: 427 – 428; Hansen et al., 2016: 16) as well as the others (Ghosh and Ruby, 2015: 177). Russian authorities established coordination centers organizing SAR and oil spill response operations. The centers have adequate equipment to cope with harsh conditions. However, infrastructure and institutions for salvage, repair, and maintenance are not adequately developed (Hill et al., 2015: 73 – 74). The icebreaker fleet is not sufficient to support SAR operations, in this way, context of SAR is restricted (Tseng and Cullinane, 2018: 427 – 428). Hereby, those of the safety and recovery-related technical operations are thorny and much pricier. In addition, financially and operationally, lack of logistical infrastructure influences both land support of salvage and mobility of crew in case of injury (Hill et al., 2015: 73 – 74). Therefore, Arctic Council reached SAR, oil pollution response, and scientific research agreement to cooperatively coordinate and struggle against risky environment (Boylan, 2021: 1 – 2; Ghosh and Ruby, 2015: 177).

A few years ago, IMO took the necessary action (Ma et al., 2021: 847; Guy and Lasserre, 2016: 301) by setting an extensive set of rules and, in January 2017, approved Polar Code that highlights safety issues in the Arctic (Boylan, 2021: 3; Melia et al., 2017: 16 – 17). It was published as an amendment to SOLAS and MARPOL, not as a novel convention (Guy and Lasserre, 2016: 301 – 302). Polar code, which is mandatory for commercial ships (Lee and Kim, 2015: 268) and directs Arctic governance, strictly regulates requirements for hull structure and navigational factors to ensure Arctic shipping operations are conducted safely and without any threats to ecology (Boylan, 2021: 1). Polar code for vessels navigating in polar regions intends to identify and to alleviate potential risks (Guy and Lasserre, 2016: 301). The code broadly covers ship design and propulsion, emergency routines, safety equipment, basic crew requirements (Boylan, 2021: 3 – 4; Guy and Lasserre, 2016: 301 – 302), and icy voyages (Boylan, 2021: 3 – 4). According to the code, deck officers should be trained with all details of Arctic navigation and drills may include less detail. Shipping is highly practical rather than theoretical. So, providing appropriate training is a mystery because worldwide expertise is scarce for icy waters (Guy and Lasserre, 2016: 301 – 302). Furthermore, Polar Code acts as a guide for underwriters in creating a base for insurance policies. It also develops insurability of vessels to navigate along ASR (Ma et al., 2021: 847; Boylan, 2021: 2).

2.4.6.4.3. Legal – Political Barriers

In this section, it is clarified legal and political aspects of ASR and interests of countries over the Arctic region. Because Polar Code is handled in previous section, it will not be mentioned again in this section.

2.4.6.4.3.1. Legal Aspect of the Arctic Region

The different dimensions of Arctic region and Arctic shipping were widely talked at the antecedent sections of the study. Tseng and Pilcher (2017) say that the other important matters subjected to NSR are political conflicts and legal status of Arctic Waters (Tseng and Pilcher, 2017: 395). Arctic Ocean is a frozen sea that was not legally regarded as water. However, with the increasing ice melts, legal status of the Arctic has been changing (www.climate.nasa.gov) and new debates and challenges have been coming to light in terms of sovereignty, exclusive economic zones (EEZ), international straits, territorial sea, internal waters, and contiguous zone.

A sea may be international water or under a country's jurisdiction, and the determined rules and regulations are followed by companies. A sea being under a country's jurisdiction can impose some mandatory services generating additional costs (Tseng and Pilcher, 2017: 395 – 396). The Arctic governance and legal status that should be properly adapted to minimize shipping-related risks (Guy and Lasserre, 2016: 301) have an established guide, UNCLOS (Boylan, 2021: 3; Tseng and Pilcher, 2017: 395). UNCLOS identifies that the vessels with any flag have right of innocent passage along the territorial seas. These vessels must observe regulations of coastal states (Boylan, 2021: 3). Hereafter, mandatory Russian ice pilots cannot be avoided in the NSR. Next, Guo et al (2022) indicate that UNCLOS supports participation of non-Arctic countries like China in the governance of ASR (Guo et al, 2022: 5). The relevant chapter of UNCLOS argues that in glaciers, coastal states may adopt regulations to avoid vessel-based pollution in icy waters without any discrimination. Even, these regulations extend over their EEZ in order to control climate conditions, prevent marine pollution, and protect marine environment and ecology. Although UNCLOS gives several rights to the coastal states in regulating laws and protecting ice-covered seas, it remains unclear how states can enforce those laws. Also, an absolute environmental regulation preserving ecosystems is neglected. There would

be a potential incompatibility between right of innocent passage and environmental laws of coastal states (Boylan, 2021: 3 – 4).

To exemplify the debates, NSR, where majority of ice melts have been occurring, has been discussed whether to be internal waters or territorial waters. Some also claim that NSR has a wide range of straits serving international traffic and those should be deemed as international straits (Tseng and Pilcher, 2017: 395 – 396) while as has been accepted by many (Tseng and Pilcher, 2017: 396) Russia has asserted (Beveridge et al., 2016: 404; Lee and Kim, 2015: 265; Kiiski, 2017: 72 – 73) that jurisdiction of NSR belongs to Russia (Beveridge et al., 2016: 404; Lee and Kim, 2015: 265; Tseng and Pilcher, 2017: 396) and Canada has asserted that jurisdiction of NWP belongs to Canada (Beveridge et al., 2016: 404; Guo et al, 2022: 5). These claims are still disputed by the USA and EU (Kiiski, 2017: 72 – 73; Beveridge et al., 2016: 404). USA and EU stay against for a country to privatize the polar shipping routes. They both agreed on ASR to be multilaterally regulated. Because they claim they have rights in Arctic (Guo et al, 2022: 5). For instance, Beaufort Sea, which lies northeast right Alaska and northwest Canada, is a dispute between USA and Canada. Canada asserts that the Sea is within the inclusion of its EEZ with a 200 nm distance from coastal zone, on the other side USA claims boundary of that sea lies parallel to about 200 nm distance from Alaskan coast. The dispute between these two countries is related to exploiting an additional 21,000 km^2 area (Boylan, 2021: 4).

2.4.6.4.3.2. Political Concerns in Arctic Region and Interests of Countries in the Arctic Region

A global issue, Arctic governance, covers policies on climate change, boundaries, environment, and energy (Wan et al., 2021: 4). Arctic countries have recently updated their national policies up to exploitation of the Arctic region. The policies express several strategies to obtain covetable results concerning the region (Kiiski, 2017: 72). The policies of Arctic and non-Arctic countries rely on establishing mutual understanding, the partnership of collaboration, and trust in Arctic region (Hong, 2021: 321 – 322). United Nations and Arctic Council are fundamentals of international endeavors on technological, environmental, legal, and political aspects of Arctic shipping (Boylan, 2021: 1). The Arctic Council, which supports cooperation and coordination (Kiiski, 2017: 72; Ho, 2010: 714), is the initial community addressing Arctic region with organizing characteristics without having legal enforcement

(Boylan, 2021: 3 – 4). The council's members are USA, Denmark, Finland, Sweden, Iceland, Canada, Norway, and Russia. The council has Permanent Participants that consist of six local bodies and thirteen observer states (www.arctic-council.org). The members of Council promote sustainably and environmental-friendly development of the region (Tseng and Cullinane, 2018: 426 – 427; Ho, 2010: 714; Kiiski, 2017: 72). To achieve overall objectives mechanism should work as an inclusive umbrella. Arctic issues, particularly shipping, may influence non-member stakeholders. At this point, Malacca Straits Cooperative Mechanism that involves stakeholders such as IMO, International Chamber of Shipping, etc. to deal with safety and environmental protection may be a pioneer for Arctic council (Ho, 2010: 714 – 715).

The Arctic area is strategically vital for Russia to protect geopolitical balance (Wan et al., 2021: 4). NSR and Arctic resources are strategic precedences for Russian policies because Russia is highly dependent on natural resources economically (Kiiski, 2017: 72 – 73). Russia undoubtedly has political objectives over the Arctic and is willing to develop NSR (Kiiski, 2017: 72; Guo et al, 2022: 5). This situation was ratified through Putin's declaration of their desire to make NSR a globally commercial checkpoint (Kiiski, 2017: 72). Nevertheless, Russia maintains a conflicting attitude about Arctic-related collaborations and enforces restrictions to the countries (Wan et al., 2021: 4). The vessels to pass NSR must be assisted by Russian icebreakers, and to serve in a sustainable and profitable price contains political decisions such as price and service discriminations (Tseng and Cullinane, 2018: 426). Some of the states like China may be a potential threat to Arctic ecology and Siberian peoples' interests, hence Russia is on guard against China despite their cooperation (Wan et al., 2021: 4). In other respects, with the development of sanctions on Russia after Ukraine dispute, Russia overstrides towards China, and they have made agreements on energy and NSR usage (Kiiski, 2017: 73).

Within the Arctic countries, the biggest icebreaker of Russia is 34 m. long. With this icebreaker capacity, only vessels with around 5000 TEU capacity can sail in the Arctic. However, Russia decides to invest in a bigger icebreaker with a $1.2 b. (Wan et al., 2021: 4). Canada does not have enough fleet capacity capable to serve in the Arctic (Hill et al., 2015: 74). Denmark and Norway remain their political interests in the region and have direct attention on Arctic shipping. Besides, Finland, Sweden, and Iceland look for ways to exploit Arctic resources easier in the future (Tseng and Cullinane, 2018: 426 – 427). In line with their national transportation plan, Norway expects that national shipping activities on both land and sea are going to evolve by

a total of 30% in ten years. This policy needs huge and strategic investments in road and maritime transportation. The environmental considerations are premier in this plan. As sea transportation is the most efficient means of transport in terms of cost and GHG emissions, seaports, and connections have been strategically kept developing (Guo et al., 2022: 4 – 5).

There are some disputes between non-Arctic nations and Arctic nations on the asserts about frontiers (Hill et al., 2015: 74). On the other hand, due to increasing global awareness on melting ice, cooperations in scientific research, environment, and sustainability between Arctic and non-Arctic countries remain developing (Hong, 2021: 321). The Arctic has captivated Asian countries (Kiiski, 2017: 72) and those countries articulate their strategic position toward Arctic resources and Arctic shipping (Tseng and Cullinane, 2018: 426). This appeal of Asian countries is more about economics rather than environment and security (Kiiski, 2017: 72) as NSR is worthy to establish policies and strategies for the states like China who has a strict tie with maritime trade (Hong, 2021: 323; Kiiski, 2017: 72). Japan deals with Arctic research (Kiiski, 2017: 72 – 73; Hong, 2021: 310) while South Korea that is interested in shipping provides reductions on port fees as an incentive for vessels navigating along NSR (Kiiski, 2017: 72 – 73). South Korean perspective sees Arctic as a steady way for energy supply and for maintaining their core industries such as shipbuilding, trade, and logistics. In this manner, South Korea established Arctic-related policies and made a move to cooperation with Norway and Denmark (Hong, 2021: 310 – 311). However, Arctic countries worry about that non-Arctic nations' workings at high pressure to build icebreakers and ice-reinforced ships. Because it is unclear whether either non-Arctic nations' purpose is to maintain their interests in Polar regions or to be a party of Arctic waters (Hill et al., 2015: 74).

Arctic reserves are thought to be identical to Middle East resources (Tseng and Pilcher, 2017: 395). And it takes interest of many companies and countries around the world. Non-Arctic states have no sovereignty over Arctic region, but they can control activities of the companies, which are registered in non-Arctic states like Japan, China, South Korea, etc. These states may encourage those companies by providing incentives and support. In this way, Arctic navigation can facilitate and develop (Lee and Kim, 2015: 265 – 266). The melting Arctic is found as an opportunity that gives rise to international trade and new resources by China, Japan, and South Korea (Hong, 2021: 312). China, which aspires for Arctic resources to be exploited and transported (Hong, 2021: 311 – 312), officially proposed the idea of Polar Silk

Road (PSR) in 2018 as a component of BRI (Wan et al., 2021: 4). China has now two icebreakers and Chinese shipbuilding facilities build ice class vessels on their own account (Hong, 2021: 312 – 313), but they announced operation and investment (port, road, logistics facilities, etc.) decisions on NSR. Particularly, port investments are important to make a hinterland a viable trade node. The development of the local ports of Arctic region conceives financial support of Western economies. Economic viability and political situation of the region are uncertain, hence shipping companies have a wait-and-see perspective (Wan et al., 2021: 4). Moreover, South Korea, having largest shipyards Samsung Heavy Industries, states that Samsung shipyards can meet technological gap for delivering Arctic reserves to Eastern Asia, and may build double-acting ships that have same flexibility as open water ships and same icebreaking capability as icebreakers. Japan authorities indicate that ice erosion-sourced Arctic shipping will be a strategic alternative by means of shorter distances (Hong, 2021: 312 – 313). And, Singapore and India have declared their attention to NSR to extract natural resources (Tseng and Pilcher, 2017: 396).

The interests of those countries set ground for Arctic-related cooperation. In 2009, China and Russia had a move on promoting and strengthening cooperation in the areas of shipping activities, infrastructure development, extraction and distribution of reserves, tourism, environmental measures, and scientific research. Beginning in 2012, China ad Iceland had several agreements that cover leasing of observatories in Iceland, investments in raw material extractions, and funding land operations. Also, China and Finland agreed on founding an Arctic research center, which will be jointly operated for observation and data and information exchange. The provided data and information that are mainly on climate conditions -in the same manner as the cooperation agreement between China and Norway- are related to environmental observation and navigation-like activities. In 2018, Arctic states and some observer states (China, EU, South Korea) reached an agreement to organize fishing in the Arctic Ocean from coasts to center. They decided not to use center of the Arctic Ocean for commercial fishing activities unless appropriate information on fish population within the region is acquired. The contracting parties also agreed to establish a research program to understand and monitor Arctic ecosystems. Japan, Finland, Norway, and Japan supported China’s 10,000 km. fiber optic connection project between Europe and Asia. From the Russian perspective, China and other non-Arctic states are the pivots for improvement of infrastructure and technology investments in the Arctic. Hence, Russia welcomes amplified cooperation with non-

Arctic states for energy and mineral reserves, trade, and transportation. USA is annoyed about China's strong involvement in the Arctic region Furthermore, Arctic will turn into South China Sea as a result of accelerating collaborations between China and Arctic states, stated by Mike Pompei-US Secretary of State. On the other hand, Greenland, where US military missile and early warning systems are located, is viewed as strategically crucial by the USA. Therefore, airport construction agreement between China and Greenland, in 2018, worried the USA (Hong, 2021: 324 – 329).

2.4.6.5. Arctic Shipping Routes from Sustainability Perspective

The increasing temperature and climate change are major treats for ecosystems and environment (Ho, 2010: 713; Afenyo et al., 2019: 476). As a result, Arctic ice has increasingly been melting (Afenyo et al., 2019: 476), and ASR have become a hot topic for policymakers, researchers, shipping companies, and their stakeholders in the last decade (Huang et al., 2015: 59 – 61) by following IMO official adoption of ASR and MAERSK trial voyage through NSR.

The term sustainability is a multidimensional matter including environmental, economic, and social factors. The three dimensions integratedly fall under triple bottom line approach (Fasoulis and Rafet, 2019: 1 – 3). ASR are core sustainability challenges and core examples to project triple bottom line approaches of companies. From the environmental perspective, Ho (2010) says Arctic navigation accelerates ice erosion due to GHG emissions. This situation endangers ecological balance and habitats of the region (Zhu et al., 2018: 459 – 460). Gulas et al. (2017) and Aksenov et al. (2017) clarify that Arctic environment is challenging for shipping, and there are still uncertainties about operations against accidents and oil spills. From the economic perspective, several studies such as Tseng and Pilcher (2017), Meng et al. (2017), and Pruyn (2016) indicate that ASR provide cost-efficient service under favor of shorter transit time and distance while Petrov (2016) identifies that Arctic faces environmental, economic, and social changes. Vasilyev et al. (2011) and Vylegzhanina (2017) find that social dimension of ASR are much greater than supposed. By virtue of the ever-changing nature of the region and gradually disrupting infrastructure and superstructure elements negatively affects residents. Zhu et al. (2018) argue that both local and global communities may encounter unexpected results of the increasing Arctic exploration. On the contrary, they also argue a proper environmental and operational strategy provides social welfare for residents.

The shipping industry is critical for global sustainability because shipping gets in touch with triple bottom line components by its nature. It generates negative environmental and social impacts through massive greenhouse gas (GHG) emissions while providing positive economic and social benefits with efficient and cost-effective service (Klumpp, 2018: 1 – 2). According to Zhou et al. (2022), social media posts concerning triple bottom line components unveil the emotional states of practitioners and provide better stakeholder engagement for shipping companies. As engagement levels increase, companies strengthen relationships with stakeholders (Zhou et al., 2020: 1 – 2). As a result, because stakeholders' engagement is a pathfinder for shipping companies in business strategies and decisions (Muňoz-Pascual et al., 2019: 3), in social media, shipping companies, not surprisingly, tend to share issues like eco-friendly service, sustainability, cost-efficient transportation, and corporate social responsibility, strategic decisions. One of those, Arctic shipping stimulates the nerve endings of community.

2.5. SELECTION AND CHOICE-BASED STUDIES IN TRANSPORTATION

In the last part of literature review, selection-based studies are examined. In this section carrier and route selection literature are handled. Also, transportation mode selection studies were checked and listed in Appendix 1 and 3 but are not reported in detail because they do not have an absolute tie with the aim and objectives of the study.

2.5.1. Carrier Selection

Carrier selection studies mainly target to reveal determinants in selection process and to clarify behaviors of shippers and carriers. From those studies, Coulter et al. (1989) conduct a survey to clarify carrier selection criteria. They establish five factor class with sub-factors such as transit time reliability, speed, freight rate, logbook on loss and damage, financial strength of carrier, service coverage, service quality, pricing flexibility, handling capabilities, etc. Reliability of performance is found most significant construct. and reliability of transit time, reliability of pick-up service, speed, freight rates, and insurance services are given priority respectively. Brooks (1990) explores the perceived significance levels of ocean carrier selection criteria of shippers. She performs a repeating study that was conducted in 1982 and compares

the changes within two studies. The criteria used in this study are cost, service frequency, transit time, direct service, on-time delivery, cooperation between companies, tracing availability, reputation on reliability, past data of loss and damage, quick response to claims, sales services, and advertising. From 1982 to 1989, carriers seem to develop their performance on frequency, cost, and transit time. The study conducted in 1989 indicates that transit time and door-to door transit time became having high priority. Murphy et al. (1997) find the relative significance of route selection factors, and the similarities and differences between shippers and carriers. They also actuarially compare significance of the differences. They use a Likert-based questionnaire with several factors such as reliability, equipment, pickup and delivery service, door-to-door rates, loss and damage, door-to-door transit time, pricing flexibility, schedule reliability, etc. They discuss that the difference degree between carrier and shipper is high. Results show that reliability and equipment are most important items for both groups. Lehmusvaara et al. (1999) give a decision support model in carrier selection benefiting Analytical Hierarchy Processing (AHP) and Mixed Integer Programming. The criteria (and sub-criteria) in the study are customer service (reliability, flexibility, quality, and facilities equipment), pricing and rates (basic rates, flexibility of rates), and strategic compatibility (long-term relationship, strategic fit, and continuous improvement). Reliability, strategic fit, and flexibility are found most important criteria respectively while facilities equipment, long-term relationship, and flexibility of rates are the least important. Then they give some technical restrictions in different scenarios and determine best available option. Caiwen and Yan (2007) investigate carrier selection optimization model. They argue that carrier selection is a complex process. They try to optimize the process using genetic algorithms-based simulation. Mohammaditabar and Teimoury (2008) first determine five categories from literature (customer service, cost, insurance, handling services, strategic compatibility), second, criteria are weighted using AHP technique, and last, network and amount of shipment are optimized with mixed integer programming. In AHP procedure, they compare factors relevant to carrier selection literature. In linear programming, the inputs are carrier, origin, destination, product type, number of carriers, number of markets, number and amount of products, and transit time. Wong et al. (2008) evaluate carrier selection of six different types of shippers in the scenarios of multimodal transport mode operators by using AHP method. They use fifty factors such as distance, door-to-door price, door-to-door transit time, reliability of service and transit time, distance, loss and damage frequency, flexibility, service

quality, geographical coverage, etc. They indicate that reliability of service, special preference of shipper, geographical coverage, pickup service, value of cargo, loss and damage frequency have the highest factor loadings in their categories. Lin and Yeh (2010) identify a model for network reliability of freight shipments based on optimal carrier selection. Genetic algorithm for delivery of a single type of product integrates minimum paths and optimal carrier selection by addressing network reliability. Kannan et al. (2011) use AHP to evaluate container carrier selection of Indian shippers. From the 45 criteria (low freight, pricing flexibility, responsiveness, reliability, custom clearance, safety, quality, physical facilities, equipment, geographical coverage, etc.), prices and pricing flexibility are the most significant factors. The least important are gift and compliments, online booking, and facilities. Lin and Yeh (2013) optimize selection within supply chain perspective. They benefit from genetic algorithms to optimize carrier selection. Cost and time factors are found crucial in freight shipment. Robinson et al. (2013) work on safety and quality of food supply chains. They highlight importance of risk-reducing criteria like traceability, transparency, testability, crew trainings, time, and trust. Choudhary and Shankar (2014) propose the goal programming model for minimizing costs, late deliveries, and rejected items in carrier selection that is specified with inventory lot size. Garver (2016) applies the situational choice models for carrier selection. He compares the shippers, who are willing to pay higher freight for fast deliveries, with the shippers, who are willingness lower prices for longer transit time, in normal and crisis situations. He finds there are huge differences in preferences, and the preferences are not influenced by small price discounts while it is affected by small daily-base changes in transit time for a constant price. Sramek et al. (2020) examine environmental and social responsibility issues in carrier selection. They aim to reveal the influence degree of sustainability matters on shippers' selection and perception. They perform scenario-based experiments by isolating the study from economic dimensions that have highly influences on decisions. According to the results, in long-term decisions, environmental sustainability has a more important status while social dimensions are for the short-term due to quick reaction and response generating ability of social policies.

2.5.2. Route Selection

Route selection attributes are very similar to carrier selection and transport mode selection attributes. Some are expressed differently, and as a matter of course some are evaluated from a reverse angle. The attributes of route selection used in the literature are available in Appendix 1.

From very limited publications, Hsu and Hsieh (2007) model vessel routing decisions in liner shipping. They establish the model through Pareto optimal solutions by making a trade-off between cost items. By comparing shipping (capital cost, fuel cost, and port charges) and inventory costs (cargo waiting cost and time cost), the model defines sailing frequency, routing, and vessel size optimally. They, later, perform sensitivity analysis to add effects of hub port prices and efficiency in the model. Shippers are found to be prone to select the route including hubs with lower charges and/or higher efficiency. Moon et al. (2015) compare shipping routes between Korea and Europe. The study includes both qualitative and quantitative factors. Qualitative factors are transportation service, safety, and awareness while quantitative are distance, time, and cost. They use TOPSIS in ranking competitiveness degree of the six route alternatives. According to the findings, quantitative factors have an almost equal impact on the competitiveness of routes, and qualitative factors change the rankings of routes' competitiveness. Kashiha et al. (2016) compare route selection behaviors of coastal and landlocked countries. They model impacts of geography and transportation costs on shippers' decisions with two logit models. They find significant differences between these two types of countries in terms of distance, number of borders passed, infrastructure, efficiency, connectivity, Mediterranean hub, nautical distance, volume, and value per unit. Wang and Yeo (2017) combine Fuzzy Delphi and Fuzzy ELECTRE methods for intermodal route selection. They determine five initial factors and sub-factors: cost (transportation costs, handling, and storage costs, and empty container return rate), reliability (mode connectiveness, performance of forwarder, information system), capability (load capacity, per month shipping route), time (transportation time, custom procedure time, and total transit), and security (damage and loss, lack of facility). Total cost and reliability are found most crucial by logistics companies. Woo et al. (2017) address a scenario analysis on modeling multimodal route selection of Korean exporters by using the inventory-theoretic model. They use total logistics costs, transport cost per unit, annual demand, inventory carrying cost, average transit time, and order quantity

as input variables. In that study, transit time variable is transformed into a measurable cost item. Wang et al. (2017) optimize route selection in an uncertain environment using Monte Carlo simulation. They benefit amoeba algorithm to solve problem of shortest path scenario. Shibasaki et al. (2017), different from route selection literature, focus on modeling route selection of dry bulk carriers. They create a ground to predict actual route selection based on movement logs of ships and perform an aggregated logit model to estimate shares of trade routes such as Suez Canal, Panama Canal, and Cape of Good Hope. They examine the following independent variables, inventory cost, piracy expenses, bunker, fuel consumption, interest rate, length of contract, operation day rate, and operation cost of ship in addition to dependents, share of routes, load factor, unit price, risk, vessel size, speed, and distance. Tran et al. (2017) optimize liner shipping route design. They consider environmental factors, cost, inventory, and inland shipments. Main objective of the optimization model is to minimize costs containing capital, operation, bunker, CO_2, inventory and inland or feeder costs, and port dues. Pham et al. (2018) examine effects of Panama Canal enlargement on liner route choice. Expert opinion is performed in first stage, and fuzzy set theory is integrated into TOPSIS method in second. The criteria are time, cost, reliability, and basic characteristics of route. They find transportation cost and reliability as most important. Park et al. (2019) try to identify optimum route selection by adopting Consistent Fuzzy Preference Relation technique. Both qualitative and quantitative factors are integrated. Quantitative factors are load factor, freight rates, cost involving cargo cost (equipment, stevedoring, and transportation), and operation cost (bunker, charter fees, and port dues); and qualitative factors are service scope, competitiveness within the port sequence, reliability, freight volatility, and cargo commitment. Cargo commitment is determined with highest priority. Wen et al. (2019) investigate effect of BRI on route selection between China and Europe. They consider cost, environment, reliability of transportation mode, security, transit time, and infrastructure reliability. A route utility function is created by using the factors as input. They reveal that BRI corridors are more advantageous than sea routes. The participants say infrastructure reliability is the most important factor.

CHAPTER III
METHODOLOGY

3.1. RESEARCH METHODS USED IN THE DISSERTATION

3.1.1. Social Media Content Analysis

Of the social media platforms, Twitter and LinkedIn users are more responsive to global phenomena. Besides, attaining the proficiency of users in these two platforms is easier. Therefore, it is analyzed posts from multiple channels as proposed by Altuntaş et al. (2021); and it is performed a social media analysis based upon posts and hashtags on Twitter and LinkedIn posts of shipping companies.

Twitter and LinkedIn are the first two platforms, where B2B companies prefer to be visible (Barnes et al., 2020) and where shipping companies inform stakeholders to get their insights on a decision (Wang et al. 2021: 124). Twitter is an extensive platform with 436.4 million users (Global Digital Reports, 2022) and millions of daily interactions among users (Gaye et al., 2021: 1). Hence, it provides a rich source to understand stakeholders' standings about service and decisions (Shofiya and Abidi, 2021: 2). As well as Twitter, LinkedIn is also preferred to engage with stakeholders by shipping companies (Altuntaş et al., 2021: 14). LinkedIn reached 808.4 million users at the end of 2021 according to Kepios. LinkedIn is a platform for professional networking, where more than 1 billion interactions/month occurs. 98% of marketers in B2B utilize it for content marketing. It is seen as almost three times more effective than its peers for B2B companies to establish a relationship with business partners.

In this study, a business discussion on the ShipsGo LinkedIn account has rung the bell in our minds. ShipsGo, which provides digital services for shipping companies, is a global container shipping platform. Generally, social media (SM) accounts of ShipsGo post information about routes, container shipping companies' features and developments, and global phenomena. Therefore, many liner shipping companies and their stakeholders follow and interact with this digital forwarder. When we have come across this discussion about ASR, this has let us to concern with that issue. It is illustrated in more detail in Figure 2, which explains the overall model and process map of the research.

The research question has been answered by fulfilling research objectives that provide a broad picture of stakeholders' perspectives. We have manually coded the

standings of stakeholders against ASR. Then, we cleaned and processed data using Bidirectional Encoder Representation from Transformers (BERT) algorithm. We have conducted Sentiment Analysis (SA) and Emotion Detection (ED) in Python with lexically classified data. And last, we have examined themes embedded in comments via Thematic Analysis (TA).

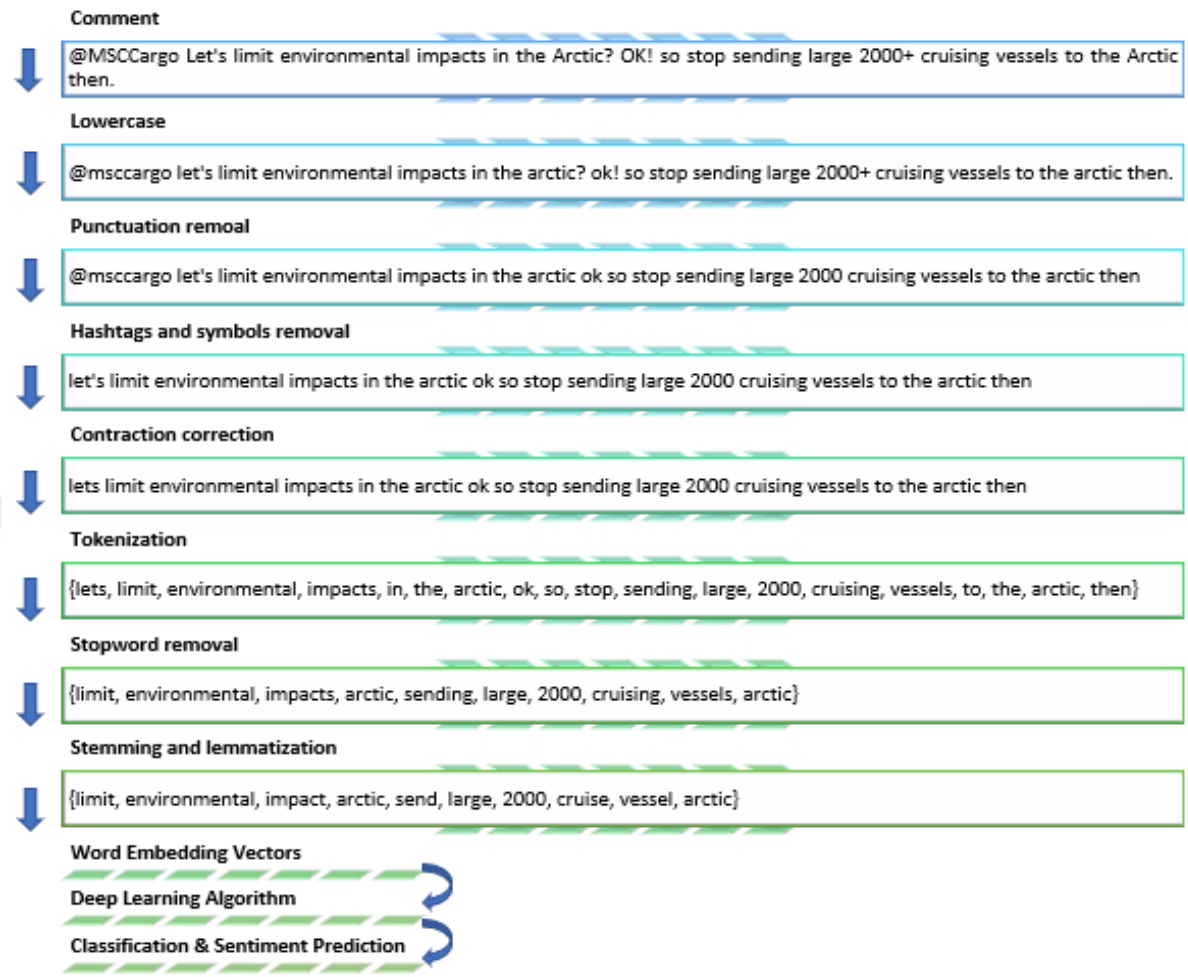
In coding dataset, we adjusted MacPhail et al. (2015)'s method to our model. For validity and reliability in the classification of stakeholders' standings and TA, the dataset has been iteratively read and evaluated within different time frames. At the end of iterations, cross-validation has been rendered with discussions on class labels, and then a final consensus has been reached. To confirm the reliability, intercoder verifications have been conducted. In coding standings of stakeholders, *Krippendorff's Alpha* is applied to intercoder reliability (ICR) of the study, in which two researchers independent from the study have been consulted. In TA, *Average Pairwise Percent Agreement* is used in coding themes.

3.1.1.1. Text Pre-Processing and Classification Using BERT Algorithm

This part of the study aims to reveal practitioners' emotional and cognitive perspectives about ASR by examining SM comments. Sentiment and ED on texts data benefits from Natural Language Processing (NLP) which incorporates lexical and computation techniques (Kusal et al., 2021: 2). Lexicon-based deep learning algorithms gain great achievements in NLP (Chiorrini et al., 2021: 2; Krommyda et al., 2021: 1 – 2).

Devlin et al. (2019) introduce BERT, a pre-trained (3.3 b. words from BookCorpus and Wikipedia) transformer encoder. They thusly prove transformer-based deep learning approaches are more successful in word model text classification. In the training procedure, transformers simultaneously use encoder and decoder mechanisms from left to right and vice versa (Devlin et al., 2019: 1 – 5). The encoder randomly reads input sentences and beclouds some words. The decoder generates predictions for beclouded words as output (Acheampong et al., 2021: 5798). What makes BERT excellent is that transformers can bidirectionally process two sentences regardless of their lengths (Pota et al., 2020: 4). Moreover, BERT has a 96% accuracy level in opinion, idea, and sentiment extraction (Acheampong et al., 2020: 2) and a 98% accuracy level in text classification on Twitter data (Başarslan and Kayaalp, 2021: 46).

Figure 27: Text Pre-processing Steps



Source: Created by author.

SM has a unique language involving informal expressions (Chiorrini et al., 2021: 2). Because it includes emojis, hashtags, misspellings, mentions, street talks, and contractions, the noisy SM jargon is needed to be cleaned by removing unnecessary items and by converting words into their root forms (Acheampong et al., 2020: 2; Gaye et al., 2021: 5 – 6). SM text to be analyzed must be uniformed to provide semantics. To obtain plain and uniform texts (Gaye et al., 2021: 5; Hazarika et al., 2020: 63 – 64), we use BERT in pre-processing, word cloud generation, and emotional classification of the dataset. In pre-processing, we adopted Kusal et al. (2021) and Pota et al. (2020)'s procedures that reduce noise and sustain accuracy performance (Figure 28).

We benefit from (1) Python TensorFlow and Pandas libraries; Natural Language ToolKit (NLTK) package; and RE (Regular Expression), BertModel,

BertTokenizer, AutoTokenizer modules for pre-processing; (2) seaborn library that provides a high-level interface for matplotlib; (3) matpilotib library that is designed and work very similar to MATLAB and (4) WordCloud package, OS and Pillow modules for the word cloud generation.

3.1.1.2. Sentiment Analysis & Emotion Detection

By enabling companies to test the perception of stakeholders on a decision (Gaye et al., 2021: 2; Nandwani and Verma, 2021: 81), SA is seen in marketing as a tool for improving relationship between stakeholders and companies (Nave et al., 2018: 69). SA broadly categorizes feelings about a certain product or service (Nandwani and Verma, 2021: 80) as positive, negative, and neutral (Krommyda et al., 2021: 1). It is an algebraic calculation (Shofiya and Abidi, 2021: 2) employing a neural network method of word embeddings that vectorizes the words into numbers (Chiorrini et al, 2021: 1-2). Sentiments can be identified with lexicon-based models (Zhou et al., 2022: 4) such as WordNet ontology or with deep learning models such as BERT or with hybridization of both models (Hazarika et al., 2020: 64). We prefer to hybridize both models via TextBlob lexical dictionary that integrates Naive Bayes Analyzer and WordNet Ontology. It is a Python library and is mainly used in sentiment analysis by exercising NLTK. As an outcome, TextBlob provides polarity and subjectivity to measure sentiment. Nemes and Kiss (2021) say polarity defines the way and strength or weakness of sentiment. It ranges between [-1,1] where -1 represents pure negative pole, 1 represents absolute positive and 0 identifies neutrality. On the other hand, subjectivity projects personal judgments rather than information-based rationality. (Nemes and Kiss, 2021: 8). After pre-processing of dataset, we use TextBlob by receiving support from Torch library and Numpy and Optim packages to reveal what the words say about stakeholders' sentiments on ASR. We analyze sentiments using polarity and subjectivity rates, regardless standings of stakeholders. According to content of posts, comments may vary, and sentiments in text may differ from their standings. Moreover, because VADER can perform better in some cases, we also checked VADER results and compared them with TextBlob.

Emotion detection (ED) is a sub-division of SA (Acheampong et al., 2020: 1) and intends to determine emotion embedded in texts (Acheampong et al., 2021: 5790). Unlike sentiment analysis, which regards generalized feelings as positive or

negative or neutral, ED not only focuses on sentiments, but also tries to identify co-occurrence of emotions (Krommyda et al., 2021: 2; Madhuri and Lakshmi, 2021: 4095). Nevertheless, owing to complex structure of SM posts, ED from a SM content is relatively difficult (Nandwani and Verma, 2021: 3; Murthy and Kumar, 2021: 1). However, machine learning and deep learning models provide more reliable and identical results (Madhuri and Lakshmi, 2021: 4096; Murthy and Kumar, 2021: 1 – 2). Krommyda et al. (2020) argue that labeling the emotions as positive or negative is not sufficient to establish a decision ground. To overcome this, Kusal et al. (2021) and Chiorrini et al. (2021) suggest deep learning algorithms are optimum way and ED from user-generated textual data.

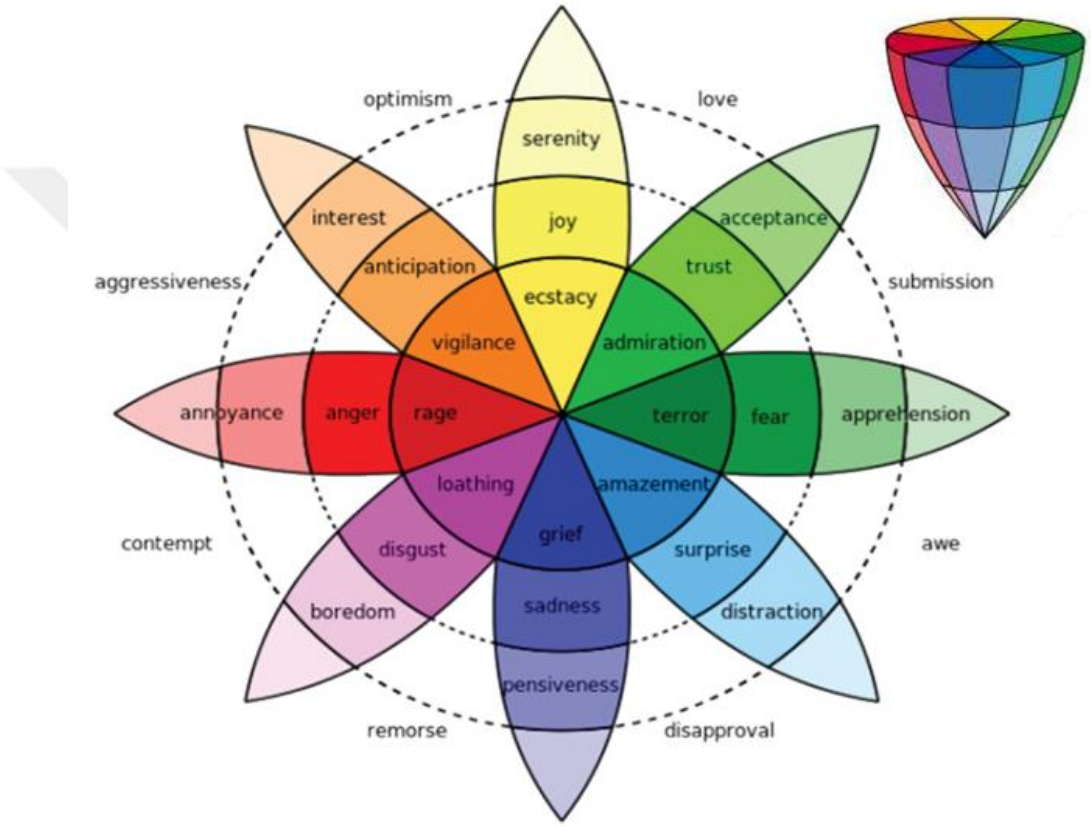
Furthermore, there are different emotion models and Landowska (2018) indicates that there is no consensus on emotion models for ED, but according to Nandwani and Verma (2021) studies generally adapt models of Paul Ekman and Robert Plutchik. In this paper, we apply Plutchik's Wheel of Emotion as proposed by Krommyda et al. (2020). Hereunder eight basic emotion classes are anger, fear, sadness, disgust, surprise, anticipation, trust, and joy. To identify emotions, we employ Pandas library, BERT-based Pytorch library as submitted by Singh et al. (2021), and PyPlutchik library as submitted by Semeraro et al. (2021). Further, we utilize scikit-learn library that vectorizes data aiding Numpy package; seaborn and matplotlib libraries.

Emotions are specific, temporary, temperamental feelings (Xu, 2010: 18); and mental models to evaluate situations (Lazaruz, 1991: 38; Smith and Ellsworth, 1985: 817). Emotions have an influence on thoughts, motivations, behaviors, and decisions (Salmeron, 2012: 3704; Nandwani and Verma, 2021: 3). Human decision-making process is under the influence of cognition and emotions in as much as their rationality (Rostomyan, 2015: 1269), and in some situations, cognition and emotions prevail other factors in decisions (Lerner et al., 2015: 33.3). Therefore, rational choice is constrained by cognition, circumstances, and emotions (Lerner et al., 2015: 33.2).

Robert Plutchik offered grouping emotions into eight basic categories. This model is highly accepted in marketing and behavioral fields (Watson and Spence, 2007: 489). Plutchik (1980) claims that cognition is the modeling of the environment by processing limited information after neural encoding in mind. This mental model gives humans the ability to estimate future events, identify needs, and customize behavior. Nevertheless, appraisal approaches to emotion neglect evolution of the brain. However cognitive abilities tend to evolve in line with emotions and further,

decisions on an event are shaped by collaboration of cognition and emotion (Plutchik, 1980: 12 – 14; Plutchik, 1982: 543 – 545; Griffiths, 1989: 298 – 300; Plutchik, 2001: 347). Besides, a few basic emotions are not sufficient to represent the language of emotions (Krommyda et al., 2021: 2-3), and multiple emotions can take place (Hofmann et al., 2020: 126).

Figure 28: Wheel of Emotions



Source: Plutchick, 2001: 349.

Plutchik (1982) visualizes the theory in a multi-dimensional model namely “Wheel of Emotions” (Figure 28). According to the wheel, “trust, joy, surprise, fear, anticipation, sadness, disgust, anger” are principal emotions and they are placed oppositely in terms of intention. In the conic figuration, the shades of each color on the vertical axis represent intensity of emotion obtained via perception of an event or phenomenon, while the horizontal axis shows similarity levels among categories (Plutchik, 2001: 348 – 350). The inner and outer layers in two-dimensional view are respectively derivatives and permutations of primary emotions (Kusal et al., 2021: 6).

3.1.1.3. Thematic Analysis

Arctic routes are wide and multidimensional issues. The stakeholders being favor or unfavor in exploitation of the Arctic region can include several cognitive perspectives. Thus, themes embedded in comments provide deep insight into how they view this phenomenon. It is flexible and convenient for coders inside or outside of research to evaluate data from different perspectives. This is the premise motives behind selecting thematic analysis in our research.

Thematic analysis (TA) is a technique for methodically and systematically discovering, categorizing, and interpreting themes embedded in the dataset (Benedict et al., 2016: 8; Norwell et al., 2017: 2). Thematic analysis defines the themes to catch customers' perception and behaviors by grounding in appraisal theory (Braun and Clark, 2006: 95 – 96). Using interpretations (Alhojailan, 2012: 41), TA unearths patterns related to data and provides a wider understanding for researchers rather than clarifying meanings in it (Chen et al., 2020: 6 – 7). Themes can be determined inductively or deductively. In the inductive method, data identifies themes research-specifically and regardless of theoretical base while in the deductive approach, according to their expectations, researchers find pre-described themes based on theory from data (Braun and Clarke, 2006: 83 – 84).

Typically, a thematic analysis involves 6 phases: Familiarization, coding, generating themes, reviewing themes, defining, and naming themes, and write-up (Benedict et al., 2016: 8). In first phase, we have iteratively read and analyzed comments one by one. Second, we have produced keywords and word patterns from dataset. The codes have been extended or adapted in every next comment. In third phase, we have generated a broad theme list. Next, the theme list has been reviewed, discussed, and reduced. In last two phases, themes have been named and reported.

The codes have been adjusted in two stages: First, identification and verification of initial codes and comparison with relevant literature. Hence, the categories of keywords have been checked from WordNet; and usage of word patterns in Arctic-based literature has been examined, as adapted from Wu and Gao (2019). In reviewing phase, themes that are not completely explicit have been excluded; and themes containing similar patterns in Arctic literature have been gathered under the same roof. For example, distance and transit time-related word patterns are associatedly used in Tseng and Pilcher (2017), Meng et al. (2017), etc. Therefore, these two categories have been united.

In accordance with Braun and Clarke (2006), we inductively address TA because inductive approach is not required to conform into a pre-described coding pattern. Also, Norwell et al. (2017) argue that it depends on scope and epistemology of study whether to use or not use TA as an independent method. Similarly, we used TA as a process that assists methodology of studies and supports arguments to tick research objectives. Arctic routes are wide and multidimensional issues. The stakeholders being favor or unfavor in exploitation of Arctic region can include several cognitive perspectives. Hence, themes embedded in comments provide deep insight about how they view this phenomenon. It is flexible and convenient for coders from or outside of research to evaluate data from different perspectives. This is the premise motives behind selecting TA in our research.

3.1.2. Multi-Criteria Decision-Making Methods

Decisions contain several processes: problem definition, determination of preferences, assessment procedure, and selection of best option. A single criterion problem is highly dependent on intuitions while multiple criteria should be evaluated in terms of weights, preferences, dependencies, relationships, and conflicts (Erdogan et al., 2019: 7; Tzeng and Huang, 2011: 1; Ramanathan et al., 2017: 22), because multiple criteria include non-identical qualitative specifications, measurement scale, and relative weighting techniques (Erdogan et al., 2019: 7). Multiple criteria problems are required more complex and sophisticated techniques. Those problems, particularly, are solved with Multiple Criteria Decision-Making (MCDM) methods (Tzeng and Huang, 2011: 1). MCDM problems show several conflicting objectives and interests, uncertainties, and a variety of perspectives (Büyüközkan and Güleryüz, 2016: 437). MCDM, which combines outcomes of alternatives across a variety of contradictory criteria resulting in a solution that requires to be agreed on (Khan et al., 2018: 5), facilitates the decision-makers to identify the most appropriate solution for decision problems in terms of their requirements and preferences (Ramanathan et al., 2017: 22; Khan et al., 2018: 5; Büyüközkan and Güleryüz, 2016: 437).

MCDM are classified as Multi-Attribute Decision-Making (MADM) and Multi-Objective Decision-Making (MODM). The main difference between MADM and MODM is the characteristics of data type and alternatives. MADM has a finite number of alternatives while MODM has infinite and continuous sets (Tzeng and Huang, 2011: 1; Ramanathan et al., 2017: 24 – 25). MADM techniques cover the majority of the

approaches such as utility-based (Utility theory, Multi-Attribute Utility Theory, AHP, ANP, etc.), outranking approaches (ELECTRE, PROMETHEE, DEMATEL, etc.), fuzzy set, and many statistical methods such as factor analysis, principal components analysis, etc. (Ramanathan et al., 2017: 25 – 27).

A company's decision can be strategic (site location, distribution center), tactical (production, transportation inventory level), or operational level (short-term plans). All components of supply chain are core MCDM problems because they involve numerous attributes and factors, and making decisions contain many trade-offs leading ceaseless comparisons (Khan et al., 2018: 4 – 5).

3.1.2.1. DEMATEL Method

In behavioral issues and factors particularly, using DEMATEL method that has been proposed by the *Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1971 and 1976* (Zhou et al., 2014: 164) gives appropriate outcomes. People's insights and perceptions of complex problems are subjective and impressible (Tzeng and Huang, 2011: 135; Zhou et al., 2014: 164). DEMATEL is a graph theory-based technique (Gupta and Ilgin, 2018: 46; Yang and Tzeng, 2011: 1418; Tzeng and Huang, 2011: 258) for fixing and processing clear interfaced and complicated cases. It was introduced to identify complex problems (Jeng and Bailey, 2012: 1573; Tzeng and Huang, 2011: 134 – 135; Liu et al., 2020: 7) within the scope of a hierarchical form (Büyüközkan and Güleryüz, 2016: 437), inner dependencies (Zhou et al., 2014: 164) and interdependencies within criteria (Yang and Tzeng, 2011: 1418), interaction level among dimensions and criteria (Tzeng and Huang, 2011: 259 – 260; Zhou et al., 2014: 165), and casual relationships within the entire system (Jeng and Bailey, 2012: 1573; Gupta and Ilgin, 2018: 10; Tzeng and Huang, 2011: 259 – 260). The method may validate the dependency among the attributes and confine the relationship (Büyüközkan and Güleryüz, 2016: 437) that reflects the feature with a fundamental system and maturation trend, based on the concrete features of objective concerns (Tzeng and Huang, 2011: 135). The technique provides a casual scheme by using digraphs – represented with directed graphs – and by reflecting the power of the influence among criteria (Yang and Tzeng, 2011: 1418; Jeng and Bailey, 2012: 1573; Gupta and Ilgin, 2018: 10 – 11). The digraphs imply networks and relationships (Yang and Tzeng, 2011: 1418). Thus, the method that pragmatically visualizes (Tzeng and Huang, 2011: 260) can transform cause-effect relationships

within the criteria through a perceivable structural network scheme (Zhou et al., 2014: 164; Yang and Tzeng, 2011: 1418; Jeng and Bailey, 2012: 1573).

DEMATEL technique is proposed for several research areas such as safety measurement (Büyüközkan and Öztürkcan, 2010: 5836; Jeng and Bailey, 2012: 1575; Yang and Tzeng, 2011: 1418; Liou et al., 2007: 244), innovation policy (Jeng and Bailey, 2012: 1575; Yang and Tzeng, 2011: 1418), green building evaluation (Liu et al., 2020: 7), sustainable development (Büyüközkan and Güleryüz, 2016: 437; Liu et al., 2020: 7), marketing strategies and consumer behavior (Jeng and Bailey, 2012: 1575; Liou et al., 2007: 244), knowledge management, project management and selection (Büyüközkan and Öztürkcan, 2010: 5836; Jeng and Bailey, 2012: 1575), new product development, service quality, location selection (Büyüközkan and Öztürkcan, 2010: 5836), industrial planning, regional environmental assessment, and other real-world problems (Büyüközkan and Güleryüz, 2016: 437).

Table 9: DEMATEL Scale

	I	**II**	**III**	**IV**	**V**
Influence Score	0	1	2	3	4
Linguistic Term	*No Influence*	*Very Low Influence*	*Low Influence*	*High Influence*	*Very High Influence*

Source: Yang and Tzeng, 2011: 1418.

The steps to be followed in DEMATEL technique are listed below in accordance with Wang (2012), Jeng and Bailey (2012), Tzeng and Huang (2011), Gupta and Ilgin (2018), and Liu et al. (2020). In the first step, the average matrix is calculated. The direct influences among criteria are rated by participants using a scale ranging from 0 to 4 (Table 9).

The constructed matrix $\boldsymbol{T}$ is in the form of n ^{x} n obtained by pairwise comparisons of cause-effect groups. Assume there are *H* participants and *n* criteria in the study. The notation $\boldsymbol{T}_{ij}$ indicates the degree to which participants assign criterion *i* as influencing criterion *j*. If *i = j*, diagonal criteria are set to zero.

$$[a_{ij}]_{nxn} = \frac{1}{H}\sum_{k=1}^{H}[X_{ij}^{k}]_{nxn} \quad (1)$$

The scores by participants provide result matrix $\boldsymbol{X}^{k} = \left[X_{ij}^{k}\right]_{nxn}$, with $1 \leq k \leq H$. Hence, $\boldsymbol{X}^{1}$, $\boldsymbol{X}^{2}$, …$\boldsymbol{X}^{H}$ generate result matrices for each of the H participants, and each criterion of $\boldsymbol{X}^{k}$ is an integer indicated by $X_{ij}^{k}(\mathrm{Eq.}\,1)$.

In the second step, direct influence matrix is initially calculated. The average matrix $\boldsymbol{A}$ is normalized, and then initial direct influence matrix $\boldsymbol{M}$ is acquired. The normalization processes are as the following equations:

$$M = k \times A \tag{2}$$

$$k = min\left(\frac{1}{max}\sum_{\substack{j=1\\1\leq i\leq n}}^{n}\left|a_{ij}\right|, \frac{1}{max}\sum_{\substack{j=1\\1\leq j\leq n}}^{n}\left|a_{ij}\right|\right) \tag{3}$$

In the third step, sum of the rows and columns is computed to obtain a total influence matrix $\boldsymbol{T}$, which is derived in line with Equations 4 where $\boldsymbol{M}$ is normalized direct influence matrix and $\boldsymbol{I}$ represent identity of matrix.

$$T = M + M^{2} + M^{3} + \ldots = \sum_{i=1}^{\infty} M^{i} \tag{4}$$

$$T = (I - M)^{-1} \tag{5}$$

In step four, threshold value is set, and influence-digraph maps are acquired. The influence (or relationship) map can be depicted by using criteria of total influence matrix. A graph involving all criteria will be highly complex. To diminish the complexity and to make whole system manageable, threshold value is calculated, and the influence degree that is higher than threshold value is included in the influence-digraph map. Liaw et al. (2020) and Ulu and Şahin (2021) explain that in determining a relationship, D_i indicates that criterion an influence on others (directly or indirectly) while R_i expresses that one criterion is affected by other criteria. $D_i + R_i$ is identified as total influence that specifies effect degree, $D_i - R_i$ states total influence for each criterion. The influence of criterion i over others is found where $D_i - R_i$ has positive value – called as cause degree, while criterion i is influenced by others when $D_i - R_i$ has negative – called as effect degree. Peleckis (2021) explains that threshold value is used to calculate final value to be used in drawing influential network relation maps.

Threshold value is calculated by determining average value of matrix T. After threshold value was computed, the values higher than threshold value are marked, and the values lower than threshold value are marked as zero. Then, a new INRM matrix is established.

$$X = [(t_i^+)^2 + (t_i^-)^2]^{\frac{1}{2}} \quad (6)$$

$$W_i = \frac{x}{\sum_{i=1}^{n} x} \quad (7)$$

In the fifth step, influential weights can be calculated by using results of DEMATEL method, as proposed by Liaw et al. (2020), Kobryń (2017), and Ulu and Şahin (2021). In calculation, first length of horizontal and vertical vectors is acquired by using equation 6 and then normalized weights are obtained with equation 7.

3.1.2.2. Best-Worst Method

BWM assesses weights or priority degrees of different criteria. Decision-makers select two criteria, the best and the worst. The best one is assigned as the most important and the worst criteria is the least (Mahmoudi et al., 2020: 332 – 333; Sotoudeh-Anvari et al., 2018: 397; Liu et al., 2020: 9; Orji et al., 2020: 1527). Then, the best criterion is compared to others and the other criteria are compared to the worst one. In this way, an optimum value for the weights and consistency ratios can be obtained (Ghaffari et al., 2017: 299 – 300; Mahmoudi et al., 2020: 332 – 333). This method gives rise to the decision-makers regarding opinions instead of monolog comparisons (Sotoudeh-Anvari et al., 2018: 397) by using a simple linear model to optimize pairwise comparisons (Ghaffari et al., 2017: 300). Rezaei (2020) indicates that MCDM problems can be solved by BWM method with linear or non-linear modeling. Mohammadi and Rezai (2020) indicate that, from a stochastic perspective, criteria are random facts. The theory of probability says the criteria weights can be evaluated as their occurrence probability. Thus, it is practical and suitable to use stochastic modeling in research areas with highly complex structures. In these stochastic models, inputs and outputs should be interpreted as multinomial distributions. (Mohammadi and Rezai, 2020: 3 – 4). From this point, Saner (2021) discusses that Bayesian BWM may provide more reliable and accurate results in

complex problems with highly complex structures. BWM naturally provides results in linear perspective and then the Bayesian BWM with a stochastic approach can be applied to the results.

The initial advantage of BWM is it provides more consistent results with lower pairwise comparisons compared to other MCDM methods (Ahmadi et al., 2017: 101; Orji et al., 2020: 1527). BWM overcomes inconsistency problems caused by pairwise comparisons (Sotoudeh-Anvari et al., 2018: 397). Also, BWM works highly compatible in hybridization with other MCDM methods (Pamučar et al., 2020: 3). BWM is one of the best fits for real-world problems (Pamučar et al., 2020: 3; Ahmadi et al., 2017: 101). This method has several specific application areas such as sustainable material selection, green performance of airports (Liu et al., 2020: 9), energy efficiency (Ahmadi et al., 2017: 101; Pamučar et al., 2020: 3 – 4), manufacturing, transportation (Pamučar et al., 2020: 3 – 4), technological innovation (Ahmadi et al., 2017: 101; Mahmoudi et al., 2020: 334; Pamučar et al., 2020: 3 – 4), sustainable supply chain (Mahmoudi et al., 2020: 334; Pamučar et al., 2020: 3 – 4; Sotoudeh-Anvari et al., 2018: 397), supplier selection (Ahmadi et al., 2017: 101; Mahmoudi et al., 2020: 334; Sotoudeh-Anvari et al., 2018: 397), optimal line bundling, liner service configuration, risk assessment (Ahmadi et al., 2017: 101; Mahmoudi et al., 2020: 334), research and development, medical tourism development (Sotoudeh-Anvari et al., 2018: 397), transport mode selection (Ahmadi et al., 2017: 101).

The steps of BWM are clarified in detail by Rezaei (2015), Orji et al. (2020), Sotoudeh-Anvari et al. (2018), Ahmadi et al. (2017), Ghaffari et al. (2017), Mahmoudi et al. (2020) as follows:

In the first step, decision attributes are determined and finalized in line with a theoretical framework and expert validations. For the criteria n, those are expressed as $\{c_1, c_2, \ldots c_n\}$. (Orji et al., 2020: 1527; Sotoudeh-Anvari et al., 2018: 398). In the second step, the most important or desirable criteria (denoted as *Best*) and the least important or desirable criteria (denoted as *Worst*) are identified from the pre-described criteria (in first step) under dimensions or classes (Rezaei, 2015: 51; Ahmadi et al., 2017: 101).

In third and fourth steps, a decision matrix of pairwise comparisons is obtained. The comparisons are among the best criteria and the others (*Best-to-Others*), and the others and the worst criteria (*Others-to-Worst*), respectively. This step critically implies direct opinion of decision-makers about supremacy and importance level of

criteria over others. A scale from 1 to 9 is used to linguistically state decision-makers' selection (Table 8) (Orji et al., 2020: 1527 – 1528; Ghaffari et al., 2017: 299 – 300).

Table 10: Best-Worst Scaling

Rate	**1**	**3**	**5**	**7**	**9**	**2, 4, 6, 8**
Label	Equal importance	Moderate importance	Strong importance	Very strong importance	Extreme importance	Intermediate value
Description	*Equal importance*	*Moderately more important*	*Strongly more important*	*Very strongly important*	*Absolutely more important*	*Somewhat between equal and moderate importance*

Source: Rezaei, 2015: 51.

The vector of *Best-to-Others* is as follows:

$$C_B = (c_{B1}, c_{B2}, \dots, c_{Bn}) \tag{8}$$

where c_{Bj} expresses the choice of the most important criterion *B* over criterion *J* amongst the criteria pool, and $c_{BB} = 1$.

The vector of *Others-to Worst* is as follows:

$$C_W = (c_{W1}, c_{W2}, \dots, c_{Wn})^q \tag{9}$$

where c_{Wj} expresses the choice of criterion *J* over the least important criterion *W* amongst the criteria pool, and $c_{WW} = 1$ (Sotoudeh-Anvari et al., 2018: 398 – 400; Rezaei, 2015: 51 – 52).

In last step, the optimal weights are calculated $(w_1^*, w_2^*, \dots, w_n^*)$. The optimal weights of criteria are computed with the maximum absolute differences for all criterion *j* should be minimized through $\{|w_B - c_{Bj}w_j|, |w_j - c_{jW}w_W|\}$ The minmax model for the problem is formulated as shown below (Orji et al., 2020: 1528 – 1529; Sotoudeh-Anvari et al., 2018: 399 – 400; Rezaei, 2015: 51 – 52):

$$min\, max_j \left\{\left|\frac{w_B}{w_j} - c_{Bj}\right|, \left|\frac{w_j}{w_W} - c_{jW}\right|\right\} \tag{10}$$

Subject to (s.t.):

$$\sum_{j}^{s.t.} w_j = 1$$

$w_j \geq 0$, for all criterion *j*

A linear programming structure (Model 11) is utilized to formulate the model (Model 8) to be solved (Rezaei, 2015: 52):

$$\begin{aligned} & Min\ P^L \\ \text{s.t. } & \left|w_B - c_{Bj}\, w_j\right| \leq P^L, \text{ for all criterion j} \\ & \left|w_j - c_{jw} w_W\right| \leq P^L, \text{ for all criterion } j \\ & \sum_{j} w_j = 1 \\ & w_j \geq 0, \text{ for all criterion } j \end{aligned} \qquad (11)$$

The results of the linear model provide optimal weights and optimal value P^L, which is the initial determinant for the system to be consistent. And then, consistency (P^L) levels are identified. In short, it is expected the value is close to zero; the lower value means the results become more consistent and the higher consistency implies that the comparisons are more reliable (Orji et al., 2020: 1529; Ahmadi et al., 2017: 102).

The comparisons can be consistent if $c_{Bj} \times c_{jW} = c_{BW}$, for all *j*, where c_{Bj}, c_{jW} and c_{BW} represent the selection of best-to-criterion *j*, the criterion *j*-to-worst, and best-to-worst, respectively. Consider this, $c_{ij} \in \{1, \ldots, c_{BW}\}$, where highest value may be 9 for c_{BW}. The consistency level reduces if $c_{Bj} \times c_{jW}$ is higher or lower than c_{BW}. The highest value in the model is c_{BW}, and when maximum value is appointed to c_{Bj} and c_{jW} the highest inequality ξ is obtained. Obviously, $(w_B/w_j) \times (w_j/w_W) = w_B/w_W$. To give the maximum value by c_{Bj} and c_{jW} results in the highest inequality, and the usage of the value ξ is as follows (Rezaei, 2015: 52 – 53):

$$(c_{Bj} - \xi) \times (c_{jW} - \xi) = (c_{BW} + \xi) \qquad (12)$$

And furthermore if $c_{Bj} = c_{jW} = c_{BW}$ a minimum consistency is acquired, because

$$(c_{BW} - \xi) \times (c_{BW} - \xi) = (c_{BW} + \xi) \quad (13)$$

$$\Longrightarrow \xi^2 - (1 + 2c_{BW})\,\xi + (c_{BW^2} - c_{BW}) = 0 \quad (14)$$

The consistency is simply computed by using Eq.13:

$$Consistency\ Ratio = \frac{\xi^*}{Consistency\ Index} \quad (15)$$

The index given in consistency ratio is represented in the table below. As indicated before, BWM always gives consistent results compared to other methods like AHP, where the validity of comparisons must be verified via consistency ratio. However, in BWM, this ratio identifies the reliability level (Sotoudeh-Anvari et al., 2018: 400).

Table 11: Consistency Index

c_{BW}	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Consistency index	*0.00*	*0.44*	*1.00*	*1.63*	*2.30*	*3.00*	*3.73*	*4.47*	*5.23*

Source: Rezaei, 2015: 52.

3.1.2.3. Hybrid Multi-Criteria Decision-Making Methods and Hybridization of Methods in the Dissertation

The MCDM methods may have internal deficiencies and weaknesses. The deficiencies of a method A can be overcome by replacing its weaker sides with a method B, which is stronger in deficiencies of method A (Tzeng and Huang, 2011: 157 – 158; Baykasoglu and Durmusoglu, 2014: 616). This hybrid technique is more successful in complex real-world problems such as stakeholder preferences, choice under uncertainty, inter-related and/or conflicting criteria-based issues, etc. (Erdogan et al., 2019: 7) because those of the problems are too difficult to defeat (Tzeng and Huang, 2011: 172).

DEMATEL has been extensively hybridized with other MCDM methods in several research areas (Tzeng and Huang, 2011: 172; Büyüközkan and Öztürkcan,

2010: 5836). For instance, Tzeng and Huang (2011) and Zhou et al. (2014) combine DEMATEL and ANP, Pamučar et al. (2018) integrate DEMATEL and MAIRCA, Şimşir et al. (2018) hybridize DEMATEL, TOPSIS and ELECTRE, Arjomandi et al. (2021) use DEMATEL, ANP, and VIKOR methods together. Zhou et al. (2013) indicate that MCDM methods neglect direct and indirect interdependencies among criteria and sub-criteria. DEMATEL fills this deficiency (Zhou et al., 2013: 164), and the inner dependencies and relations are handled by DEMATEL. Major contribution of this method is that it clearly defines reciprocal relations among criteria, as close as real-world (Vujanović et al., 2012: 10557 – 10558). In other words, probably the reciprocal effects of two criteria are not identical and DEMATEL integration of any other MCDM method overcomes this shortcoming. BWM does not concern with defeating inner dependence (Liu et al., 2020: 11 – 13). However, because DEMATEL scale is used to specify degree of relation, the degree of relations between criteria can be ascertained independently from each other with the integration of DEMATEL. DEMATEL deals with finding out complicated relationships among criteria (Tzeng and Huang, 2011: 172). Hence, that can be coped by integration of DEMATEL to establish a network relationship matrix showing inter-relations within the criteria (Tzeng and Huang, 2011: 157 – 158; Büyüközkan and Öztürkcan, 2010: 5836). As proposed by Büyüközkan and Öztürkcan (2010) the interdependencies and internal relations are obtained by DEMATEL (Liou et al., 2013: 201) using lambda correlation measurement (Zhou et al., 2013: 163), weights are computed by other MCDM methods (BWM in this study) that consider outer dependencies among criteria through interdependence relations (Liou et al., 2013: 201; Lee et al., 2011: 8378; Moghadam-Jafari et al., 2017: 236). The BWM is already one of the latest MCDM methods and hybridization of BWM is strictly limited in literature. The combination procedures of DEMATEL and BWM were adapted from Liu et al. (2020), Qazvini and Maleki (2022), and Alimohammadlou and Sharifian (2022). Figure 29 explains the proposed model of the methodological approach of the study, inspiring by Peng and Tzeng (2013), Wang and Tzeng (2012), Chiu et al. (2013), Lee (2014), and Kuo et al. (2015):

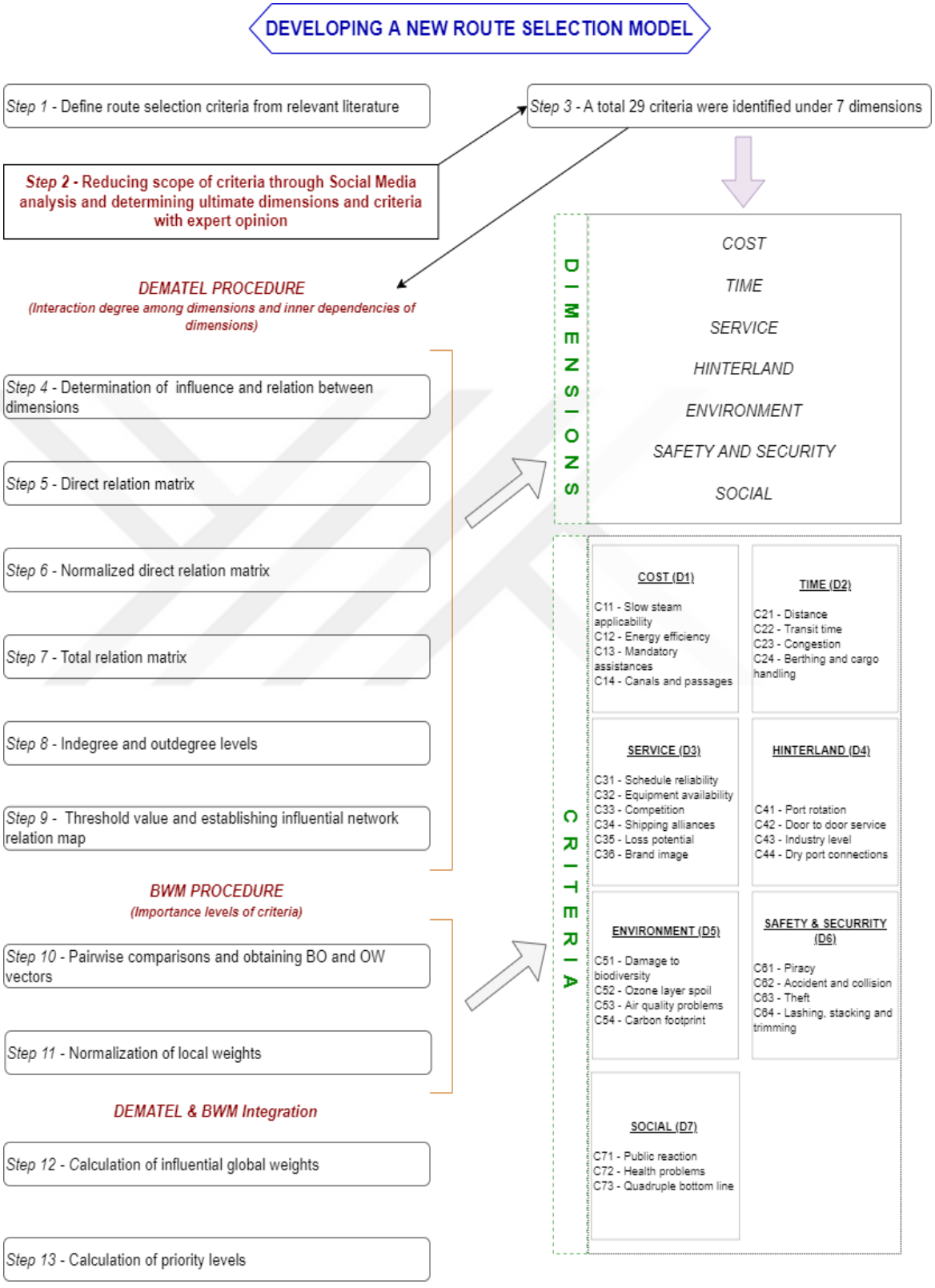
In the first step, route selection and Arctic shipping literature have been handled. In the following step scope of the criteria has been narrowed down by using results of Social Media analysis and then the dimensions and criteria have been discussed with experts from sector and academia. In the third step, 29 criteria under 7 dimensions have been defined. In addition to social media content analysis conducted, the methodology consists of two main parts. In the first part, DEMATEL

method has been applied to dimensions in a body while in the second part, BWM method has been applied to criteria in a hybrid way. The next three steps (Step 4, 5, and 6) are the first three steps of classical DEMATEL method that reflects inner dependencies and interaction degree of dimensions. These are (1) determination of influence and relations among dimensions through DEMATEL scale; (2) establishing a direct relation matrix; (3) normalization of direct relation matrix. After the relation matrix $\boldsymbol{T}$ has been normalized, a total relation matrix $\boldsymbol{T_D}$ (including direct and indirect relations) has been calculated by computing direct relation matrix and normalized direct relation matrix in Step 7.

According to the results of DEMATEL, indegree (D+R) and outdegree (D-R) levels have been determined and threshold value and influential network relation map (INRM) have been obtained in Step 8 and 9. In the next step, BWM procedure has been used for pairwise comparisons of criteria, and Best-to-Others (BO) and Others-to-Worst (OW) vectors have been obtained (Step 10), and local weights have been calculated by using these vectors. After BO and WO vectors have been normalized in Step 11. Ulu and Şahin (2021) and Liaw et al. (2020) indicate that a criterion with high effect over others normally has a higher weight. Hence, subjective weights of dimensions are computed within the context of DEMATEL analysis. In Step 12 weights of each dimension have been acquired by DEMATEL and BWM decision vectors have been integrated. The influential global weights are obtained by multiplying local weights of each criterion (BWM) with weights of their dimensions (DEMATEL); and because the number of criteria under each dimension is not identical, proportional weights for each dimension have been arranged, as proposed by Alimohammadalou and Sharifian (2022). In last, priorities have been calculated by using influential global weights of each criterion and normalized values of local weights (Liu et al., 2020: 11 – 14), thusly subjectivity of decision-makers has been minimized.

These attributes not only provide some knowledge about route selection behaviors of decision-makers, but also a direct que whether they prefer Arctic routes or not. In this research, *Microsoft Excel* and www.diagram.net. have been utilized in establishing and solving matrices of DEMATEL method; and the template prepared by Rezaei (www.bestworstmethod.com) in the form of *Microsoft Excel* has been utilized in BWM and transforming total relation matrix into weights of dimensions. At the end of analysis, consistency ratio has been calculated for BWM methods.

Figure 29: Methodological and Hybridization Process



Source: Created by author.

CHAPTER IV
EMPIRICAL RESULTS

4.1. RESULTS

4.1.1. Results of Social Media Content Analysis

In total, 11,797 LINKEDIN and TWITTER posts and hashtags were scanned. Over 9,630 posts, 2,167 posts of REUTERS, BBC, and Arctic corporations were reviewed, but were not included in this study. Over 7,092 scanned posts only 102 posts (1.44%) are found related to ASR. IMO has the highest frequency (73 posts) thanks to the Polar Code introduction and reminders. CMA-CGM and MSC persistently declare their position, while Maersk is silent about Arctic shipping even though the company was the first liner operator to perform an Arctic voyage. Even, there is no post about the Arctic trial of M/V Venta Maersk. HAPAG and MOL also refer to Arctic routes with 5 and 4 posts, respectively. From the top ten liner companies COSCO, EVERGREEN, and YANG MING have no analyzable data on SM.

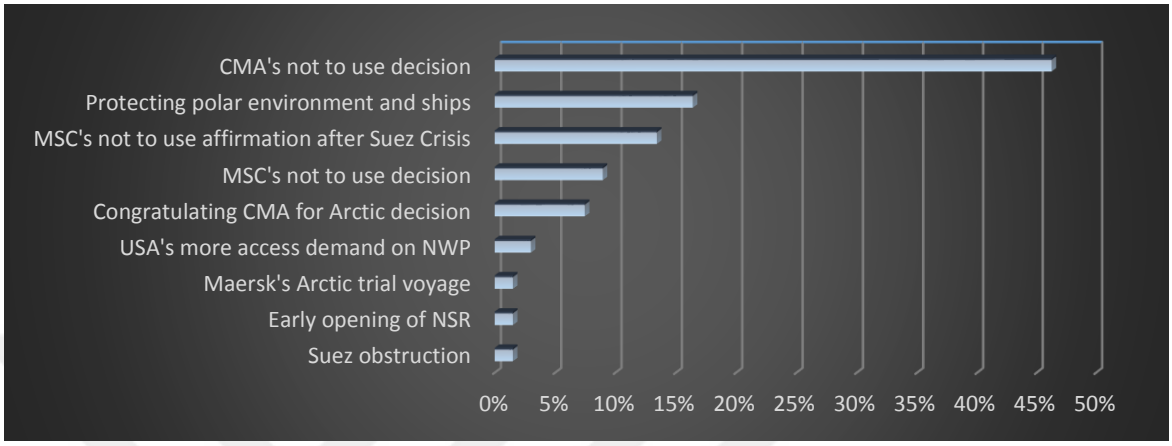
From the above-mentioned hashtags in section 1.5.2.1, 2,538 posts were reached, and the most frequently used hashtag within Arctic-related posts is #ArcticOcean (300). Many of the posts involving this tag are about scientific research, legal aspects, geopolitics, ecology, and policy. It is followed by #ArcticShipping (184) and #NorthernSeaRoute (177), and #PolarSilkRoad (113). Last, tags about Suez blockage are relatively high (1302). #SuezCanalBlockage is included in 465 posts while #EverGiven is included in 448, #SuezCanal in 250, and #SuezBlockage in 137.

The direction of comments analyzed in this study is shaped in line with which post they are written. The content of Arctic-based posts and posts of hashtags included in this study are shown in Figure 30. Hereunder majority of the reviewed SM substance is shipping companies' declarations on they will not exploit ASR (68,6%). Polar environment protection and safe shipping implementations have a 16,4% share. Other main topics are Suez blockage, early opening Northern Sea Route, USA's requests, and so on.

In current paper, 70% of relevant comments are from LinkedIn and 30% from Twitter. The commentors were classified as 3PL (24%), carrier (18%), ship management & services (12%), Arctic foundations & specialists (12%), digital

shipping services (10%), warehouse & terminal operator (7,5%), consulting firms in shipping (6%), BCO (6%), Arctic-originated news agency (3%), and Brokering (1,5%).

Figure 30: Contents in ASR-based Posts



Source: Created by author.

Upon the environment was created, Python 3.10.0 and Python libraries such as Pandas, Pytorch, matplotlib, etc. from GitHub and Hugging Face were used in Colab. It has been performed the model on Intel Core i7 CPU 2.60 GHz with 8GB ram operating the system under Windows 10 64-bit for BERT procedures, SA, and ED.

4.1.1.1. Lexical Classification Procedure

The data was classified, and results were identified using BERT transformer before conducting manual coding and sentiment analysis.

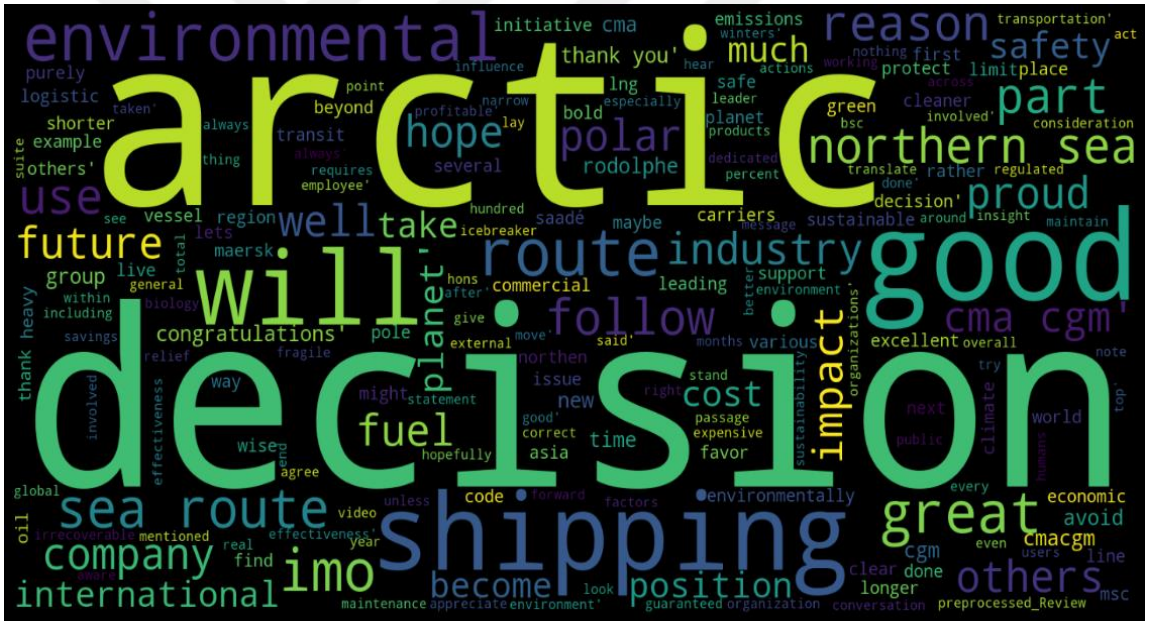
Table 12: Examples of Standings

Comment	Standing
If due to various reasons the Northern Sea route become accessible, then in future it maybe more environmentally prudent to use the northern routes rather than burn more bunker and more emissions.	Favor
Appreciate your clear stand on this issue! As leader in the industry, it will influence several others.	Unfavor
The decision is not for environmental reason but for overall cost effectiveness	Inbetween

Source: Created by author.

The standings are exemplified in Table 12. The results show that 70% of stakeholders are unfavor of ASR usage, 21% are indecisive or hesitant, and 9% are FAVOR of Arctic exploitation. Also, comments of some UNFAVORs involve sarcasm and express the contrary to what they write. 32% of the UNFAVORs consist of commenters working at 3PL, 15% are Carrier, 15% are Digital Shipping Service companies, 10% are Warehouse & Terminal Operator, 9% are BCO, and 6% are Arctic Foundations & Specialists. 36% of the in-betweens consists of Ship Management & Services, 21% is Arctic Foundations & Specialists, 14% is for each of Carrier and Consulting Companies, and 7% is 3PL. Also, half of the favors consists of Carrier, 33% is Arctic Foundations and Specialists, and 17% is Ship Management & Services.

Figure 31: Word Cloud of Comments on Arctic-based Posts

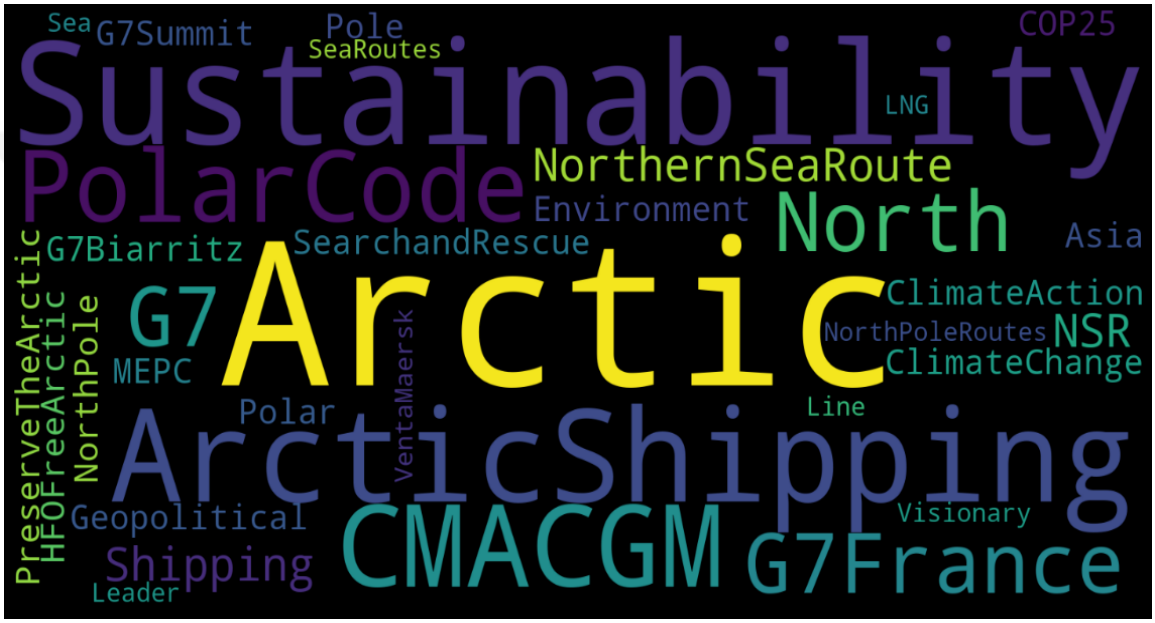


Source: Created by author.

To visualize comments on the LinkedIn and Twitter posts shared within the study's timeframe about Arctic shipping routes, we generate a word cloud. The word cloud illustrated in Figure 31 dimensionally represents the centrality of the concepts and issues. In this sense, the keywords such as decision, Arctic, will, shipping, future, and environmental attract more attention. Most of those posts are about companies' not using claims, hence, not surprisingly, "decision" is used most frequently. When we consider the posts involving these keywords, "future" and "will" indicate ASR are not

found as today's phenomenon, but it is an unavoidable act. The words like Arctic, route, northern, shipping, and sea route root in the nature of the subject. Besides, some tricky and signifying words such as environmental, fuel, transit, icebreaker, polar code, and heavy oil may show the cognitive status of stakeholders in Arctic shipping. And some thanksgiving and congratulating words such as good, well, great, proud, follow, and thank directly refer to being unfavor of Arctic usage.

Figure 32: Word Cloud of Hashtags used in Arctic-based Posts



Source: Created by author.

Figure 32 renders hashtags contained in LinkedIn and Twitter posts examined in this paper. As hashtags are mainly for the categorization and tracking of subjects. The majority of tags compose of #Arctic, #ArcticShipping, #NorthernSeaRoute, #NorthPole; #Sustainability, #Environment, #ClimateChange, #ClimateAction, #HFOFreeArctic; #PolarCode, #GeoPolitical, #G7; and #SearchandRescue. By considering the posts reviewed, Arctic labeled hashtags and their derivatives are for tracking the posts. We can observe that Arctic shipping is probably categorized under environment, policy, safety, and sustainability. The G7-related tags may be evaluated as a call for G7 countries to prevent Arctic shipping. Further, hashtags related to Suez blockage were checked. However, there were no meaningful posts applicable to this study.

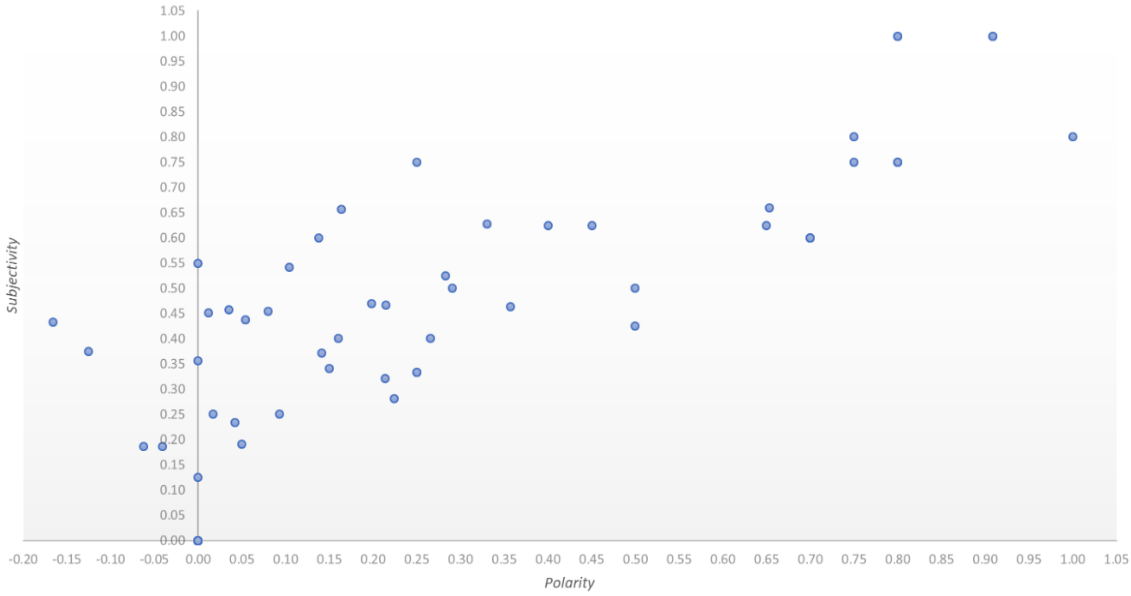
4.1.1.2. Sentiment Analysis & Emotion Detection

According to the content of posts, stakeholders' comments may vary. Regardless standings of stakeholders, the wording is essential to recognize sentiments embedded in written comments, and those may differ from standings. Nemes and Kiss (2021) say polarity defines the way and strength or weakness of sentiment. It ranges between [-1,1] where -1 represents pure negative pole, 1 represents absolute positive and 0 identifies neutrality. On the other hand, subjectivity projects personal judgments rather than information-based rationality. (Nemes and Kiss, 2021: 8). The intensifier words like "very", "too" etc. may lead the machines to misestimate sentiments. It is important where the intensifiers are used. Accordingly, TextBlob counts on the intensifiers and their descendants in the decision process.

The sentiments were examined using TextBlob. The positive sentiments in comments dominate over the others (55%); neutral sentiments also have a considerable share (39%), and negatives are a minute amount (6%). Although most stakeholders unfavor of Arctic usage, positive and neutral sentiments dominate sentiment analysis. This is because comments under the category of unfavor are shared under the posts concerning ASR refusals of shipping companies. The neutral feelings are written on informing and IMO's regulatory posts in general. Besides, negative sentiments comprise a little bit of sarcasm. By considering standings and sentiments, data has been reviewed. TextBlob results have been found successful, but not perfect and consistent in comparison with what sentiments we have labeled and what the standings have been.

The figure below shows that there are a few stakeholders with absolute polarity and subjectivity. Overall results display those stakeholders have 0.516 subjectivities on average. It means they are fairly subjective in their comments and evaluation of ASR. The higher subjectivity expresses lower rational evaluations. Irrespective of the sentiment category, almost 77% of comments involve fluctuant subjective judgments that are directed in conformity with personal beliefs and feelings. Stakeholders with positive sentiments having stronger subjectivity are to state the obvious because those comments are obtained from the posts declaring not to use decisions about ASR. Herewith, comments on these posts incorporate intense feelings sure enough. A negative polarity represents negative sentiment, but negative comments have polarity between -0.05 and -0.20; this is to say these sentiments are slightly negative.

Figure 33: Polarity and Subjectivity of Comments



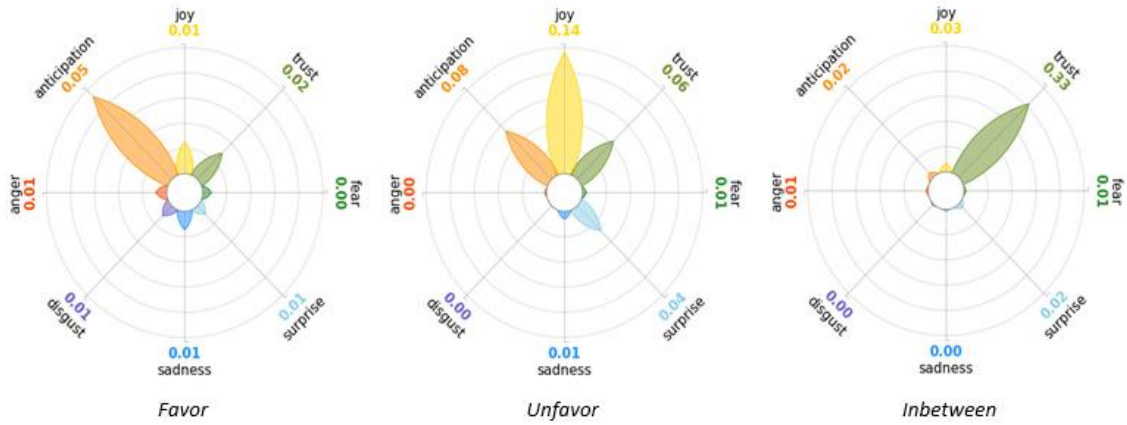
Source: Created by author.

Plutchik (1982) indicates that a stimulus does not come out with a single emotion. Multiple emotions establish a balance of mind. Therefore, the wheel of emotions shows co-occurrence of basic emotions as a response to a stimulus. Figure 34 shows the snapshot of stakeholders' emotional status by grouping them according to their standings. The strength of emotions is represented by the size of the petals. The stakeholders being favor of ASR usage are strongly aroused by *Anticipation*. Also, *Trust* and *Joy* have prominence. FAVORs, anticipation is prominent due to their expectation of ASR will be viable. Further, the feeling of trust implies that they trust IMO and regulatory bodies will establish a proper base for Arctic shipping. In the UNFAVOR category, *Joy* has a great share compared to other basic emotions. That is assisted by *Anticipation*, *Trust*, and *Surprise*. UNFAVORs mainly write supportive messages on not to use decisions of MSC and CMA-CGM. These messages contain a lot of positive words, thusly joy is the flagship for UNFAVORs. Otherwise, Anticipation and trust connotative comments represent stakeholders' confidence in these two companies and stakeholders' demand on not to use declaration of other carriers. And last, *Trust* dominates emotions of INBETWEENs.

In addition to basic emotions, some emotions laying in the subconscious arise from co-occurrence of multiple emotions. Karimova (2022) says that co-occurrence tells us the ultimate feelings of an individual about an event. For instance, the

combination of anticipation & trust indicates *hope*, anticipation & joy is *optimism*, joy & trust is *love*, joy & surprise is *delight*, and trust & surprise is *curiosity* (www.positivepsychology.com). By reviewing all comments, we find these results suitable to what comments say. In this way, as a result of the combination of emotions, FAVORs feel hope and optimism. UNFAVORs experience love and delight, supported by optimism while INBETWEENs feel curiosity about ASR. The vast majority of unfavor comments are detected on not to use declarations of shipping companies. Hence, to be delighted and optimistic is advisable. Similarly, INBETWEENs mainly mention the blurred areas of ASR and stakeholders' expectations. So, it is sensible they feel curiosity.

Figure 34: Emotion Wheel for Arctic-based SM Posts



Source: Created by author.

4.1.1.3. Thematic Analysis

TA mirrors stakeholders' mind maps by digging keywords derived from their sentences. The keywords wear stakeholders' knowledge, feelings, opinions, and approaches. Thus, the word patterns generating themes reveal how stakeholders perceive and from which perspective they evaluate ASR. In determining themes, at the end of the iterative processes, we narrowed down the list by eliminating or combining themes and we identified 10 parental themes (Table 13).

The majority of stakeholders underline the environmental dimensions and ecological effects of ASR. They also support not to use decisions with similar word patterns, and they call for all actors in the industry to act in the same manner. As

result, *Environmental Considerations*, *Business Attitudes & Behaviors* have a dominant share, 23.3%, and 22.5% respectively. *Policy* theme (13.5%) is detected mainly in the posts of IMO and on the appeal for companies to establish a sustainable policy against ASR. *Corporate Social Responsibility* comprises 12.8% of themes while *Sustainability* is 8.3%. The rest are *Awareness* (5,3%), *Cost* (5,3%), *Geography* (3,8%), *Distance & Transit Time* (3,0%), and *Safety Issues* (2,2%).

Table 13: Examples for Lexical Classification of Themes

Thematical Categories	**Word Patterns**
Environmental Considerations	Environment, Green, Emissions, Climate change, Irrecoverable
Business Attitudes & Behaviors	Decision, Stand, Followed by others, Act, Wise move
Policy	International agreement, Code, Guaranteed, International organizations, G7
Corporate Social Responsibility	Leadership, Right thing, Imitated
Sustainability	Our future, Preserve, Protect
Awareness	Insight, Aware, Fragile, Conscious, Evidence
Cost	Cost effectiveness, Saving, Commercial, Profitable
Geography	Narrow, Accessible, Map of power, Region
Distance & Transit Time	Shorter, Transit, Distance
Safety Issues	Safety, Safe

Source: Created by author.

Some examples of word patterns are demonstrated in Table 13. The first five themes are outstanding categories. *Environmental Considerations* are the most prominent issues in stakeholders' minds. Exactly, some keywords such as green, emissions, and climate change are correlated with environmental considerations. However, we also have considered word patterns (i.e., irrecoverable act) that are implicitly related to environmental considerations. From the posts and comments, we have guessed that the stakeholders, who comment on Arctic-based posts, deem the decisions and actions of companies about ASR are directly influenced by companies' behaviors. Therefore, the keywords like decision, act, move, and stand are accepted as indicators of *Business Attitude & Behaviors*. *Policy* is identified with keywords like code, international organizations, international agreements, etc. Leadership, right thing, and imitated are keywords that are or may be the conclusion of *Corporate Social*

Responsibility actions. *Sustainability* refers to keywords such as preserve, protect, and our future.

4.1.2. Results of MCDM Analysis

4.1.2.1. Profile of Respondents

An introductory information has been given about profile of the respondents in section 1.5.2.2. This information cover population, share of participants over target population, sectoral distribution of sampling, and data collection. In this section other general characteristics of participants will be explained.

Table 14 shows the experience level and age of the sample. Majority of the sample have the experience higher than 10 years. Almost half of the sample have at least 20 years' experience. 21,4% of them have the experience higher than 25 years, 21,4% have experience between 20-24 years, and 14,3% have the experience between 15-19 years. For age distribution, majority of participants are between 30-49 years old. A few numbers of them are between 20-29, 14,3% of them are between 50-55, and 10.75% of them are older than 55 years.

Table 14. Experience and Age Distribution of Sample

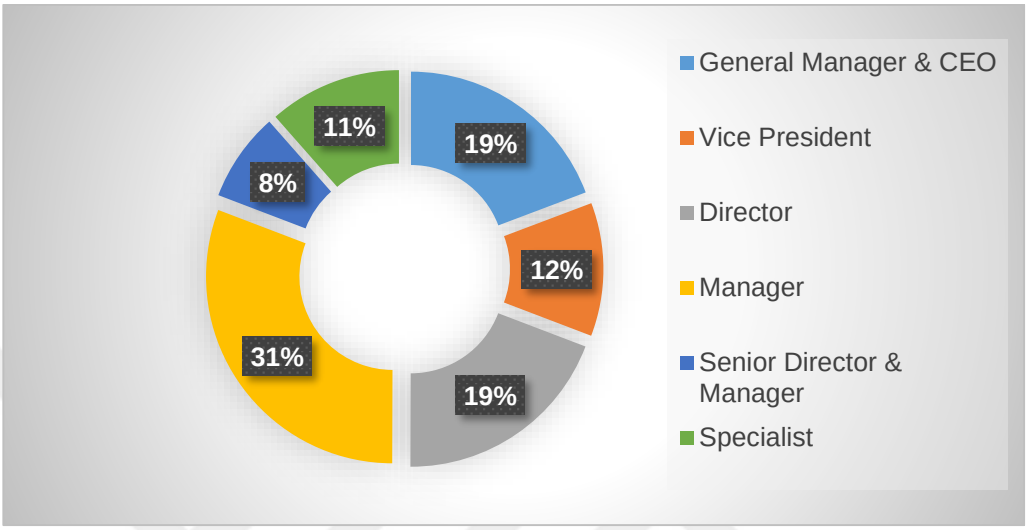
Experience		**Age**	
Year	*Share*	*Year*	*Share*
5 - 9	14,30%	20 - 29	3,55%
10 - 14	28,60%	30 - 34	25,00%
15 - 19	14,30%	35 - 39	17,85%
20 - 25	21,40%	40 - 44	3,55%
25+	21,40%	45 - 49	25,00%
		50 - 55	14,30%
		55+	10,75%

Source: Created by author.

To find out more accurate indications, target audience has been determined as top managers that have decision-making and strategy development authority. In this way, when positions of sampling are looked at (Figure 35), it is found that 19% of participants are General Manager or CEOs, 12% of them are Vice President, 19% of

them are Director, 8% of them are Senior Director or Senior Manager, 31% are Manager, and 11% are Specialist.

Figure 35. Positions of Sampling



Source: Created by author.

Table 15. Distribution of Company Size

	Large	Medium-Large	Medium	Small
Carrier	41,60%	-	8,35%	-
3PL	25,00%	-	-	-
BCO	16,70%	8,35%	-	-
Expert	N/A	N/A	N/A	N/A

**For carriers: 0-9999 TEU Small, 10,000-49,999 TEU Medium, 50,000+ TEU Large (Balcı and Çetin, 2017: 1106).*

***For 3PL: 0-3000 Micro, 3001-12000 TEU Small, 12001-25000 TEU Medium, 25001+ TEU Large (Balcı and Doğu, 2020: 3).*

****For BCO: 20-49 persons and up to 38,5 m.$ annual revenue Small, 50-249 persons and 38,5 m.$-1 b.$ annual revenue Medium, 250+ persons and 1 b.$+ annual revenue Large (www.data.oecd.org).*

Source: Created by author.

Table 15 explains the size of companies that are included in this study. The sizes of companies have been determined according to academic literature and OECD's description. For carriers and 3PL, sizes have been determined by TEU capacity, and for BCOs the number of employees and annual revenue have been

considered. Naturally, experts have not been categorized. 83,3% of the companies are large sized, 8,35% are medium-large sized, and 8,35% are medium sized.

Table 16. Country Distribution of Sectors

Sector	Country	Number	Share
Carrier	Türkiye	5	41,60%
	EU	4	33,30%
	Scandinavia	2	16,60%
	Oceania	1	8,50%
3PL	Türkiye	2	33,30%
	EU	3	50,00%
	Asia	1	16,60%
BCO	Türkiye	4	66,80%
	EU	1	16,60%
	Scandinavia	1	16,60%
Expert	Türkiye	1	25,00%
	North America	2	50,00%
	Asia	1	25,00%

Source: Created by author.

Table 16 shows country distribution of the sectors. To fit the table into the page, countries have been gathered under the roof of regions. For a wider explanation of country-level distribution please see Appendix.4, which gives a broader picture on profiles of the participants. 41,6% of carriers are from Türkiye while others disperse around world (Germany, France, Netherlands, Sweden, Denmark, Australia). 50% of 3PL companies are from EU countries (Netherlands, Spain), 33,3% are from Türkiye, and 16,6% are from Asia (China). For BCOs, majority of participants are from Türkiye, and distribution of Experts is from USA and Canada (25%), India (25%), and Türkiye (25%). In summary, majority of participants have more than 15 years' experience, company sizes are mainly large-sized, and respondents are high-level managers mostly. It is easy to say that sampling of study has decision-making authority and strong representative power.

4.1.2.2. Results of DEMATEL

The beginning of DEMATEL results is *Step 4 – Determination of Influence and Relation between Dimensions*, according to Figure 30. In this step, pairwise

comparisons were handled. The participants compare the seven dimensions in terms of influence level.

Table 17. Average Direct Relation Matrix

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	**0,0000**	2,6250	3,1458	1,5833	2,5833	1,7500	1,1875
Time	3,3333	**0,0000**	2,9792	1,6875	1,7083	1,6042	1,0833
Service	3,1458	2,5000	**0,0000**	2,2292	1,7708	1,8542	1,7083
Hinterland	2,6875	3,1458	2,9583	**0,0000**	2,4583	1,6875	1,9167
Environment	2,5000	1,5000	1,6875	1,5417	**0,0000**	1,8958	3,1250
Safety & Security	2,0417	2,1667	1,8333	1,2500	1,9792	**0,0000**	2,4167
Social	1,7292	0,8750	1,8125	1,5000	2,8125	1,7292	**0,0000**

Source: Created by author.

Step 5 – Direct Relation Matrix

The table above that has been generated based on 28 participants' decisions shows mean value of all participants' initial direct relation matrix (Sector-based direct relation matrices are available in Appendix 5).

Step 6 – Normalized Direct Relation Matrix

In the normalization procedure, maximum value among the values consisting of sum of row vectors in average direct relation matrix is determined. Each value in the matrix above is divided by this maximum value. And normalized direct relation matrix X (Table 18) is obtained in line with Equation 3 in the methodology section (Sector-based normalized direct relation matrices are available in Appendix 6). After Step 6, total relation matrix T is calculated by using Equation 4 and Equations 5.

Table 18. Normalized Average Direct Relation Matrix

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	**0,0000**	0,1767	0,2118	0,1066	0,1739	0,1178	0,0799
Time	0,2244	**0,0000**	0,2006	0,1136	0,1150	0,1080	0,0729
Service	0,2118	0,1683	**0,0000**	0,1501	0,1192	0,1248	0,1150
Hinterland	0,1809	0,2118	0,1992	**0,0000**	0,1655	0,1136	0,1290
Environment	0,1683	0,1010	0,1136	0,1038	**0,0000**	0,1276	0,2104
Safety & Security	0,1374	0,1459	0,1234	0,0842	0,1332	**0,0000**	0,1627
Social	0,1164	0,0589	0,1220	0,1010	0,1893	0,1164	**0,0000**

Source: Created by author.

Step 7 – Total Relation Matrix

The formulation of total relation matrix T is found by using normalized direct relation matrix X and unit matrix I. By using the equation $(I - X)^{-1}X$, total relation matrices are computed (See Appendix 7).

Table 19. Average Total Relation Matrix

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	**0,8370**	0,8555	0,9609	0,6563	0,8662	0,6953	0,6998
Time	1,0005	**0,6902**	0,9361	0,6470	0,8040	0,6717	0,6728
Service	1,0307	0,8678	**0,8064**	0,7019	0,8455	0,7142	0,7381
Hinterland	1,1012	0,9761	1,0582	**0,6340**	0,9580	0,7705	0,8187
Environment	0,9175	0,7440	0,8321	0,6147	**0,6794**	0,6654	0,7642
Safety & Security	0,8682	0,7554	0,8129	0,5799	0,7680	**0,5311**	0,7035
Social	0,7845	0,6324	0,7465	0,5491	0,7555	0,5897	**0,5204**

Source: Created by author.

Step 8 – Indegree and Outdegree Levels

To determine indegree and outdegree levels of dimensions, D values, which are obtained by sum of rows, and R values, which are obtained by sum of columns, are computed for each sector and for the average of all participants. Hence, causality of dimensions is identified. $D + R$ gives the degree of importance of a dimension over other dimensions and $D - R$ gives net influence of a dimension over the system. $D - R$ provides causality of criteria. A positive value of $D - R$ says the dimension is causal and a negative value of $D - R$ says the dimension is an effect. That is to say, a cause dimension affects others while an effect dimension is influenced by others.

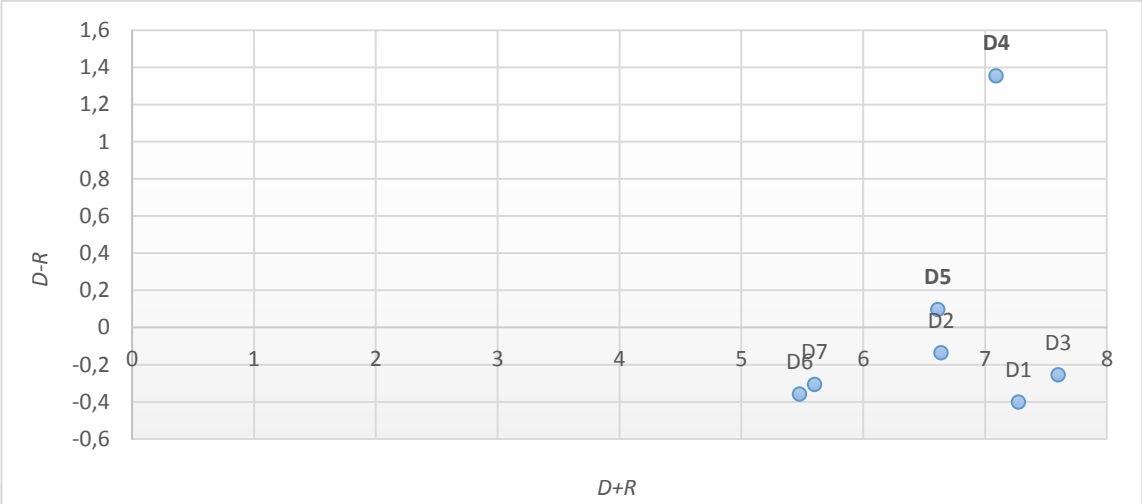
Table 20. Carrier Cause & Effect Levels

Dimensions	D	R	D + R	D - R	Identity
Cost	3,436256	3,837205	7,273461	-0,400948	Effect
Time	3,251496	3,387596	6,639092	-0,136099	Effect
Service	3,673104	3,926819	7,599922	-0,253715	Effect
Hinterland	4,223106	2,867163	7,090269	1,355942	**Cause**
Environment	3,354506	3,256474	6,610980	0,098032	**Cause**
Safety & Security	2,560517	2,917523	5,478040	-0,357006	Effect
Social	2,647293	2,953498	5,600792	-0,306205	Effect

Source: Created by author.

Table 20 shows cause and effect levels for carriers and Figure 36 is the causal diagram of carriers that is drawn by using the values in the table above.

Figure 36. Carrier Causal Diagram



Source: Created by author.

According to the results, carriers think that cost, time, service, safety & security, and social dimensions are affected by Hinterland and Environment dimensions. The results show that Hinterland dimension has a significant effect over others. It is assumed that hinterland and environment have higher priorities compared to other dimensions. Service and cost dimensions have the strongest network among others (highest $D + R$ value).

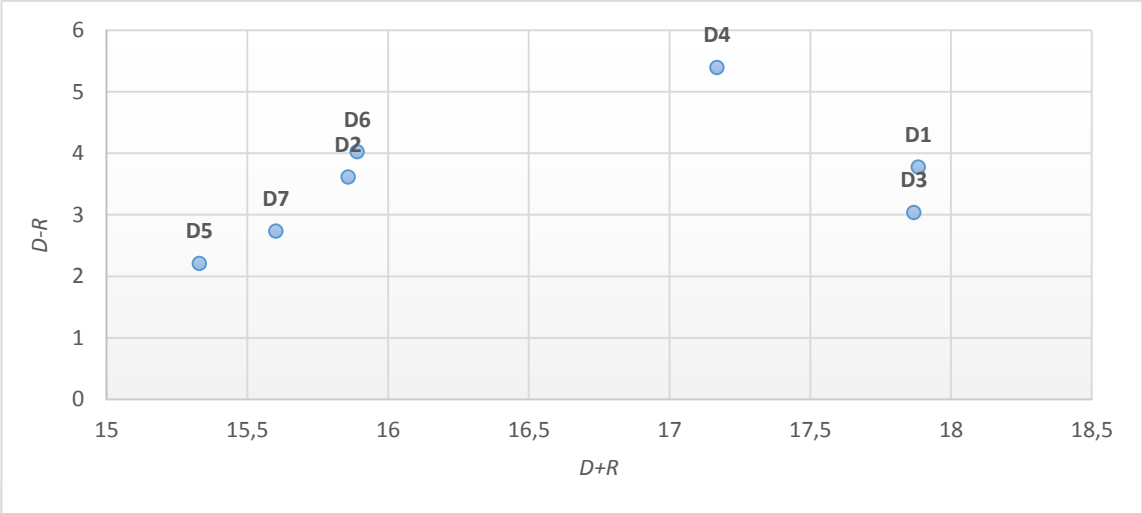
Table 21. 3PL Cause & Effect Levels

Dimensions	D	R	D + R	D - R	Identity
Cost	10,830364	7,053062	17,883426	3,777302	**Cause**
Time	9,735951	6,122069	15,858020	3,613883	**Cause**
Service	10,453993	7,41383	17,867823	3,040163	**Cause**
Hinterland	11,282990	5,885282	17,168272	5,397709	**Cause**
Environment	8,770938	6,557968	15,328906	2,212970	**Cause**
Safety & Security	9,957970	5,932034	15,890004	4,025936	**Cause**
Social	9,169883	6,431281	15,601164	2,738602	**Cause**

Source: Created by author.

Table 21 and Figure 37 shows priority levels and causality relations of dimensions for 3PL companies.

Figure 37. 3PL Causal Diagram



Source: Created by author.

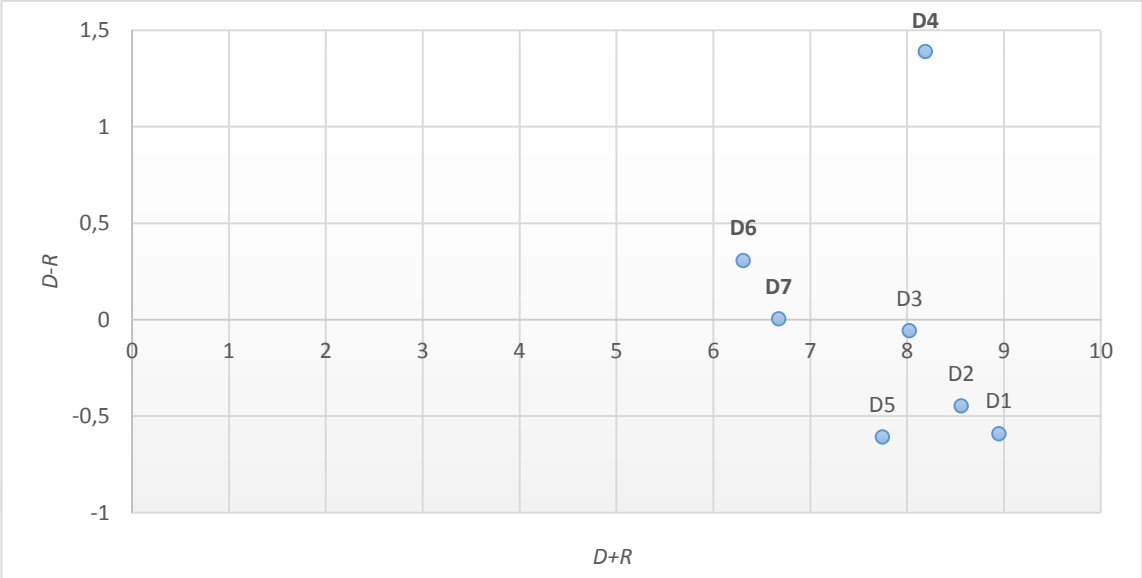
All the values are positive, and the participants from 3PL companies rate the dimension as all of them have an effect over others. Nevertheless, according to $D - R$ values, hinterland and safety & security have higher priority levels while environment and social dimensions have lowest priority levels. For 3PL companies also, service and cost have strong links with other dimensions.

Table 22. BCO Cause & Effect Levels

Dimensions	D	R	D + R	D - R	Identity
Cost	4,1783682	4,768849	8,9472168	-0,59048	Effect
Time	4,0549723	4,501533	8,5565054	-0,446561	Effect
Service	3,9833589	4,04064	8,0239987	-0,057281	Effect
Hinterland	4,7881117	3,398347	8,1864583	1,389765	**Cause**
Environment	3,5684131	4,175399	7,7438124	-0,606986	Effect
Safety & Security	3,3071772	2,999968	6,3071451	0,3072094	**Cause**
Social	3,3387604	3,334426	6,6731868	0,0043339	**Cause**

Source: Created by author.

Figure 38. BCO Causal Diagram



Source: Created by author.

The causality diagram of BCO (Figure 38), and cause and effect levels of BCO (Table 22). According to the BCOs hinterland, safety & security, and social affect other factors. Hinterland has the highest effect over other dimensions, as it was found for carrier and 3PL companies. Also, dimensions are specified up to their priority levels as hinterland, safety & security, social, time, service, cost, and environment, respectively. BCOs consider cost and time have stronger networks with others.

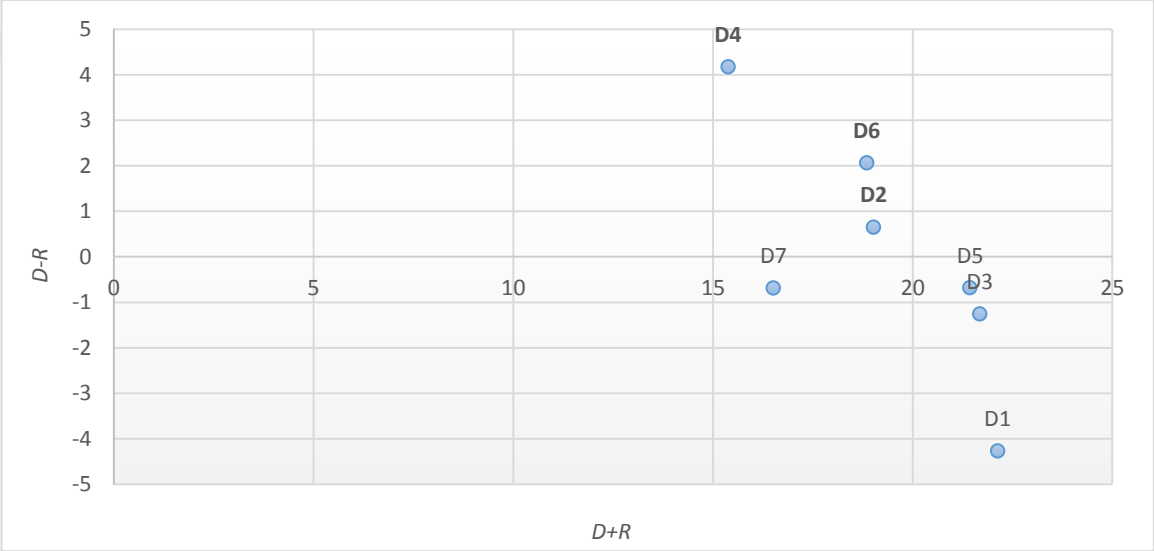
Table 23. Expert Cause & Effect Levels

Dimensions	D	R	D + R	D - R	Identity
Cost	8,9301068	13,1945	22,124609	-4,264396	Effect
Time	9,8346297	9,187227	19,021857	0,6474028	**Cause**
Service	10,211486	11,46849	21,679977	-1,257004	Effect
Hinterland	9,7785129	5,601371	15,379884	4,1771415	**Cause**
Environment	10,375659	11,05789	21,433554	-0,682236	Effect
Safety & Security	10,455552	8,391639	18,847191	2,0639134	**Cause**
Social	7,912751	8,597573	16,510324	-0,684822	Effect

Source: Created by author.

According to the experts (Table 23 and Figure 39), the most influential dimension is hinterland. Additionally, safety & security and time considerably affect other dimensions. Cost is found as the most affected factor against other dimensions while service, social, and environment are severally influenced by the other six dimensions. The dimensions can be listed by their priority levels as hinterland, safety & security, time, environment, social, service, and cost, from top to bottom. In Experts' opinion, cost, service, and environment have most powerful connection with other dimensions, respectively.

Figure 39. Expert Causal Diagram



Source: Created by author.

The overall results of cause-effect relations and causal diagrams for all participants are shown in Table 24 and Figure 41. According to the table above, hinterland and safety & security affect other dimensions while cost, time, service, environment, and social are influenced by other dimensions.

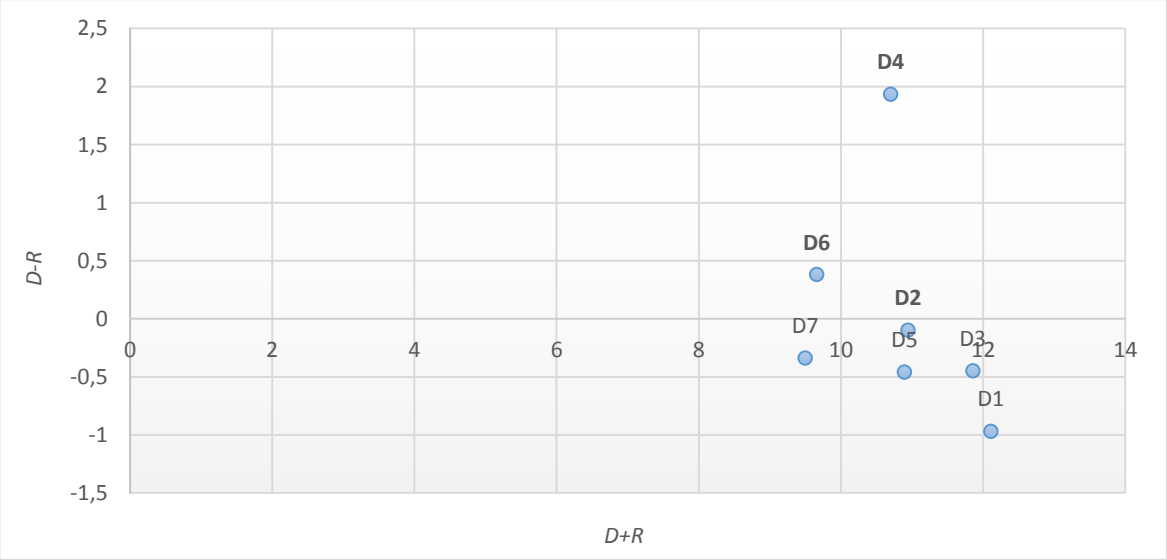
Table 24. Average Cause & Effect Levels

Dimensions	D	R	D + R	D - R	Identity
Cost	5,5710526	6,539679	12,110732	-0,968627	Effect
Time	5,422323	5,521431	10,943754	-0,099108	Effect
Service	5,7045708	6,15313	11,857701	-0,448559	Effect
Hinterland	6,3167481	4,382927	10,699676	1,9338206	**Cause**
Environment	5,2172274	5,676488	10,893715	-0,45926	Effect
Safety & Security	5,0190484	4,63792	9,6569681	0,3811287	**Cause**
Social	4,5780437	4,917439	9,4954826	-0,339395	Effect

Source: Created by author.

In figure 40, it can be clearly seen that all dimensions are located close to each other, except hinterland and cost. D1 (Cost) is found most influenced dimensions. The average responses of all participants reveal that cost dimension has highly intense network with other dimensions; besides, service is determined to have second strongest link.

Figure 40. Average Causal Diagram



Source: Created by author.

Step 9 – Threshold Value and Influential Network Relation Map

In this step, threshold values are computed like it was explained in methodology section. The final threshold values, given at the Table 25, are 0,515 for carriers, 1,038 for 3PLs, 0,611 for BCOs, 1,560 for experts, and 0,857 for average of 29 respondents.

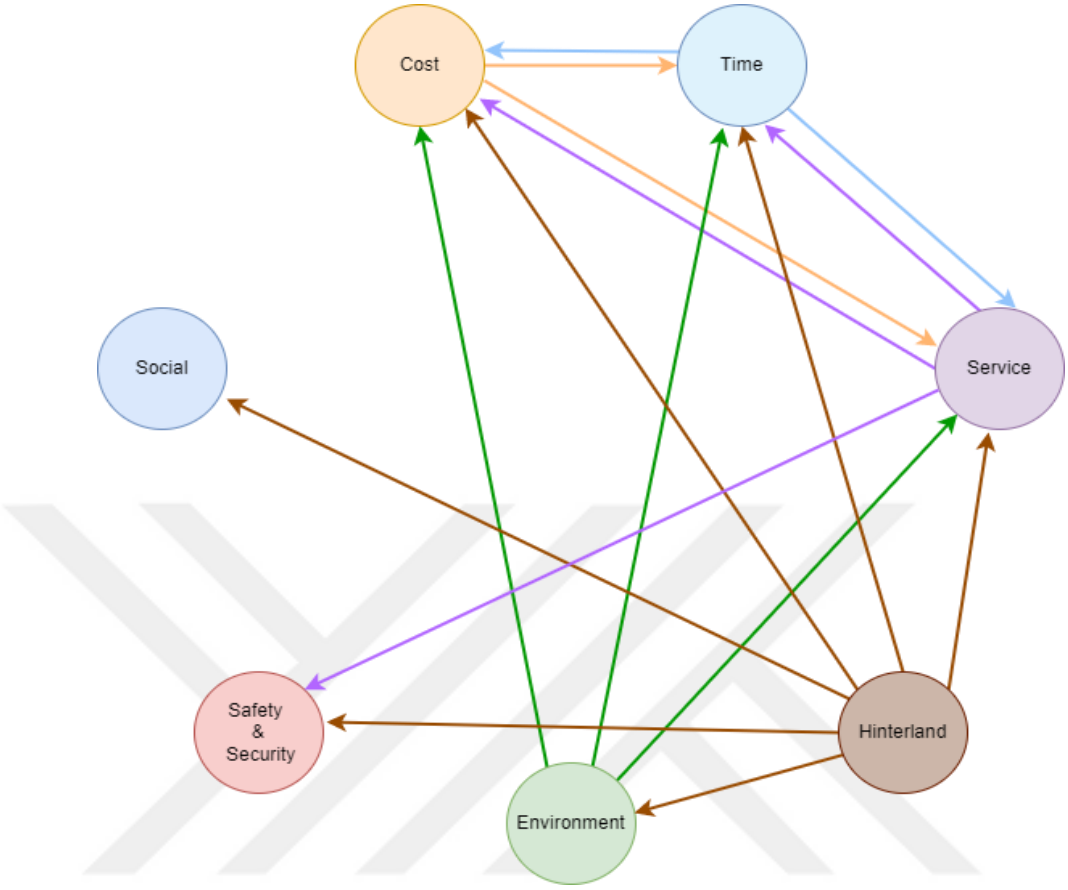
Table 25. Threshold Values

	Carrier	**3PL**	**BCO**	**Expert**	**Average**
α	0,515448	1,038087	0,611073	1,560000	0,857358

Source: Created by author.

The casual diagrams provide insight into overall cause and effect status of dimensions, but they do not give an absolute direction of these relations. Therefore, influential network relation maps are drawn by using the threshold values. In some studies, casual diagrams and INRM are given in the same figure, but it has been preferred to figure them separately in this study. To draw INRM, the total relation matrices have been used, and the values lower than threshold values in total relation matrix T are accepted as zero. Thus, for instance, let only two dimensions (i.e., time, hinterland) have values higher than zero from cost to other dimensions. It means that cost dimension has an absolute relation with time and hinterland dimensions. When drawing the following INRMs, internal dependencies of dimensions have been neglected because DEMATEL method is not completely fit for detecting internal relationships.

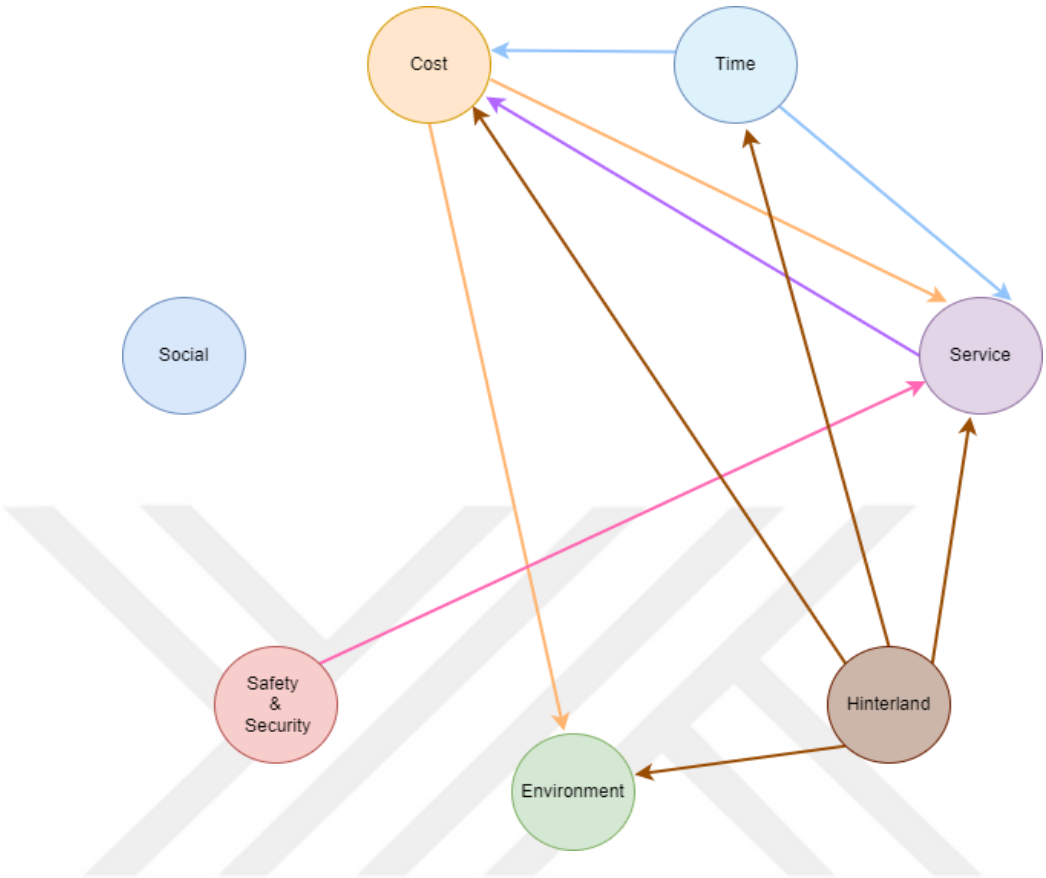
Figure 41. Carrier INRM



Source: Created by author.

Figure 41 shows INRM of carriers. Cost, time, and service have mutual effects, and service also has effect on safety & security. Environment has influence on cost, time, and service while hinterland affects all other dimensions. The strongest influences occur from hinterland to service (0,746), from hinterland to cost (0,695), and from hinterland to time (0,669) while the weakest effects are from environment to social (0,530), from environment to service (0,534), and from hinterland to social (0,536).

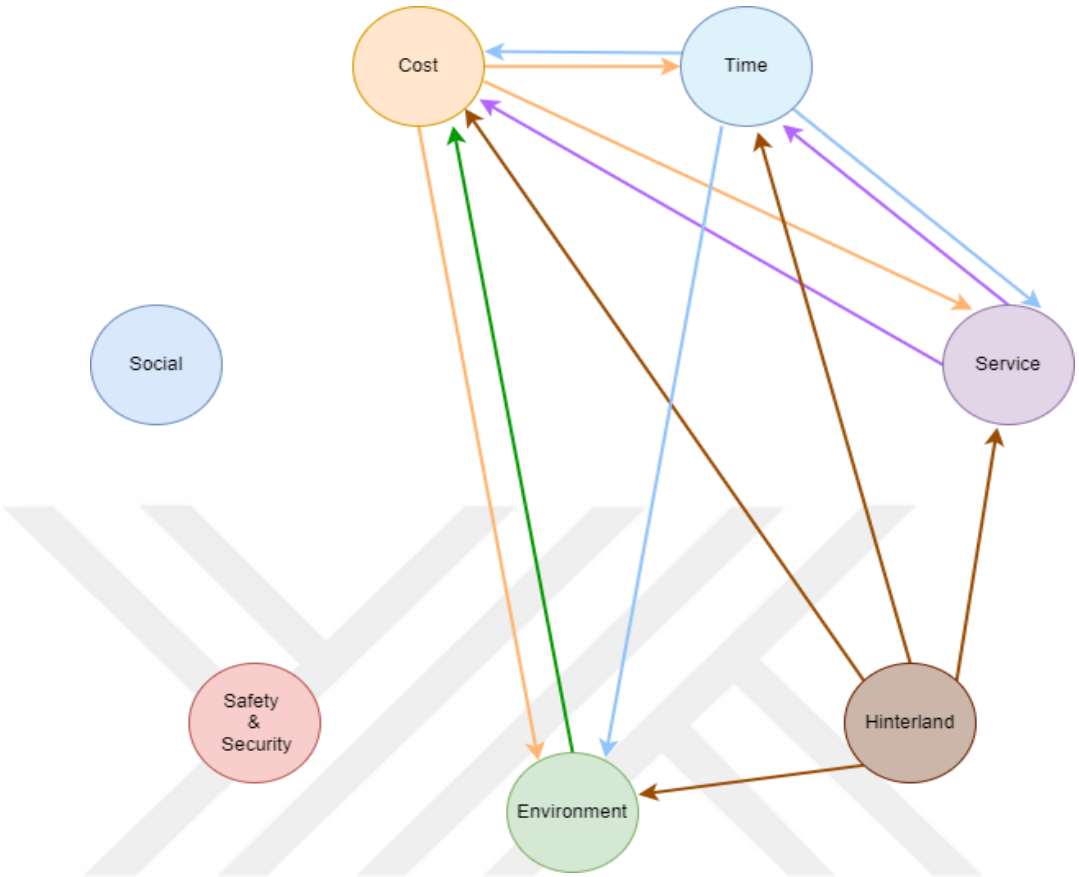
Figure 42. 3PL INRM



Source: Created by author.

INRM of 3 PL (Figure 42) indicates that cost and service have mutual effects, and cost influences environment, additionally. Time has effect on both cost and service, safety & security have effects on service while hinterland affects cost, time, service, and environment dimensions. The lowest effects are from time to cost (1,038), from cost to environment (1,050), and from safety & security to service (1,051). Otherwise, the highest influence is seen from hinterland to service (1,2239).

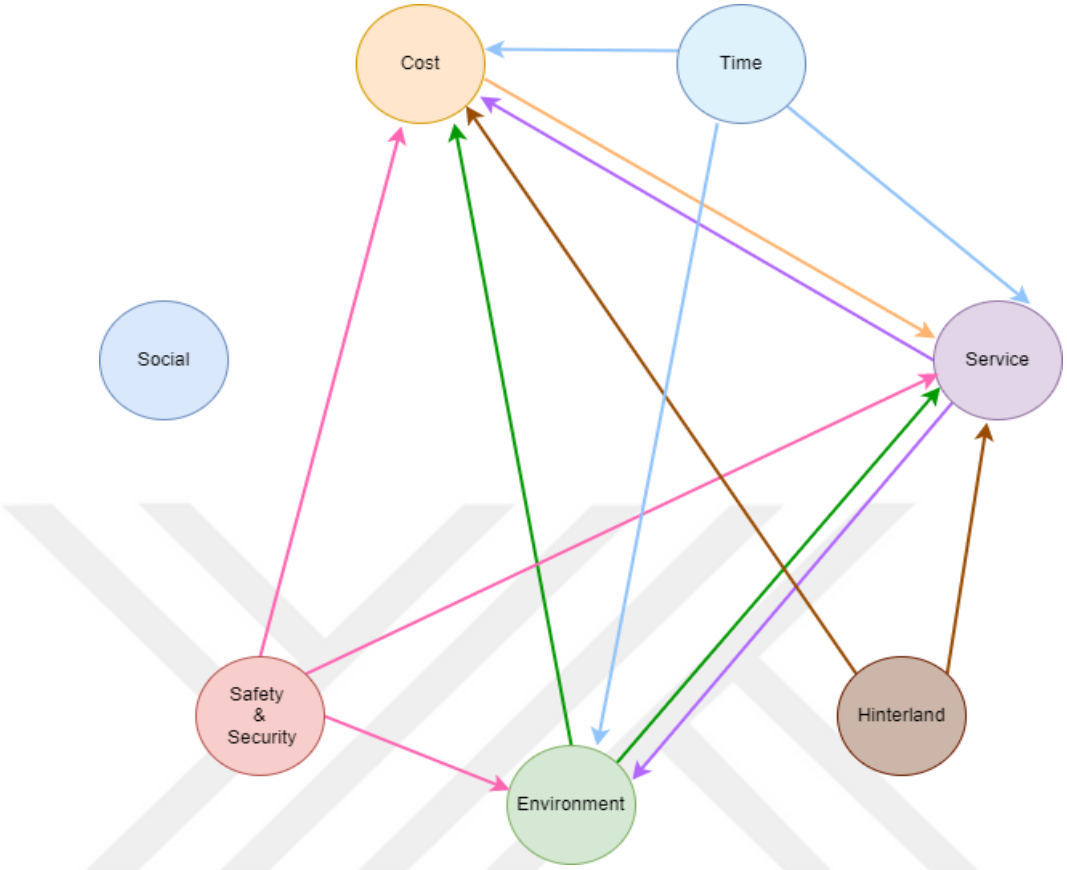
Figure 43. BCO INRM



Source: Created by author.

The figure above says that there are many mutual influences. These are cost and time, cost and service, cost and environment, and time and service. Additionally, time influences environment dimension, and hinterland influences cost, time, service, and environment. BCOs consider that the strongest effect is from hinterland to cost (0,847) and from hinterland to time (0,829) while the lowest effect is from time to environment (0,610). Figure 44 shows that cost influences service, time influences cost, service, and environment, and hinterland influences cost and service. Service and environment that both have effect on cost dimension mutually affect each other. Different from all other participants, experts believe safety & security may influence cost, service, and environment. The highest positions are from environment to cost (2,042), from safety & security to cost (2,032), and from service to cost (2,031). The lowest positions occur from cost to service (1,595), from time to environment (1,624), and from time to service (1,712).

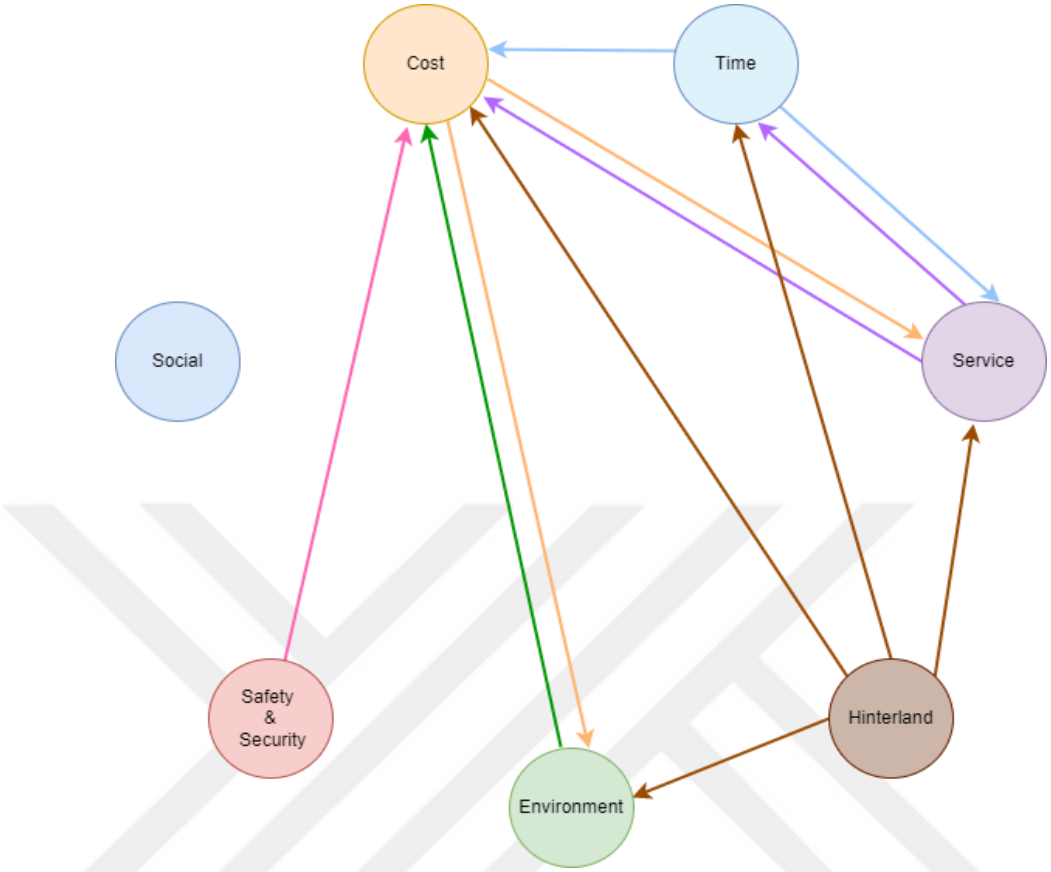
Figure 44. Expert INRM



Source: Created by author.

The average values of the respondents in total relation matrix have been handled and the values that are higher than the threshold value have been marked as an influence. Thus, Figure 45 has been drawn. According to this figure, cost has mutual effects with service and environment. Time, which influences cost, also has mutual effect with service. Hinterland has no mutual effect with any other dimension while it affects cost, time, service, and environment. Last, safety & security dimension has effect on cost. From these influential relations, the highest value is found between the relationship between hinterland and cost (1,101). The following strong influences are from hinterland to service (1,058), from service to cost (1,030), and from time to cost (1,000). On the other hand, the lowest influences are from cost to environment (0,866), from service to time (0,867), and from safety & security to cost (0,868).

Figure 45. Average INRM



Source: Created by author.

4.1.2.3. Results of Best-Worst Method

The results of Best-Worst method begin with pairwise comparisons of criteria within the same dimensions (Step 10). The average values of Best-to-Others vectors are listed in Table 26 and the average values of Others-to-Worst vectors are listed in Table 27 (Overall results of pairwise comparisons are available in Appendix 11 and 12).

In the table below, a criterion having a lower average BO score means this criterion is mostly rated as Best Criterion within its dimension. The best criterion is appointed “1” and maximum value is given to the worst one because best criterion must be superior compared to others (see BWM scale in methodology section). Some of the participants have evaluated two criteria equally important (i.e., respondents 10 and 11 for C11 and C12). In cost dimension slow steam applicability (C11) and energy

efficiency (C12) have generally been selected as the best criterion. Carriers and BCOs are for C11 while 3PLs and experts are for C12.

Step 10 – Pairwise Comparisons and Obtaining BO and OW Vectors

Table 26. Average Best-to-Others Results

		Carrier	3PL	BCO	Expert	General
Dimension	*Criteria*	*Best-to-Others*				
Cost	*C11*	2,91667	3,66667	3,16667	4,75000	*3,39286*
	C12	3,75000	3,33333	3,33333	1,50000	*3,25000*
	C13	5,00000	5,83333	5,33333	8,00000	*5,67857*
	C14	5,16667	4,00000	4,50000	4,00000	*4,60714*
Time	*C21*	3,16667	4,33333	5,00000	5,25000	*4,10714*
	C22	3,41667	1,66667	3,00000	2,25000	*2,78571*
	C23	4,00000	4,33333	4,00000	3,50000	*4,00000*
	C24	5,33333	5,50000	4,83333	5,00000	*5,21429*
Service	*C31*	3,50000	1,83333	2,66667	2,75000	*2,85714*
	C32	3,50000	2,33333	3,33333	2,00000	*3,00000*
	C33	4,00000	4,16667	4,33333	5,25000	*4,28571*
	C34	5,33333	6,66667	5,66667	4,50000	*5,57143*
	C35	5,66667	5,16667	3,33333	5,00000	*4,96429*
	C36	5,33333	5,66667	2,66667	5,25000	*4,82143*
Hinterland	*C41*	4,25000	3,33333	2,83333	3,75000	*3,67857*
	C42	3,83333	2,83333	1,66667	4,00000	*3,17857*
	C43	4,41667	3,66667	5,00000	3,50000	*4,25000*
	C44	5,91667	6,16667	5,50000	6,00000	*5,89286*
Environment	*C51*	3,58333	3,83333	3,83333	4,50000	*3,82143*
	C52	2,75000	3,66667	3,00000	6,25000	*3,50000*
	C53	2,91667	2,83333	4,66667	4,75000	*3,53571*
	C54	3,83333	3,66667	1,16667	2,50000	*3,03571*
Safety & Security	*C61*	3,00000	4,66667	3,66667	3,25000	*3,53571*
	C62	2,58333	4,16667	4,16667	1,50000	*3,10714*
	C63	5,91667	3,16667	4,00000	7,25000	*5,10714*
	C64	3,83333	4,16667	3,66667	4,00000	*3,89286*
Social	*C71*	5,41667	4,00000	2,16667	4,00000	*4,21429*
	C72	2,66667	3,66667	4,50000	2,50000	*3,25000*
	C73	2,75000	4,00000	2,16667	4,75000	*3,17857*

Source: Created by author.

In the time dimension, transit time (C22) criterion is far and away the best, but only carriers' decisions are slightly on behalf of distance (C21). Carriers and experts think equipment availability (C32), BCOs and 3PLs think schedule reliability (C31) is the best criterion in service dimension, mostly. For hinterland, carriers, 3PLs, and

BCOs agree on door-to-door service (C42) while experts choose industry level (C43). Environment tears between criteria. It is hard to say exact best but air quality problems for 3PLs, and carbon footprint for carriers, BCOs, and experts shine out. In the safety dimension, carriers and experts generally determine accident and collision (C62) as the best while BCOs determine piracy (C61), and 3PLs determine theft (C63). In the last dimension, carriers, 3PLs, and experts stay at health problems (C72), and BCOs give equal importance to public reaction (C27) and quadruple bottom line (C73).

Table 27. Average Others-to-Worst Results

		Carrier	**3PL**	**BCO**	**Expert**	**General**
Dimension	*Criteria*	*Others-to-Worst*				
Cost	*C11*	5,16667	4,83333	4,16667	3,75000	*4,67857*
	C12	5,00000	5,00000	4,16667	7,50000	*5,17857*
	C13	3,00000	2,33333	2,16667	1,00000	*2,39286*
	C14	3,91667	4,33333	2,66667	4,25000	*3,78571*
Time	*C21*	5,08333	3,66667	2,83333	2,75000	*3,96429*
	C22	4,66667	6,16667	5,00000	6,00000	*5,25000*
	C23	4,00000	4,00000	3,83333	4,75000	*4,07143*
	C24	2,66667	3,00000	2,83333	3,75000	*2,92857*
Service	*C31*	5,91667	6,83333	6,33333	6,25000	*6,25000*
	C32	6,50000	6,66667	5,00000	6,25000	*6,17857*
	C33	5,33333	5,00000	4,00000	3,25000	*4,67857*
	C34	3,33333	2,50000	2,66667	4,25000	*3,14286*
	C35	3,33333	3,16667	5,16667	3,25000	*3,67857*
	C36	4,16667	2,50000	5,16667	3,00000	*3,85714*
Hinterland	*C41*	4,00000	4,66667	4,66667	4,50000	*4,35714*
	C42	4,58333	5,00000	5,83333	4,50000	*4,92857*
	C43	4,50000	4,16667	2,50000	5,00000	*4,07413*
	C44	3,08333	1,83333	2,16667	2,50000	*2,53571*
Environment	*C51*	3,50000	3,50000	2,16667	4,00000	*3,28571*
	C52	4,08333	3,16667	2,33333	2,00000	*3,21429*
	C53	3,75000	4,00000	1,16667	3,50000	*3,21429*
	C54	3,00000	3,16667	4,66667	5,50000	*3,75000*
Safety & Security	*C61*	4,33333	3,66667	4,00000	4,75000	*4,17857*
	C62	5,50000	3,33333	3,16667	7,00000	*4,75000*
	C63	2,16667	4,16667	3,66667	1,50000	*2,82143*
	C64	3,75000	3,66667	3,83333	3,75000	*3,75000*
Social	*C71*	1,41667	3,00000	4,16667	4,00000	*2,71429*
	C72	4,16667	3,66667	2,00000	5,50000	*3,78751*
	C73	3,91667	3,33333	4,50000	3,50000	*3,85714*

Source: Created by author.

In the table above, a criterion having a lower average OW score means this criterion is mostly rated as Worst Criterion within its dimension. In this direction, canals and passages (C14) is mainly the worst for BCOs and mandatory assistance is (C13) for the others in the cost dimension. For the time dimension, experts say distance (C21) is, and the others say berthing and cargo handling (C24) is the worst in general. Next, carriers select loss potential (C35), BCOs select shipping alliances (C34) and brand image (C36) as the worst, 3PLs stay between C34 and C36. For the hinterland dimension, carriers, 3PLs, and experts mostly rated dry-port connection (C44) as the worst criterion. Even though BCOs selections show that C44 has the lowest average value, industry level (C43) is determined as the worst one mostly. Carriers and 3PLs decide that carbon footprint (C54) is the worst one in the environment dimension while BCOs decide on air quality problems (C53) and experts decide on ozone layer spoil (C52). For the safety & security dimension, carriers and experts have the same worst – theft (C63) – and 3PLs and BCOs have the same worst – lashing, stacking and trimming (C64). And the last, in general, carriers and experts believe public reaction (C71) is the worst criterion; 3PLs believe quadruple bottom line (C73) is the worst criterion, and BCOs believe health problems (C72) is the worst one for the social dimension.

Table 28 reveals average local weights of each criterion for each sector (Overall local weights are available in Appendix 13). In the table below, a criterion with a higher value specifies that the criterion is more important than the lower one.

Table 28. Average Local Weights

Dimension	Criteria	Carrier	3PL	BCO	Expert	General
		Local Weights (Average)				
Cost	*C11*	0,33124	0,32054	0,32513	0,15611	0,28326
	C12	0,28684	0,28352	0,28552	0,52767	0,34589
	C13	0,19573	0,11445	0,11878	0,06335	0,12308
	C14	0,18619	0,28149	0,27057	0,25287	0,24778
Time	*C21*	0,33011	0,21791	0,17506	0,14559	0,21717
	C22	0,28411	0,43850	0,39330	0,31519	0,35778
	C23	0,20684	0,22903	0,29965	0,32462	0,26503
	C24	0,17894	0,11455	0,13199	0,21460	0,16002
Service	*C31*	0,21888	0,27825	0,22803	0,22389	0,23726
	C32	0,24965	0,28745	0,20790	0,28571	0,25768
	C33	0,21391	0,16913	0,12501	0,09649	0,15114
	C34	0,10550	0,06492	0,09974	0,12051	0,09766
	C35	0,10951	0,10682	0,15620	0,13376	0,12657
	C36	0,10254	0,09343	0,18312	0,13965	0,12969
Hinterland	*C41*	0,27878	0,30415	0,23591	0,20787	0,25668
	C42	0,37310	0,30641	0,43678	0,32883	0,36128
	C43	0,21469	0,27396	0,18065	0,34296	0,25307
	C44	0,13344	0,11548	0,14666	0,12034	0,12898
Environment	*C51*	0,21761	0,23122	0,16622	0,23041	0,21136
	C52	0,27496	0,19639	0,20404	0,13053	0,20148
	C53	0,24755	0,32756	0,12751	0,23345	0,23402
	C54	0,25988	0,24483	0,50223	0,40562	0,35314
Safety & Security	*C61*	0,28036	0,22299	0,33365	0,27306	0,27751
	C62	0,37530	0,21642	0,19633	0,46825	0,31408
	C63	0,13591	0,33415	0,21326	0,07709	0,19010
	C64	0,20843	0,22644	0,25677	0,18160	0,21831
Social	*C71*	0,16141	0,28366	0,42681	0,25821	0,28252
	C72	0,45487	0,36478	0,16333	0,52308	0,37652
	C73	0,38371	0,35155	0,40986	0,21871	0,34096

Source: Created by author.

In the result of obtaining BO and OW vectors, local weights of the criteria (Table 28) – also called optimal weights – have been computed with BWM Excel Solver (available at www.bestworstmethod.com). By using the solver, output-based consistency ratios (CR) are also calculated. CR will be discussed at the following sections in detail.

Step 11 – Normalization of Local Weights

Table 29. Normalized Average Local Weights

		Carrier	3PL	BCO	Expert	General
Dimension	*Criteria*	*Normalized Weights (Average)*				
Cost	*C11*	0,47368	0,45838	0,46493	0,22324	0,43275
	C12	0,42693	0,42200	0,42498	0,78539	0,47667
	C13	0,28476	0,16650	0,17280	0,09217	0,20791
	C14	0,27712	0,41897	0,40272	0,37637	0,34861
Time	*C21*	0,49135	0,32435	0,26056	0,21670	0,36687
	C22	0,43780	0,67570	0,60605	0,48568	0,53167
	C23	0,32094	0,35537	0,46495	0,50369	0,38528
	C24	0,28572	0,18291	0,21076	0,34268	0,25576
Service	*C31*	0,43777	0,55650	0,45607	0,44777	0,46856
	C32	0,52519	0,60471	0,43736	0,60104	0,53424
	C33	0,39421	0,31169	0,23037	0,17782	0,31050
	C34	0,33094	0,20363	0,31285	0,37801	0,30651
	C35	0,32027	0,31241	0,45681	0,39118	0,35798
	C36	0,27705	0,25242	0,49476	0,37731	0,33275
Hinterland	*C41*	0,39461	0,43052	0,33392	0,29425	0,37496
	C42	0,54280	0,44578	0,63545	0,47840	0,53266
	C43	0,32499	0,41472	0,27347	0,51916	0,36092
	C44	0,38696	0,33489	0,42530	0,34898	0,37859
Environment	*C51*	0,41498	0,44093	0,31697	0,43938	0,40303
	C52	0,39994	0,28566	0,29679	0,18986	0,32333
	C53	0,42121	0,55734	0,21696	0,39721	0,40318
	C54	0,34650	0,32644	0,66964	0,54083	0,43921
Safety & Security	*C61*	0,44267	0,35208	0,52681	0,43114	0,43964
	C62	0,58743	0,33875	0,30730	0,73291	0,49490
	C63	0,21153	0,52009	0,33192	0,11999	0,29037
	C64	0,32775	0,35606	0,40375	0,28555	0,34407
Social	*C71*	0,21805	0,38320	0,57657	0,34880	0,34894
	C72	0,59819	0,47972	0,21479	0,68789	0,50346
	C73	0,48187	0,44148	0,51471	0,27466	0,45065

Source: Created by author.

In step 11 optimal scores have been normalized (Table 29). The normalization procedure conducted in the DEMATEL method (explained in Step 6) has been used to normalize local weights of BWM (see Appendix 14 for overall normalized weights).

4.1.2.4. Results of Hybridization of DEMATEL and Best-Worst Method

In this section, Step 12 provides importance degree of dimensions and criteria by DEMATEL and BWM hybridization, which are computed by multiplying local weights of criteria and weights of dimensions.

Step 12 – Calculation of influential global weights

Table 30. Influential Global Weights of Carriers

Dimension	Weight	Rank	Criteria	Weight	Rank
Cost	0,15680	2	C11	0,07574	3
			C12	0,06559	8
			C13	0,04476	17
			C14	0,04257	21
Time	0,14293	4	C21	0,06799	7
			C22	0,05852	10
			C23	0,04261	20
			C24	0,03686	23
Service	0,16368	1	C31	0,07333	4
			C32	0,08363	1
			C33	0,07166	5
			C34	0,03534	25
			C35	0,03669	24
			C36	0,03435	26
Hinterland	0,15538	3	C41	0,05705	11
			C42	0,07635	2
			C43	0,04393	19
			C44	0,02731	27
Environment	0,14231	5	C51	0,04466	18
			C52	0,05643	12
			C53	0,05080	16
			C54	0,05333	13
Safety & Security	0,11816	7	C61	0,05100	15
			C62	0,06827	6
			C63	0,02472	28
			C64	0,03791	22
Social	0,12073	6	C71	0,02165	29
			C72	0,06101	9
			C73	0,05146	14

Source: Created by author.

Table 30 shows carriers' perspectives in terms of dimension and criteria. Service is the most important dimension, cost is the second, and hinterland is the third while the least one is safety & security and social respectively. Carriers think that equipment availability (C32) is the most important, door-to-door service (C42) is second, slow steam applicability (C11) is third, schedule reliability (C31) is fourth, and competition (C33) is fifth important criteria while least important five criteria are public

reaction (C71), theft (C63), dry-port connections (C44), brand image (C36), and shipping alliances (C34) respectively. The next relatively important five criteria also are accident and collision (C62), distance (C21), energy efficiency (C12), health problems (C72), and transit time (C22). According to the table above, importance degree of criteria under service dimension diverges. Half of those criteria have high importance levels while others have very low importance levels. The criteria under cost dimension stay similar to service. The criteria of environment dimension are moderate while safety & security and social dimensions' criteria have the lowest rankings, more or less.

Table 31. Influential Global Weights of 3PLs

Dimension	Weight	Rank	Criteria	Weight	Rank
Cost	0,15440	1	C11	0,07330	4
			C12	0,06483	6
			C13	0,02617	28
			C14	0,06437	7
Time	0,13739	5	C21	0,04489	18
			C22	0,09032	3
			C23	0,04718	16
			C24	0,02360	27
Service	0,15310	2	C31	0,09322	2
			C32	0,09630	1
			C33	0,05666	11
			C34	0,02175	29
			C35	0,03579	24
			C36	0,03130	25
Hinterland	0,15202	3	C41	0,06224	9
			C42	0,06271	8
			C43	0,05606	12
			C44	0,02363	26
Environment	0,13083	7	C51	0,04745	15
			C52	0,04030	21
			C53	0,06722	5
			C54	0,05024	13
Safety & Security	0,13847	4	C61	0,04056	20
			C62	0,03937	22
			C63	0,06078	10
			C64	0,04119	19
Social	0,13380	6	C71	0,03805	23
			C72	0,04893	14
			C73	0,04715	17

Source: Created by author.

Table 31 shows a compression of 3PLs' responses. Cost (0,1544), service (0,1531), and hinterland (0,1520) dimensions are the most important dimensions. These are followed by safety & security (0,1384), time (0,1373), social (0,1338), and environment (0,1308). In the same way as carriers, the most important criteria are

equipment availability (C32), the second one is schedule reliability (C31), the third one is transit time (C22), the fourth one is slow steam applicability (C11), and the fifth one is air quality problems (C53). The next five important criteria are energy efficiency (C12), canals and passages (C14), door-to-door transportation (C42), port rotation (C41), and theft (C63). The least important five criteria are shipping alliance (C34), mandatory assistance (C13), berthing and cargo handling (C24), dry-port connections (C44), and brand image (C36). Criteria of cost dimension are dominant towards other criteria, and criteria under social and safety & security dimensions are the criteria having lowest average importance levels.

Table 32. Influential Global Weights of BCOs

Dimension	Weight	Rank	Criteria	Weight	Rank
Cost	0,16417	1	C11	0,07435	5
			C12	0,06529	7
			C13	0,02716	27
			C14	0,06187	8
Time	0,15687	2	C21	0,03606	21
			C22	0,08101	3
			C23	0,06172	9
			C24	0,02719	26
Service	0,14692	4	C31	0,07639	4
			C32	0,06965	6
			C33	0,04188	17
			C34	0,03341	24
			C35	0,05233	14
			C36	0,06135	10
Hinterland	0,15203	3	C41	0,04828	15
			C42	0,08939	2
			C43	0,03697	20
			C44	0,03001	25
Environment	0,14222	5	C51	0,03411	23
			C52	0,04187	18
			C53	0,02617	28
			C54	0,10307	1
Safety & Security	0,11561	7	C61	0,06069	11
			C62	0,03571	22
			C63	0,03879	19
			C64	0,04670	16
Social	0,12218	6	C71	0,05724	12
			C72	0,02191	29
			C73	0,05497	13

Source: Created by author.

The table above reflects BCOs opinion about route selection criteria. The heading dimension is cost (0,1641), which strictly differs from others. The next two are time (0,1568), and hinterland (0,1520) while service is the fourth (0,1469), environment is the fifth (0,1422), social is the sixth (0,1221), and safety & security

(0,1156). The table shows that carbon footprint-C54 is the most important criterion (0,1030). The second one is door-to-door service-C42 (0,0893), third one is transit time-C22 (0,0810), fourth one is schedule reliability-C31 (0,763), and fifth one is distance-C11 (0,0743). These five criteria continue with equipment availability-C32, transit time-C12, canals and passages-C14, congestion-C23, and brand image-C36; and their weights are 0,0696; 0,0652; 0,0618; 0,0617; and 0,0613 respectively. When it is considered average rankings social and environment dimensions have the criteria with lower rankings. For BCOs, the criteria under cost, service, and time dimensions surpass the criteria under other dimensions.

Table 33. Influential Global Weights of Experts

Dimension	Weight	Rank	Criteria	Weight	Rank
Cost	0,16550	1	C11	0,03570	20
			C12	0,12066	1
			C13	0,01449	28
			C14	0,05782	11
Time	0,13980	4	C21	0,02999	24
			C22	0,06492	10
			C23	0,06687	9
			C24	0,04420	17
Service	0,15951	2	C31	0,07500	5
			C32	0,09571	2
			C33	0,03232	23
			C34	0,04037	19
			C35	0,04481	16
			C36	0,04678	15
Hinterland	0,11706	7	C41	0,04254	18
			C42	0,06729	8
			C43	0,07018	6
			C44	0,02463	27
Environment	0,15751	3	C51	0,04728	14
			C52	0,02679	26
			C53	0,04791	13
			C54	0,08324	4
Safety & Security	0,13926	5	C61	0,04967	12
			C62	0,08517	3
			C63	0,01402	29
			C64	0,03303	22
Social	0,12137	6	C71	0,03463	21
			C72	0,07016	7
			C73	0,02933	25

Source: Created by author.

Table 33 explains Experts' considerations on importance levels of dimensions and criteria. Thusly, dimensions importance levels are sorted as cost (0,1655), service (0,1595), environment (0,1575), time (0,1398), safety & security (0,1392), social (0,1213), and hinterland (0,1170). Taking of that most important five criteria are

determined as energy efficiency (C12), equipment availability (C32), accident and collision (C262), carbon footprint (C54), and schedule reliability (C31). The importance levels of following five criteria are industry level-C43 (0,0701), health problems-C72 (0,0701), door-to-door service-C42 (0,0672), congestion-C23 (0,0668), and transit time-C22 (0,0649). On the other hand, the least important five criteria are theft (C63) with 0,0140 weight, mandatory assistance (C13) with 0,0144 weight, dry-port connections (C44) with 0,0246, ozone layer spoil (C52) with 0,0267 weight, and quadruple bottom line (C73) with 0,0293 weight.

Table 34. Average Influential Global Weights

Dimension	Weight	Rank	Criteria	Weight	Rank
Cost	0,16007	1	C11	0,06920	6
			C12	0,07323	4
			C13	0,03268	27
			C14	0,05356	11
Time	0,14419	3	C21	0,05077	14
			C22	0,07107	5
			C23	0,05115	13
			C24	0,03299	28
Service	0,15634	2	C31	0,07848	2
			C32	0,08508	1
			C33	0,05645	9
			C34	0,03273	26
			C35	0,04100	22
			C36	0,04126	21
Hinterland	0,14325	5	C41	0,05421	10
			C42	0,07493	3
			C43	0,04879	16
			C44	0,02672	29
Environment	0,14365	4	C51	0,04337	20
			C52	0,04562	19
			C53	0,04863	17
			C54	0,06760	7
Safety & Security	0,12733	6	C61	0,05065	15
			C62	0,05751	8
			C63	0,03393	25
			C64	0,03980	23
Social	0,12518	7	C71	0,03464	24
			C72	0,05135	12
			C73	0,04813	18

Source: Created by author.

Table 34 demonstrates overall importance levels of all dimensions and criteria. Not surprisingly, cost is determined as the most important and influential dimension with 0,1600 weight. The second most important dimension is service with 0,1563 weight, which is slightly lower than the weight of cost. The third, fourth, and fifth dimensions are lined up marginally close. Their weights are 0,1441, 0,1436, and

0,1432, respectively. The lowest importance level points out social dimension with 0,1251 weight, and the second least important dimension is safety & security with 0,1273 weight.

Overall scores given in Table 34 show that equipment availability-C32 (0,0850), schedule reliability-C31 (0,784), door-to-door service-C42 (0,0749), energy efficiency-C12 (0,0732), and transit time-C22 (0,0710) are the first five most important criteria. Following that slow steam applicability-C11 (0,0692), carbon footprint-C54 (0,0676), accident and collision-C62 (0,0575), competition-C33 (0,0564), and port rotation-C41 (0,0542) also have high importance levels compared to rest of criteria. The next criterion, canals and passages-C14, does not have a big difference from 10th important criterion. However, with 7th important criterion, carbon footprint weights appreciably diminish. The criteria with moderate importance levels are congestion-C23 (0,0511), distance-C21 (0,0507), piracy-C61 (0,0506), industry level-C43 (0,0487), air quality problems-C53 (0,0486), and quadruple bottom line-C73 (0,0481). The least important criterion is dry-port connection-C44 (0,0267), followed by berthing and cargo handling-C24 (0,0329), mandatory assistance-C13 (0,0326), shipping alliances-C34 (0,0327), theft-C63 (0,0339), public reaction-C71 (0,0346), and lashing, stacking and trimming-C64 (0,0398).

Step 13 –Calculation of priority levels

Table 34 explains pure weights that imply importance level while Table 35 arrays the criteria according to priority perception and relative importance thereby including normalized values in calculation. Because, in such a complicated situation, data are to be adjusted to diminish probability distribution with the intention of acquiring normal distribution. Apart from some exceptions, the priority levels are similar for each sector. Only the sequences are different for the first ten criteria. Carriers think that equipment availability (C32), door-to-door service (C42), schedule reliability (C31), accident and collision (C62), and slow steam applicability (C11) have the highest priority levels respectively in route selection. Then, energy efficiency (C12), health problems (C72), transit time (C22), distance (C21), and carbon footprint (C54) follow them. Otherwise, theft (C63), public reaction (C71), berthing and cargo handling (C24), mandatory assistance (C13), and dry-port connections (C44) are the least preferential.

Table 35. Average Priority Levels

		Carrier		3PL		BCO		Expert		General	
Dimension	Criteria	Score	*Rank*	Score	*Rank*	Score	*Rank*	Score	*Rank*	Score	*Rank*
Cost	*C11*	0,03278	5	0,03172	5	0,03217	6	0,01545	18	0,02995	6
	C12	0,03126	6	0,03090	6	0,03112	7	0,05751	1	0,03491	5
	C13	0,00931	26	0,00544	29	0,00565	29	0,00301	29	0,00679	29
	C14	0,01484	20	0,02244	10	0,02157	11	0,02016	12	0,01867	15
Time	*C21*	0,02442	9	0,01612	20	0,01295	22	0,01077	23	0,01823	16
	C22	0,03010	8	0,04646	2	0,04167	3	0,03339	8	0,03655	4
	C23	0,01565	19	0,01733	19	0,02267	10	0,02456	10	0,01879	14
	C24	0,00898	27	0,00575	28	0,00662	28	0,01077	24	0,00803	28
Service	*C31*	0,03436	3	0,04368	3	0,03579	5	0,03514	7	0,03677	3
	C32	0,04468	1	0,05145	1	0,03721	4	0,05113	2	0,04545	1
	C33	0,02225	13	0,01759	18	0,01300	21	0,01004	25	0,01753	18
	C34	0,01083	24	0,00667	27	0,01024	27	0,01237	20	0,01003	26
	C35	0,01313	21	0,01281	24	0,01873	14	0,01604	15	0,01468	21
	C36	0,01143	23	0,01041	25	0,02041	12	0,01557	17	0,01373	22
Hinterland	*C41*	0,02139	14	0,02334	9	0,01810	15	0,01595	16	0,02033	12
	C42	0,04067	2	0,03340	4	0,04761	1	0,03584	5	0,03991	2
	C43	0,01586	18	0,02023	13	0,01334	20	0,02533	9	0,01761	17
	C44	0,01034	25	0,00895	26	0,01136	23	0,00932	26	0,01011	25
Environment	*C51*	0,01800	17	0,01912	15	0,01375	18	0,01906	14	0,01748	19
	C52	0,01824	16	0,01303	23	0,01354	19	0,00866	27	0,01475	20
	C53	0,02048	15	0,02710	7	0,01055	26	0,01932	13	0,01961	13
	C54	0,02342	10	0,02207	11	0,04527	2	0,03656	4	0,02969	7
Safety & Security	*C61*	0,02242	12	0,01783	16	0,02668	8	0,02184	11	0,02227	10
	C62	0,03378	4	0,01948	14	0,01767	16	0,04215	3	0,02846	8
	C63	0,00718	29	0,01765	17	0,01126	24	0,00407	28	0,00985	27
	C64	0,01304	22	0,01417	21	0,01607	17	0,01137	22	0,01369	23
Social	*C71*	0,00755	28	0,01328	22	0,01998	13	0,01208	21	0,01209	24
	C72	0,03072	7	0,02463	8	0,01103	25	0,03532	6	0,02585	9
	C73	0,02319	11	0,02125	12	0,02477	9	0,01322	19	0,02169	11

Source: Created by author.

The results show that influential priorities of carriers and 3PLs are quite similar. 3PLs prefer equipment availability (C32), transit time (C22), schedule reliability (C31), door-to-door service (C42), and slow steam applicability (C11) as most prior criteria while the next five are energy efficiency (C12), air quality problems (C53), health problems (C72), port rotation (C41), and canals and passages (C14). Mandatory assistance (C13), berthing and cargo handling (C24), shipping alliances (C34), dry-

port connections (C44), and brand image (C36). 3PLs pay the least attention to mandatory assistance (C13), berthing and cargo handling (C24), shipping alliances (C34), dry-port connections (C44), and brand image (C36). BCOs responses show that door-to-door service (C42), carbon footprint (C54), transit time (C22), equipment availability (C32), and schedule reliability (C31) are given the highest priority. Also, slow steam applicability (C11), energy efficiency (C12), piracy (C61), quadruple bottom line (C73), and congestion (C23) follow the first five criteria. The criteria at the lowest ranking are mandatory assistance (C13), berthing and cargo handling (C24), shipping alliances (C34), air quality problems (C53), and health problems (C72). The results of experts partially differ in general. Thuswise, energy efficiency (C12), equipment availability (C32), accident and collision (C62), carbon footprint (C54), and door-to-door service (C42) stay at the highest rankings in priority table. Further, the table continues with health problems (C72), schedule reliability (C31), transit time (C22), industry level (C43), and congestion (C23). In the table, mandatory assistance (C13), theft (C63), ozone layer spoil (C52), dry-port connections (C44), and competition (C33) are listed at the bottom. When the general overview is checked, equipment availability (C32) has the highest priority as it was ranked at the top by almost all participants. Then, door-to-door service (C42), schedule reliability (C31), transit time (C22), and energy efficiency (C12) stay at the next four places. Slow steam applicability (C11), carbon footprint (C54), accident and collision (C62), health problems (C72), and piracy (C61) come after. The least priority levels belong to mandatory assistance (C13), berthing and cargo handling (C24), theft (C63), shipping alliances (C34), and dry-port connections (C44).

4.1.2.5. Validity and Reliability of Study

Social media analysis relies on a studiously performed coding process. In coding dataset, it was adjusted MacPhail et al. (2015)'s method to our model. For validity and reliability in the classification of stakeholders' standings and TA, the dataset has been iteratively read and evaluated within different time frames. At the end of iterations, cross-validation has been rendered with discussions on class labels, and then a final consensus has been reached. To confirm the reliability, intercoder verifications have been conducted. In coding standings of stakeholders, Krippendorff's Alpha is applied to intercoder reliability (ICR) of the study, in which two

researchers independent from the study have been consulted. In TA, Average Pairwise Percent Agreement is used in coding themes.

In the coding procedure, which is exemplified in Table 12, one of the researchers from the study and two coders that are blind rats about research objectives manually processed data. Independent coders have just been told that they determine what they understand from comments on the selected posts. They have also been asked they iteratively examine data within the different periods. ICR, calculated with the formula of Krippendorff (2011), was found 0.81 from 201 decisions. As advised by Krippendorff (2011), ICR results seem above the acceptable range ($\alpha \geq 0.80$).

To calculate Intercoder reliability same researchers have coded the data. Similar to labeling the standings, independent coders have been requested they iteratively evaluate data. Distinct from the standings, they have not been completely blind herein. They have been given the determined 10 themes and have been asked to label the data with at least one and at most four theme(s) from the list. Due to the complexity of calculating ICR in labeling 67 comments using 10 different nominal tags, we have preferred the percent agreement method (Scott, 1995: 322 – 323) instead of Krippendorff's alpha. The results show that coders have coded 268 themes, non-identically and with different sizes of themes (Table 36). Overall ICR is calculated as 0.876, which is strongly acceptable. ICR between Coder-1 and Coder-2 is 0.873, between Coder-1 and Coder-3 is 0.888, and between Coder-2 and Coder-3 is 0.869, these two also seem fair.

Table 36. Inter-rater Agreements

	Coder 1/2	**Coder 1/3**	**Coder 2/3**
N.of Coded Theme	268	268	268
N.of Agreement	234	238	233
N.of Disagreement	34	30	35
Percent Agreement	0.8731343	0.8880597	0.8694029
Average Percent Agreement	0.8768656		

Source: Created by author.

The original procedure of DEMATEL method is deemed as reliable by its nature (Shieh and Wu, 2013: 1) because it is assumed that total relation matrix would converge to zero through the formulation of $\boldsymbol{T = \lim_{n\to\infty}\left(D + D^2 + \cdots + D^m\right) = D(1 - D)^{-1}}$ (Lee et al., 2013: 6747 – 6749). The determination of threshold value is

another issue in DEMATEL procedure and there are three approaches for threshold value. First (x), threshold value can be computed by sum of total relation matrix T (Shieh and Wu, 2013: 1), second (y), median value of total relation matrix T can be multiplied by 1,5 (Hsieh et al., 2016: 9), and last, calculated threshold value can be touched up by expert (Liaw et al., 2020: 11). In this study, first and second method are handled primarily. In first method threshold values were too low and INRMs were complicated and became incomprehensible due to many relationship arrows. Then, second method was conducted, but resulting INRMs were not enough to explain the system. Also, Peleckis (2021) highlights that only expert decisions in determination of threshold value may influence causal relationships (Peleckis, 2021: 2). Therefore, it was decided to hybridize the three approaches. In this way, average value of first two methods was computed. The final values were discussed with two experts, and it was decided to accept 10% error margin. For example, threshold value for a group is calculated as

$$\boldsymbol{\alpha = [Mean(x, y)] - \frac{10}{100}[Mean(x, y)]}$$

Several comparisons of different scales and BWM scale are handled by various studies. It is found that BWM gives considerably reliable and consistent results (Kiritchenko and Mohammad, 2017: 469; Burton et al., 2019: 8-9; Parvin et al., 2016: 6). In BWM, reliability and consistency levels of comparisons are obtained from consistency ratio (CR) index that is represented by ξ. CR that converges to "0" means higher consistency, and $\boldsymbol{\xi < 0,10}$ is accepted as highly reliable and consistent (Alimohammadiou and Sharifian, 2022: 17).

Table 37. BWM Average Consistency (ξ) Results

Dimension	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social	Average ξ
Sector								
Carrier	0,0949	0,1250	0,0976	0,1076	0,0936	0,1015	0,0566	0,0967
3PL	0,1063	0,0986	0,0826	0,0788	0,0860	0,0967	0,0775	0,0895
BCO	0,0908	0,0840	0,0830	0,0819	0,0786	0,0983	0,0772	0,0848
Expert	0,1027	0,0877	0,0815	0,0989	0,0740	0,0836	0,0974	0,0894
Average ξ of Dimensions	*0,0987*	*0,0988*	*0,0862*	*0,0918*	*0,0830*	*0,0950*	*0,0772*	***0,0901***

Source: Created by author.

Table 37 shows the average CR results of the BWM for each dimension (see Appendix 10 for overall CR results). Overall average ξ score was found 0,0901. The reliability and consistency of the results were found acceptably high. Although ξ score of some criteria and dimensions were found higher than 0,10, these stay within an acceptable range.

To provide validation of the results, as proposed by Munim et al. (2020), results of both DEMATEL and BWM were discussed with five experts (two carriers, one 3PL, one BCO, and one expert), who have already participated in the study. And as proposed by Çetinkaya (2020) the five experts were requested to re-answer the questionnaire. First, DEMATEL results were checked, and it was indicated that some additional relationships can be added. These feedbacks were noted for future studies and will be detailed in discussion section but, there is no need to change the results. Then, the second applications of BWM were slightly found different from the first one. The participants did not change their previous decisions generally. The changes were mainly on the decision Best-to-Other vectors and Others-to-Worst Vectors, rather than changing the Best or the Worst criterion.

Additionally, knowledge and perception of decision-makers affect their answers. To test consistency of participants' answers, some of the criteria with similar effects and implications were intentionally chosen. These were not randomly appointed. Particularly, the questions that are highly concerned about Arctic shipping were determined. For instance, it is found in the social media analysis that public reaction has become a factor to be considered. if a decision-maker gives importance to brand image, she/he will probably mind public reaction. Also, air quality problems are the initial cause of health problems, and these should be evaluated within the same perspective. Again, theft and lashing, stacking, and trimming are the probabilities resulting in a loss. Hence, the criteria of loss potential, theft, and lashing stacking, and trimming should stay close. The results show that the above-explained criteria were rated nearly equivalent. That is to say, participants have high knowledge; they may tie their knowledge and perception and they did not lose their concentration when responding to questions.

CHAPTER V
CONCLUSION

5.1. SUMMARY OF MAIN FINDINGS AND DISCUSSION

The study consists of three analyses – Social Media content analysis, DEMATEL, and BWM. First, criteria have been determined from route selection and carrier selection literature after a comprehensive review. To form the ultimate shape of dimensions and criteria, first, perspectives of practitioners have been examined, and then expert opinion has been consulted. Second, DEMATEL questionnaire has been applied to 28 participants from different sectors of the shipping industry. Third, local weights of criteria have been determined by benefiting pairwise comparisons of BWM. And last, DEMATEL and BWM have been hybridized to calculate influential global weights and priority levels. In line with the study inflow, the main findings of implemented methodology will be summarized and discussed respectively.

Social media analysis includes lexical classification, sentiment & emotion detection, and thematic analysis. Lexical classification shows that majority of the comments are written on the post of shipowners' no to use declaration. Others are related to environmental protection and safe shipping in polar zones, early opening of NSR, and Suez obstruction. To answer the second research question of this study (How do shipping companies perceive and see establishment and usage of ASR?). The comments identify that practitioners are significantly unfavor for Arctic usage while some stays in-between and a few are favor of it. The words used in comments such as decision, shipping, future, environmental, and good have the highest frequency while Arctic, sustainability, Arctic Shipping, Polar Code, and CMA CCGM are for hashtags. Although standings of practitioners have been given before, sentiments embedded in written texts may differ. The results show that positive sentiments are dominant, neutral sentiments are also unignorable, and negative sentiments are very low in comments. Despite most of the practitioners being unfavor of ASR usage, positive sentiments stay significant. The reason is that unfavor comments are texted on not to usage decisions of companies in a positive manner. Besides, comments are found to be written with high subjectivity in keeping with personal beliefs and feelings. In emotion detection, practitioners' emotions are grouped in conformity with their standings. The practitioners, who are favor to ASR usage, are stimulated by anticipation, trust, and joy; unfavors' feelings are listed as

joy, anticipation, trust, and surprise; and in-betweens' emotions rely on trust. Last, the themes in comments can be sorted as environmental considerations, business attitudes & behaviors, policy, corporate social responsibility, sustainability, awareness, cost, geography, distance & transit time, and safety issues with respect to their shares.

The participants in this study are asked to answer questionnaires including both DEMATEL and BWM surveys. Most of the participants have at least 10 years of experiences. The participants are to have decision-making authority. Their positions vary from manager to CEO, accordingly. Also, more than 90% of the company addressed large size. Almost half of them are a carrier that is the initial arbiter in routing. Further, the study is tried to be implemented worldwide. The rest of the participants are dispersed in EU, Scandinavia, Asia, North America, and Oceania while %43 of them are from Türkiye.

In the DEMATEL method, seven dimensions (cost, time, service, hinterland, environment, safety & security, and social) have been compared to determine influence level of dimensions over each other. After conducting several steps of DEMATEL method, first, total relation matrices have been obtained; second, causal diagrams have been figured out; and then influential network relation maps have been drawn by using threshold values. The results show that hinterland and safety & security affect cost, time, service, service, environment, and social, generally speaking. In other words, hinterland and safety & security have causal effects on others. The causal diagrams reflect all dimensions are found in juxtaposition except hinterland. Time and cost are the most influential dimensions. Also, cost and service have the strongest network with others. By using threshold values, influential relations have been reduced and INRMs have been produced. The average responses show that cost dimension mutually influences both service and environment dimensions. Hinterland affects cost, time, service, and environment, but no dimension affects hinterland. Also, cost is affected by safety & security. The influential relations indicate that the strongest relationship is appointed between hinterland and cost. The strength of influences from hinterland to service, from service to cost, and from time to cost are higher than others. Otherwise, the influences from cost to environment, from service to time, and from safety & security to cost have the lowest values respectively.

The results of BWM are obtained from a pairwise comparison of criteria in the same dimension. As a reply to the first research question of this study (What are the priorities and behavior of shipping companies in route selection?), the results show

that slow steam applicability-C11 and energy efficiency-C12 in the cost dimension; transit time-C22 in the time dimension; equipment availability-C32 and schedule reliability-C31 in the service dimension; door-to-door service-C42 in the hinterland dimension; accident and collision-C62 and piracy-C61 in the safety & security dimension; and health problems-C72 are strongly appointed as best criteria while no criteria come to the forefront in the environment dimension. The criteria that are primarily appointed as worst are C13 (mandatory assistance), C24 (berthing and cargo handling), C34 (shipping alliances) and C36 (brand image), C44 (dry-port connection), and C63 (theft) and C64 (lashing, stacking and trimming). In environment and social dimensions, there is no absolute consensus on the worst criteria. Even, the scores given to the criteria belonging to these two dimensions are all similar and not relatively low. After DEMATEL and BWM were hybridized, global weights and priorities have been computed. In this way, service, cost, and time dimensions are found as the most important three criteria. The least important two dimensions are social and safety & security. The influential global weights show that C32 (equipment availability), C31 (schedule reliability), C42 (door-to-door service), C12 (energy efficiency), and C32 (transit time) have the top importance levels while the least important criteria are C44 (dry-port connections), C24 (berthing and cargo handling), C13 (mandatory assistance), C34 (shipping alliances), C63 (theft), and C71 (public reaction), in turn. Following the influential global weights, priority levels have also been computed. The priority levels imply that C32 (equipment availability), C42 (door-to-door service), C31 (schedule reliability), C22 (transit time), and C12 (energy efficiency) have the highest scores while C13 (mandatory assistance), C24 (berthing and cargo handling), C63 (theft), C34 (shipping alliances), and C44 (dry-port connections) have the least priority.

Arctic shipping routes provide a significant distance and transit time advantage in principle. Aksenov et al. (2017) simulate that for two different bulk carriers, ASR decrease distance by up to 40% and CO2 emissions by 49-78% between Far East and Europe on paper. Also, efficiency is almost doubled correlatively. Zhu et al. (2018) indicate that among all means of transport, maritime transportation has the lowest impact on the environment with regards to per ton-kilometer. Fewer distance lowers emissions per voyage but owing to the high volume transportation characteristics of vessels, yearly average emissions may outweigh the constantly spoken advantages of ASR (Zhu et al., 2018). These routes stay as two sides of the same coin. It is hard to decide whether ASR reduce environmental hazards by reducing fuel consumption

or whether environmental and social damages from using ASR would be higher than Suez Canal route because of smaller vessel usage and potential environmental hazards. Nevertheless, the results of this dissertation that reflect considerations and behaviors of stakeholders may guide decision-makers and policymakers.

Discussion of Social Media Analysis Results

The results of social media analysis yield a generalized framework for the perception of practitioners on ASR. Kusal et al. (2021) say that together with their needs and requirements, opinions and emotional states of stakeholders are drivers in such contestable B2B industries for relationship marketing. On SM, issues touching customers' feelings have better engagement such as sustainability and ecology (Denktaş-Şakar and Sürücü, 2018). Suitably, it is determined in this study that most of the comments and reactions are posted on declarations of companies against ASR. Li et al. (2021) reveal that social media strategy as a relationship marketing tool should imply the company generating worthful and on-time content that touches upon stakeholders' emotions. For instance, ASR were rewarmed after the Ever Given Case in March 2021. Some Russian authorities and some stakeholders in the maritime industry underlined ASR are still a vital alternative to Suez Canal. Then, it is found that the CEO of MSC drastically reaffirms MSC will not use the Northern Sea Route towards re-escalating Arctic discussions. This decision is required to be approached multidimensionally. MSC's shipments, direct services between Asia and North Europe, and port call structure must be reviewed. Nevertheless, this social media announcement was observed by the stakeholdes as MSC acts responsibly in an especially environmental and social way. MSC also announces their environmental and social behaviors with bold letters. For instance, Altuntaş-Vural et al. (2021) indicate that Maersk tries to position itself with sustainability issues and eco-friendly services using social media engagement. To support this, Skjoldborg (2022) reports Maersk has strict objectives concerning ESG strategy (a sustainability strategy setting environmental, social, and corporate governance issues). On the contrary, Maersk, which is the first company officially sending a container ship through the Northern Sea Route, does not utter a word about ASR on social media platforms. Even, they did not share any posts about the trial Arctic voyage on social media platforms. Unsurprisingly, such a company might not desire to be questioned about an issue probably that may not be perceived from a sustainability and environmental-friendly

perspective. In this study, a stakeholder was also detected sarcastically asking Maersk why they did not make any sharing after the great effort of passing through ASR. This situation supports the arguments of the study and can be deemed as proof that stakeholders are conceivably against Arctic shipping and see this phenomenon as an environmental bottleneck.

Lerner et al. (2015) say that when there are knowledge gaps and uncertainties about a subject, stakeholders' behaviors would be biased and shaped by their emotions. It is seen in comments that most liner companies stay masked about Arctic waters. Information flow on communication tools is not adequate Hence, stakeholders have insufficient knowledge and cannot agree on either ASR compose costs or benefits. Considering this, stakeholders, who are directed by cognitive appraisals and emotions, are found strongly against Arctic exploitation, a few are favor it while a considerable number of stakeholders stay in-between.

Before conducting analysis, raw data have been pre-processed and standardized using BERT, which is asserted to perform almost perfectly by Başarslan and Kayaalp (2021). Two pieces of word clouds have been generated from cleaned data and the hashtags on comments and posts. The first cloud reveals that practitioners consider ASR are being subject to shipping companies' decisions and behaviors. In this cloud, practitioners find ASR are the reality of the future and are discussed with environment and safety solicitudes. The second one shows how practitioners tag Arctic-related issues. These tags reflect stakeholders' knowledge and opinion. Further, this cloud portrays how practitioners position themselves and want to announce this subject. The results demonstrate that hashtags indicating, and implying ASR are used for categorizing the post or comment. The other high-frequency hashtags concerning environment, policy, safety, and sustainability are figured to catch more attention and to make this issue heard. Accordingly, Pilař et al. (2021) identify that hashtags are messages expressing knowledge, experience, and opinion representation.

It has been benefited from BERT-based libraries such as TextBlob and PyPlutchik to detect the sentiments and emotions of stakeholders as proposed by Nemes et al. (2021) and Semeraro et al. (2021). Zhou et al. (2022) find that VADER works better than TextBlob in some cases. Therefore, VADER has also been tested with current data to ensure sentimental categories but has not been reported. It is found both methods provide a similar level of achievement. For this dataset, TextBlob has performed better in detecting positive and negative sentiments while VADER

works better by a mile in detecting neutral sentiments. Even though TextBlob fails in categorizing some muddy sentiments due to wording, it has been presented without intervention.

The results of sentiment analysis show that comments were commonly shared on companies' declarations against ASR. For this reason, positive sentiments mean to be on the negative side, and negatives are to be on the positive side. Overall results of sentiment analysis disclose that evaluations of stakeholders that have high subjectivity are clear of rationality. Among the stakeholders, the negative side expresses environmental and social dimensions typically. Likewise, within shipping and supply chain literature, where sentiment analysis is counted on the fingers of one hand, Tseng and Cullinane (2018) argue that TBL components are key concerns for ASR. Zhou et al. (2022) find that environmental and social subjects attract stakeholders more and trigger positive sentiments, in a similar manner to this paper. The positive side argues that ASR are inevitable and total emissions decreases around the world for the sake of shorter distance [i.e., "If due to various reasons the Northern Sea Route become accessible (notwithstanding no structural shipping lanes being established) then in future it may be more environmentally prudent to use the northern routes rather than burn more bunker and more emissions. These are interesting times that we live in... having to choose between lesser evils, rather than choosing between the good and the bad....]. Neutrals also advocate wait and see attitude. They do not use bold statements and assess the condition. They mention that on the condition IMO, companies, and international organizations provide a sustainable and safe base, ASR can be viable (i.e., "Great video and an insight to our fragile environment"; "Shorter does not always translate into savings. Arctic route transit requires an icebreaker for 9 months of the year. The passage is narrower and being a vessel, there is more maintenance involved. Various external factors involved"). When it is considered the main approaches of stakeholders, there are no significant differences between labeled standings and results of sentiment analysis. However, sentiment analysis reveals that, for example, a neutral sentiment may be automatically extracted from the comments labeled as FAVOR or UNFAVOR owing to lexical patterns of comments.

In this study, stakeholders take a poor view of ASR, and companies not to use declarations generate trust and anticipation. The emotion detection analysis reveals that anticipation, trust, and joy are dominant emotions found in the comments of stakeholders. Also, surprise is another prominent emotion. Chiorini et al. (2021) and

Acheampong et al. (2020) say that sentiment and emotion detection studies are challenging and have been paid very little attention in business and marketing disciplines. From limited literature, Dhar and Bose (2020) discuss that the more positive emotions of stakeholders such as happiness and joy, the more increased stock prices while detected tweet-wise negative emotions such as anger, fear, and sadness do not show a considerable change. Zimand-Sheiner et al. (2021) argue that SM posts on negatively perceived events prompting distrust surpass rivals by creating engagement paths. The results are refinedly controlled with datasets one by one. It is found that the deep-learning-based automatic emotion detection tool outperforms in this dataset despite some unimportant defects. To illustrate that, the comment “much appreciated and a great decision. Hope others follow suit” includes joy, trust, and anticipation. Again, the comment “This is political decision only…” is found to have no emotion, and “The driving concern is the reduction of Arctic Sea ice and the potential for more shipping. We are already seeing that happen” strongly involves anticipation. It has been observed that PyPlutchik library is successful in identifying main possessor emotions, but it may execute mislabeling on very long sentences. Moreover, the co-occurrence of emotions draws a general overview of stakeholders. The results show that hope and optimism are prominent in the FAVORs’ comments. They see ASR as an unavoidable end, and those should be grounded on a safe and sustainable base. This situation can be seen in their sentences. UNFAVORs’ comments are mainly on expressing their gratitude for MSC’s and CMA CGM’s decisions, hence love and delight co-occur in their mind. And INBETWEENs’ comments that typify curiosity are extremely neutral and robotic.

The content of SM posts depicts stakeholders’ minds. These pictures shaped by opinions, knowledge, and perspectives of stakeholders comprise themes about ASR. The results indicate stakeholders’ mind is relevant to what the literature is talking about ASR. From several dimensions of ASR, environmental factors and companies’ behavior are found planted in the comments. The environmental factors imply that what if regular shipping services are eventualized, it may generate unpredicted and irreparable global environmental devastation. Companies’ behaviors mainly compose from environmental sustainability emphasis, decisions against these routes, and calls for being organized against Arctic usage. Policy thematic comments, in which keywords strongly reflect regulatory and country-level actions, and deal with companies’ environmental policies, hinge upon i.e., IMO Polar Code and HFO ban in the Arctic. Polar Code guarantees environmental and safety standards for polar

navigations, as indicated by Zhu et al. (2018). Nonetheless, Polar Code does not regulate a specific ballast water management system for the vessels navigating through the Arctic. HFO ban in Polar zones is practical to minimize black carbon and exhaust particles along with reducing hazards of potential oil spills and sludge, as emphasized by Ghosh and Ruby (2015). However, it does not create a restriction or standard for the vessels carrying HFO through the Arctic. The dilemma is whether oil spills potential of HFO-burning vessels is higher than low-sulfur fuel burning but HFO-carrying vessels. Even though there are some strong environmental regulations, practitioners point at either ASR being crossed off or stricter norms being made obligatory. Corporate social responsibility and sustainability have been compelling to distinguish unless directly related words have not been used obviously. By considering the usage of word patterns in comments, sustainability indicating words would have been interwoven with environmental considerations while corporate social responsibility has been with business attitudes & behaviors. Although there have been ambiguities, it has been reviewed both literature and raw data. For instance, the word "leadership" can be labeled with different themes, but comments containing "leadership" tell us about companies' socially responsible acts. Awareness theme is determined by using some tricky keywords such as insight, fragile, evidence, etc. resembling stakeholders' knowledge. Nevertheless, cost, geography, distance & transit time, and safety issues are typified by distinct words. Hence these four themes have been labeled without any doubt.

Discussion of MCDM Analysis Results

The discussion of MCDM analysis results will be handled from three different perspectives. First, the criteria will be validated by comparing Arctic shipping and route selection literature. Second, the methods that are benefited in this study are examined by considering similar studies. Third, the results of both methods will be discussed by comparing the results of each participant group. Last, results of these studies will be addressed by referring to Arctic shipping and selection-based studies in shipping and supply chain literature.

a- Discussion of Criteria

Theory of social cost says that economic activities project primary and secondary negative consequences to society and the next generations. Theory of ecological modernization argues that modernization and industrialization cause environmental problems, and to rectify the design defo by bringing contemporary solutions for environmental problems the economy must be ecologized. Behavioral decision theory also suggests that available information, expectations, and utility perception are important in the real-life decisions taken among alternatives, environmental, organizational, and social factors. As it is advised by the abductive reasoning process, theoretical knowledge was synthesised with the real-life information on route selection and Arctic shipping. Herewith, a possible inference can be obtained with current information. In the light of the basics of these theories and the abductive reasoning approach, it was not preferred a stereotype approach in determining the criteria. All criteria are determined by considering characteristics of Arctic routes, differences between ASR and SCR, the purpose of the study, research questions, research objectives, and theoretical framework of the study. For instance, Wan et al. (2021) say that fuel prices, ice-class ship prices, economies of scale, and freight rates are initial cost factors, but these criteria are important regardless of the route to be selected. Also, especially fuel prices, ship prices, and freight are under the direct influence of the global economy (Wan et al., 2021: 2 – 7). It is obvious that major appeal of SCR is the opportunity of exploiting economies of scale thanks to huge vessels. And it is the one of the crucial factors for all parties in supply chains. Nonetheless, it would be a stereotype approach to add economies of scale as a criterion. Because ASR and SCR are not comparable in terms of draft levels and size of hosting vessels. Therefore, Rome is not required to be rediscovered. Speed decision is found as a substantial route selection criterion by Wen et al. (2019) and Fagerholt et al. (2010). In this study, slow steam application that is key a concern for Arctic shipping (Pruyn, 2016: 661) and cost saving (Meng et al., 28) is determined as a speed decision and cost factor. Slow steam provides energy efficiency but does not explain energy efficiency completely. Although ASR precede slow steaming, SCR can compete in energy efficiency that covers all shipping operations because to nuclear ice-breaker requirements, cold temperature-related energy consumptions, and diseconomies of scale of ASR may affect energy efficiency of ASR. Hence, energy efficiency is included as proposed by Sramek et al. (2020) and Williams et al. (2013).

In route selection studies such as Pham et al. (2018), Tischler (2017), and (Woo et al. (2017) ship-related dues are included in cost factors. Accordingly, mandatory assistance (matter of ASR) and canal and passage (matter of SCR) dues are selected as other cost factors.

In time dimension, distance, as indicated by Wen et al. (2019) and Shibasaki et al. (2017) and transit time, as indicated by Wang and Yeo (2018) and Park et al. (2019) are the first two factors. Although ASR provide enormous distance reduction, transit time for SCR may be lower due to speed differences. Also, congestion that occurs in canals, passages, and mooring affects total transit time; and the time spent on berthing and cargo handling operations is significantly higher in less developed regions in terms of logistical infrastructure. The criteria under service dimension are handled in this study within the same manner. Route selection literature such as Woo et al. (2017), Moon et al. (2015), and Teodorovic and Kalic (1995) use service frequency and schedule. In this study, these were converged under schedule reliability. Except some carrier selection studies such as Solakivi and Ojala (2017) and Wong et al. (2008) examining condition of equipment, there is no study arguing the importance of equipment availability along the selected route and return path. Also, service scopes of both competitors and alliance partners are considered because these are the factors that may affect routing and vessel deployment decisions of carriers. Loss potential refers to potential freight loss and damage that may happen in harsh environments and navigational conditions like ASR. Also, it is indicated in several studies like Tiwari et al (2003), Coulter et al. (1989), and Robinson et al. (2013) that loss and damage leads negative reputation for carrier, Brand image is affected from both companies' reputation and stakeholders' reactions against a decision taken.

Within the hinterland dimension, Park et al. (2019) test port rotation, which implies both capabilities and sequences of ports to be called, in route selection. Wang et al. (2018) and Tischler (2017) use transportation network; Tischler (2017) consider geographical conditions and oceanic connectivity of hinterland; and Wen et al. (2019) set to infrastructure reliability. All these criteria form door-to-door service, which means reliability of the hinterland's transportation network. Besides, Yang et al. (2014) focus on characteristics of goods, Kashiha e al. (2016) and Teodorovic and Kalic (1995) say volume and size of shipment are important while Kashiha et al. (2016) are for shipper's characteristics (including origin and size of company). Those point out industrialization degree of a region. Despite huge Chinese (Hong, 2021: 312

– 313) and Russian investments (Tseng and Pilcher, 2017: 396), the Arctic region still has a big enough lack of industrialization level to attract regular shipping services. In addition to industrial investments of China and Russia, Canada, Russia, and China also have investments in logistical networks. China particularly tries developing railway connections of NSR to connect it with the Belt & Road Initiative under the name of Polar Silk Road (Wan et al., 2021: 4). In this study, dry-port connection is used to refer logistical facilities and railway connections, whose importance is high in developed economies' transportation networks, revealed by Padilha and Ng (2012).

Environment and sustainability are handled by several selection studies such as Wen et al. (2019), Fagerholt et al. (2010), and Sramek et al. (2020), etc. It was aimed to use most of the criteria under environment dimension indirectly. In this way, the rationality of participants would decrease, and more behavioral selections would be performed. For instance, instead of using emissions level, which is significantly highlighted by several transportation studies like Klumpp (2018), ozone layer spoil is used. Lindstad et al. (2016) and Hansen et al. (2016) indicate that the substantial cause of ozone layer spoil is the increasing emissions levels in Polar zone, where increasing transportation activities trigger emissions release. Also, ASR decrease total emissions levels worldwide by courtesy of fewer distance, and Dai et al. (2021) argue that air quality is strongly affected by global emissions levels. Last, ASR are to be approached from a sustainability perspective, and carbon footprint has become key sustainability consideration of companies within the supply chain.

Piracy is not needed to comment on in detail. It is the ongoing bottleneck of a part of SCR prolonging between Malacca Straits and Suez Canal. Accident and collision may happen in all waters. However, these risks have been minimized via IMO regulations, SOLAS, MARPOL, continuous amendments to manuals, handbooks, and chapters. Further, information such as weather conditions, charts, and oceanographic situations are provided to the vessels. On the flip side, regulations for Arctic voyages are blurred because newly adopted IMO Polar Code needs time to be properly implemented. Such aforementioned information cannot be completely provided for ASR. Arctic routing will probably become the fact between a few major hubs without several stops. Thus, theft risk is very low under the conditions of fewer port sequences and compelling Arctic environment. Again, vessel stability is one of the most crucial points for shipping. Lashing, stacking, and trimming are the factors leading to instability, crew safety, and even sinking. For those factors that are calculated and implemented blow-by-blow, the unpredictable deep wavy and stormy

conditions of the Arctic region can be a big problem. The criteria of social dimension are public reaction, health problems, and quadruple bottom line. Public reaction, which is involved in Tseng and Cullinane (2018) as stakeholder concerns, was decided to be involved after seeing in the results of social media analysis that the largest shipowner companies consider public reaction in their actions. Likewise, the criteria are determined for both indirectly double-checking some criteria and testing behavior of shipping companies against sustainability issues.

b- Discussion of Methodology

In Arctic shipping literature and route selection literature, different methodologies are used. In Arctic shipping literature, Irina and Peeta (2016) employ a binary probit model. Tseng and Pilcher (2017) use grounded theory analysis. Lee and Kim (2015) practice case studies, semi-structured interviews, and document examination. Koçak and Yercan (2021) benefit from first cost, revenue, and profit calculation model, and then refine the findings by using Fuzzy AHP. Xu et al. (2018) apply shipping cost model by integrating spatiotemporal mapping. Yuan et al. (2019) use a fuzzy cognitive map. Gleb and Jin (2021) formulate a feasibility model for a cost comparison of different routing alternatives. Theocharis et al. (2019) use a speed optimization model to reveal feasibility of NSR. Wang et al. (2018) conduct a discrete choice model by virtue of stated preference and scenario analysis. Beveridge et al. (2016) employ semi-structured interviews. Wan et al. (2021) implement fuzzy DEMATEL. Tseng and Cullinane (2018) and Shyu and Ding (2016) use Fuzzy AHP. Furuichi and Otsuka (2015) conduct a scenario analysis. Fu et al. (2018) benefit from AHP. Zhang et al. (2016) provide a cost estimation model. Jiang et al. (2018) combine Fuzzy ANP and Interpretive Structural Modeling methods. In route selection literature, Moon et al. (2015) perform TOPSIS method. Shibasaki et al. (2017) establish a model for route choice estimation and use aggregated logit model to estimate shares of alternative routes. Wen et al. (2019) formulate a mathematical model for the route utility function. Wang and Yeo (2017) combine Fuzzy Delphi and Fuzzy ELECTRE. Woo et al. (2017) use a static comparative analysis based on different scenarios. Wang et al. (2017) apply Monte Carlo simulation method. Pham et al. (2018) conduct Fuzzy TOPSIS technique. Different from existing literature on Arctic routes and route selection, this study is the first study that integrates DEMATEL and Best-Worst

methods. Also, it is the first study where the potential criteria are reduced with several steps including literature review, expert opinion, and social media analysis.

c- Comparisons of the respondent group's results and their possible choice between ASR and SCR

The respondents in this study are from different sectors of shipping industry. These are carrier, 3PL, BCO, and expert. There are both similarities and differences in their answers. When DEMATEL results are examined, hinterland was found as the most significant dimension for all sectors. Safety & security is the second dimension for 3PLs, BCOs, and experts while environment is for carriers. Also, results of carriers and 3PLs, show that service and cost have the strongest networks with other dimensions while BCOs thinks cost and time have the strongest link with other dimensions, and experts reveal cost, service, and environment have the powerful connection with others. Furthermore, the highest influence occurs from hinterland to service and from hinterland to cost for carriers, 3PLs, and BCOs respectively. Expert differs from others in source of influence, and the highest effect occurs from environment to cost. The weakest effects are not identical. All sectors agree on there is a mutual effect between cost and service. Carriers, BCOs, and experts determine that there is a mutual effect between cost and time. Different from all other participants, experts believe safety & security may influence cost, service, and environment. Overall weights of dimensions show that cost and service are to most important dimensions for 3PLs, BCOs, and experts while BCOs reveals that cost and time are the most important ones. Again, except for experts, who identifies that environment is at the third ranking, hinterland is at the third ranking for others. On the other hand, social is selected as the second least important dimension, but there is no concurrence on the least important one.

When BWM results are examined, there is no consensus on best criterion for each dimension. Only in time dimension, 3PLs, BCOs, and experts determine transit time as the best. Besides, all sectors determine that mandatory assistance is the worst in cost dimension. In time dimension, sectoral groups select berthing and cargo handling as the worst except experts, who indicate transit time is the worst. The same situation in the time dimension also presents in the service dimension. Except expert, others settle on shipping alliances. In hinterland dimension, dry-port connection is agreed uupon by all. In environment, safety & security, and social dimensions,

participants significantly differ, and scores are highly close to each other. When the criteria are examined, there is no commonplace in the most important and least important criteria. However, equipment availability and schedule reliability are in the first five for all; and slow steam applicability is in the first five for carriers, 3PLs, and BCOs. Otherwise, only criterion C44 (dry-port connections) stays in the last five for all, and mandatory assistance stays in the last five for 3PLs, BCOs, and experts. The priority levels are similar to importance levels, but there are some nuances. Equipment availability and door-to-door service have the high priority for each sector while schedule reliability is also top five for carriers, 3PLs, and BCOs. Also, criterion C62 (accident and collision) is found in the top five for carriers and experts, and slow steam applicability is for carriers and 3PLs. Mandatory assistance is significantly least important for all, berthing and cargo handling criterion is for carriers, 3PLs, and BCOs, and dry-port connection is for carriers, 3PLs, and experts.

d- Discussion of the findings

Maritime trade routes are substantial channelers for international trade because maritime transportation shoulders the majority of international trade. The share of maritime trade branches into several sub-groups such as dry-bulk, liquid bulk, general cargo, ro-ro, etc. Even though both dry and wet bulkers compose more than half of the maritime cargo transported (UNCTAD, 2020: 4), Notteboom and Rodrigue (2008) indicate that container transportation creates much more value for international trade and supply chains (Notteboom and Rodrigue, 2008: 171 – 172) due to its unique characteristics and operational requirements like industrial zones, adequate land transportation network, and capable port facilities. Schøyen and Bråthen (2011) say that bulk carriers are known as being less time-sensitive, requiring fewer procedures, and having fewer factors to consider (Schøyen and Bråthen, 2011: 979). Compared to bulkers, container crafts have more complicated mechanisms. In this way, container shipping has many factors to pay attention to. Similarly, container shipping's ship routing approaches including route establishment and route selection have a highly complex structure.

Arctic shipping has been a myth for many, but it has begun to turn into reality. Ever-accelerating global warming led the Arctic ice to enormously melt. Hence, Arctic region has become on countries' agenda not only with natural resources but also Arctic shipping routes that provide shorter and cost-efficient global access for big

industrialized economies. Due to above-mentioned differences in characteristics of bulk shipping and container shipping, Arctic voyage has been exploiting by tankers and bulk carriers. Nowadays, suitability of these routes for container shipping and regular transportation is being talked about. In this direction, it is examined route selection behavior of shipping companies with regards to route selection criteria in this thesis. The usage and characteristics of these routes have been researched by many scholars likewise.

Arctic shipping routes have many advantages that lead these routes to be preferred and have many bottlenecks that strengthen arguments of the opposite side. Some of the advantages are distance and transit time reduction, benefiting from slow steam, escaping from piracy, congestion, and high canal dues, as indicated by Tseng and Pilcher (2017); and decreasing worldwide emissions levels, as indicated by Koçak and Yercan, (2021). On the other hand, initial disadvantages are uncertain sea ice and weather conditions, irrecoverably damaging risk to region in case of accident and oil spills, ambiguous search and rescue operations, inability of exploiting economies of scale, ice-breaker fees, and incapable transportation infrastructure, stated by Meng et al. (2017). As per the pros and cons of ASR, the majority of the Arctic shipping literature such as Xu et al. (2018), Lindstad et al. (2016), and Furuichi and Otsuka (2015) underline cost advantage of ASR. Also, Liu and Kronbak (2010) and Pavlenko and Glukhareva (2010) underline fuel consumption differences between alternative routes while Beveridge et al. (2016), Xu et al. (2018), and Theocharis et al. (2019) are for the feasibility of ASR; Shyu and Ding (2016) and Aksenov et al. (2017) are for sea ice conditions and navigability of ASR; Theocharis et al. (2019), Furuichi and Otsuka (2015) and Solakivi et al. (2018) are for ice-breaker costs and capabilities; and Hong (2014) and Shyu and Ding (2016) are for political aspects. However, no one highlights decision-making behavior of shipping companies by considering a range of comprehensive criteria. Besides, route selection literature is also scarce, even lower than Arctic shipping literature. Namely, Hsu and Hsieh (2007) model liner shipping vessel routing decision. Moon et al. (2015) evaluate alternative shipping routes from Korea and Europe. Kashiha et al. (2016) analogize route selection behaviors of shippers in coastal and landlocked countries. Wang and Yeo (2017) create different intermodal combinations by considering route selection factors. Woo et al. (2017) examine different maritime shipping-centric multimodal route selection scenarios for Korean exporters. Wang et al. (2017) perform route selection optimization under uncertain environments. Shibasaki et al. (2017) model

route selection of dry bulk carriers. Tran et al. (2017) design optimized liner shipping routes, and Pham et al. (2018) address Panama Canal expansion and its effects on route selection of liner shipping companies, but no one considers and includes ASR as an alternative to shipping routes. In harmony with the purpose of this dissertation, this study introduces route selection behaviors of shipping companies through questionnaires, where different criteria directly and indirectly imply a route alternative.

The findings imply that the Arctic Ocean can not be deemed as an alternative shipping route for stakeholders today. In the same way, Tseng and Pilcher (2017) discuss the results of Arctic literature related to feasibility and other factors with stakeholders. They find that ASR are challenging and uncertain within the current situation. Thus, ASR remain theoretical. This dissertatation proposes that Arctic routes can not be a major trade route in present-day conditions, and Suez Canal route can integratedly be supported by Arctic routes. Similarly, Beveridge et al. (2015) argue that ASR are more convenient for destinational shipments rather than transshipments. Xu et al. (2018) and Gleb and Jin (2021) indicate integration of NSR and SCR in container shipping services may be more cost-effective and competitive. Zhang et al. (2016) find that in comparison with SCR, NSR still does not provide an economic advantage for overall operations, but for small or medium size vessels it may be more practical. And Zhao et al. (2016) explore that container shipping are more likely to be a supplementary route due to seasonality and cargo volume. Social media analysis in this dissertation says that practitioners are strictly unfavor of ASR according as Irina and Peeta (2016), who explore the relationship of decision makers' operational and behavioral features against companies navigating through the Arctic. They find the majority of practitioners are not favor of ASR. They also find that decision-makers in other sectors are more likely to use ASR compared to freight forwarders while high-volume East-Asian shippers are less likely. However, this dissertation has no exact cue on significant differences between sectors in the shipping industry. Again, SM analysis shows that bounded rationality and inadequate information flow lead practitioners to make behavioral decisions as suggested by behavioral decision theory. Beveridge et al. (2015) also argue that poor knowledge and monitoring bring to a standstill the plans related to ASR.

In this study, cost, service, and time are found as most influential dimensions. Accordingly, Tseng and Cullinane (2018) say that economic factors are the most influential ones among the key factors influencing the choice of ASR. They also say that safety, technical, and political factors follow economic factors. Shyu and Ding

(2016) reveal that safety and risk, and cost are crucial factors in building ASR. Unlike these papers, safety & security is the 6th influential one within seven dimensions in this dissertation. Wan et al. (2021) suggest that ice condition, weather, cost, and political aspects are the cause elements while ice-breaking fees and navigational service quality (including icebreaker, pilotage, search & rescue, etc.) are effect factors. In this dissertation, it is also found that service – similarly – and cost – differently – are the effect elements. Wan et al. (2021) also say that ice-breaking fees affect other factors, and Zhao et al. (2016) find that ice breaker fees are important barriers to Arctic usage, on the contrary, this dissertation indicates that the costs related to mandatory assistance like icebreaker and ice-pilot are one of the least important criteria. Shyu and Ding (2016) reveal that cargo source is also appointed at the high ranking while industry level has an average priority and importance level in results of this thesis. Tseng and Cullinane (2018) say that reduction in fuel consumption is the most important criteria. Theocharis et al. (2019) discuss that as low-sulfur fuel obligations will be applied worldwide and bunker prices rise, the possibility of Arctic usage will increase. These two papers rigidly support the dissertation's base and problem statement that proposes companies seek cost minimization and environmental considerations are not priority. The cases in 2020-2022 (uncertainties, global pandemic, supply chain corruptions, chip crisis, lockdowns, regional crisis, wars, worldwide inflationist pressure, energy crisis, etc.) directly or indirectly rocketed brent petroleum prices from around $45 to $120 per barrel. Imagine a vessel's average fuel consumption. Wan et al. (2021) indicate that fuel costs constitute 30-50% of total navigation cost. Melia et al. (2017) calculate that ASR provide almost $300.000 per trip from South Korea to Rotterdam in 2009 (Melia et al., 2017: 19). Such a reduction whets companies' appetite more than normal with the effects of global cases listed above and fluctuating bunker prices. In the same direction with literature, this dissertation reveals that the criteria affecting fuel consumption such as slow-steaming, and energy efficiency are found highly important. Ecological modernization theory correlatively suggests that transportation-based environmental damages should be diminished. Fuel consumption reduction through slow-steaming and energy efficiency applications may support ecologization of the economy by minimizing potential social costs. Tseng and Cullinane (2018) also find that harsh weather conditions strongly affect decision-makers' route selection. Besides, environmental concerns and search and rescue are the fourth and sixth important criteria while this dissertation finds that environmental and safety & security

factors have importance and priority levels between average and low. The importance of shipping alliances is rated very low by the participants. On the other hand, Jiang et al. (2018) bring a different perspective to the alliance mechanism and argue that alliances may be evolved into Arctic shipping alliances for minimizing risks by effectively observing environment, service, and communication.

In route selection literature, Moon et al. (2015) find that distance is the most competitive factor while, as it is found in this dissertation Wen et al. (2019) argue that distance has average priority. Moon et al. (2015) also find that the other highly competitive factors are reliability, frequency, and flexibility. These are direct concern of schedule reliability that is found as highly important by Wang and Yeo (2017), Pham et al. (2018), and by the participants of this dissertation. Wang and Yeo (2017), Woo et al. (2017), Pham et al. (2018), and Wen et al. (2019) emphasize that cost and cost factors are the most important factors. However, this thesis finds that cost is the most influential dimension while the first two cost criteria are important rather than the most important ones, and the other two cost criteria have low importance levels. Further, in line with the findings of this dissertation, Wang and Yeo (2017), Pham et al. (2018), and Woo et al. (2017) find that transit time highly influences decision-makers' behavior. Also, thesis' participants find that door-to-door service availability is the second most prior and third most important criterion. However, door-to-door transportation needs for infrastructure development, which will cause countless social cost. Wen et al. (2019) very much like arguing the importance of infrastructure reliability for logistical planning. Besides, Pham et al. (2018) reveal that route characteristics (including port sequences and political environment) have higher priority respectively. This thesis inversely provides that port rotation can be accepted as a subsidiary in route selection and does not test effects of political environment. Last, Moon et al. (2015) and Wang and Yeo (2017) find that safety of transportation (accidents, etc.) and safety of freight (damage or theft) are potentially important factors. However, this dissertation is not a side of safety & security factors in route selection. Some of the participants keynoted that technology has been developing, and navigational preventions and regulations are clear. Hence, safety & security factors are not primary considerations in today's conditions due to strict IMO regulations and regular audits. Moon et al. (2015) compare alternative routes including road and rail. They indicate that transit time and distance make ASR advantageous. On the contrary, safety issues, uncertainties on regular service, and awareness of stakeholders (that imply how stakeholders perceive the route) weaken

competitiveness of ASR. They reveal that ASR may be advantageous not today but in near future, in a similar way the findings of this dissertation addresses.

The most remarkable result of the study, equipment availability is the top priority of the stakeholders in shipping industry. Equipments and their positioning have already been important for both industry and researchers. However, it is the first study that find equipment availability as most important and prior. This situation shows that the results fleet on the same line with real world problems. Again, this situation indirectly may prove that participants have paid great attention and have not lost their focus. Another remarkable argument is that a 3PL participated in this study has stated that schedule reliability has begun to lose its strong ground for the parties in last three years. Beveridge et al. (2015) argue that weather, ice conditions, and remoteness are major risks for the safety of shipments. They also underline schedule reliability is hard to be provided owing to these risk factors. However, this study shows that schedule reliability still stays at the top of priority rankings in line with Schøyen and Bråthen (2011), which argue schedule reliability is the key concern of ASR being a viable alternative. Besides, Wang et al. (2018) find that risk factors negatively affect the possibility of a route being selected. Also, they find that increasing profitability may lead to a route being prominent.

The table below is produced by using the available information in Chapter II. The table shows which route are expected to be more advantageous in dimensions and criteria given. The years 2030s and 2050s are selected, because most environmental scenarios, projections, and estimations in the Arctic shipping literature address Arctic region and global climate being anticipated to incur considerable change around these two periods. In the table, ticks show which route is expected to be more advantageous in that dimension or criteria, and circles mean that no significant differences are expected to eventuate between the selection of the routes given. The answers of the participants within each dimension clarify that they would select Suez Canal route by 2030 under today's conditions. On the other hand, almost all factors stay on behalf of ASR by 2050. Not only the criteria with highest priority but also other criteria signalize ASR. Although it is strictly hard to establish a proper transportation infrastructure and superstructure in a few decades, enormous investment plans of big countries and competition among nations will probably accelerate international trade dynamics for the Arctic region. Thus, if it is said ASR will potentially be viable and preferable in the next decades, it was not gone beyond the purpose when behavioral decisions of participants are focused. The priority levels

of some critical criteria such as slow steaming, distance, piracy, etc. give us a hint that they would not be strictly against ASR.

Otherwise, in the survey phase, a 3PL said that there is a roadway project prolonging from Eastern Asia to Northern Sea Route, and this project is performed by contribution of several stakeholders in order that shipping lines add new routes. This project is evaluated as an indirect preparation for ASR. He also indicated that this route may support Belt and Road Initiative in fast service requiring commodities, and Con-Ro type vessels can be benefited for utilizing fast and direct services through NSR. Another 3PL expressed that the nature and structure of services have begun to change with supply chain corruption. In this way, agility and alternative plans have become crucial, as it was tested in Suez obstruction by M/V Ever Given. A carrier from the participants stated that ASR have intensively remained on their agenda before the COVID-19 pandemic. This carrier said that particularly some of the Chinese Guangzhou-centered bulk cargo operations have plannedely begun to be shifted to ASR. They act conformably to general behavior of alliance, but a strict part of the company from China works at high effort for adopting ASR into the company Furthermore, another carrier indicated that intra-Asia competition has increased, and competition structure of the region has become critical. When competition comes to bind alley, cost efficiency and even each cent step in. Therefore, this participant also said that the approach of this study is suitable for the conjuncture, and ASR will be the reality whether or not.

Table 38. Comparison of Strength and Weakness of ASR and SCR in Terms of Criteria Used

ASR (by 2030)	SCR (by 2030)	ASR (by 2050)	SCR (by 2050)	Dimension		Criteria	ASR (by 2030)	SCR (by 2030)	ASR (by 2050)	SCR (by 2050)
	✓	✓		**Cost**	C11	*Slow steam applicability*	✓		○	○
					C12	*Energy efficiency*		✓	✓	
					C13	*Mandatory assistance*		✓	○	○
					C14	*Canals and passages*	✓		✓	
✓		✓		**Time**	C21	*Distance*	✓		✓	
					C22	*Transit time*		✓	✓	
					C23	*Congestion*	✓		✓	
					C24	*Berthing and cargo handling*	✓		✓	
	✓		✓	**Service**	C31	*Schedule reliability*		✓	✓	
					C32	*Equipment availability*		✓	○	○
					C33	*Competition*	✓		○	○
					C34	*Shipping alliances*	○	○	○	○
					C35	*Loss potential*		✓	○	○
					C36	*Brand image*		✓	✓	
	✓		✓	**Hinterland**	C41	*Port rotation*		✓		✓
					C42	*Door-to-door service*		✓		✓
					C43	*Industry level*		✓		✓
					C44	*Dry-port connections*		✓		✓
	✓	✓		**Environment**	C51	*Damage to biodiversity*		✓	○	○
					C52	*Ozone layer spoil*		✓	✓	
					C53	*Air quality problems*		✓	✓	
					C54	*Carbon footprint*		✓	✓	
○	○	✓		**Safety & Security**	C61	*Piracy*	✓		✓	
					C62	*Accident and collision*		✓	○	○
					C63	*Theft*	✓		✓	
					C64	*Lashing, stacking and trimming*		✓	○	○
	✓	✓		**Social**	C71	*Public reaction*		✓	○	○
					C72	*Health problems*	○	○	✓	
					C73	*Quadruple bottom line*		✓	✓	

Source: Created by author by benefiting “Literature Review” chapter.

The participants' priorities and the results of social media analysis revealed that they reject ASR usage regardless pros of ASR if we ask them whether they prefer it or not. Because they have the bounded rationality and perceive these routes bringing too many social costs. However, a company can survive by sustaining its profits, and its priorities are a sign of them being close to be convincible. This study proposes that both routes can circumstantially be benefited and may be used interchangeably. Asia-North Europe maritime trade covers more than 80 weekly calls for more than 30 ports, and ASR can easily take some of these calls. ASR seem to be more applicable for dry and liquid bulk shipping, but container shipping needs more action to be taken. Only destinational and small volume shipments can be transported through ASR by the 2030s. In spite of the fact that economies of scale, uncertainties, and the limited number of icebreakers are the initial bottlenecks of ASR, these routes may logically be planned and added to the schedules. In the summer period ASR may develop supply chain resilience and flexibility, particularly in bulk shipping. Ever Given case has proved that viable alternatives are required for agility of the service. The supply chains have already been corrupted due to COVID-19 pandemic, and Suez blockage shows that more agile supply chains should be developed with several alternatives. Therefore, it is suggested the integration of ASR and SCR. If and only if, it must clearly be explained to the stakeholders that shipments will be performed more climate-friendly. Hence, the economic and environmental sustainability objectives, which lie behind ecological modernization, can be achieved in long run.

5.2. IMPLICATIONS OF STUDY

Social media analysis focused on the emotional and cognitive perspectives of stakeholders about ASR. The official Twitter and LinkedIn accounts of the top ten liner shipping companies are used to explore the inner meanings that are carried in the comments of stakeholders. The results revealed that stakeholders tend to be more responsive to liner companies' decisions not to use ASR. Also, it was found that stakeholders' comments impartially reflected anticipation, trust, and joy within the basic emotions. From a broader perspective, they were found optimistic, delighted, and curious about the future of ASR. On the other hand, MCDM analysis focused on the priorities of shipping companies between route selection criteria. The participants consist of twelve carriers, six 3PLs, six BCOs, and four experts.

The findings of social media analysis have the potential for shipping companies to clarify first their Arctic policies due to the need for a straight Arctic policy expected by stakeholders and second their SM-based engagement strategies. Garcia-Alcaraz et al. (2022) say that today, not only firm-based actions but also environmental policies for the whole supply chain are required (Garcia-Alcaraz et al., 2022: 1 – 19) to be successful in TBL components, as suggested by the frameworks of ecological modernization and social cost theories. Groening et al. (2015) find that actors in chains, even end-users, count their carbon footprint, and they want to know environmental effects of their consumption (Groening et al., 2015) to establish reliable environmental policies and to make them spotlighted for attracting stakeholders. Thus, shipping companies to establish clear, monitorable, realistic, and sustainable environmental policies for Arctic shipping may be a developed tool for practitioners to cling on their services. Although the criterion C73 (carbon footprint) is positioned at the 7th ranking, and environmental and social dimensions have low influential weights according to participants, SM analysis show sthat these factors should be paid more attention to. Bounded rationality directs people to act with their emotions and would decrease their rational thinking ability. Therefore, if they decide to use ASR, they must explain the reasons by referring to their environmental policies to convince practitioners. For instance, if ASR is found more advantageous in terms of commercial and environmental costs, sharing operational details (such as actual fuel consumption, average speed, emissions per nautical mile, etc.) may be a tool for showing environmental benefits of using ASR compared to conventional routes. The results show that companies are better to position themselves as Arctic-free and eco-friendly. The answers of participants in the MCDM analysis also show that shipping companies do not find ASR logical and applicable by 2030. However, it will probably be more advantageous by 2050 in terms of cost and environment. Past research says that price and service quality-directed components are reasons for preference (Lancioni, 2005: 111 – 114; Avlonitis et al., 2005: 696 – 714; Olshavsky et al., 1995: 207 – 218). Of course, economic factors are crucial, and firms normally prioritize economic factors. However, in this study, it is found that cost criteria have high priorities but not the highest one. In such an industry where companies' services are very similar, and differentiation is hard, economic factors are quite easily imitable by competitors. Therefore, companies may differentiate via their behaviors and attitudes to be perceived as inimitable. The results of MCDM indicate that equipment availability, schedule reliability, and door-to-door service are the most crucial criteria

in route selection. These three criteria are the essentials for healthy supply chain flows. The shipping companies' behaviors reveal that decision-makers should focus on developing coordination within the supply chain. All parties have been suffering from incapable equipment positioning since the beginning of 2020. Even though both carriers and shippers (3PL and BCO in this study) find it highly important, schedule reliability is still a hurdle for a flowing supply chain. Otherwise, the criteria under environment dimension have a relatively low importance level, except carbon footprint. Damage to biodiversity is 20th while ozone layer spoil is 19th and air quality problems is 17th over 29 criteria. Stakeholders in SM analysis highlight the importance of biodiversity and risk of ballast-based habitat exchange on the contrary. Make sure that in MCDM analysis, if it was asked to the participants about the importance of water pollution, emissions levels, and air pollution instead of damage to biodiversity, ozone layer spoil, and air quality problems respectively, their responses would be different due to lack of information and their perception. Unlike selections of participants, the results of SM analysis show that environmental factors have considerable effects on the decisions of stakeholders, especially for Arctic routes. Therefore, as indicated by Zhang et al. (2020), environment-specific Arctic governance would provide both sustainable shipping activities and the Arctic environment (Zhang et al., 2020: 10).

Hereafter, behavioral factors and emotional appraisals are noticed by customers in SM analysis. In this way, companies should decisively act to obtain a leading position in stakeholders' mind because there are a few companies that strictly states their behavior regarding ASR. Clark and Melancon (2013) say that relationship marketing, which is found crucial in B2B industries, proposes companies follow clients' feelings and opinions to sustain competitiveness and customer loyalty (Clark and Melancon, 2013: 132 – 142). By using relationship marketing tools, liner shipping companies may strengthen their position. At this point, sustainability emphasis on the emissions-intensive shipping industry may be a strategic tool, because Siems and Seuring (2021) argue that stakeholders request a sustainable supply chain (Siems and Seuring, 2021: 3105 – 3119). In another respect, today's customer profile is prone to explicitly say what they feel about products and services and to seek solutions. The same profile uses SM as a weapon to declare feelings and opinions and to interact with companies. Thus, companies may skim stakeholders' opinions about a decision or service through SM. SM should be used as a strategic way to keep customers loyal by engaging them. In line with it, our results show that stakeholders having reciprocal

interactions with companies reflect more positive emotions. On one hand, Arctic shipping routes are considered with their functionality, on the other hand, these routes are concerned with environmental factors that stimulate feelings of both stakeholders and the community. In SM findings, companies' reactions to Arctic talks after the Suez obstruction have higher interactions. It is found that companies being responsive to global cases create positive sentiments in stakeholders' minds and take thankfulness from stakeholders. In MCDM findings, cost, service, and time dimensions have higher influential importance levels. When it is also considered the high-ranking criteria of these dimensions, the opportunity perception may lead the actors' behaviors in the shipping industry. Opportunity of sharply reducing transit time and accordingly more yearly shipment opportunity, opportunity of increasing energy efficiency and accordingly more sustainable service opportunity, and opportunity of offering highly reliable service and accordingly more loyal customers may persuade the parties within the supply chain by offering safe, secure, and environmentally and socially sustainable services.

5.3. LIMITATIONS OF RESEARCH AND RECOMMENDATIONS FOR THE FUTURE RESEARCH

The several contributions and implications are not independent of limitations. First, personal data protection procedures have rendered complicated data and information acquisition on social media platforms. LinkedIn search queries and filters do not work extensively due to some legal restrictions LinkedIn has faced before. This has made the data collection process more difficult and repetitive. Also, LinkedIn provides retrospective search ability for up to five years. Therefore, we could not handle any posts and comments after mid-June of 2021, if available. Additionally, because Arctic shipping is a niche topic, the obtained sample size is relatively small. It generates a limitation when generalizing the results. Thus, the results must be carefully read and generalized due to the relatively smaller sample size. In this study, the number of total scanned posts is too much even though the number of examined posts and comments is limited. Hence, we did not evaluate some classical points of view such as "number of retweets", "number of likes" etc. SM accounts of some Arctic corporations and worldwide news agencies have been scanned. There have been too many posts and junks; most of the comments have been articulated by households,

and it has been almost impossible to determine commenters' proficiencies. Thus, we did not involve these SM accounts in our research.

In conducting MCDM analysis, COVID-19 pandemic and lockdowns brought great restrictions. It the beginning, it was planned to apply the survey, especially in Nordic countries by benefiting student exchange programs. This plan has been revised after countries closed their borders. The new plan was to apply the survey within the global context. The expert opinion was required, but it was not possible to consult them face-to-face and experts do not have enough time to evaluate criteria because uncertainties, container and chip crisis, and adoption difficulties of distance working made them postpone our requests. Furthermore, in collecting data, finding the correct person and the inducement process of the big companies' managers were hard. And the respondents were tried to pick up internationally. All these troubles generated a great time limitation. Also, the limited number of studies in both route selection and Arctic shipping beclouded establishing main structure of the study. Many of the limited route selection literature is outdated. The changes and novelties in the nature of supply chains and shipping industry are neglected. Besides, Arctic routes have unique characteristics and specifications. Transforming old-shcool route selection criteria into contemporary and adopting them into the Arctic shipping routes were compelling. This complicated process of determining criteria included several checks. Last, it has been planned to hybridize DEMATEL and BWM-based ANP and the analysis has been conducted within this direction. However, it has been realized that ANP procedure did not make any significant contribution to the study and did not implicitly address research objectives. Therefore, ANP procedure has been canceled, and the analysis has been conducted again through hybridizing DEMATEL and BWM.

Arctic Region has several dimensions that are worth to be researched such as political, legal, technical, environmental, etc. Arctic governance is still puzzlement. Arctic governance concerns Arctic states at first glance, but non-Arctic states, especially members of Arctic Council, should pay more attention to governance and implementation of regulatory bodies of Arctic Region. Due to nature of the region Arctic shipping needs a dynamic, ever-updating, and definite governance model. Therefore, further studies should advise to the establishment of governance and political structure of the Arctic routes. Again, Polar Code is the indivisible part of Arctic shipping, but Polar Code still needs some additions such as ballast water management, polar-congruent antifouling applications, drills about crew safety in icy

waters etc. Again, future studies should evaluate deficiencies, pros and cons, applicability, and environmental hazard prevention potential of the Polar Code.

On the other hand, this study strongly focuses on business perspectives rather than other dynamics. Mental models of people are shaped through their knowledge and emotions. To converge these two, a broad picture of stakeholders' perspectives is needed to be drawn. It is found that feelings and opinions of stakeholders having different standings on ASR are needed to analyze with different methodologies such as Fuzzy Cognitive Mapping. By benefiting characteristics of Arctic shipping routes and other trade routes, a set of alternatives including maritime trade routes and multimodel routes can be created. And these alternatives can be evaluated with route selection criteria by using one or more MCDM techniques that would be formalized via sensitivity analysis. Also, Belt and Road Initiative seems to be natural competitor of ASR because of limited carrying capacity of these routes. Therefore, integration of BRI and ASR and comparisons of BRI and ASR should be handled in future studies. Besides, the perspective of end-users is required to examine because they are the ultimate decision-makers of supply chains. Finally, a similar study may be conducted by using bulk shipping companies as source data. In this way, similarities and differences of both industries may be revealed.

REFERENCES

Abdulhafedh, A. (2017). The Panama Canal: A man-made engineering marvel. *International Journal of Social Science and Humanities Research*, 5(1): 318-342.

Abioye, O. E., Dulebenets, M. A., Pasha, J. and Kavoosi, M. (2019). A vessel schedule recovery problem at the liner shipping route with emission control areas. *Energies*, 2012: 1-28.

Acciaro, M. and McKinnon, A. (2013). **Efficient Hinterland Transport Infrastructure and Services for Large Container Ports**. *OECD International Transport Forum Discussion Paper, No. 2013-19*. September 2013, Paris.

Acciaro, M. and Sys, C. (2020). Innovation in the maritime sector: Aligning strategy with outcomes. *Maritime Policy & Management*, 47(8): 1045-1063.

Acheampong, F.A., Henry, N., Chen, W., and Niyongabo, R.A. (2020). Recognizing Emotions from Texts Using a Bert-based Approach. *17th International Computer Conference on Wavelet Active Media Technology and Information Processing (ICCWAMTIP)* (pp. 62-66), Organizer University of Electronic Science and Technology of China, Chengdu, 18-21 November 2020.

Acheampong, F.A., Nunoo-Mensah, H. and Chen, W. (2021). Transformer models for text-based emotion detection: a review of BERT-based approaches. *Artif. Intell. Rev*. 54: 5789–5829.

Afenyo, M., Jiang, C. and Ng, A. K. Y. (2019). Climate change and Arctic shipping: A method for assessing the impacts of oil spills in the Arctic. *Transportation Research Part D*, 77: 476-490.

Ahmadi, H. B., Sarpong-Kusi, S. and Rezaei, J. (2017). Assessing the social sustainability of supply chains using Best Worst Method*. Resources, Conservation & Recycling*, 126(C): 99-106.

Ahmed, G. (2012). Krugman trade theory and developing economies. *China-USA Business Review*, 11(12): 1557-1564.

Aksenov, Y., Popova, E. E., Yool, A., Nurser, G. A. J., Williams, T. D., Bertino, L. and Bergh, J. (2017). On the future navigability of Arctic sea routes: High-resolution projections of the Arctic Ocean and sea ice. *Marine Policy*, 75: 300-317.

Alam, A. (1994). The new trade theory and its relevance for developing countries. *Policy Research Working Paper*, 1274: 1-33.

Albracht, B. C. (2012). *A New Service Development Process for A Logistics Service Provider* (Published MSc Thesis), Eindhoven: Eindhoven University of Technology School of Industrial Engineering.

Alimohammadlou, M. and Sharifian, S. (2022). Industry 4.0 implementation challenges in small and medium size enterprises: A hybrid method of interval valued fuzzy BWM and DEMATEL. *Soft Computing*. https://www.researchsquare.com/article/rs-1264244/v1, (14.07.2022).

Alhojailan, M. I. (2012). Thematic analysis: A critical review of its process and evaluation. *West East Journal of Social Sciences*, 1(1): 39-47.

Altuntaş Vural, C., Baştuğ, S. and Gülmez, S. (2021). Sustainable brand positioning by container shipping firms: Evidence from social media communications. *Transportation Research Part D*, 97, 102938: 1-18.

Alvarez-Herranz, A. and Martinez-Ruiz, M. (2012). Evaluating the economic ad regional impact on national transport and infrastructure policies with accessibility variables. *Transport*, 27(4): 414-427.

Arctic Council (12.11.2017). *Arctic Council, Arctic council observers.* https://www.arctic-council.org/about/observers/non-arctic-states/, (21.11.2021).

Arctic Council (23.04.2016). *Arctic Council, Arctic states.* https://www.arctic-council.org/about/states/, (21.11.2021).

Arjomandi, M. A., Dinmohammadi, F., Mosallanezhed, B. and Shafiee, M. (2021). A fuzzy DEMATEL-ANP-VIKOR analytical model for maintenance strategy selection of safety critical assets. *Advances in Mechanical Engineering*, 13(4): 1-21.

Armstrong, M. (26 November 2021). Is peak social media already behind us? https://l24.im/faip, (19.03.2022).

Arslan, R. (2018). *Çok Kriterli Karar Verme Yöntemlerinin Karşılaştırılması ve Bütünleştirilmesi: OECD Verileri Üzerine Bir Uygulama* (Published PhD Thesis), Sivas: Cumhuriyet Üniversitesi Sosyal Bilimler Enstitüsü.

Arvis, J. F., Vesin, V., Carruthers, R., Ducruet, C. and de Langen, P. (2019). *Maritime Networks, Port Efficiency, and Hinterland Connectivity in the Mediterranean*. Washington: World Bank Publications.

Avlonitis, G. J., Indounas, K. A. and Gounaris, S. P. (2005). Pricing objectives over the service life cycle: Some empirical evidence. *European Journal of Marketing*, 39(5,6): 696-714.

Balcı, G. and Çetin, I. B. (2017). Market segmentation in container shipping services: A qualitative study. *Management Research Review*, 40(10): 1100-1116.

Balcı, G. and Doğu, O. H. (2020). Segmenting Freight forwarders in Turkey. *Journal of Maritime Transport and Logistics*, 1(1): 1-8.

Balogun, J., Pye, A. and Hodgkinson, G. P. (2008). Cognitively Skilled Organizational Decision Making: Making Sense of Deciding. *The Oxford Handbook of Organizational Decision Making* (pp. 233-249). Editor: Hodgkinson, G. P. and Starbuck, W. H., New York: Oxford University Press.

Barbieri, J. C. and Teixera-Alvares, A. C. (2016). Sixth generation innovation model: Description of a success model. *Revista de Administraçao e Inovaçao*, 13(2): 88-112.

Barnes N.G., Mazzola A., Killeen M., (2020). Oversaturation & disengagement: the 2019 Fortune 500 social media dance. *Center for Marketing Research UMass*

Dartmouth. https://www.umassd.edu/cmr/research/2019-fortune-500.html, (09.01.2020).

Baruönü, F.Ö. and Sanrı, Ö. (2019). Social media usage patterns of Turkish maritime businesses: A study on Facebook. *JEMS*, 7(2): 165-177.

Başarslan, M.S. and Kayaalp, F. (2021). Sentiment analysis on social media reviews with deep learning approach. *Sakarya University Journal of Computer and Information Sciences*, 4(1): 35-49.

Bayraktutan, Y. (2003). Bilgi ve uluslararası ticarest teorileri. *C.Ü. İktisadi Ve İdari Bilmler Dergisi*, 4(2): 175-186.

Becker, G. M. and McClintock, C. G. (1967). Value: Behavioral decision theory. *Annual Review of Psychology*, 18: 239-286.

Ben-Akiva, M. E. and Lerman, S. R. (1985). *Discerete Choice Analysis: Theory and Application to Travel Demand*. MIT Press.

Benedict, L., Leach, L. F., Winn, P., and Baker, C. (2016). A thematic analysis of the use of social media marketing in higher education. *Southwestern Mass Communication Journal*, 31(2). http://swecjmc.wp.txstate.edu, (10.12.2021).

Bergantino, A. and Veenstra, A. W. (2002). Interconnection and Co-ordination: An application of network theory to liner shipping. *International Journal of Maritime Economics*, 4: 231-248.

Berger, S. (2008). K. William Kapp's theory of social costs and environmental policy: Towards political ecological economics. *Ecological Economics,* 67: 244-252.

Bergqvist, R. (2008). Evaluating road-rail intermodal transport services – a heuristic approach. *Journal of Supply Chain Management*, 11(3): 179-199.

Beveridge, L., Fournier, M., Lasserre, F., Huang, L. and Tetu, P. L. (2016). Interest of Asian shipping companies in navigating the Arctic. *Polar Science*, 10: 404-414.

Bitiktaş, F. and Tuna, O. (2021). Social media usage in container shipping companies: Analysis of Facebook messages. *Research in Transportation Business and Management*, 34, 100454: 1-11.

Borra, C. and Palma, L. (2004). Analyzing the determinants of freight shippers' behavior: Own account versus purchased transport in Andalusia*. International Journal of Transport Economics*, 32(3): 339-360.

Bourbonnais, P. and Lasserre, F. (2015). Winter shipping in the Canadian Arctic: Toward year-round traffic?. *Polar Geography*, 38(1): 70-88.

Boylan, B. M. (2021). Increased maritime traffic in the Arctic: Implications for governance of Arctic sea routes. *Marine Policy*, 131: 104566.

Braun, V. and Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2): 77-101.

Brooks, B., Coltman, T. and Yang, M. (2016). Technological innovation in the maritime industry: The case of Remote pilotage enhanced navigational assistance. *The Journal of Navigation*, 69: 777-793.

Brooks, M. R. (1990). Ocean carrier selection criteria in a new environment. *Logistics and Transportation Review*, 26(4): 339-355.

Bucheli, M. (2020). *Coursera, The three stages of globalization.* https://www.coursera.org/lecture/global-strategy/the-three-stages-of-globalization-MlcFn, (16.11.2020).

Buist, J. (13.07.2018). *CIPS, Trade corridors busier than ever.* https://www.cips.org/supply-management/analysis/2018/july/trade-corridors-busier-than-ever/, (21.12.2020).

Burton, N., Burton, M., Rigby, D., Sutherland, C. A. M. and Rhodes, G. (2019). Best-worst scaling improves measurements of first impressions. *Cognitive Research: Principles and Implications*, 4(36): 1-10.

Buttel, F. H. (2000). Ecological modernization as social theory. *Geoforum*, 31: 57-65.

Büyüközkan, G. and Öztürkcan, D. (2010). An integrated approach for Six Sigma project selection. *Expert Systems with Applications*, 37(8): 5835-5847.

Caiwen, M. A. and Yan, S. (2007). Carrier Selection Optimization Model and Algorithms for Various Sections of Multimodal Transportation. *First International Conference on Transportation Engineering.* (pp. 1403-1408). Organizer Southwest Jiaotong University, Chengdu, 22-24 July 2007.

Calcerrada, J. (2011). *New Service Development of SMS Lending Companies in Sweden.* (Published MSc Thesis). Vaxjö: Linnaeus University School of Business and Economics.

Campbell, T. C. (1963). Transportation and regional economic development. *Transportation Journal*, 3(1): 7-13.

Cariou, P and Cheaitou, A. (2014). Cascading effects, network configurations and optimal transshipment volumes in liner shipping. *Maritime Economics & Logistics*, 16(3): 321-342.

Carolan, M. S. (2004). Ecological modernization theory: What about consumption?. *Society & Natural Resources: An International Journal*, 17(3): 247-260.

Chapman, R. L., Soosay, C. and Kandampully, J. (2002). Innovation in logistics services and the new business model: A conceptual framework. *Managing Service Quality: An International Journal*, 12(6): 358-371.

Chen, J. M., Tan, P. H., Hsieh, C. H., Liu, J. S., Chen, H. S., Hsu, L. H. and Huang, J. L. (2014). Seasonal climate associated with major shipping routes in the North Pacific and North Atlantic. *Terr. Atmos. Ocean. Sci*. 25(1): 381-400.

Chen, S., Liu, X., Yan, J., Hu, G. and Shi, Y. (2021). Processes, benefits, and challenges for adoption of blockchain technologies in food supply chains: A thematic analysis. *Information Systems and e-Business Management*, 19: 909-935.

Chiorrini, A., Diamantini, C., Mircoli, A. and Potena, D. (March 2021). **Emotion and sentiment analysis of tweets using BERT**. *EDBT/ICDT Workshops.* March 2021.

Chiu, W.-Y. and Tzeng, G.-H. (2013). A new hybrid MCDM model combining DANP with VIKOR to improve e-store business. *Knowledge-Based Systems*, 37: 48-61.

Cho, S-C. and Perakis, A. N. (1996). Optimal liner fleet routing strategies. *Maritime Policy and Management*, 23(3): 249-259.

Choudhary, D. and Shankar, R. (2014). A goal programming model for joint decision making of inventory lot-size, supplier selection and carrier selection. *Computers & Industrial Engineering*, 71: 1-9.

Christiansen, M., Fagerholt, K. and Ronen, D. (2004). Ship routing and scheduling: Status and perspectives. *Transportation Science*, 38(1): 1-18.

CIA World Factbook (01.01.2020). *Index Mundi, Top 20 Oil importing countries.* https://www.indexmundi.com/g/r.aspx?t=20&v=93&l=en, (15.03.2021).

Clark, M. and Melancon, J. (2013). The influence of social media investment on relational outcomes: A relationship marketing perspective. *International Journal of Marketing Studies*, 5(4): 132-142.

Clayton, G. E. (2000). *Economics, Principles & Practices.* Ohio: McGraw-Hill.

Coccia, M. (2006). **Classifications of Innovations Survey and Future Directions**. *CERIS-CNR, Working Paper*, No.: 2/2006. https://arxiv.org/ftp/arxiv/papers/1705/1705.08955.pdf, (17.11.2020).

Combes, P. P., Mayer, T. and Thisse, J. F. (2008). *Economic Geography: The Integration of Regions and Nations.* New Jersey: Princeton University Press.

Coulson, N. E., Lipscomb, C. A. and Wang, Y. (2017). *Palgrave Macmillan, Triple bottom line, or quadruple bottom line?.* https://www.palgrave.com/gp/campaigns/sustainability/triple-bottom-line-or-quadruple-bottom-line, (10.01.2021).

Coulter, R. L., Darden, W. R., Coulter, M. K. and Brown, G. (1989). Freight transportation carrier selection criteria. *Journal of Business Research*, 19: 51-66.

Czarnota, J. (2015). *Co-creation, Innovation and New Service Development: The Case of the Videogames Industry.* (Published PhD Thesis), Manchester: University of Manchester Faculty of Humanities School of Business.

Çetinkaya, V. (2020). *Çoklu Taşımacılık Koridorlarının Sürdürülebilir Ulaştırma Açısından İncelenmesi.* (Published PhD Thesis) İzmir: Dokuz Eylül University, The Graduate School of Natural and Applied Sciences.

Dai, L., Jing, D., Hu, H. and Wang, Z. (2021). An environmental and techno-economic analysis of transporting LNG via Arctic route. *Transportation Research Part A*, 146: 56-71.

De, P. (2014). **Strengthening Regional Trade and Production Networks through Transport Connectivity in South and South-West Asia**. *South and South-West Development Papers*, No: 1401, United Nations ESCAP.

De Jong, J. P. J. and Vermeulen, P. A. M. (2003). Organizing successful new service development: A literature review. *Management Decision*, 41(9): 844-858.

De Tremerie, L. M. F. (2018). *An Application of Quantitative and Qualitative Methods in Freight Mode Choice Modelling*. (Published PhD Thesis), Leeds: The University of Leeds Institute for Transport Studies.

Denktaş-Şakar, G. and Sürücü, E. (2018). Stakeholder engagement via social media: An analysis of third-party logistics companies, *The Service Industries Journal*, 40(1): 1-24.

Derse, O. and Göçmen, E. (2019). Transportation mode choice using fault tree analysis and mathematical modeling approach. *Journal of Transportation Safety & Security*, 1-19.

Devlin, J., Chang, M-W., Lee, K. and Toutanova, K. (2019). BERT: Pre-training of deep bidirectional transformers for language understanding. arXiv:1810.04805v2 [cs.CL], (16.08.2021).

Dhar, S. and Indranil, B. (2020). Emotions in twitter communication and stock prices of firms: The impact of Covid-19 pandemic. *Decision*, 47(4): 385-399.

Dompere, K. K. (1995). The theory of social costs and costing for cost-benefit analysis in a fuzzy-decision space. *Fuzzy Sets and Systems*, 76: 1-24.

Ducruet, C., Lee, S-W. NG, A. K. Y. (2010). Centrality and vulnerability in liner shipping networks: Revisiting the Northeast Asian port hierarchy. *Maritime Policy and Management*, 37(1): 17-36.

Ducruet, C. and Lugo, I. (2013). Structure and Dynamics of Transportation Networks: Models, Methods, and Applications, *The SAGE Handbook of Transport Studies* (pp. 347-364). Editors: Rodrigue, J-P., Notteboom, T. E and Shaw, J. London: SAGE.

Ducruet, C. and Notteboom, T. (2015). Developing Liner Service Networks in Container Shipping. *Maritime Logistics: A Complete Guide to Effective Shipping and Port Management* (pp.125-148). Editors: Song, D. W. and Panayides, P., London: Kogan Page.

EC (20.01.2020). *European Commission, Climate action – Protection of the ozone layer.* https://ec.europa.eu/clima/eu-action/protection-ozone-layer_en, (05.01.2022).

Editorial Team (05.04.2021). *Safety for Sea, Which are the world's most important maritime choke points.* https://safety4sea.com/which-are-the-worlds-most-important-maritime-choke-points/, (16.03.2021).

Edwards, W. (1961). Behavioral decision theory. *Annual Review of Psychology*, 12: 473-498.

Ehmke, J. F., Campbell, A. M. and Urban, T. L. (2015). Ship routing and scheduling problems with the time windows and stochastic travel times. *European Journal of Operational Research*, 240(2): 1-35.

Einhorn, H. J. and Hogarth, R. M. (1981). Behavioral decision theory: Process of Judgment and Choice. *Journal of Accounting Research*, 19(1): 1-31.

Erdogan, S. A., Ŝaparasukas, J. and Turskis, Z. (2019). A multi-criteria decision-making model to choose the best option for sustainable construction management. *Sustainability*, 11, 2239: 1-19.

Evers, H. D. and Gerke, S. (2006). **The Strategic Importance of the Straits of Malacca for World Trade and Regional Development**. *Center for Development Research Working Paper Series*, No. 17, University of Bonn. https://www.econstor.eu/bitstream/10419/88407/1/578445646.pdf, (16.03.2021).

Fagerholt, K. (2004). Designing optimal routes in a liner shipping problem. *Maritime Policy and Management*, 32(4): 259-268.

Fagerholt, K. and Lindstad, H. (2007). TurboRouter: An interactive optimization-based decision support system for ship routing and scheduling. *Maritime Economics & Logistics*, 9: 214-233.

Fagerholt, K., Laporte, G. and Norstad, I. (2010). Reducing fuel emissions by optimizing speed on shipping routes. *Journal of Operation Research Society*, 61: 523-529.

Fan, L., Wilson, W. W. and Dahl, B. (2012). Impacts of new routes and ports on spatial competition for containerized imports into the United States. *Maritime Policy & Management*, 39(5): 479-501.

Fanzone, A., Schmöcker, J., Ma, J. and Fukuda, D. (2012). Link-based route choice considering risk aversion, disappointment, and regret. *Transportation Research Record 2322*: 119-128.

Fasoulis, I. and Rafet, E.K. (2019). Embracing sustainability in shipping: Assessing industry's adaptations incited by the, newly, introduced 'triple bottom line' approach to sustainable maritime development. *Social Sciences*, 8(7), 208.

Fehlings, S. and Melkumyan, H. (2018). Transnational trade, trade routes, and local marketplaces between the Caucasus and Central Asia. *Anthropological Researches*, IV: 7-12.

Fithra, H., Sirojuzilam, Saleh, S. M. and Erlina (2018). Effect of Freight Transportation for Regional Development in the North Zone of Aceh. *Proceedings of MICoMS 2017, Vol.1* (pp. 35-42). Emerald Reach Proceedings Series. Emerald Publishing Limited. https://www.emerald.com/insight/publication/doi/10.1108/S2516-2853201801, (08.06.2020).

Flint, D. J., Larsson, E., Gammelgaard, B. and Mentzer, J. T. (2005). Logistics innovation: A customer value-oriented social process. *Journal of Business Logistics*, 26(1): 113-147.

Frank, R. H., Bernanke, B, S., Antonovics, K. and Heffetz, O. (2018). *Principles of Economics 7th Edt.* New York: McGraw-Hill.

Friesz, T. L. and Harker, P. T. (1985). Freight Network Equilibrium: A Review of the State of the Art. *Analytical Studies in Transport Economics* (pp.161-205). Editor: Andrew F. Daughety. Sidney: Cambridge University Press.

Fu, S., Yan, X., Zhang, D. and Zhang, M. (2018). Risk influencing factors analysis of Arctic maritime transportation systems: A Chinese perspective. *Maritime Policy & Management*, 45(4): 439-455.

Furuichi, M. and Otsuka, N. (2015). Proposing a common platform of shipping cost analysis of the Northern Sea Route and the Suez Canal oute. *Maritime Economics & Logistics*, 17: 9-31.

Garcia-Alcaraz, J. L. G., Diaz Reza, J. R., Arredondo Soto, K. C., Hernández Escobedo, G., Happonen, A., Puig I Vidal, R. and Jiménez Macias, E. (2022). Effect of green supply chain management practices on environmental performance: Case of Mexican manufacturing companies. *Mathematics*, 10, 1877: 1-19.

Garcia-Menédez, L., Martinez-Zarzoso, I. and De Miguel, D. P. (2004). Determinants of mode choice between road and shipping for freight transport. *Journal of Transport Economics and Policy*, 38(3): 447-466.

Garver, M. (2016). Examining carrier selection with situational choice models. *Transportation Journal*, 55(2): 224-236.

Gaye, B., Zhang, D. and Wulamu, A. (2021). A tweet sentiment classification approach using a hybrid stacked ensemble technique. *Information*, 12, 374.

Gebremeskel, A. B. (2011). *New Service Development: Energy Efficiency Consultancy Service*. (Published MSc Thesis). Eskilstuna: Malardalen University School of Innovation Design and Engineering Production and Logistics Program.

Geva, A. (2000). Moral decision making in business: A phase-model. *Business Ethics Quarterly*, 10(4): 773-803.

Ghaffari, S., Arab, A., Nafari, J. and Manteghi, M. (2017). Investigation and evaluation of key success factors in technological innovation development based on BWM. *Decision Science Letters*, 6: 295-306.

Ghosh, S. and Rubly, C. (2015). The emergence of Arctic shipping: Issues, threats, costs, and risk-mitigating strategies of the Polar Code. *Australian Journal of Maritime & Ocean Affairs*, 7(3): 171-182.

Gleb, S. and Jin, J. G. (2021). Evaluating the feasibility of combined use of the Northern Sea Route and the Suez Canal Route considering ice parameters. *Transportation Research Part A*, 147: 350-369.

Global Digital Reports. (2022). Digital 2022: Global overview report. https://l24.im/efUHdP, (10.01.2022).

Gondolfo, G. (1987). *International Economics I – The Pure Theory of International Trade*. New York: Springer-Verlag.

Gonzalez, M. M. and Trujillo, L. (2009). Efficiency measurement in the port industry: A survey of the empirical evidence. *Journal of Transport Economics and Policy*, 43(2): 157-192.

Grey, E. (04.02.2020). *Ship Technology, Maritime chokepoints: The backbone of international trade.* https://www.ship-technology.com/features/featuremaritime-chokepoints-the-backbone-of-international-trade-5939317/, (15.03.2021).

Griffiths, P. E. (1989). The degeneration of the cognitive theory of emotions. *Philosophical Psychology*, 2(3): 297-313.

Groening, C. J., Inman, J. J. and Ross Jr, W. T. (2015). The role of carbon emissions in consumer purchase decisions. *International Journal of Environmental Policy and Decision Making*, 1(4): 261:261-296.

Guericke, S. (2014) *Liner Shipping Network Design: Decision Support and Optimization Methods for Competitive Networks.* (Published PhD Thesis). Paderborn: Paderborn University International Graduate School of Dynamic Intelligent Systems.

Gupta, S. M. and Ilgin, M. A. (2018). *Multiple Criteria Decision Making Applications in Environmentally Conscious Manufacturing and Product Recovery*. Florida: CRC Press.

Gulas, S., Downton, M., D'Souza, K., Hayden, K. and Walker, T.R. (2017). Declining Arctic Ocean oil and gas developments: Opportunities to improve governance and environmental pollution control. *Marine Policy*, 75: 53-61

Guo, J., Guo, S. and Lv, J. (2022). Potential spatial effects of opening Arctic shipping routes on the shipping network of ports between China and Europe. *Marine Policy*, 136(3): 104885.

Guy, E. and Lasserre, F. (2016). Commercial shipping in the Arctic: New perspectives, challenges and regulations. *Polar Record*, 52(264): 294-304.

Hansen, C. Ø., Grønsedt, P., Graversen, C. L. and Hendriksen, C. (2016). *Arctic Shipping – Commercial Opportunities and Challenges***.** Copenhagen Business School & The Arctic Institute, CBS Maritime, Denmark.

Hastings, J. G. (2014). The rise of Asia in a changing Arctic: A view from Iceland. *The Polar Geography*, 37(3): 215-233.

Hayhtiö, M., Harjanne, A. and Rajakangas-Tolsa, J. (2017). Sustainable new service development: Insights of food wastage data – Case: University catering unit. *The Journal of Sustainable Development*, 17(1): 75-102.

Hazarika, D., Konwar, G., Deb, S., and Bora, D.J. (2020). Sentiment Analysis on Twitter by Using TextBlob for Natural Language Processing. *Proceedings of the International Conference on Research in Management & Technovation* (pp. 63–67), Organizer Adarsh Vidya Mandir's KDM Girls College. Nagpur. 5-6 December 2020.

Hennig, F., Nygreen, B., Furman, K. C. and Song, J. (2015). Alternative approaches to the crude oil tanker routing and scheduling problem with split pickup and split delivery. *European Journal of Operational Research*, 243(1): 41-51.

Hermann, R. R. (2017). Drivers for environmental technologies selection in the shipping industry: A case study of the Northern European Sulphur Emission Control Area. *International Journal of Environmental Technology and Management*, 20(3/4): 139-162.

Hill, E., LaNore, M. and Véronneau, S. (2015). Northern sea route: An overview of transportation risks, safety, and security. *Journal of Transportation Security*, 8: 69-78.

Hinz, O., van der Aalst, W. M. P. and Weinhardt, C. (2019). Blind spots in business and information systems engineering. *Business Information Systems Engineering*, 61(2): 133-135.

Ho, J. (2010). The implications of Arctic sea ice decline on shipping. *Marine Policy*, 34(3): 713-715.

Hofmann, J., Troiano, E., Sassenberg, K. and Klinger, R. (2020). Appraisal theories for emotion classification in text. https://arxiv.org/abs/2003.14155, (12.07.2021).

Holsapple, C. W. (1995). Knowledge management in decision making and support. *Knowledge, Technology, and Policy*, 8(1):5-22.

Hong, N. (2014). Emerging interests of non-Arctic countries in the Arctic: A Chinese perspective. *The Polar Journal*, 4(2): 271-286.

Hong, N. (2021). Non-Arctic States' Role in the High North: Participating in Arctic Governance through Cooperation. *Marine Biodiversity of Areas beyond National Jurisdiction* (pp. 307-330). Editors: Nordquist, M. H. and Long, R. Brill. http://www.jstor.org/stable/10.1163/j.ctv1sr6jp5, (04.01.2022).

Hsieh, Y-F., Lee, Y-C. and Lin, S-B. (2016). Rebuilding DEMATEL threshold value: An example of a food and beverage information system. *Springerplus*, 5(1): 1385.

Hsu, C-I and Hsieh, Y-P. (2007). Routing, ship size, and sailing frequency decision-making for a maritime hub-and-spoke container flow. *Mathematical and Computer Modelling*, 45: 899-916.

Hsuing, C. W. (2016). China ad Arctic energy: Drivers and limitations. *The Polar Journal*, 6(2): 243-258.

Hu, Y and Zhu, D. (2009). Empirical analysis of the worldwide maritime transportation network. *Physica A*, 388: 2061-2071.

Huang, L., Lasserre, F. and Alexeeva, O. (2015). Is China's interest for the Arctic driven by Arctic shipping potential?. *Asian Geographer*, 32(1): 59-71.

Humpert, M. and Raspotnik, A. (2012). The Future of Arctic Shipping. Global Issues, The Arctic Institute. https://www.porttechnology.org/wp-content/uploads/2019/05/The_future_of_Arctic_shipping.pdf, (25.12.2021).

IACS (April 2016). *IACS, Polar class descriptions and application.* https://www.iacs.org.uk/download/6292, (13.09.2021).

Iammarino, S. and McCann, P. (2013). *Multinationals and Economic Geography*. Cheltenham: Edward Elgar.

IMO (03.01.2020). *International Maritime Organization, Ships' routeing.* https://www.imo.org/en/OurWork/Safety/Pages/ShipsRouteing.aspx, (21.02.2021).

International Shipping News, (06.07.2020). *Hellenic Shipping News, Container shipping sails into a future driven by technology*. https://www.hellenicshippingnews.com/container-shipping-sails-into-a-future-driven-by-technology/, (17.03.2021).

Irina, V. B. and Peeta, S. (2016). A binary probit model to analyze freight transportation decision-maker perspectives for container shipping on the Northern Sea Route. *Maritime Economics & Logistics*, 20(3): 358-374.

Ivanova, M. (2011). Oil spill emergency preparedness in the Russian Arctic: A study of the Murmansk region. *Polar Research*, 30(1): 1-14.

Janic, M. (2010). Integrated transport systems in the European Union: An overview of some recent developments. *Transport Reviews: A Transnational Transdisciplinary Journal*, 21(4): 469-497.

Jansson, J. O. and Shneerson, D. (1987). *Liner Shipping Economics*. London: Chapman and Hall.

Jeng, D. J-F. and Bailey, T. (2012). Assessing customer retention strategies in mobile telecommunications. *Management Decision*, 50(9): 1570-1595.

Jerman, R. E., Anderson, R. D. and Constantin, J. A. (1978). Shipper versus carrier perceptions of carrier selection variables. *International Journal of Physical Distribution & Materials Management*, 9(1): 29-38.

Jiang, X., Fan, H., Zhang, Y. and Yuan, Z. (2018). Using interpretive structural modeling and fuzzy analytic network process to identify and allocate risks in Arctic shipping strategic alliance. *Polar Science*, 17: 83-93.

Johnson, S. P., Menor, L. J., Chase, R. B. and Roth, A. V. (2000). A Critical Evolution of The New Services Development Process: Integrating Service Innovation and Service Design. *New Service Development, Creating Memorable Experience*. (pp. 1-32). Editors: Fitzimmons, J. A. and Fitzimmons, M. J. California: Sage Publications.

Jorgensen, A. K. (2016). Environment, development, and ecologically unequal exchange. *Sustainability*, 8(227): 1-15.

Jovic, M., Filipovic, M., Tijan, E. and Jardas, M. (2019). A review of blockchain technology implementation in shipping industry. *Multidisciplinary Scientific Journal of Maritime Research*, 33: 140-148.

Kannan, V., Bose, S. K. and Kannan, N. G. (2011). An evaluation of ocean container carrier selection criteria: An Indian shipper's perspective. *Management Research Review*, 34(7): 754-772.

Kapp, K. W. (1971). *The Social Costs of Private Enterprise*. New York: Schocken Books.

Kapp, K. W. (1972). Environmental Disruption and Social Costs: A Challenge to Economics. Kyklos, 23(4): 833-848.

Kapp, K. W. (1978). *The Social Costs of Business Enterprise*. Nottingham: Russell Press Ltd.

Karimova, H. (2022). The emotion wheel: What it is and how to use it. https://positivepsychology.com/emotion-wheel/, (02.02.2022).

Kashiha, M., Thill, J. C. and Depken II, C. A. (2016). Shipping route choice across geographies: Coastal vs. landlocked countries. *Transportation Research Part E*, 91: 1-14.

Keren, G. (1996). Perspectives of behavioral decision making: Some critical notes. *Organizational Behavior and Human Decision Processes*, 65(3): 169-178.

Khan, S. A., Chaabane, A. and Dweiri, F. T. (2018). Multi-Criteria Decision-Making Methods Application in Supply Chain Management: A Systematic Literature Review. *Multi-Criteria Methods and Techniques Applied to Supply Chain Management* (pp.3-31). Editor: Salomon, V. Sao Paolo: IntechOpen.

Kiiski, T. (2017). *Feasibility of Commercial Cargo Shipping Along the Northern Sea Route.* (Published PhD Thesis). Turku: Turun Yliopisto University of Turku School of Economics Department of Marketing and International Business.

Kiln and UCL (01.05.2012). *Shipmap, Vizuallisation of global cargo ships.* https://www.shipmap.org/, (16.03.2021).

Kim, H. C., Ahn, S. and Ulfarsson, G. F. (2018). Transportation infrastructure investment and the location of new manufacturing around South Korea's west coast expressway. *Marine Policy*, 66: 146-154.

Kim, H. C. and Nicholson, A. (2013). Freight Transport Modal Shift in NZ: Building Understanding of Shippers' Mode Choice. *IPENZ Transportation Group Conference*. (pp. 1-14), Dunedin. 14-16 April 2013.

Kim, H. C., Nicholson, A. and Kusumasuti, D. (2016). Analyzing freight shippers' mode choice preference heterogeneity using latent class modelling. *Transportation Research Procedia*, 25: 1109-1125.

Kingsley, C. (2019). Designing container shipping routes for heterogeneous fleet for coastal services. *Open Journal of Applied Sciences*, 9: 799-817.

Kiritchenko, S. and Mohammad, S. M. (2017). Best-Worst Scaling More Reliable than Rating Scale. *Proceedings of the 55th Annual Meeting of the Association for Computational Linguistics* (pp. 465-470), Organizer Association for Computational Linguistics. Vancouver. 30 July-4 August 2017.

Kitsios, F., Champipi, E. and Grigoroudis, E. (2015). New Service Development: Strategy and Innovation Process in Cultural and Creative Industries using MCDA. *4th International Symposium & 26th National Conference on Operational Research* (pp. 36-42). Organizer Hellenic Operational Research Society. Chania, 4-6 June 2015.

Kjeldsen, K. H. (2011). Classification of ship routing and scheduling problems in liner shipping. *INFOR Journal*, 49(2): 139-152.

Klumpp, M. (2018). How to achieve supply chain sustainability efficiently? Taming the triple bottom line split business cycle. *Sustainability*, 10(2), 397.

Knowler, G. (19.04.2021). *JOC, Asian container shortage set to intensify into May.* https://www.joc.com/maritime-news/asian-container-shortage-set-intensify-may_20210419.html, (20.05.2021).

Kobryń, A. (2017). DEMATEL as a weighting method in multi-criteria decision analysis. *Multiple Criteria Decision Making*, 12: 153-167.

Koch, J., Eisend, M. and Petermann, A. (2009). Path dependence in decision-making process: Exploring the impact of complexity under increasing returns. *Business Research*, 2(1): 67-84.

Koçak, S. T. and Yercan, F. (2021). Comparative cost-effectiveness analysis of Arctic and international shipping routes: A fuzzy analytic hierarchy process. *Transport Policy*, 114: 147-164.

Kotilainen, J., Tysiachniouk, M., Kuliasova, A., Kuliasov, I. and Pchelkina, S. (2008). The potential for ecological modernization in Russia: Scenarios from the forest industry. *Environmental Politics*, 17(1): 58-77.

Kotler, P., Armstrong, G., Saunders, J. and Wong, V. (1999). *Principles of Marketing 2nd European Edt.* New Jersey: Prentice Hall Inc.

KPMG International Cooperative (2018). *Navigating the Future-Changing Business Models*. Switzerland: KPMG International Cooperative. https://assets.kpmg/content/dam/kpmg/xx/pdf/2018/11/navigating-the-future-changing-business-models-shipping-insights.pdf, (16.11.2020).

Kramer, R., Subramanian, A., Vidal, T. and Cabral, L. D. A. F. (2015). A metaheuristic approach for the pollution-routing problem. *European Journal of Operational Research*, 243: 523-539.

Krippendorff, K. (2011). *Computing Krippendorff's Alpha reliability.* https://repository.upenn.edu./asc_papers/43, (11.03.2022).

Krommyda, M., Rigos, A., Bouklas, K. and Amditis, A. (2020). Emotion detection in Twitter posts: a rule-based algorithm for annotated data acquisition. *7th Annual International Conference on Computational Science and Computational Intelligence (CSCI)* (pp.257-262), Organizer American Council on Science and Education. Las Vegas. 16-18 December 2020.

Krommyda, M., Rigos, A., Bouklas, K. and Amditis, A. (2021). An experimental analysis of data annotation methodologies for emotion detection in short text posted on social media. *Informatics*, 8(1), 19: 1-15.

Krugman, P. (2000). Where in the World Is the “New Economic Geography?. *The Oxford Handbook of Economic Geography* (pp. 49-61). Editors: Clark, G. L., Feldman, M. P. and Gertler, M. S. New York: Oxford University Press.

Kull, T. J., Oke, A. and Dooley, K. J. (2014). Supplier selection behavior under uncertainty: Contextual and cognitive effects on risk perception and choice. *Decision Sciences*, 45(3): 467-505.

Kuo, T., Hsu, C.-W. and Li, J.-Y. (2015). Developing a green supplier selection model by using the DANP with VIKOR. *Sustainability*, 7: 1661 – 1689.

Kusal, S., Patil., S, Kotecha, K., Aluvalu, R. and Varadarajan, V. (2021). AI based emotion detection for textual big data: Techniques and contribution. *Big Data Cogn. Comput*., 5(3), 43: 1-45.

Kutin, N., Guillotreau, P. and Valée, T. (2018). **Assessing Competition on Maritime Routes in Liner Shipping Industry through Multivariate Analysis.** *HALSHS Working Paper*, No: 01828643, Université de Nantes and National Camboge University of Management. https://halshs.archives-ouvertes.fr/halshs-01828643/document, (16.03.2021).

Kveiborg, O. (2005). Linking International Trade and Transport – What Are the Determining Factors?. *45th ERSA Conference*. (pp. 1-13). Orgnizer The European Regional Science Association. Amsterdam.23-27 August 2005.

Lai, K. H., Lun, V. Y. H., Wong, C. W. Y. and Cheng, T. C. E. (2011). Green shipping practices in the shipping industry: Conceptualization, adoption, and implications. *Resources, Conservation and Recycling*, 55: 631-638.

Lai, K. H., Pang, Y., Wong, C. W. Y., Lun, V. and Ng, Y. N. E. (2019). Are trade and transport logistics activities mutually reinforcing? Some empirical evidences from ASEAN countries. *Journal of Shipping and Trade*, 4(2): 1-17.

Lakshmanan, T. R. (2011). The broader economic consequences of transport infrastructure investments. *Journal of Transport Geography*, 19: 1-12.

Lancioni, R. (2005). Pricing issues in industrial marketing. *Industrial Marketing Management*, 34(2): 111-114.

Landowska, A. (2018). Towards new mappings between emotion representation models. *Appl. Sci*, 8(2), 274: 1-18.

Lau, R. R. and Levy, J. S. (1998). Contributions of behavioral decision theory to research in political science. *Applied Psychology: An International Review*, 47(1): 29-44.

Lazarus, R. S. and Smith, C. A. (1988). Knowledge and appraisal in the cognition—emotion relationship, *Cognition and Emotion*, 2(4): 281-300.

Lazarus, R. S. (1991). *Emotion and Adaptation*. New York: Oxford University Press.

Lee, T. and Kim, H. J. (2015). Barriers of voyaging on the Northern Sea Route: A perspective from shipping companies. *Marine Policy*, 62: 264-270.

Lee, W.-S. (2014). A new hybrid MCDM model combining DANP with VIKOR for the selection of location – Real estate brokerage services. *International Journal of Information Technology & Decision Making*, 13(1): 197-224.

Lee, W.-S., Huang, A. Y., Chang, Y-Y. and Cheng, C.-M. (2011). Analysis of decision making factors for equity investment by DEMATEL and Analytic Network Process. *Expert Systems with Applications*, 38: 8375-8383.

Lehmusvaara, A., Tuominen, M. and Korpela, J. (1999). An integrated approach for truck carrier selection. *International Journal of Logistics: Research and Applications*, 2(1): 5-20.

Lerner, J.S., Li, Y., Valdesolo, P. and Kassam, K. (2015). Emotion and decision making. *Annu. Rev. Psychol*. 66: 33.1–33.25.

Li, F., Larimo, J. and Leonidou, L. C. (2021). Social media marketing strategy: definition, conceptualization, taxonomy, validation, and future agenda. *Journal of the Academy of Marketing Science,* 49: 51–70.

Liaw, C-F., Hsu, W-C. J. and Lo, H-W. (2020). A hybrid MCDM model to evaluate and classify outsourcing providers in manufacturing. *Symmetry*, 12, 1962: 1-23.

Liberatore, M. J. and Miller, T. (1995). A decision support approach for transport carrier and mode selection. *Journal of Business Logistics*, 16(2): 85-115.

Lighthouse (2015). *Maritime Research and Innovation for the Future*, Sweden. https://www.lighthouse.nu/sites/www.lighthouse.nu/files/attachments/160630_eng_lighthouse_programomraden_webb.pdf, (16.11.2020).

Lin, Y. K. and Yeh, C. T. (2013). Determine the optimal carrier selection for a logistics network based on multi-commodity reliability criterion. *International Journal of System Science*, 44(5): 949-965.

Linder, S. B. (1961). *An Essay on Trade and Transformation*. Upsala: Almquist-Wiksells.

Lindstad, H., Bright, R. M. and Stromman, A. H. (2016). Economic savings linked to future Arctic shipping trade are at odds with climate change mitigation. *Transport Policy*, 45(22): 24-30.

Liou, J. J. H., Tzeng, G-H. and Chang, H-C. (2007). Airline safety measurement using a hybrid model. *Journal of Air Transport Management*, 13(4): 243-249.

Lirn, T. C. and Wong, R. D. (2013). Determinants of grain shippers' and importers' freight transport mode choice behavior. *Production Planning & Control*, 24(7): 575-588.

Lirn, T. C., Wu, Y. C. J. and Chen, Y. J. (2012). Green performance criteria for sustainable ports in Asia. *International Journal of Physical Distribution and Logistics Management*, 43(5): 427-451.

Liu, M. and Kronbak, J. (2010). The potential economic viability of using the Northern Sea Route (NSR) as an alternative route between Asia and Europe. *Journal of Transport Geography*, 18(3): 434-444.

Liu, P. C. Y., Lo, H-W. and Liou, J. J. H. (2020). A combination of DEMATEL and BWM-based ANP methods for exploring the green building rating system in Taiwan. *Sustainability*, 12(8), 3216: 1-19.

Liu, W. (2016). *Determining the Importance of Factors for Transport Modes in Freight Transportation*. (Published MSc Thesis). Delft: Delft University of Technology Technology, Policy and Management Program.

Loewenstein, G. (1996). Behavioral Decision Theory and Business Ethics: Skewed Trade-Offs Between Self and Other. *Code of Conduct: Behavioral Research into Business Ethics* (pp. 214-227). Editors: Messick, D. M. and Tenbrunsel, A. E. New York: Russel Sage Foundation.

Loo, B. P. Y. and Banister, D. (2015). Decoupling transport from economic growth: Extending the debate to include environmental and social externalities. *Journal of Transport Geography*, 57: 134-144.

Lun, Y.H.V., Lai, K.-H. and Cheng, T. C. E. (2010). *Shipping and Logistics Management*. London: Springer.

Ma, A. (13.01.2020). *Businessinsider, How the Strait of Hurmuz, a narrow stretch of water where ships carry $1.2 billion of oil every day, is at the heart of spiraling tensions with Iran.* https://www.businessinsider.com/strait-of-hormuz-explainer-oil-us-iran-tensions-2019-7, (16.03.2021).

Ma, X., Zhou, Q., Liu, Y. and Qiao, W. (2021). Security of the Arctic route from resilience perspective. The ideal state, influencing factors, and evaluation. *Maritime Policy & Management*, 48(6): 846-859.

MacPhail, C., Khoza, N., Abler, L. and Ranganathan, M. (2015). Process guidelines for establishing Intercoder Reliability in qualitative studies. *Qualitative Research*, 16(2): 198-212.

Maciulis, A., Vasiliauskas, A. V. and Jakubauskas, G. (2009). The impact of transport on the competitiveness of national economy. *Transport*, 24(2): 93-99.

Madhuri, S. and Lakshmi, S.V. (2021). Detecting emotion from natural language text using hybrid and NLP pre-trained models. T*urkish Journal of Computer and Mathematics Education,* 12(10): 4095-4103.

Maersk (12.08.2016). *Maersk, Shipping from Europe to Asia Pacific – AE6 Eastbound.* https://www.maersk.com/local-information/shipping-from-europe-to-asia-pacific/ae6-eastbound, (16.03.2021).

Mahmoudi, A., Mi, X., Liao, H., Feylizadeh, M. R. and Turskis, Z. (2020). Grey Best-Worst Method for multiple experts multiple criteria decision making under uncertainty. *Informatica*, 31(2): 331-357.

Maleky, H. (2015). The Inventory Pollution-Routing Problem Under Uncertainty. *Green Logistics and Transportation* (pp. 83-117). Editors: Fahimnia, B., Bell, M. G. H., Hensher, D. A. and Sarkis, J. New York: Springer.

Mankiw, N. G. (2017). *Principles of Microeconomics 8th Edt.* Boston: Cengage Learning.

Mateer, D. and Coppock, L. (2018). *Principles of Economics 2nd Edt.* New York: W. W. Norton & Company Inc.

McCarthy, N. (25.03.2021). *Statista, The evolution of traffic transiting the Suez Canal.* https://www.statista.com/chart/24511/vessels-and-net-tonnage-transiting-the-suez-canal/, (21.06.2021).

Melancon, J.P. and Dalakas, V. (2018). Consumer social voice in the age of social media: Segmentation profiles and relationship marketing strategies. *Business Horizons*, 61(1): 157-167.

Melia, N., Haines, K. and Hawkins, E. (2017). *Future of the Sea: Implications from Opening Arctic Sea Routes.* Foresight Government Office for Science, Crown: London.

Meng, Q., Zhang, Y. and Xu, M. (2017). Viability of transarctic shipping routes: A literature review from the navigational and commercial perspectives. *Maritime Policy & Management*, 44(1): 16-41.

Menon, A. (19.01.2021). *Marine Insight, Guide to oil terminels – everything you wanted to know.* https://www.marineinsight.com/know-more/guide-to-oil-terminals-everything-you-wanted-to-know/, (15.03.2021).

Menor, L. J., Tatikonda, M. V. and Sampson, S. E. (2002). New service development: Areas for exploitation and exploration. *Journal of Operation Management*, 20(2): 135-157.

Merk, O. and Notteboom, T. (2015) **Port Hinterland Connectivity**. *OECD International Transport Forum Discussion Paper,* No. 2015-13. May 2015.

MESA (2014). *Maritime Innovations for the 21st Century-Success Stories from EU Research*. Belgium. https://www.waterborne.eu/images/documents/mesa-project-documents/files/tra-2016-brochure-final.pdf, (15.11.2020).

Milani, L. (01.10.2021). *McKinsey, Built to last: Making sustainability a priority in transport infrastructure.* https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/built-to-last-making-sustainability-a-priority-in-transport-infrastructure, (22.06.2021).

MI News Network (06.03.2021). *Marine Insight, What are maritime chokepoints?* https://www.marineinsight.com/marine-navigation/what-are-maritime-chokepoints/, (15.03.2021).

Mitra, S. (2013). Discrete Choice Model of Agricultural Shipper's Mode Choice. *Transportation Journal*, 52(1): 6-25.

Mlambo, C. (2021). The impact of port performance on trade: The case of selected African states. *Economics*, 9(135): 1-18.

Moghadam-Jafari, S., Zali, M. R. and Sanaeepour, H. (2017). Tourism entrepreneurship policy: A hybrid MCDM model combining DEMATEL and ANP (DANP). *Decision Science Letters*, 6: 233-250.

Mohammadi, M. and Rezaei J. (2020). Bayesian Best-Worst Method: A Probabilistic Group Decision Making Model. *Omega*, 96: 102075.

Mohammaditabar, D. and Teimoury, E. (2008). Integrated freight transportation carrier selection and network flow assignment: Methodology and case study. *Journal of Applied Sciences*, 8(17): 2928-2938.

Mol, A. P. J. (1997). Ecological Modernization: Industrial Transformations and Environmental Reforms. *The International Handbook of Environmental Sociology* (pp. 138-149). Editors: Redclift, M. and Woodgate, G. London: Edward Elgar.

Mol, A. P. J., Spaargen, G. and Sonnenfeld, D. A. (2013). Ecological Modernization Theory – Taking Stock, Moving Forward. *Routledge International Handbook of Social and Environmental Change* (pp. 15-30). Editors: Lockie, S., Sonnenfeld, D. A. & Fisher, D. R. London: Routledge.

Moon, D. S., Kim, D. J. and Lee, E. K. (2015). A study on competitiveness of sea transport by comparing international transport routes between Korea and EU. *The Asian Journal of Shipping and Logistics*, 31(1): 001-020.

Morozov, Y. (2012). Arctic 2030: What are the consequence of climate change?. *Bulletin of the Atomic Scientists*, 68(4): 22-27.

Moschovou, T. P. and Giannopoulos, G. A. (2012). Modeling Freight Mode Choice in Greece. *Social and Behavioral Sciences*, 48: 597-611.

Mou, N., Wang, C., Chen, J., Yang, T., Zhang. And Liao, M. (2021). Spatial pattern of location advantages of ports along the Maritime Silk Road. *Journal of Geographical Sciences*, 31(1): 149-176.

Msakni, M. K., Fagerholt, K., Meisel, F. and Lindstad. (2020). Analyzing different designs of liner shipping feeder service networks: A case study. *Transportation Research Part E*, 134, 101839: 1-17.

MSC (May 2017). *Mediterranean Shipping Company, Transatlantic-North Europe network.* https://www.msc.com/-/media/files/msc-cargo/msc-solutions/trades/transatlantic-north-europe.pdf, (16.03.2021).

Munim, Z. H., Friese-Sornn, H. and Dushenko, M. (2020). Identifying the appropriate governance model for green port management. Applying Analytic Network Process and Best-Worst methods to ports in the Indian Ocean Rim. *Journal of Cleaner Production*, 268, 122156: 1-13.

Munim, Z. H. and Schramm, H. J. (2018). The impacts of transport infrastructure and logistics performance on economic growth: The mediating role of seaborne trade. *Journal of Shipping and Trade*, 3(1): 1-19.

Muñoz-Pascual, L., Curado, C. and Galende, J. (2019). The triple bottom line on sustainable product innovation performance in SMEs: A mixed methods approach. *Sustainability*, 11(6), 1689: 1-22.

Murthy, A.R. and Kumar, K.M.A. (2021). A Review of Different Approaches for Detecting Emotion from Text. *IOP Conf. Ser.: Mater. Sci. Eng.* 1110: 012009.

Murphy, P. R., Daley, J. M. and Hall, P. K. (1997). Carrier selection: Do shippers and carriers agree, or not?. *Transportation Research Part E*, 33(1): 67-72.

Myllylä, Y., Kaivo-oja, J. and Juga, J. (2016). Strong prospective trends in the Arctic and future opportunities in logistics. *Polar Geography*, 39(3): 145-164.

Nandwani, P. and Verma, R. (2021). A review on sentiment analysis and emotion detection from text. *Social Network Analysis and Mining*, 11: 81: 1-19.

Nasreen, S., Saidi, S. and Öztürk, İ. (2018). Assessing links between energy consumption, freight transport, and economic growth: Evidence from dynamic simultaneous equation models. *Environmental Science and Pollution Research*, 25(17): 1-17.

Naugrey, A., Liu, Z. and Woolley, T. (2007). Sustainable supply chain and transportation networks. *International Journal of Sustainable Transportation*, 1(1): 29-51.

Nave, M., Rita, P. and Guerreiro, J. (2018). A decision support system framework to track consumer sentiments in social media. *Journal of Hospitality Marketing & Management*, 27(6): 693-710.

Nemes, L. and Kiss, A. (2021). Information extraction and named entity recognition supported social media sentiment analysis during the COVID-19 pandemic. *Appl. Sci*., 11, 11017: 1-33.

Ng, A. K. Y. and Tongzon J. L. (2010). The transportation sector of India's economy: Dry ports as catalysts for regional development. *Eurasian Geography and Economics*, 51(5): 669-682.

Nowell, L. S., Norris, J. M., White, D. E. and Moules, N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods*, 16(1): 1–13.

Notteboom, T. E. (2006). The time factor in liner shipping services. *Maritime Economics & Logistics*, 8: 19-39.

Notteboom, T. E. (2012). Towards a new intermediate hub region in container shipping? Relay and interlining via the Cape route vs. the Suez route. *Journal of Transport Geography*, 22, 167-178.

Notteboom, T. E. and Rodrigue, J. P. (2008). Containerization, box logistics and global supply chain: The integration of ports and liner shipping networks. *Maritime Economics & Logistics,* 10: 152-174.

Notteboom, T. E. and Rodrigue, J.P. (2009). **Economic Cycles and the Organizational and Geographical Attributes of Global Value Chains: Is The Pendulum Changing Direction?**, *Integrating Maritime Transport in Value Chains Workshop,* 10-12 June 2009*,* Montreal, Canada.

Notteboom, T. E. and Rodrigue, J. P. (05.05.2019). *Port Technology, Challenges to and challengers of Suez Canal.* https://www.porttechnology.org/wp-content/uploads/2019/05/PT51-11.pdf, (16.03.2021).

Notteboom, T. E. and Vernimmen, B. (2009). The effect of high fuel costs on liner service configuration in container shipping. *Journal of Transport Geography*, 17: 325-337.

Oduori, F. N. (2017). *New Service Development Strategy and Process: Considering Concepts from The Financial Sector in An Analysis of The Hospitality in Kenya.* (Published PhD Thesis). Stellenbosch: Stellenbosch University Business Management and Administration.

OECD (2002). *Impact of Transport Infrastructure Investment on Regional Development.* OECD Publishing, Paris. https://www.itf-oecd.org/sites/default/files/docs/ 02rtrinveste.pdf, (21.02.2021).

OECD (2019). *Regions in Industrial Transition: Policies for People and Places.* OECD Publishing, Paris. https://www.oecd.org/cfe/regionaldevelopment/Draft_policy_highlights_RIT_FINAL.pdf, (20.07.2021).

OECD (2022). *OECD Data, Enterprises by business size (indicator).* https://data.oecd.org/entrepreneur/enterprises-by-business-size.htm, (08.06.2022).

Olshavsky, R. W., Aylesworth, A. B. and Kempf, D. S. (1995). The price-choice relationship: A contingent processing approach. *Journal of Business Research*, 33: 207-218.

Olufikayo, A. and Grace, A. (2014). Risk perceiton and their influence on road transportation. *Journal of Transport Literature*, 3(2): 100-112.

Orhan, G. (2004). Sürdürülebilir kalkınma, ekolojik modernizasyon ve Türkiye çevre politikası. *Çevre Bilim & Teknoloji*, 2(1): 13-28.

Orji, I.J., Kusi-Sarpong, S. and Gupta, H. (2020). The critical success factors of using social media for supply chain social sustainability in the freight logistics industry. *International Journal of Production Research*, 58(5): 1522-1539.

Osman, M. (2022). *Mind-blowing LinkedIn statistics and Facts.* https://l24.im/Mf0TO, (10.01.2022).

Padilha, F. and Ng, A. K. Y. (2012. The spatial evolution of dry ports in developing economies: The Brazilian experience. *International Journal of Maritime Economics*, 14(1): 99-121.

Pamučar, D. S., Ecer, F., Cirovic, G. and Arlasheedi, M. A. (2020). Application of improved Best Worst Method (BWM) in real-world problems. *Mathematics*, 8(8), 1342: 1-19.

Pamučar, D. S., Terle, S. P. and Parezanovic, T. (2018). New hybrid multi-criteria decision-making DEMATEL-MAIRCA model: Sustainable selection of a location for the development of multimodal logistics center. *Economic Research*, 31(1): 1641-1665.

Panayides, P. M. and Cullinane, K. (2002). Competitive advantage in liner shipping: A review and research agenda. *International Journal of Maritime Economics*, 4: 189-209.

Papastathopoulou, P. and Hultink, E. J. (2012). New service development: An analysis of 27 years of research. *Journal of Product Innovation Management*, 29(5): 705-714.

Papastathopoulou, P., Gounaris, S. P. and Avlonitis, G. J. (2012). The service elimination decision-making during the service life cycle. *European Journal of Marketing*, 46(6): 844-874.

Park, Y. I., Lu, W., Nam, T. H. and Yeo, G. T. (2019). Terminal vitalization strategy through optimal route selection adopting CFPR methodology. *The Asian Journal of Shipping and Logistics*, 35(1): 041-048.

Parvin, S., Wang, P. and Uddin, J. (2016). Using best-worst scaling method to examine consumers' value preferences: A multidimensional perspective. *Cogent Business & Management*, 3(1): 1-14.

Pavlenko, V. I. and Glukhareva, K. (2010). Environmental changes and the economic growth in regions of the Russian Arctic. *Studies on Russian Economic Development*, 21(2): 158-164.

Pedersen-Gronholt, J. (27.06.2017). *Reuters, Maersk says global IT breakdown caused by cyber attack.* https://www.reuters.com/article/us-cyber-attack-maersk-idUSKBN19I1NO, (19.11.2020).

Peleckis, K. (2021). Application of the DEMATEL model for assessing IT sector's sustainability. *Sustainability*, 13, 13866: 1-14.

Peng, K.-H. and Tzeng, G.-H. (2013). A hybrid dynamic MADM model for problem-improvement in economics and business. *Technological and Economic Development of Economy*, 19(4): 638-660.

Pepper, D. (1998). Sustainable development and ecological modernization: A radical homocentric perspective. *Sustainable Development*, 6: 1-7.

Perunovic, Z. and Vidic-Perunovic, J. (2011). Innovation in The Maritime Industry. *POMS 22nd Annual Conference*. Nevada. 29 April-2 May 2011. https://www.pomsmeetings.org/confpapers/020/020-0355.pdf, (11.02.2020).

Peter, J. P. and Tarpey, L. X. SR. (1975). A comparative analysis of three consumer decision strategies. *Journal of Consumer Research*, 2: 29-37.

Peters, G. P., Nilssen, T. B., Lindholt, L., Eide, M. S., Glomsrod, S., Eide, L. I. and Fuglestvedt, J. S. (2011). Future emissions from shipping and petroleum activities in the Arctic. *Atmospheric Chemistry and Physics*, 11: 5305-5320.

Petrov, A. N. (2016). Exploring the Arctic's "other economies": Knowledge, creativity and the new frontier. *The Polar Journal*, 6(1): 51-68.

Pham, T. Y., Kim, K. Y. and Yeo, G. T. (2018). The Panama Canal expansion and its impact on east – west liner shipping route selection. *Sustainability*, 10(12): 1-16.

Pilař, L., Stanislavská, L. K., Kvasnička, R., Bouda, P. and Pitrová, J. (2021). Framework for social media analysis based on hashtag research. *Applied Sciences*, 11, 3697.

Placek, M. (01.07.2020). *Statista, Container shipping – sttistics & facts.* https://www.statista.com/topics/1367/containershipping/#:~:text=In%20terms%20of%20value%2C%20 global,trillion%20U.S.%20dollars%20in%202017, (22.11.2020).

Plutchik, R. (1980). A General Psychoevolutionary Theory of Emotions. *Emotion: Theory, Research, and Experience Volume 1: Theories of Emotion* (pp.3-33). Editors: Plutchik, R. and Kellerman, H. Virginia: Academic Press.

Plutchik, R. (1982). A psychoevolutionary theory of emotions. *Social Science Information*, 21(4-5): 529-553.

Plutchik, R. (2001). The Nature of emotions: Human emotions have deep evolutionary roots, a fact that may explain their complexity and provide tools for clinical practice. *American Scientist*, 89(4): 344-350.

Polat, O. and Günther, H-O. (2016). The impact of seasonal demand fluctuations on service network design of container feeder lines. *Journal of Transportation and Logistics*, 1(1): 39-58.

Polyak, L,. Alley, R. B., Andrews, J. T., Grete-Brigham, J., Cronin, T. M., Darby, D. A., Dyke, A. S., Fitzpatrick, J. J., Funder, S., Holland, M., Jennings, A. E., Miller, G. H., O'Regan, M., Savelle, J., Serreze, M., St. John, K., White, J. W. C. and Wolff, E. (2010). History of sea ice in the Arctic. *Quaternary Science Reviews*, 29(15-16): 1757-1778.

Porter, M. E. (March-April 1990). *Harvard Business Review, The competitive adcantage of nations.* https://hbr.org/1990/03/the-competitive-advantage-of-nations, (21.02.2021).

Posner, M. V. (1961). International and interregional trade. *Oxford Economic Papers*, 13: 323-341.

Pota, M., Ventura, M., Catelli, R. and Esposito, M. (2021). An effective BERT-based pipeline for twitter sentiment analysis: A case study in Italian. *Sensors*, 21(3), 133: 1-21.

Pradhan, R. P. and Bagchi, T. P. (2013). Effect of transportation infrastructure on economic growth in India: The VECM approach. *Research in Transportation Economics*, 38: 139-148.

Premeaux, S. R., Abshire, R. D. and Rader, C. H. (1992). Perceptual differences between motor carriers and shippers regarding the importance of carrier selection criteria. *Journal of Transportation Management*, 4(1): 125-139.

Prus, P. and Sikora, M. (2021). The impact of transport infrastructure on the sustainable development of the Region-Case study. *Agriculture*, 11(279): 1-15.

Pruyn, J.F.J. (2016). Will the Northern Sea Route ever be a viable alternative? *Maritime Policy & Management*, 43(6): 661-675.

Punakivi, M. and Hinkka, V. (2006). Selection criteria of transportation mode: A case study in four Finnish industry sectors. *Transport Reviews*, 26(2): 207-219.

Qazvini, Z. E. and Maleki, M. R. (2022). A triple bottom line multi-criteria decision-making framework for supplier selection. *International Journal of Management and Decision Making*, 21(2): 144-160.

Ramanathan, R., Ravindran, A. R. and Mathirajan, M. (2017). Multi-Criteria Decision Making: An Overview. *Big Data Analytics Using Multiple Criteria Decision-Making Models* (pp. 21 – 66). Editors: Ramanathan, R., Mathirajan. And Ravindran, R. Florida: CRC Press.

Rau, P. and Spinler, S. (2017). Alliance formation in a cooperative container shipping game: Performance of a real options investment approach. *Transportation Research Part E*. 101: 155-175.

Reuters Staff (24.02.2018). *Reuters, Russia remains China's top oil supplier as pipeline expands.* https://www.reuters.com/article/us-china-economy-trade-crude/russia-remains-chinas-top-oil-supplier-as-pipeline-expands-idUSKCN1G808M , (15.03.2021).

Rezaei, J. (2015). Best-worst multi-criteria decision-making method. *Omega*, 53(C): 49-57.

Rezaei, j. (2015). *Best worst method: A multi-criteria decision-making method.* https://www.bestworstmethod.com (10.03.2022).

Rieck, J., Ehrenberg, C. and Zimmermann, J. (2014). Many-to-many location-routing with inter-hub transport and multi-commodity pickup-and-delivery. *European Journal of Operational Research*, 236(3): 863-878.

Robbins, L. (1998). *A History of Economic Thought: the LSE Lectures*. New Jersey: Princeton.

Robinson, J. L., Thomas, R. W. and Manrodt, K. B. (2013). Food for thought in the transportation carrier-selection decision. *Transportation Journal*, 52(2): 277-296.

Rodrigue, J. P. (2004). Straits, passages and chokepoints: A maritime geostrategy of petroleum distribution. *Cahiers de géographic du Québec*, 48(135): 357-374.

Rodrigue, J. P. (2017). "Maritime Transport", *International Encyclopedia of Geography: People, the Earth, Environment and Technology* (pp. 1-7). Editors: Richardson, D., Castree, N., Goodchild, M. F., Kobayashi, A., Liu, W. and Marston, R. A. New York: Wiley-Blackwell.

Rodrigue, J. P. (28.05.2020). *Transport Geography, Domains of maritime circulation.* https://transportgeography.org/?page_id=1782, (20.12.2020).

Rodrigue, J. P. (28.05.2020). *Transport Geography, Main maritime shipping routes.* https://transportgeography.org/?page_id=1782, (20.12.2020).

Rodrigue, J. P. (28.05.2020). *Transport Geography, The route selection process.* https://transportgeography.org/contents/methods/route-selection-process/, (18.01.2021).

Rodrigue, J. P. (April 2019). *LinkedIn, ITF Roundtable on Future Maritime Trade Flows*. https://www.linkedin.com/pulse/itf-roundtable-future-maritime-trade-flows-jean-paul-rodrigue, (11.05.2021).

Rodrigue, J. P. (28.05.2020). *Transport Geography, Globalization and international trade.* https://transportgeography.org/contents/chapter7/globalization-international-trade/, (25.05.2021).

Rodrigue, J. P., Comtois, C. and Slack, B. (2009). *The Geography of Transport Systems 2nd Edt*. New York: Routledge.

Rodrigue, J. P. and Notteboom, T. E. (28.05.2020). *Transport Geography, Maritime transportation.* https://transportgeography.org/?page_id=1762, (16.11.2020).

Rodrigue, J. P. and Notteboom, T. E. (2021). *Port Economics Management, Interoceanic passages.* https://porteconomicsmanagement.org/pemp/contents/part1/interoceanic-passages/, (15.03.2021).

Rodrigue, J. P. and Notteboom, T. E. (2021). *Port Economics Management, Potential impacts of interoceanic passages and canals.* https://porteconomicsmanagement.org/pemp/contents/part1/interoceanic-passages/potential-impacts-interoceanic-passages-canals/, (15.03.2021).

Rodrigue, J. P. and Notteboom, T. E. (2010). Comparative North American and European gateway logistics: The regionalism of freight distribution. *Journal of Transport Geography*, 18(4): 497-507.

Rokicki, B. and Stepniak, M. (2018). Major transport infrastructure investment and regional development – an accessibility-base approach. *Journal of Transport Geography*, 72: 36-49.

Rondinelli, D. and Berry, M. (2000). Multimodal transportation, logistics and the environment: Managing interactions in a global economy. *European Management Journal*, 18(4): 398-410.

Rothwell, R. (1994). Towards the fifth-generation innovation process. *International Marketing Review*, 11(1): 7-31.

Rostomyan, A. (2015). The impact of emotions on decision making process in the field of Neuroeconomics. *Journal of Business and Economics*, 6(7): 1268-1276.

Rudnikas, E. (27.01.2013). *Sea Law, Straits, canals and cargo ship safety.* https://www.sealaw.com/straits-canals-and-cargo-ship-safety/, (15.03.2021).

Sakalys, A. and Palsaitis, R. (2006). Development of intermodal transport in new European Union states. *Transport*, XXI(2): 148-153.

Salandha, J. P., Tyworth, J. E., Swan, P. F. and Russel, D. W. (2009). Cutting logistics costs with ocean carrier selection. *Journal of Business Logistics*, 30(2): 175-195.

Salmeron, J.L. (2012). Fuzzy cognitive maps for artificial emotions forecasting*. Appl. Soft Comput.* 12, 3704–3710.

Sameraro, A., Vilella, S. and Ruffo, G. (2021). PyPlutchik: Visualizing and comparing emotion-annotated corpora. *PLoS ONE*, 16(9), e0256503: 1-24.

Samimi, A., Kawamura, K. and Mohammadian, A. (2011). A behavioral analysis of freight mode choice decisions. *Transportation Planning and Technology*, 34(8): 857-869.

Saner, H. S. (2021). *Hastanelerin Afete Hazırlığına Yönelik Bayesyen BWM ve VIKOR Temelli Bütünsel Bir Model Önerisi.* (Published MSc. Thesis). Tunceli: Munzur Üniversitesi Lisansüstü Eğitim Enstitüsü.

Santos, T. A. and Soares, C. G. (2016). Modeling transportation demand in short shea shipping. *Maritime Economics & Logistics*, 19(4): 695-722.

Satta, G., Parola, F., Ferrari, C. and Persico, L. (2013). Linking growth to performance: Insights from shipping line groups. *Maritime Economics & Logistics*, 15: 349-373.

Saunders, M., Lewis, P. and Thornhill, A. (2007). *Research Methods for Business Students 6th Edt.* London: Pearson.

Schröder, C., Reimer, N. and Jochmann, P. (2017). Environmental impact of exhaust emissions by Arctic Shipping. *Ambio*, 46(3): 400-409.

Schøyen, H. and Bråthen, S. (2011). The Northern Sea Route versus the Suez Canal: Cases from bulk shipping. *Journal of Transport Geography*, 19: 977-983.

Scott, W. A. (1995). Reliability of content analysis: The case of nominal scale coding. *Public Opinion Quarterly*, 19(3), 321-325.

Sea Distances (21.03.2021). *Sea Distances, Online tool for calculation distances between sea ports.* https://sea-distances.org. (21.03.2021).

Sen, S. (2005). International Trade Theory and Policy: A Review of the Literature. *Development and Change*, 36(6): 1011-1029.

Seyidoğlu, H. (2003). *Uluslararası İktisat*, İstanbul: Güzem Yayınları.

Simon, H. (1957). *Administrative Behavior: A Study of Decision Making Process in Admnistrative Organization*. New York: McMillan.

Shabani, Z. D. and Safaie, S. (2018). Do transport infrastructure spillovers matter for economic growth? Evidence on road and railway transport infrastructure in Iranian provinces. *Regional Sciences Policy and Practice*, 10: 49-63.

Shapira, Z. (2008). On the Implications of Behavioral Decision Theory for Managerial Decision Making: Contributions and Challenges. *Organizational Decision Making* (pp. 287-304). Editors: Hodgkinson, G. P. and Starbuck, W. H. New York: Oxford University Press Inc.

Shatz, H. J. and Venables, A. J. (2000). Globalization, Localization, and Trade. *The Oxford Handbook of Economic Geography* (pp. 125-145). Editors: Clark, G. L., Feldman, M. P. and Gertler, M. S. New York: Oxford University Press.

Shekar, A. (2007). An innovative model of service development: A process guide for service managers. *The Innovation Journal: The Public Sector Innovation Journal*, 12(1): 1-18.

Shibasaki, R., Azuma, T., Yoshida, T., Teranishi, H. and Abe, M. (2017). Global route choice and its modelling of dry bulk carriers based on vessel movement database:

Focusing on the Suez Canal. *Research in Transportation Business & Management,* 25: 51-65.

Shieh, J-I. and Wu, H-W. (2013). Measures of consistency for DEMATEL method. *Communications in Statistics*, 45: 1-10.

Shinghal, N. and Fowkes, T. (2002). Freight mode choice and adaptive stated preferences. *Transportation Research Part E*, 38: 367-378.

Shofiya, C. and Abidi, S. (2021). Sentiment analysis on COVID-19-related social distancing in Canada using twitter data. *Int. J. Environ. Res. Public Health*, 18(11), 5993: 1-10.

Shyu, W-H. and Ding, J-F. (2016). Key factors influencing the building of Arctic Shipping Routes. *The Journal of Navigation*, 69: 1261-1277.

Siems, E. and Seuring, S. (2021). Stakeholder management in sustainable supply chains: A case study of the bioenergy industry. *Business Strategy and Environment*, 30(7): 3105-3119.

Singh, M., Jakhar, A.K. and Pandey, S. (2021). Sentiment analysis on the impact of coronavirus in social life using the BERT model. *Social Network Analysis and Mining*, 11(1), 33: 1-11.

Skjoldborg, E. H. (2022). *All the Way: A. P. Moller – Maersk Sustainability Report 2021.* https://www.maersk.com/~/media_sc9/maersk/corporate/sustainability/files/resources/2021/maersk-sustainability-report_2021.pdf, (24.01.2022).

Slovic, P., Fischhoff, B. and Lichtenstein, S. (1977). Behavioral decision theory. *Ann. Rev. Psychol*. 28(1): 1-39.

Sokol, M. (2011). ***Economic Geography***. International Programs Guide by The London School of Economics and Political Science, London: University of London Publications.

Solakivi, T., Kiiski, T. and Ojala, L. (2018). The impact of ice class on the economics of wet and dry bulk shipping in the Arctic waters. *Maritime Policy & Management*, 45(4): 530-542.

Solakivi, T. and Ojala, L. (2017). Determinants of carrier selection: Updating the survey methodology into the 21st century. *Transportation Research Procedia* 25: 511-530.

Sotoudeh-Anvari, A., Sadjadi, S. J., Molana, S. M. H. and Nezhad-Sadi, S. (2018). A new MCDM-based approach using BWM and SAW for optimal search model. *Decision Science Letters*, 7: 395-404.

Soutworth, F. and Peterson, B. E. (2000). Intermodal and international freight network modeling. *Transportation Research Part C*, 8: 147-166.

Smith, C. A. and Ellsworth, P. C. (1985). Patterns of cognitive appraisal in emotion. *Journal of Personality and Social Psychology*, 48(4): 813-838.

Spaargaren, G. (2000). Ecological modernization theory and domestic consumption. *Journal of Environmental Policy & Planning*, 2: 323-335.

Sramek, B. D., Robinson, J. L., Darby, J. and Thomas, R. W. (2020). Exploring the differential roles of environmental and social sustainability in carrier selection decisions. *International Journal of Production Economics*, 227, 107660.

Sramek, B. D., Thomas, R. W. and Fugate, B. S. (2018). Integrating behavioral decision theory and sustainable supply chain management: Prioritizing economic, environmental, and social dimensions in carrier selection. *Journal of Business Logistics*, 39(2): 1-14.

Starostka-Patyk, M. and Grabara, J. K. (2010). Reverse logistics process in industrial waste management as an element of sustainable development. *Annales Universitatis Apulensis Series Oceonomica*, 12(2): 698-707.

Stevens, E. and Dimitriadis, S. (2005). Managing the new service development process: Towards a systemic model. *European Journal of Marketing*, 39(1/2): 175-198.

Stopford, M. (2009). *Maritime Econmics 3rd Edt*. New York: Routledge.

Sürücü-Balcı, E., Balcı, G. and Yuen, K.F. (2020). Social media engagement of stakeholders: A decision tree approach in container shipping. *Computers in Industry*, 115, 103152: 1-12.

Şimşir, F., Demir. H. İ. And Azdemir, S. (2018). Demir çelik sektöründe hibrid DEMATEL ve TOPSİS-ELECTRE yöntemleri ile hata türleri ve etkileri analizi. *Academic Platform Journal of Engineering and Science*, 6(3): 22-34.

Taferner, B. (2017). A next generation of innovation models? An integration of the innovation process model big picture – Towards the different generations of models. *Review of Innovation and Competitiveness*, 3(3): 47-60.

Takemura, K. (2014). *Behavioral Decision Theory: Psychological and Mathematical Descriptions of Human Choice Behavior*. Tokyo: Springer.

Takemura, K. (28.09.2020). *Oxford Research Encyclopedias, Behavioral decision theory.* https://oxfordre.com/politics/view/10.1093/acrefore/9780190228637.001.0001/acrefore-9780190228637-e-958, (11.02.2020).

Teodorovic, d. and Kalic, M. (1995). A fuzzy route choice model for air transportation networks. *Transportation Planning and Technology*, 19(2): 109-119.

The Institute of Chartered Shipbrokers (2011). *Liner Trades*. Glasgow: Witherby.

Theocharis, D., Rodrigues, V. S., Pettit, S. and Haider, J. (2019). Feasibility of the Northern Sea Route: The role of distance, fuel prices, ice breaking fees and ship size for the product tanker market. *Transportation Research Part E*, 129: 111-135.

Tikoudis, I., Sundberg, M. and Karlström, A. (2018). The effects of transportation infrastructure on regional economic development: A simulated spatial overlapping generations model with heterogenous skill. *Journal of Transport and Land Use*, 5(2): 77-101.

Tillman, H., Jian, Y. and Nielsson, E. T. (2018). The polar silk road: China's new frontier of International Cooperation. *China Quarterly of International Strategic Studies*, 4(3): 345-362.

Ting, S-C. and Tzeng, G-H. (2003). Ship scheduling and cost analysis for route planning in liner shipping. *Maritime Economics & Logistics*, 5: 378-392.

Tischler, S. (2017). Finding the right way – a new approach for route selection procedures?. *Transportation Research Procedia*, 25: 2809-2823.

Tiwari, P., Itoh, H. and Doi, M. (2003). Shippers' port and carrier selection behavior in China: A Discrete Choice Analysis. *Maritime Economics & Logistics*, 5: 23-39.

Tonami, A. (2014). The Arctic policy of China and Japan: Multi-layered economic and strategic motivations. *The Polar Journal*, 4(1): 105-126.

Tran, N. K., Haasis, H-D. and Buer, T. (2017). Container shipping route design incorporating the costs of shipping, inland/feeder transport, inventory and CO_2 emission. *Maritime Economics & Logistics*, 19: 667-694.

Trenberth, K. E. (2018). Climate change caused by human activities is happening and it already has major consequences. *Journal of Energy & Natural Resources Law*: 1-19.

Tseng, P-H. and Cullinane, K. (2018). Key criteria influencing the choice of Arctic shipping: A fuzzy analytic hierarchy process model. *Maritime Policy & Management*, 45(4): 422-438.

Tseng, P.-H. and Pilcher, N. (2017). Assessing the shipping in the Northern Sea Route: A qualitative approach. *Maritime Business Review*, 2(4): 389-409.

Tsirimpa, A., Polydoropoulou, A. and Tsouros, I. (2019). Route Choice preferences: Insights from Portuguese freight forwarders and truck drivers. *Transportation Planning and Technology*, 42(7): 729-738.

Tzeng, G. H., Shieh, H. M. and Shiau, T. A. (1989). Route choice behavior in transportation-an application of the multi-attribute utility theorem. *Transportation Planning and Technology,* 13: 289-301.

Tzeng, G-H. and Huang, J-J. (2011). *Multiple Attribute Decision Making*. Florida: CRC Press.

Ulu, M. and Şahin, H. (2021). An integrated approach for fire extinguishers selection with DEMATEL and TODIM methods. *BMIJ*, 9(4): 1696-1707.

UNCTAD (2017). *Review of Maritime Transport 2017*. New York: UN Publications. https://unctad.org/system/files/official-document/rmt2017_en.pdf, (19.12.2020).

UNCTAD (2018). *50 Years of Review of Maritime Transport 1968-2018: Reflecting on the Past, Exploring the Future*. New York: UN Publications. https://unctad.org/system/files/official-document/dtl2018d1_en.pdf, (19.12.2020).

UNCTAD (2019). *Review of Maritime Transport 2019*. New York: UN Publications. https://unctad.org/system/files/official-document/rmt2019_en.pdf, (19.12.2020).

UNCTAD (2020). *Review of Maritime Transport 2020*. New York: UN Publications. https://unctad.org/system/files/official-document/rmt2020_en.pdf, (19.12.2020).

UNCTAD (2021). *Review of Maritime Transport 2021*. New York: UN Publications. https://unctad.org/system/files/official-document/rmt2021_en_0.pdf, (09.07.2021).

UNESCAP (2015). *Regional Shipping and Port Development*. New York: UN Publications. https://www.unescap.org/sites/default/files/pub_2484_fulltext.pdf, (16.03.2021).

Vachon, S. (2007). Green supply chain practices and the selection of environmental technologies. *International Journal of Production Research* 45: 4357-4379.

Vaferi, M., Fallah, M. S. and Tayebi, A. H. (2018). A metaheuristic for the containership feeder routing problem with port choice process. *The Asian Journal of Shipping and Logistics*, 34(2): 119-128.

Valentinov, V. (2013). K. William Kapp's theory of social costs: A Luhmannian interpretation. *Ecological Economics*, 97: 28-33.

Vasilyev, V.V., Selin, V.S. and Tereshchenko, E.B. (2011). Socioeconomic consequences of anticipated climate change in the Arctic. *Regional Research of Russia*, 1(2): 128–132.

Verter, N. (2015). The application of international trade theories to agriculture. *Mediterranean Journal of Social Science*, 6(6): 209-219.

Villar, L. and Hamilton, M. (01.08.2017). *US Energy Information Administration, Maritime chokepoints are critical to global energy security.* https://www.eia.gov/todayinenergy/detail.php?id=32292, (15.03.2021).

Vizza, R. and Segal, M. (06.02.2020). *NASA Global Climate Change, Arctic ice melt is changing ocean currents.* https://climate.nasa.gov/news/2950/arctic-ice-melt-is-changing-ocean-currents/, (21.11.2021).

Vujanović, D. Momčilović, V., Bojović, N. and Papić, V. (2012). Evaluation of vehicle fleet maintenance management indicators by application of DEMATEL and ANP. *Expert Systems with Applications*, 39(12): 10552-10563.

Vylegzhanina, A.O. (2017). Certain socioeconomic problems of development of the Arctic territories. *Studies on Russian Economic Development*, 28(2): 180–190.

Wagner, S. M. (2008). Innovation management in the German transportation industry. *Journal of Business Logistics*, 29(2): 215-231.

Wan, Z., Nie, A., Chen, J., Ge, J., Zhang, C. and Zhang, Q. (2021). Key barriers to the commercial use of the Northern Sea Route: View from Chine with a fuzzy DEMATEL approach. *Ocean and Coastal Management*, 208: 105630.

Wang, T-C. (2012). The interactive trade decision-making research: An application case of novel hybrid MCDM model. *Economic Modeling*, 29(3): 926-935.

Wang, N., Wang, Z., Liu, X. and Wei, D. (2018). Optimal route selection based on Monte Carlo method and adaptive amoeba algorithm under uncertain environment. *International Journal of Parallel, Emergent and Distributed Systems*, 33(2): 157-171.

Wang, S. and Liu, Z. (2015). Efficient Global Container Transport Network Design. *Handbook of Ocean Container Transport Logistics* (pp. 359-395). Editors: Lee, C. Y. and Meng, Q. Switzerland: Springer.

Wang, S., Alharbi, A. and Davy, P. (2015). Ship Route Schedule Based Interactions Between Container Shipping Lines and Port Operators. *Handbook of Ocean Container Transport Logistics* (pp. 279-313). Editors: Lee, C. Y. and Meng, Q. Switzerland: Springer.

Wang, Y. and Yeo, G. T. (2018). Intermodal route selection for cargo transportation from Korea to Central Asia by adopting Fuzzy Delph and Fuzzy ELECTRE I methods. *Maritime Policy & Management*, 45(1): 3-18.

Wang, Y., Meng, Q. and Kuang, H. (2019). Intercontinental liner shipping service design. *Transportation Science*, 53(2): 344-364.

Wang, Y.-L. and Tzeng, G.-H. (2012). Brand marketing for creating brand value based on a MCDM model combining DEMATEL with ANP and VIKOR methods. *Expert Systems with Applications*, 39: 5600-5615.

Wang, X., Wong, Y. D., Li, K. X. and Yuen, K. F. (2021). Shipping industry's sustainability communications to public in social media: A longitudinal analysis. *Transport Policy*, 110: 123-134.

Wangwe, S. (1993). **New trade theories and developing countries: Policy and technological implications**. *UNU/INTECH Working Paper*, 7: 1-34.

Watson, I. and Spence, M.T. (2007). Causes and consequences of emotions on consumer behavior: A review and integrative cognitive appraisal theory. *European Journal of Marketing,* 41(5-6): 487-511.

Wellesley, L., Preston, F., Lehne, J. and Bailey, R. (2017). Chokepoints in global food trade: Assessing the risks. *Research in Transportation Business & Management*, 25: 15-28.

Wen, X., Ma, H-L., Choi, T-M. and Sheu, J-B. (2019). Impacts of the belt and road initiative on the China-Europe trading route selections. *Transportation Research Part E*, 122: 581-604.

Williams, Z., Garver, M. S. and Taylor, S. (2013). Carrier Selection: Understanding the needs of less-than-truckload shippers. *Transportation Journal*, 52(2): 151-182.

Wilmsmeier, G. and Notteboom, T. (2011). Determinants of liner shipping network configuration: A two-region comparison. *GeoJournal*, 76: 213-228.

Wong, P. C., Yan, H. and Bamford, C. (2008). Evaluation of factors for carrier selection in the China Pearl River delta. *Maritime Policy & Management*, 35(1): 27-52.

Woo, S. H., Kim, S. N., Kwak, D. W. and Pettit, S. (2017). Multimodal route choice in maritime transportation: The case of Korean auto-parts exporters. *Maritime Policy & Management,* 45(1): 19-33.

World Shipping Council (2019). *World Shipping, Major trade routes.* https://www.worldshipping.org/about-the-industry/global-trade/trade-routes, (16.03.2021).

World Shipping Council (2019). *World Shipping, Suez canal route.* https://www.worldshipping.org/pdf/Suez-Canal-Presentation.pdf, (16.03.2021).

World Shipping Council (2019). *World Shipping, The top 50 container ports.* https://www.worldshipping.org/top-50-ports, (16.03.2021).

Wu, S.-H. and Gao, Y. (2019). Understanding emotional customer experience and co-creation behaviors in luxury hotels. *International Journal of Contemporary Hospitality Management*, 31(11): 4247-4275.

Xinmin, M. (2019). China's Arctic policy on the basis of international law: Identification, goals, principles and positions. *Marine Policy*, 100: 265–276.

Xu, H., Yang, D. and Weng, J. (2018). Economic feasibility of an NSR/SCR-combined container service on the Asia-Europe Lane: A new approach dynamically considering sea ice extent. *Maritime Policy & Management*, 45(4): 514-529.

Xu, W. (2010). *The Effects of Emotions on Strategic Decision-Making: A China-U.S. Cross-Cultural Experimental Study.* (Published PhD Thesis). Norfolk: Old Dominion University Business Administration-Strategic Management.

Yang, D., Ong, G. P. and Chin, A. T. H. (2014). An exploratory study on the effect of trade data aggregation on international freight mode choice. *Maritime Policy & Management*, 41(3): 212-223.

Yang, J. L. and Tzeng, G-H. (2011). An integrated MCDM technique combined with DEMATEL for a novel cluster-weighted with ANP method. *Expert Systems with Applications*, 38(3): 1417-1424.

Yercan, F. and Yıldız, T. (2012). International Maritime Trade and Logistics. *Maritime Logistics-A Complete Guide to Effective Shipping and Port Management* (pp. 23-42). Editors: Song, D. W. and Panayides, P. M. London: Kogan Page.

Yuan, C-Y., Hsieh, C-H. and Su, D-T. (2020). Effects of new shipping routes on the operational resilience of container lines: Potential impacts of the Arctic Sea Route and the Kra Canal on the Europe-Far East seaborne trades. *Maritime Economics & Logistics*, 22: 308-325.

Zacharioudakis, P. G., Iordanis, S., Lyridis, D. V. and Psaraftis, H. N. (2011). Liner shipping cycle cost modelling, fleet deployment optimization and what-if analysis. *Maritime Economics & Logistics*, 13(3): 278-297.

Zhang, N., Ma, B., Yan, W. and Zhu, J. (2006). A cognitive planning model for transport and logistics*. 4th IEEE International Conference on Industrial Informatics*, (pp.1153-1158). Organizer Singapore Institute of Manufacturing Technology. Singapore. 16-18 August 2006.

Zhang, Y., Meng, Q., and Ng, S. H. (2016). Shipping efficiency comparison between Northern Sea Route and the conventional Asia-Europe shipping route via Suez Canal. *Journal of Transport Geography*, 57: 241-249.

Zhang, Q., Wan, Z., Fu, S. (2020). Towards sustainable Arctic shipping: Perspectives from China. *Sustainability* 12(21): 9012.

Zhou, Y., Li, X., Wang, X., Yuen, K.F., 2022. Intelligent container shipping sustainability disclosure via stakeholder sentiment views on social media. *Marine Policy*, 135(1): 104853.

Zhao, H., Hu, H. and Lin, Y. (2016). Study on Chine-EU container shipping network in the context of Northern Sea Route. *Journal of Transport Geography*, 53: 50-60.

Zhou, J-L., Bai, Z-H. and Sun, Z-Y. (2014). A hybrid approach for safety assessment in high-risk hydropower-construction-project work systems. *Safety Science*, 64: 163-172.

Zhou, S., Zhuo, X., Chen, Z. and Tao, Y. (2020). A new separable piecewise linear learning algorithm for the stochastic empty container repositioning problem. *Mathematical Problems in Engineering*, 2020: 1-16.

Zhou, Y., Li, X., Wang, X. and Yuen, K.F. (2022). Intelligent container shipping sustainability disclosure via stakeholder sentiment views on social media. *Marine Policy*, 135, 104853: 1 – 11.

Zhu, S., Fu, X., Ng, A.K.Y., Luo, M. and Ge, Y.-E. (2018). The environmental costs and economic implications of container shipping on the Northern Sea Route, *Maritime Policy & Management*, 45:4: 456-477.

Zimand-Sheiner, D., Levy, S. and Eckhaus, E. (2021). Exploring negative spillover effects on stakeholders: A case study on social media talk about crisis in the food industry using data mining. *Sustainability*, 13, 10845: 1-16.

Zis, T., Angeloudis, P. and Bell, M. G. H. (2015). Economic and Environmental Trade-Offs in Water Transportation. *Green Logistics and Transportation* (pp. 159-174). Editors: Fahimnia, B., Bell, M. G. H., Hensher, D. A. and Sarkis, J. New York: Springer.

Zizlavsky, O. (2103). Past, present and future of the innovation process. *International Journal of Engineering Business Management*, 5(47): 1-8.

APPENDICIES

Appendix 1: Theoretical Frameworks and Methodologies of Route Selection, Transport Mode Selection and Carrier Selection Studies

Attribute	Author(s)
Route Selection Studies	
Sailing Time and Schedule Reliability	Tsirimpa et al. (2019); Wen et al. (2019); Park et al. (2019); Pham et al. (2018); Wang and Yeo (2018); Wang et al. (2018); Shibasaki et al. (2017); Woo et al. (2017); Moon et al. (2015); Fagerholt et al. (2010); Teodorovic and Kalic (1995)
Total Cost (Including transportation, bunker, inventory carrying costs, and port dues) and Cost Effectiveness	Tsirimpa et al. (2019); Wen et al. (2019); Park et al. (2019); Pham et al. (2018); Wang and Yeo (2018); Tischler (2017); Woo et al. (2017); Kashiha et al. (2016); Moon et al. (2015)
Security and Safety of Routes	Wen et al. (2019); Wang and Yeo (2018); Shibasaki et al. (2017); Tischler (2017); Moon et al. (2015)
Distance	Wen et al. (2019); Shibasaki et al. (2017); Kashiha et al. (2016); Moon et al. (2015); Fagerholt et al. (2010)
Fuel Consumption	Park et al. (2019); Wang et al. (2018); Shibasaki et al. (2017); Fagerholt et al. (2010)
Speed Decisions	Wen et al. (2019); Tsirimpa et al. (2019); Shibasaki et al. (2017); Fagerholt et al. (2010)
Weekly Service Frequency	Woo et al. (2017); Moon et al. (2015); Teodorovic and Kalic (1995)
Environment and Sustainability	Wen et al. (2019); Tischler (2017); Fagerholt et al. (2010)
Port Rotation and Their Technical Capabilities (Origin & Destination)	Park et al. (2019); Pham et al. (2018); Kashiha et al. (2016)
Transportation Network of Hinterlands	Wang et al. (2018); Tischler (2017); Kashiha et al. (2016)
Volume and Size of Shipment	Kashiha et al. (2016); Teodorovic and Kalic (1995)
Contract Reliability	Park et al. (2019); Pham et al. (2018)
Geographical Conditions	Tischler (2017); Kashiha et al. (2016)

Infrastructure Reliability	Wen et al. (2019)
Vessel Size	Shibasaki et al. (2017)
Shipper's Characteristics (Origin and size)	Kashiha et al. (2016)
Route Awareness	Moon et al. (2015)
Political Concerns	Pham et al. (2018)
Oceanic Connectivity of Hinterlands	Kashiha et al. (2016)
Transport Mode Selection Studies	
Transit Time	Tremerie (2018); Liu (2016); Kim et al. (2016); Mitra (2013); Lirn and Wong (2013); Kim and Nicholson (2013); Samimi et al. (2011); Garcia-Menédez et al. (2004); Shinghal and Fowkes (2002)
Volume and Size of Shipment	Derse and Göçmen (2019); Kim et al. (2016); Yang et al. (2014); Mitra (2013); Kim and Nicholson (2013); Kim and Nicholson (2013); Moschovou and Giannopoulos (2012); Samimi et al. (2011); Shinghal and Fowkes (2002)
Total Cost (Including transportation, bunker, inventory carrying costs, and port dues) and Cost Effectiveness	Derse and Göçmen (2019); Tremerie (2018); Liu (2016); Mitra (2013); Lirn and Wong (2013); Kim and Nicholson (2013); Kim and Nicholson (2013); Samimi et al. (2011); Garcia-Menédez et al. (2004)
Service Reliability	Tremerie (2018); Liu (2016); Kim et al. (2016); Lirn and Wong (2013); Kim and Nicholson (2013); Kim and Nicholson (2013); Punakivi and Hinkka (2006); Garcia-Menédez et al. (2004); Shinghal and Fowkes (2002)
Intermodal Connectivity and Accessibility	Kim et al. (2016); Kim and Nicholson (2013); Kim and Nicholson (2013); Moschovou and Giannopoulos (2012); Samimi et al. (2011); Shinghal and Fowkes (2002)
Damage and Loss Frequency	Tremerie (2018); Kim et al. (2016); Lirn and Wong (2013); Kim and Nicholson (2013); Moschovou and Giannopoulos (2012); Garcia-Menédez et al. (2004)
Service Frequency	Liu (2016); Kim et al. (2016); Lirn and Wong (2013); Kim and Nicholson (2013); Moschovou and Giannopoulos (2012); Garcia-Menédez et al. (2004)

Distance	Mitra (2013); Kim and Nicholson (2013); Moschovou and Giannopoulos (2012); Samimi et al. (2011); Shinghal and Fowkes (2002)
Characteristics of Good (Type, Value, Package, Perishability)	Yang et al. (2014); Mitra (2013); Moschovou and Giannopoulos (2012); Shinghal and Fowkes (2002)
Environment and Sustainability	Tremerie (2018); Liu (2016); Kim et al. (2016); Garcia-Menédez et al. (2004)
Rates	Kim et al. (2016); Punakivi and Hinkka (2006); Shinghal and Fowkes (2002)
Service Quality	Kim and Nicholson (2013); Moschovou and Giannopoulos (2012)
Traceability	Lirn and Wong (2013); Moschovou and Giannopoulos (2012)
Handling Capability (Frequency, Volume, Size, Specialized Requirements)	Kim et al. (2016); Moschovou and Giannopoulos (2012)
Scheduling and Schedule Reliability	Kim and Nicholson (2013); Punakivi and Hinkka (2006)
Safety and Security	Lirn and Wong (2013); Punakivi and Hinkka (2006)
Availability of Logistics Facilities	Kim and Nicholson (2013); Samimi et al. (2011);
Service Flexibility	Liu (2016); Kim et al. (2016);
Equipment Availability	Moschovou and Giannopoulos (2012)
Speed	Punakivi and Hinkka (2006)
Inventory Level	Lirn and Wong (2013)
Possibility of Accident	Derse and Göçmen (2019)
Free Time	Lirn and Wong (2013)
Infrastructure Reliability	Derse and Göçmen (2019)
Carrier Selection Studies	

Transit Time	Solakivi and Ojala (2017); Garver, (2016); Lin and Yeh (2013); Williams et al. (2013); Robinson et al. (2013); Wong et al. (2008); Caiwen and Yan (2007); Murphy et al. (1997); Premeaux et al. (1992); Brooks (1990); Coulter et al. (1989); Jerman et al. (1978)
Service Reliability	Solakivi and Ojala (2017); Lin and Yeh (2013); Williams et al. (2013); Robinson et al. (2013); Wong et al. (2008); Mohammaditabar and Teimoury (2008); Caiwen and Yan (2007); Lehmusvaara et al. (1999); Murphy et al. (1997); Premeaux et al. (1992); Brooks (1990); Coulter et al. (1989)
Damage and Loss Frequency	Solakivi and Ojala (2017); Williams et al. (2013); Wong et al. (2008); Mohammaditabar and Teimoury (2008); Lehmusvaara et al. (1999); Murphy et al. (1997); Liberatore and Miller (1995); Premeaux et al. (1992); Brooks (1990); Coulter et al. (1989); Jerman et al. (1978)
Relationship and Trust	Solakivi and Ojala (2017); Williams et al. (2013); Robinson et al. (2013); Mohammaditabar and Teimoury (2008); Tiwari et al. (2003); Liberatore and Miller (1995); Brooks (1990); Lehmusvaara et al. (1999); Premeaux et al. (1992); Jerman et al. (1978)
Total Cost (Including transportation, bunker, inventory carrying costs, and port dues) and Cost Effectiveness	Sramek et al. (2018); Solakivi and Ojala (2017); Choudhary and Shankar (2014); Lin and Yeh (2013); Wong et al. (2008); Caiwen and Yan (2007); Liberatore and Miller (1995); Brooks (1990); Coulter et al. (1989)
Flexibility for Quick Response to Customer's Needs, Claims, and Emergency Situations	Solakivi and Ojala (2017); Williams et al. (2013); Wong et al. (2008); Mohammaditabar and Teimoury (2008); Lehmusvaara et al. (1999); Murphy et al. (1997); Premeaux et al. (1992); Brooks (1990)
Traceability	Solakivi and Ojala (2017); Williams et al. (2013); Robinson et al. (2013); Mohammaditabar and Teimoury (2008); Murphy et al. (1997); Liberatore and Miller (1995); Brooks (1990); Jerman et al. (1978)
Rates	Sramek et al. (2018); Solakivi and Ojala (2017); Garver, (2016); Choudhary and Shankar (2014); Wong et al. (2008); Lehmusvaara et al. (1999); Murphy et al. (1997); Coulter et al. (1989)

Service Quality	Solakivi and Ojala (2017); Wong et al. (2008); Tiwari et al. (2003); Tiwari et al. (2003); Lehmusvaara et al. (1999); Liberatore and Miller (1995); Jerman et al. (1978)
Service Frequency	Solakivi and Ojala (2017); Williams et al. (2013); Tiwari et al. (2003); Murphy et al. (1997); Brooks (1990); Coulter et al. (1989); Jerman et al. (1978)
Information Supply, Transparency and Integrity of Information	Solakivi and Ojala (2017); Williams et al. (2013); Robinson et al. (2013); Wong et al. (2008); Liberatore and Miller (1995); Premeaux et al. (1992); Brooks (1990)
Service Availability and Geographical Coverage	Solakivi and Ojala (2017); Wong et al. (2008); Mohammaditabar and Teimoury (2008); Tiwari et al. (2003); Premeaux et al. (1992); Coulter et al. (1989)
Carrier's Reputation and Past Performance	Solakivi and Ojala (2017); Williams et al. (2013); Mohammaditabar and Teimoury (2008); Premeaux et al. (1992); Coulter et al. (1989); Jerman et al. (1978)
Flexibility in Pricing and Payment	Solakivi and Ojala (2017); Wong et al. (2008); Lehmusvaara et al. (1999); Premeaux et al. (1992); Coulter et al. (1989); Jerman et al. (1978)
Condition of Equipment	Solakivi and Ojala (2017); Wong et al. (2008); Mohammaditabar and Teimoury (2008); Lehmusvaara et al. (1999); Murphy et al. (1997); Premeaux et al. (1992);
Pickup & Delivery Schedule and Flexibility in Scheduling	Wong et al. (2008); Mohammaditabar and Teimoury (2008); Premeaux et al. (1992); Brooks (1990); Jerman et al. (1978)
Fleet Size and Capacity of Carrier	Choudhary and Shankar (2014); Lin and Yeh (2013); Wong et al. (2008); Mohammaditabar and Teimoury (2008); Tiwari et al. (2003)
Energy Efficiency and Environmental & Social Sustainability	Sramek et al. (2020); Sramek et al. (2018); Solakivi and Ojala (2017); Williams et al. (2013)
Quality and Capability of Employee	Solakivi and Ojala (2017); Robinson et al. (2013); Mohammaditabar and Teimoury (2008); Brooks (1990)
Speed	Solakivi and Ojala (2017); Williams et al. (2013); Coulter et al. (1989)
Annual TEU Processed	Tiwari et al. (2003); Coulter et al. (1989)

Security	Williams et al. (2013); Caiwen and Yan (2007)
Practicality of Website	Solakivi and Ojala (2017); Williams et al. (2013)
Certificates (Environmental, Quality Assurance etc.)	Solakivi and Ojala (2017); Robinson et al. (2013)
Logistics Network	Lin and Yeh (2013)

Source: Created by the Author

Appendix 2: Dimensions, Criteria, and Their Definitions

Dimension		Criteria		Definition
D1	COST	*C11*	Slow steam applicability	A speed decision, which influences both transit time and fuel consumption
		C12	Energy efficiency	To use less energy in performing operations and routines
		C13	Mandatory assistance	Fees to be paid for mandatory assistances
		C14	Canals and passages	Fees to be paid for canals and passages
D2	TIME	*C21*	Distance	Nautical measurement of the voyage between the port of loading and discharge
		C22	Transit time	Total duration spent on delivery of cargo from origin to destination
		C23	Congestion	Time spent on canals, passages, and mooring
		C24	Berthing and cargo handling	Time spent on berthing and cargo handling operations
D3	SERVICE	*C31*	Schedule reliability	Whether provided or not weekly service frequency
		C32	Equipment availability	Positions of equipment on backhaul
		C33	Competition	Service scope of competitors
		C34	Shipping alliances	Service scope of alliance partner(s)
		C35	Loss potential	Loss and damage potential of freight
		C36	Brand image	Possibility to damage brand image from the public perspective in conclusion to a decision
D4	HINTERLAND	*C41*	Port rotation	Capabilities and sequence of ports to be called
		C42	Door to door service	Reliability of hinterland's transportation network
		C43	Industry level	Industrialization degree and potential of the region
		C44	Dry-port connections	Railway connected centers within the hinterland
D5	ENVIRONMENT	*C51*	Damage to biodiversity	Damage potentials to biodiversity and local habitats' conditions
		C52	Ozone layer spoil	The very major cause of ozone layer spoil is emissions in the Arctic
		C53	Air quality problems	The emission-based highly prominent reason for pollution
		C54	Carbon footprint	Carbon footprint policies and expectations of stakeholders within the supply chain
D6	SAFETY & SECURITY	*C61*	Piracy	Pirate attack potential within the route
		C62	Accident and collision	Accident and collision potential within the route
		C63	Theft	Theft risks
		C64	Lashing, Stacking and Trimming	Stacking and trimming problems to be faced in deep wavy and stormy conditions
D7	SOCIAL	*C71*	Public reaction	A consequence of the public's perception towards companies' decisions and behaviors.
		C72	Health Problems	Increasing respiration, cardiovascular, and cancer disease
		C73	*Quadruple* bottom line	A sustainability perspective concerning economic, environmental, social, and cultural approaches

Appendix 3: Data Collection Form

Dear participant,

We are conducting a research to be used in my Ph.D. study with the advisory of Prof. Dr. Okan TUNA. The thesis, "Route Selection Behavior of Shipping Companies: An Analysis for Arctic Shipping Routes", is performed within the Dokuz Eylül University Institute of Social Science, Maritime Business Administration Program. In this study, we have blended route selection criteria of shipping lines with carriers' selection criteria of freight forwarders and shippers. Consequently, it was aimed to reveal shipping companies' behavior toward the main dynamics related to Arctic shipping and to obtain a model that can be used in new service development.

In this direction, the seven essential dimensions that arise from Arctic Routes, sustainable transportation, and the basics of transportation have been determined. These are Cost, Time, Service, Hinterland, Environment, Safety & Security, and Social dimensions. The relevant criteria have been identified within each dimension, and some of those criteria are directly and some are indirectly expressed in the data collection form. Thus, it is aimed to find out the difference between behaviors.

Some of those criteria represent their core meanings while some covers research-specific situations in addition to core meanings. Therefore, we have stuck short notes, which explain our expectations on how criteria should be evaluated, into the attached Excel file. When answering this file, you are first asked to watch the tutorial, and then asked to select the importance and priority degrees of criteria on a dashboard given by evaluating each criterion within its dimension.

Because the research involves three substantial actors of maritime transportation, as a matter of course, one party may find some criteria directly important, and the others may see these criteria as unimportant or indirectly important. In such cases, you are expected to benefit from short information given in the boxes, and if any, indirect effects should be evaluated if not, the criterion should be considered unimportant. All these processes, according to participants take 15 – 18 minutes.

The responses given to this research will only be used for scientific purposes, and the findings will be reported anonymously. If requested, we kindly indicate that we will be honored to share and discuss the findings of the study with you.

Thank you for your attention and support!

Res. Asst. Kemal AKBAYIRLI

Dokuz Eylül University
Ph.D. Candidate on Institute of Social Sciences

This study **AIMS TO DETERMINE PROIRITIES AND BEHAVIORS IN ROUTE SELECTION.**

The study consists of two parts.

In first part, you are expected to determine the influence of 7 main dimensions over each other.

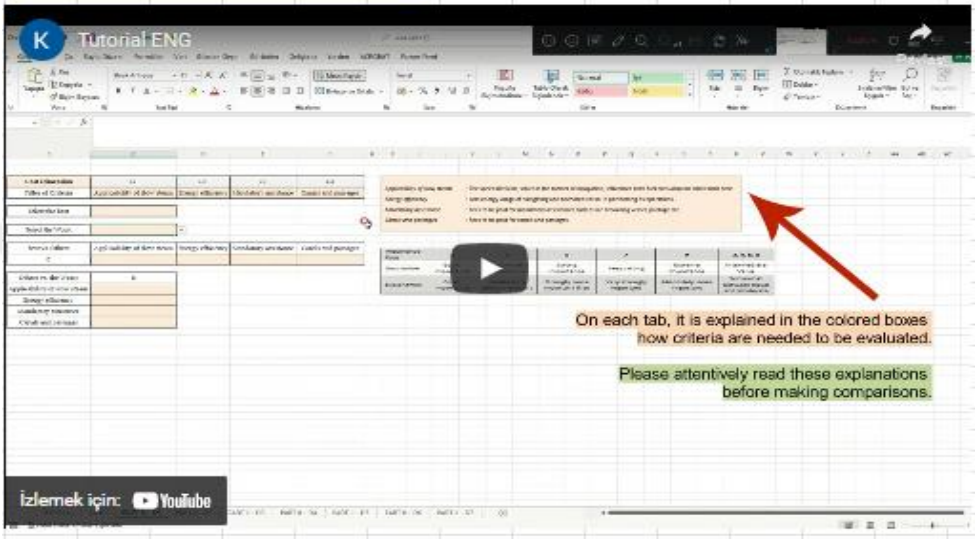
In the second part, you are expected to determine importance degree of sub-criteria by comparing sub-crteria of each dimension with each other.

BEFORE START, PLEASE ANSWER THE PROFILE QUESTIONS AND THEN, WATCH THE SHORT TUTORIAL IN ORDER TO DECREASE DURATION.

AND, BEFORE RESPOND PLEASE READ INFORMATION BOXES LOCATED AT THE BEGINNING OF BOTH PARTS.

If the video does not work please use the link below.

https://www.youtube.com/watch?v=P8aCaPVUfYg&t=26s

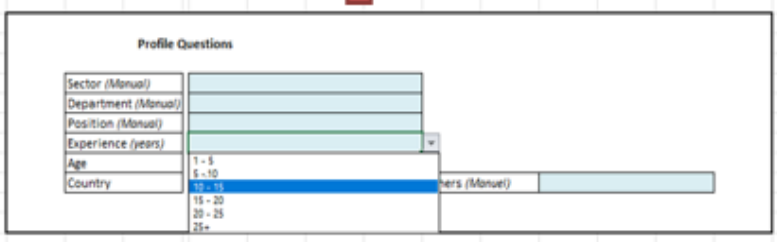


Profile Questions

Sector *(Manual)*			
Department *(Manual)*			
Position *(Manual)*			
Experience *(years)*			
Age			
Country		Others *(Manual)*	

Light blue cells with "Manual" in parentheses will be filled in manually.

For the rest, when you left-click on light blue cells, pre-described options automatically come, in the same way as the illustration below.



Part I - DEMATEL

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	-						
Time		-					
Service			-				
Hinterland				-			
Environment					-		
Safety & Security						-	
Social							-

PART I

You are expected to determine the influence of the dimensions in the matrix rows (left side) over the dimensions in the columns (right side).

Please fill the matrix by benefiting the short info given at below.

The intent of dimensions' usage in this research are:

Cost	: The costs related to speed decisions, fuel consumption, and navigational fees.
Time	: Consists of time spent on navigation, hubs, canals, etc. from cargo origin to destination.
Service	: In addition to quality and reliability, it implies, service scope of companies, rivals, and partners.
Hinterland	: Represents demand and connectivity patterns of a region or zone.
Environment	: Includes both Arctic-level and global level environmental troubles influencing ecology, future of the world, and human life.
Safety & Security	: Overall navigational, operational, and cargo-related safety and security issues that can be occur within the context of navigation, port, and geography,
Social	: Indicates negative effects of transportation on social life, perception of public, and sustainability dynamics.

0	1	2	3	4
(Has no effect)	(Has low effect)	(Has moderate effect)	(Has strong effect)	(Has very strong effect)

Please use the following comparison scale. In this scale, mutual effects **must not be identical**. For instance, Environment to Social may differ from Social to Environment in scoring.

Part II - BWM

PART II

This part consist of 7 tabs. Each tab includes the dimensions located in first part and their sub-criteria.

Primarily, this part consists of selecting the "BEST" and "WORST" criterion within the alternatives, and then separately making pairwise comparisons of "BEST" and "WORST" citerion with others.

1

Please answer this and following parts (D1 - D7) within the same perspective.

Importance Rate	*1*	*3*	*5*	*7*	*9*	*2, 4, 6, 8*
Description	Equal importance	Moderate importance	Strong importance	Very strong	Extreme importance	Intermediate Value
Explanation	Equal importance	Moderately more important	Strongly more important than	Very strongly important	Absolutely more important	Somewhat between Equal and Moderate

These numbers show the strength of a criteron over others.

Even numbers are intermediate values, and please do not use the even numbers unless it is necessary.

Cost Dimension	C1	C2	C3	C4
Titles of Criteria	Applicability of slow steam	Energy efficiency	Mandatory assistance	Canals and passages

Select the Best	
Select the Worst	

Best vs. Others	Applicability of slow steam	Energy efficiency	Mandatory assistance	Canals and passages
0				

Others vs. the Worst	0
Applicability of slow steam	
Energy efficiency	
Mandatory assistance	
Canals and passages	

2

Please make your selection by considering the definitions in the colored box.

Some criteria are directly important while some are indirectly.

Thus, if needed or when you consider the criterion is not related with your profeciency, please re-read the explanations in colored boxes.

Then, if there are, make comparison by considering indirect effects, if there are not, make your selection by considering this

3

1) First, select the "BEST" criterion. To make selection please left click on colored cells.

2) Then, select the "WORST" with the same method.

3) Your choices will automatically be filled in the comparison sections below.

4) Now, please determine supremacy level of the criteria located on the left side over the criteria located on the right side.

5) Please determine supremacy level of "BEST" criterion over others by using the scale in left box.

6) Please determine supremacy level of other criteria over "WORST" criterion by using the scale in left box.

Applicability of slow steam	: The speed decision, which is the matter of navigation, influences both fuel consumption and transit time.
Energy efficiency	: Less energy usege of navigating and anchored vessel in performing its operations.
Mandatory assistance	: Fees to be paid for mandatory assistances such as Ice breakning vessel, pilotage etc.
Canals and passages	: Fees to be paid for canals and passages.

Time Dimension	C5	C6	C7	C8
Titles of Criteria	Distance	Transit time	Congestion	Berthing and cargo handling
Select the Best				
Select the Worst				
Best vs. Others	Distance	Transit time	Congestion	Berthing and cargo handling
0				

Others vs. the Worst	0
Distance	
Transit time	
Congestion	
Berthing and cargo handling	

Distance discharge.	: Nautical measurement of the voyage between the port of loading and
Transit time	: Total duration spent on delivery of cargo from origin to destination.
Congestion	: Time spent on canals, passages, and mooring.

Service Dimension	C9	C10	C11	C12	C13	C14
Titles of Criteria	Schedule reliability	Equipment availability	Competition	Shipping alliances	Loss potential	Brand image
Select the Best						
Select the Worst						
Best vs. Others	Schedule reliability	Equipment availability	Competition	Shipping alliances	Loss potential	Brand image
0						

Others vs. the Worst	0
Schedule reliability	
Equipment availability	
Competition	
Shipping alliances	
Loss potential	
Brand image	

Schedule reliability	: Providing or getting weekly service frequency.
Equipment availability	: Positions of empty containers on port of discharge and backhaul.
Competition	: Service scope of liner shipping companies and competitiveness degree of route.
Shipping alliances	: Service scope of alliance partner(s).
Loss potential	: Loss and damage potential of freight while navigating, berthing, and unberthing.
Brand image sevice.	: Possibility to damage brand image from the public perception in conclusion of a decision or

Hinterland Dimension	C15	C16	C17	C18
Titles of Criteria	Port rotation	Door to door service	Industry level	Dry-port connections
Select the Best				
Select the Worst				
Best vs. Others	Port rotation	Door to door service	Industry level	Dry-port connections
0				

Others vs. the Worst	0
Port rotation	
Door to door service	
Industry level	
Dry-port connections	

Port rotation	: Capabilities and sequence of ports to be called.
Door to door service	: Reliability of hinterland's transportation network.
Industry level	: Industrialization degree and potential of the region.
Dry-port connections	: Railway connected logistics facilities within the hinterland.

Environment Dimension	C19	C20	C21	C22
Titles of Criteria	Damage to biodiversity	Ozone layer spoil	Air quality problems	Carbon footprint
Select the Best				
Select the Worst				
Best vs. Others	Damage to biodiversity	Ozone layer spoil	Air quality problems	Carbon footprint
0				

Others vs. the Worst	0
Damage to biodiversity	
Ozone layer spoil	
Air quality problems	
Carbon footprint	

Damage to biodiversity	: Damage potentials to biodiversity and local habitats' conditions.
Ozone layer spoil disruption.	: Increasing emissions around the world and especially in the Arctic is the very major cause of ozone layer
Air quality problems	: A highly prominent result of transportation-related water and air pollutions.
Carbon footprint	: Sustainability and carbon footprint policies and expectations of stakeholders within the supply chain.

Safety & Security Dimension	C23	C24	C25	C26
Titles of Criteria	Piracy	Accident and collision	Theft	Lashing, stacking and trimming
Select the Best				
Select the Worst				
Best vs. Others	Piracy	Accident and collision	Theft	Lashing, stacking and trimming
0				

Others vs. the Worst	0
Piracy	
Accident and collision	
Theft	
Lashing, stacking and trimming	

Piracy	: Pirate attack potential within the route.
Accident and collision	: Accident and collision potential within the route due to traffic density and geographical restrictions.
Theft	: Theft risks in storage and free time periods.
Lashing, stacking and trimming	: Lashing, stacking and trimming problems to be faced in deep wavy and stormy conditions.

Social Dimension	C27	C28	C29
Titles of Criteria	Public reaction	Health problems	Quadruple bottom line
Select the Best			
Select the Worst			
Best vs. Others	Public reaction	Health problems	Quadruple bottom line
0			

Others vs. the Worst	0
Public reaction	
Health problems	
Quadruple bottom line	

Public reaction	: The public's perception towards companies' decisions and behaviors.
Health problems	: Increasing respiration, cardiovascular, and cancer disease due to air quality problems caused by high emissions levels.
Quadruple bottom line	: A sustainability perspective that propose companies to consider economic, environmental, social, and cultural approaches in the same box.

Appendix 4. List of Overall Sampling Characteristics

Sector	Company	Size	Department	Position	Experience	Age	Country
Carrier	CA1 - R1	Large	Supply Chain	Customer Experience Developer	5 - 9	20 - 29	Germany
	CA1 - R2		Board of Director	Director	25+	55+	Denmark
	CA2 - R3	Large	Planning	Manager	10 - 14	35 - 39	Sweden
	CA3 - R4	Large	Customer Relations	Director	25+	50 - 55	France
	CA4 - R5	Large	Board of Director	Vice President	20 - 25	45 - 49	Türkiye
	CA5 - R6	Large	Sales	Senior Director	10 - 14	30 - 34	Netherlands
	CA6 - R7	Large	Business Development	Manager	10 - 14	30 - 34	Türkiye
	CA7 - R8	Large	Fleet Management	Nautical Technologies Manager	10 - 14	30 - 34	Germany
	CA8 - R9	Large	Board of Director	CEO	25+	55+	Türkiye
	CA9 - R10	Medium	Board of Director	Vice President	20 - 25	45 - 50	Türkiye
	CA9 - R11		Operation	Manager	20 - 25	45 - 50	Türkiye
	C10 - R12	Large	Marketing	Manager	5 - 9	30 - 34	Australia
3PL	FF1 - R13	Large	Customer Relations	Specialist	5 - 9	30 - 34	Netherlands
	FF2 - R14	Large	Board of Director	Value Added Service Manager	25+	50 - 55	China
	FF3 - R15	Large	Board of Director	General Manager	20 - 25	45 - 49	Türkiye
	FF4 - R16	Large	Board of Director	East Mediterranean Director	15 - 19	40 - 45	Spain
	FF4 - R17		Operation	Director	15 - 19	45 - 49	Türkiye
	FF5 - R18	Large	Board of Director	CCO	20 - 25	45 - 49	Spain
BCO	BC1 - R19	Medium - Large	Logistics	Manager	10 - 14	30 - 34	Türkiye
	BC2 - R20	Medium - Large	Logistics	Manager	15 - 19	35 - 39	Türkiye
	BC3 - R21	Large	Ocean Logistics	Service Provider Operation Developer	5 - 9	30 - 34	Sweden
	BC4 - R22	Large	Supply Chain	Supply Chain Director	15 - 19	45 - 49	Türkiye
	BC5 - R23	Large	Supply Chain	Senior Manager	10 - 14	35 - 39	Luxemburg
	BC6 - R24	Large	Supply Chain	Manager	10 - 14	30 - 34	Türkiye
Expert	EX1 - R25	N/A	Consultancy	General Manager	25+	55+	USA
	EX2 - R26	N/A	Consultancy	General Manager	20 - 25	50 - 55	India
	EX3 - R27	N/A	Academics	Prof. Dr.	25+	50 - 55	Canada
	EX4 - R28	N/A	Academics	Assistant Prof.	10 - 14	35 - 39	Türkiye

Appendix 5. Direct Relation Matrix of Each Sector

Carrier

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	**0,0000**	2,5000	3,1667	1,5000	2,3333	1,5833	0,9167
Time	3,0833	**0,0000**	3,0000	1,7500	1,4167	1,2500	0,5833
Service	3,1667	2,7500	**0,0000**	2,2500	1,5000	1,9167	1,4167
Hinterland	2,3333	3,1667	3,1667	**0,0000**	2,7500	1,9167	1,9167
Environment	2,1667	1,0833	1,4167	2,0000	**0,0000**	2,1667	3,3333
Safety & Security	1,6667	1,7500	1,4167	0,9167	0,9167	**0,0000**	2,4167
Social	1,1667	0,5833	1,9167	1,4167	2,6667	1,3333	**0,0000**

3PL

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	**0,0000**	2,8333	3,3333	1,8333	3,0000	2,1667	1,3333
Time	3,0000	**0,0000**	3,1667	1,8333	1,3333	2,0000	1,3333
Service	3,5000	2,0000	**0,0000**	2,5000	1,3333	1,8333	2,5000
Hinterland	2,6667	3,1667	3,1667	**0,0000**	2,5000	1,8333	2,0000
Environment	2,0000	1,1667	1,6667	1,5000	**0,0000**	2,0000	3,1667
Safety & Security	1,8333	2,3333	2,1667	1,8333	2,3333	**0,0000**	2,8333
Social	1,5000	1,0000	2,0000	2,3333	3,0000	2,1667	**0,0000**

BCO

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	**0,0000**	3,1667	2,8333	2,0000	2,5000	2,0000	1,5000
Time	3,5000	**0,0000**	3,0000	2,1667	1,8333	1,6667	1,1667
Service	2,6667	3,0000	**0,0000**	2,1667	2,0000	1,6667	1,6667
Hinterland	3,0000	3,5000	2,5000	**0,0000**	3,3333	2,0000	2,0000
Environment	2,8333	2,0000	1,1667	1,6667	**0,0000**	1,1667	3,0000
Safety & Security	2,1667	2,3333	1,5000	1,5000	1,6667	**0,0000**	1,6667
Social	2,0000	1,1667	2,3333	1,5000	2,8333	1,1667	**0,0000**

Expert

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	**0,0000**	2,0000	3,2500	1,0000	2,5000	1,2500	1,0000
Time	3,7500	**0,0000**	2,7500	1,0000	2,2500	1,5000	1,2500
Service	3,2500	2,2500	**0,0000**	2,0000	2,2500	2,0000	1,2500
Hinterland	2,7500	2,7500	3,0000	**0,0000**	1,2500	1,0000	1,7500
Environment	3,0000	1,7500	2,5000	1,0000	**0,0000**	2,2500	3,0000
Safety & Security	2,5000	2,2500	2,2500	0,7500	3,0000	**0,0000**	2,7500
Social	2,2500	0,7500	1,0000	0,7500	2,7500	2,2500	**0,0000**

Appendix 6. Normalized Direct Relation Matrix of Each Sector

Carrier

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	**0,0000**	0,1639	0,2077	0,0984	0,1530	0,1038	0,0601
Time	0,2022	**0,0000**	0,1967	0,1148	0,0929	0,0820	0,0383
Service	0,2077	0,1803	**0,0000**	0,1475	0,0984	0,1257	0,0929
Hinterland	0,1530	0,2077	0,2077	**0,0000**	0,1803	0,1257	0,1257
Environment	0,1421	0,0710	0,0929	0,1311	**0,0000**	0,1421	0,2186
Safety & Security	0,1093	0,1148	0,0929	0,0601	0,0601	**0,0000**	0,1585
Social	0,0765	0,0383	0,1257	0,0929	0,1749	0,0874	**0,0000**

3PL

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	**0,0000**	0,1848	0,2174	0,1196	0,1957	0,1413	0,0870
Time	0,1957	**0,0000**	0,2065	0,1196	0,0870	0,1304	0,0870
Service	0,2283	0,1304	**0,0000**	0,1630	0,0870	0,1196	0,1630
Hinterland	0,1739	0,2065	0,2065	**0,0000**	0,1630	0,1196	0,1304
Environment	0,1304	0,0761	0,1087	0,0978	**0,0000**	0,1304	0,2065
Safety & Security	0,1196	0,1522	0,1413	0,1196	0,1522	**0,0000**	0,1848
Social	0,0978	0,0652	0,1304	0,1522	0,1957	0,1413	**0,0000**

BCO

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	**0,0000**	0,1939	0,1735	0,1224	0,1531	0,1224	0,0918
Time	0,2143	**0,0000**	0,1837	0,1327	0,1122	0,1020	0,0714
Service	0,1633	0,1837	**0,0000**	0,1327	0,1224	0,1020	0,1020
Hinterland	0,1837	0,2143	0,1531	**0,0000**	0,2041	0,1224	0,1224
Environment	0,1735	0,1224	0,0714	0,1020	**0,0000**	0,0714	0,1837
Safety & Security	0,1327	0,1429	0,0918	0,0918	0,1020	**0,0000**	0,1020
Social	0,1224	0,0714	0,1429	0,0918	0,1735	0,0714	**0,0000**

Expert

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	**0,0000**	0,1481	0,2407	0,0741	0,1852	0,0926	0,0741
Time	0,2778	**0,0000**	0,2037	0,0741	0,1667	0,1111	0,0926
Service	0,2407	0,1667	**0,0000**	0,1481	0,1667	0,1481	0,0926
Hinterland	0,2037	0,2037	0,2222	**0,0000**	0,0926	0,0741	0,1296
Environment	0,2222	0,1296	0,1852	0,0741	**0,0000**	0,1667	0,2222
Safety & Security	0,1852	0,1667	0,1667	0,0556	0,2222	**0,0000**	0,2037
Social	0,1667	0,0556	0,0741	0,0556	0,2037	0,1667	**0,0000**

Appendix 7. Total Relation Matrix of Each Sector

Carrier

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	0,4613	0,5470	0,6400	0,4321	0,5123	0,4394	0,4041
Time	0,6090	0,3908	0,6131	0,4265	0,4471	0,4031	0,3620
Service	0,6639	0,5892	0,5029	0,4906	0,4998	0,4780	0,4487
Hinterland	0,6953	0,6692	0,7456	0,4189	0,6236	0,5345	0,5360
Environment	0,5567	0,4506	0,5338	0,4431	0,3799	0,4599	0,5305
Safety & Security	0,4328	0,3961	0,4299	0,3087	0,3452	0,2537	0,3940
Social	0,4183	0,3447	0,4615	0,3473	0,4485	0,3488	0,2782

3PL

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	0,9644	0,9891	1,1889	0,9066	1,0503	0,9295	0,9576
Time	1,0379	0,7576	1,0886	0,8311	0,8841	0,8433	0,8674
Service	1,1151	0,9227	0,9767	0,9129	0,9450	0,8847	0,9772
Hinterland	1,1657	1,0530	1,2390	0,8445	1,0762	0,9573	1,0347
Environment	0,8845	0,7405	0,9094	0,7380	0,7269	0,7688	0,8845
Safety & Security	0,9899	0,8958	1,0511	0,8457	0,9552	0,7445	0,9653
Social	0,8956	0,7634	0,9601	0,8065	0,9203	0,8039	0,7446

BCO

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	0,6033	0,7329	0,6585	0,5387	0,6552	0,4870	0,5028
Time	0,7638	0,5573	0,6540	0,5350	0,6101	0,4620	0,4728
Service	0,7155	0,6994	0,4884	0,5267	0,6091	0,4539	0,4902
Hinterland	0,8467	0,8295	0,7167	0,4915	0,7724	0,5414	0,5899
Environment	0,6594	0,5889	0,5057	0,4572	0,4516	0,3890	0,5165
Safety & Security	0,5925	0,5733	0,4888	0,4233	0,5072	0,2992	0,4228
Social	0,5876	0,5202	0,5284	0,4259	0,5698	0,3675	0,3393

Expert

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	1,6089	1,2475	1,5953	0,7565	1,5001	1,1082	1,1136
Time	1,9919	1,2308	1,7125	0,8230	1,6244	1,2226	1,2294
Service	2,0316	1,4233	1,6015	0,9083	1,6783	1,2915	1,2769
Hinterland	1,9302	1,3968	1,7159	0,7508	1,5552	1,1845	1,2450
Environment	2,0420	1,4052	1,7700	0,8595	1,5679	1,3322	1,3987
Safety & Security	2,0321	1,4421	1,7688	0,8500	1,7640	1,2004	1,3982
Social	1,5578	1,0415	1,3044	0,6531	1,3681	1,0522	0,9356

Appendix 8. Threshold Value-Reduced Total Relation Matrix of Each Sector

Carrier

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	0,0000	**0,5470**	**0,6400**	0,0000	0,0000	0,0000	0,0000
Time	**0,6090**	0,0000	**0,6131**	0,0000	0,0000	0,0000	0,0000
Service	**0,6639**	**0,5892**	0,0000	0,0000	0,0000	0,0000	0,0000
Hinterland	**0,6953**	**0,6692**	**0,7456**	0,0000	**0,6236**	**0,5345**	**0,5360**
Environment	**0,5567**	0,0000	**0,5338**	0,0000	0,0000	0,0000	**0,5305**
Safety & Security	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Social	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

3PL

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	0,0000	0,0000	**1,1889**	0,0000	**1,0503**	0,0000	0,0000
Time	**1,0379**	0,0000	**1,0886**	0,0000	0,0000	0,0000	0,0000
Service	**1,1151**	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Hinterland	**1,1657**	**1,0530**	**1,2390**	0,0000	**1,0762**	0,0000	0,0000
Environment	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Safety & Security	0,0000	0,0000	**1,0511**	0,0000	0,0000	0,0000	0,0000
Social	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

BCO

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	0,0000	**0,7329**	**0,6585**	0,0000	**0,6552**	0,0000	0,0000
Time	**0,7638**	0,0000	**0,6540**	0,0000	**0,6101**	0,0000	0,0000
Service	**0,7155**	**0,6994**	0,0000	0,0000	0,0000	0,0000	0,0000
Hinterland	**0,8467**	**0,8295**	**0,7167**	0,0000	**0,7724**	0,0000	0,0000
Environment	**0,6594**	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Safety & Security	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Social	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Expert

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	**1,6089**	0,0000	**1,5953**	0,0000	0,0000	0,0000	0,0000
Time	**1,9919**	0,0000	**1,7125**	0,0000	**1,6244**	0,0000	0,0000
Service	**2,0316**	0,0000	**1,6015**	0,0000	**1,6783**	0,0000	0,0000
Hinterland	**1,9302**	0,0000	**1,7159**	0,0000	0,0000	0,0000	0,0000
Environment	**2,0420**	0,0000	**1,7700**	0,0000	**1,5679**	0,0000	0,0000
Safety & Security	**2,0321**	0,0000	**1,7688**	0,0000	**1,7640**	0,0000	0,0000
Social	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

General

Route Selection Dimensions	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social
Cost	**0,8370**	**0,8555**	**0,9609**	0,0000	**0,8662**	0,0000	0,0000
Time	**1,0005**	0,0000	**0,9361**	0,0000	0,0000	0,0000	0,0000
Service	**1,0307**	**0,8678**	**0,8064**	0,0000	**0,8455**	0,0000	0,0000
Hinterland	**1,1012**	**0,9761**	**1,0582**	0,0000	**0,9580**	0,0000	**0,8187**
Environment	**0,9175**	0,0000	**0,8321**	0,0000	0,0000	0,0000	0,0000
Safety & Security	**0,8682**	0,0000	**0,8129**	0,0000	0,0000	0,0000	0,0000
Social	**0,7845**	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Appendix 9. DEMATEL Weights

Carrier

Dimensions	Importance	^2	Relation	^2	Subjective Weights (Length of Vector)	Weight
Cost	7,2735	52,9032	-0,4009	0,1608	7,2845	0,1568
Time	6,6391	44,0775	-0,1361	0,0185	6,6405	0,1429
Service	7,5999	57,7588	-0,2537	0,0644	7,6042	0,1637
Hinterland	7,0903	50,2719	1,3559	1,8386	7,2188	0,1554
Environment	6,6110	43,7051	0,0980	0,0096	6,6117	0,1423
Safety & Security	5,4780	30,0089	-0,3570	0,1275	5,4897	0,1182
Social	5,6008	31,3689	-0,3062	0,0938	5,6092	0,1207

3PL

Dimensions	Importance	^2	Relation	^2	Subjective Weights (Length of Vector)	Weight
Cost	17,8834	319,8169	3,7773	14,2680	18,2780	0,1544
Time	15,8580	251,4768	3,6139	13,0601	16,2646	0,1374
Service	17,8678	319,2591	3,0402	9,2426	18,1246	0,1531
Hinterland	17,1683	294,7496	5,3977	29,1353	17,9968	0,1520
Environment	15,3289	234,9754	2,2130	4,8972	15,4878	0,1308
Safety & Security	15,8900	252,4922	4,0259	16,2082	16,3921	0,1385
Social	15,6012	243,3963	2,7386	7,4999	15,8397	0,1338

BCO

Dimensions	Importance	^2	Relation	^2	Subjective Weights (Length of Vector)	Weight
Cost	8,9472	80,0527	-0,5905	0,3487	8,9667	0,1642
Time	8,5565	73,2138	-0,4466	0,1994	8,5682	0,1569
Service	8,0240	64,3846	-0,0573	0,0033	8,0242	0,1469
Hinterland	8,1865	67,0181	1,3898	1,9314	8,3036	0,1520
Environment	7,7438	59,9666	-0,6070	0,3684	7,7676	0,1422
Safety & Security	6,3071	39,7801	0,3072	0,0944	6,3146	0,1156
Social	6,6732	44,5314	0,0043	0,0000	6,6732	0,1222

Expert

Dimensions	Importance	^2	Relation	^2	Subjective Weights (Length of Vector)	Weight
Cost	22,1246	489,4983	-4,2644	18,1851	22,5318	0,1655
Time	19,0219	361,8310	0,6474	0,4191	19,0329	0,1398
Service	21,6800	470,0214	-1,2570	1,5801	21,7164	0,1595
Hinterland	15,3799	236,5408	4,1771	17,4485	15,9370	0,1171
Environment	21,4336	459,3972	-0,6822	0,4654	21,4444	0,1575
Safety & Security	18,8472	355,2166	2,0639	4,2597	18,9599	0,1393
Social	16,5103	272,5908	-0,6848	0,4690	16,5245	0,1214

General

Dimensions	Importance	^2	Relation	^2	Subjective Weights (Length of Vector)	Weight
Cost	12,1107	146,6698	-0,9686	0,9382	12,1494	0,1601
Time	10,9438	119,7658	-0,0991	0,0098	10,9442	0,1442
Service	11,8577	140,6051	-0,4486	0,2012	11,8662	0,1563
Hinterland	10,6997	114,4831	1,9338	3,7397	10,8730	0,1433
Environment	10,8937	118,6730	-0,4593	0,2109	10,9034	0,1437
Safety & Security	9,6570	93,2570	0,3811	0,1453	9,6645	0,1273
Social	9,4955	90,1642	-0,3394	0,1152	9,5015	0,1252

Appendix 10. BWM Consistency Results

Dimension	Respondent	Cost	Time	Service	Hinterland	Environment	Safety & Security	Social	*Average ξ of Respondents*
		ξ							
Carrier	R1	0,1935	0,2160	0,1527	0,2493	0,2273	0,2555	0,1039	0,1998
	R2	0,0763	0,1293	0,0982	0,0981	0,1007	0,0972	0,0577	0,0939
	R3	0,0870	0,0921	0,0554	0,0508	0,0650	0,0517	0,0417	0,0634
	R4	0,1598	0,1098	0,0831	0,1074	0,0741	0,0909	0,0167	0,0917
	R5	0,0361	0,1429	0,0169	0,0862	0,0976	0,1211	0,0833	0,0835
	R6	0,0741	0,1313	0,0847	0,1106	0,0714	0,1389	0,0200	0,0901
	R7	0,1185	0,1482	0,1269	0,1373	0,1070	0,1347	0,0865	0,1227
	R8	0,1007	0,1088	0,1000	0,0000	0,0556	0,0722	0,0556	0,0704
	R9	0,1329	0,1000	0,1418	0,1373	0,1373	0,0000	0,0778	0,1039
	R10	0,0571	0,0891	0,1209	0,1351	0,0787	0,1034	0,0463	0,0901
	R11	0,0597	0,0870	0,1163	0,0753	0,1082	0,0811	0,0893	0,0881
	R12	0,0435	0,1458	0,0742	0,1034	0,0000	0,0714	0,0000	0,0626
Carrier Average ξ		*0,0949*	*0,1250*	*0,0976*	*0,1076*	*0,0936*	*0,1015*	*0,0566*	*0,0967*
3PL	R13	0,1351	0,0968	0,0721	0,1070	0,0333	0,0775	0,1039	0,0894
	R14	0,0862	0,0972	0,0887	0,1064	0,1070	0,1075	0,0889	0,0974
	R15	0,1064	0,1139	0,0000	0,0000	0,0811	0,0400	0,0000	0,0488
	R16	0,0999	0,1029	0,0972	0,0807	0,0965	0,1117	0,0659	0,0935
	R17	0,1193	0,0999	0,1394	0,0604	0,0870	0,1545	0,1026	0,1090
	R18	0,0911	0,0811	0,0980	0,1185	0,1111	0,0889	0,1039	0,0989
3PL Average ξ		*0,1063*	*0,0986*	*0,0826*	*0,0788*	*0,0860*	*0,0967*	*0,0775*	*0,0895*
BCO	R19	0,0847	0,0541	0,0839	0,0370	0,0294	0,1419	0,1231	0,0792
	R20	0,1145	0,0957	0,0671	0,1215	0,1429	0,0612	0,0893	0,0989
	R21	0,0775	0,0650	0,0517	0,0231	0,0323	0,0889	0,0000	0,0484
	R22	0,0927	0,0889	0,0913	0,1369	0,0769	0,0889	0,0714	0,0924
	R23	0,0786	0,1091	0,0989	0,0708	0,0775	0,0811	0,1167	0,0904
	R24	0,0968	0,0911	0,1048	0,1019	0,1125	0,1279	0,0625	0,0996
BCO Average ξ		*0,0908*	*0,0840*	*0,0830*	*0,0819*	*0,0786*	*0,0983*	*0,0772*	*0,0848*
Expert	R25	0,1324	0,1024	0,0997	0,1265	0,0000	0,1088	0,1771	0,1067
	R26	0,0976	0,1111	0,0781	0,0927	0,0775	0,1111	0,0577	0,0894
	R27	0,0811	0,0725	0,0704	0,0714	0,0971	0,0714	0,0750	0,0770
	R28	0,0999	0,0648	0,0779	0,1049	0,1215	0,0429	0,0800	0,0845
Expert Average ξ		*0,1027*	*0,0877*	*0,0815*	*0,0989*	*0,0740*	*0,0836*	*0,0974*	*0,0894*
Average ξ of Dimensions		***0,0987***	***0,0988***	***0,0862***	***0,0918***	***0,0830***	***0,0950***	***0,0772***	**0,0901**

Appendix 11. Best-to-Others Vectors

	Dimension	Cost				Time				Service						Hinterland				Environment				Safety & Security				Social		
	Criteria	*C11*	*C12*	*C13*	*C14*	*C21*	*C22*	*C23*	*C24*	*C31*	*C32*	*C33*	*C34*	*C35*	*C36*	*C41*	*C42*	*C43*	*C44*	*C51*	*C52*	*C53*	*C54*	*C61*	*C62*	*C63*	*C63*	*C71*	*C72*	*C73*
	Respondent																													
Carrier	R1	1	9	3	7	1	7	5	9	7	1	5	3	9	7	1	9	9	7	7	1	7	9	7	1	7	5	7	1	5
	R2	1	2	7	4	5	6	3	1	3	1	9	7	4	5	5	6	1	9	5	3	2	1	5	1	9	3	7	2	1
	R3	3	3	6	1	4	1	2	5	1	2	5	7	2	5	4	1	3	6	2	1	3	5	1	2	4	3	3	1	2
	R4	7	1	5	3	6	7	1	4	3	1	7	9	1	5	9	9	1	5	3	1	1	7	1	1	3	5	4	1	7
	R5	3	1	7	9	3	1	5	3	1	1	3	3	7	3	7	1	3	1	1	3	3	7	5	3	5	1	7	1	3
	R6	6	7	3	1	5	5	7	1	1	1	3	5	5	5	1	8	4	9	1	3	3	5	4	1	7	9	7	1	3
	R7	7	9	1	6	7	1	4	7	7	6	1	5	5	9	7	1	7	5	5	2	1	7	6	5	1	7	9	6	1
	R8	1	3	2	5	1	3	7	6	1	3	5	3	3	3	1	3	1	1	1	1	3	1	3	1	7	3	1	1	3
	R9	1	7	9	7	1	3	5	6	1	7	7	3	7	5	7	1	7	5	7	5	7	1	1	1	7	1	7	7	1
	R10	1	1	9	7	1	3	3	9	5	9	1	7	9	3	3	5	1	7	3	5	1	1	1	9	9	3	7	9	1
	R11	1	1	7	5	1	3	3	6	9	9	1	5	9	5	3	1	7	7	7	7	3	1	1	5	7	3	5	1	5
	R12	3	1	1	7	3	1	3	7	3	1	1	7	7	9	3	1	9	9	1	1	1	1	1	1	5	3	1	1	1
Average Weights		2,92	3,75	5,00	5,17	3,17	3,42	4,00	5,33	3,50	3,50	4,00	5,33	5,67	5,33	4,25	3,83	4,42	5,92	3,58	2,75	2,92	3,83	3,00	2,58	5,92	3,83	5,42	2,67	2,75
3PL	R13	5	3	7	1	5	1	1	3	1	1	5	5	5	9	1	2	5	7	1	5	1	3	1	5	3	5	7	1	5
	R14	1	1	7	3	3	1	9	5	3	3	1	7	6	5	7	3	1	5	1	2	7	5	7	1	9	2	3	5	1
	R15	1	3	7	5	7	1	1	5	1	1	1	3	1	3	1	1	1	1	3	2	2	1	1	1	1	3	1	1	1
	R16	9	7	5	1	7	1	3	4	2	1	6	7	5	9	3	1	1	9	6	3	1	7	7	4	1	7	5	1	9
	R17	1	5	3	7	1	5	7	9	1	7	5	9	9	3	1	9	5	9	9	7	5	1	7	9	4	1	7	9	1
	R18	5	1	6	7	3	1	5	7	3	1	7	9	5	5	7	1	9	6	3	3	1	5	5	5	1	7	1	5	7
Average Weights		3,67	3,33	5,83	4,00	4,33	1,67	4,33	5,50	1,83	2,33	4,17	6,67	5,17	5,67	3,33	2,83	3,67	6,17	3,83	3,67	2,83	3,67	4,67	4,17	3,17	4,17	4,00	3,67	4,00
BCO	R19	1	1	5	7	1	1	5	3	1	1	3	7	5	3	1	3	1	1	3	3	7	1	7	5	4	1	7	3	1
	R20	1	6	5	7	5	1	9	5	1	9	5	1	3	3	3	1	5	9	1	1	3	1	7	1	3	1	1	5	5
	R21	3	5	5	1	5	1	2	5	3	2	1	3	2	1	2	3	1	5	3	1	2	2	1	5	5	7	1	3	1
	R22	7	5	7	1	5	5	1	7	5	1	3	9	3	1	5	1	9	8	5	5	5	1	1	5	7	5	1	7	1
	R23	1	2	7	5	7	9	1	4	5	1	9	7	1	3	2	1	9	7	5	3	5	1	5	7	1	3	2	7	1
	R24	6	1	3	6	7	1	6	5	1	6	5	7	6	5	4	1	5	3	6	5	6	1	1	2	4	5	1	2	4
Average Weights		3,17	3,33	5,33	4,50	5,00	3,00	4,00	4,83	2,67	3,33	4,33	5,67	3,33	2,67	2,83	1,67	5,00	5,50	3,83	3,00	4,67	1,17	3,67	4,17	4,00	3,67	2,17	4,50	2,17
Expert	R25	6	1	9	5	2	1	7	9	5	1	7	7	3	7	3	1	7	9	9	9	9	1	7	1	6	3	7	1	6
	R26	3	3	7	1	5	3	1	3	1	3	7	3	5	5	7	5	1	7	3	5	5	1	1	3	9	3	1	7	2
	R27	5	1	7	3	5	3	1	7	2	1	4	5	3	8	3	1	5	3	1	2	4	5	3	1	5	3	5	1	2
	R28	5	1	9	7	9	2	5	1	3	3	3	3	9	1	2	9	1	5	5	9	1	3	2	1	9	7	3	1	9
Average Weights		4,75	1,50	8,00	4,00	5,25	2,25	3,50	5,00	2,75	2,00	5,25	4,50	5,00	5,25	3,75	4,00	3,50	6,00	4,50	6,25	4,75	2,50	3,25	1,50	7,25	4,00	4,00	2,50	4,75
Average Weights		***3,39***	***3,25***	***5,68***	***4,61***	***4,11***	***2,79***	***4,00***	***5,21***	***2,86***	***3,00***	***4,29***	***5,57***	***4,96***	***4,82***	***3,68***	***3,18***	***4,25***	***5,89***	***3,82***	***3,50***	***3,54***	***3,04***	***3,54***	***3,11***	***5,11***	***3,89***	***4,21***	***3,25***	***3,18***

Appendix 12. Others-to-Worst Vectors

	Dimension	Cost				Time				Service						Hinterland				Environment				Safety & Security				Social		
	Criteria	*C11*	*C12*	*C13*	*C14*	*C21*	*C22*	*C23*	*C24*	*C31*	*C32*	*C33*	*C34*	*C35*	*C36*	*C41*	*C42*	*C43*	*C44*	*C51*	*C52*	*C53*	*C54*	*C61*	*C62*	*C63*	*C63*	*C71*	*C72*	*C73*
	Respondent																													
Carrier	R1	9	1	3	7	9	7	5	1	7	9	5	3	1	7	9	1	7	7	7	9	7	1	1	7	7	5	1	7	3
	R2	7	6	1	3	3	1	5	6	6	9	1	2	6	5	4	3	9	1	1	4	3	5	4	9	1	6	1	5	7
	R3	4	4	1	6	3	5	3	1	7	6	3	1	5	3	2	6	3	1	4	5	3	1	4	3	1	2	1	3	2
	R4	1	7	5	7	2	1	7	4	7	9	5	1	9	5	1	1	9	7	5	7	7	1	5	5	1	1	2	7	1
	R5	3	9	2	1	3	5	1	5	7	7	3	3	1	3	1	7	5	5	7	5	3	1	1	4	1	5	1	7	4
	R6	2	1	4	7	4	4	1	7	5	7	5	1	1	3	9	2	5	1	5	2	3	1	6	9	2	1	1	7	2
	R7	3	1	9	4	2	7	5	1	4	5	9	5	6	1	2	7	1	4	4	6	7	1	3	4	7	1	1	3	9
	R8	5	4	3	1	7	5	1	3	5	5	1	5	5	5	3	1	3	3	2	2	1	3	1	9	1	5	3	2	1
	R9	9	4	1	4	6	4	3	1	7	5	5	6	1	5	1	7	2	4	1	4	1	7	7	7	1	7	1	2	7
	R10	9	9	1	3	9	6	6	1	6	3	9	5	1	7	6	4	7	1	4	1	6	7	9	1	2	6	2	1	9
	R11	7	7	1	3	6	4	4	1	3	4	9	5	1	5	4	7	2	1	1	3	3	7	7	3	1	3	2	5	1
	R12	3	7	5	1	7	7	7	1	7	9	9	3	3	1	6	9	1	2	1	1	1	1	4	5	1	3	1	1	1
Average Weights		*5,17*	*5,00*	*3,00*	*3,92*	*5,08*	*4,67*	*4,00*	*2,67*	*5,92*	*6,50*	*5,33*	*3,33*	*3,33*	*4,17*	*4,00*	*4,58*	*4,50*	*3,08*	*3,50*	*4,08*	*3,75*	*3,00*	*4,33*	*5,50*	*2,17*	*3,75*	*1,42*	*4,17*	*3,92*
3PL	R13	4	6	1	7	1	3	5	3	9	9	5	3	3	1	7	6	4	1	5	1	5	1	5	1	3	1	1	7	3
	R14	7	5	1	5	6	9	1	4	5	5	7	1	2	4	1	5	7	3	7	5	1	4	4	9	1	9	3	1	5
	R15	7	5	1	3	1	7	7	5	3	3	3	1	3	1	1	1	1	1	1	3	3	3	3	2	2	1	1	1	1
	R16	1	3	4	9	1	7	5	4	8	9	5	4	5	1	7	7	9	1	3	4	7	1	2	4	7	1	3	9	1
	R17	7	4	5	1	9	4	3	1	9	5	7	5	1	5	9	2	3	1	1	3	3	9	5	1	5	9	3	1	9
	R18	3	7	2	1	4	7	3	1	7	9	3	1	5	3	3	9	1	4	4	3	5	1	3	3	7	1	7	3	1
Average Weights		*4,83*	*5,00*	*2,33*	*4,33*	*3,67*	*6,17*	*4,00*	*3,00*	*6,83*	*6,67*	*5,00*	*2,50*	*3,17*	*2,50*	*4,67*	*5,00*	*4,17*	*1,83*	*3,50*	*3,17*	*4,00*	*3,17*	*3,67*	*3,33*	*4,17*	*3,67*	*3,00*	*3,67*	*3,33*
BCO	R19	5	7	3	1	5	5	1	3	7	7	5	1	5	3	3	1	2	3	3	3	1	7	1	4	5	7	1	5	7
	R20	7	1	3	1	3	9	1	4	9	1	5	9	3	7	7	9	5	1	3	1	1	3	1	5	3	7	5	1	2
	R21	3	2	1	5	3	5	4	1	1	2	3	1	3	3	3	2	5	1	1	3	2	2	7	3	2	1	3	1	3
	R22	2	3	1	7	2	3	7	1	7	9	7	1	9	9	5	9	1	3	2	1	1	5	7	3	1	3	5	1	7
	R23	7	6	1	1	3	1	9	5	7	9	1	3	9	5	7	9	1	3	2	3	1	5	3	1	7	4	7	1	7
	R24	1	6	4	1	1	7	1	3	7	2	3	1	2	4	3	5	1	2	2	3	1	6	5	3	4	1	4	3	1
Average Weights		*4,17*	*4,17*	*2,17*	*2,67*	*2,83*	*5,00*	*3,83*	*2,83*	*6,33*	*5,00*	*4,00*	*2,67*	*5,17*	*5,17*	*4,67*	*5,83*	*2,50*	*2,17*	*2,17*	*2,33*	*1,17*	*4,67*	*4,00*	*3,17*	*3,67*	*3,83*	*4,17*	*2,00*	*4,50*
Expert	R25	3	9	1	5	7	9	4	1	4	7	2	3	5	1	7	9	3	1	1	1	1	9	1	7	3	5	1	7	4
	R26	5	5	1	7	1	4	5	4	7	3	1	5	1	1	1	3	7	1	5	1	1	5	9	7	1	5	7	1	5
	R27	3	7	1	2	2	4	7	1	7	8	5	4	6	1	3	5	1	3	5	5	3	1	3	5	1	3	1	5	4
	R28	4	9	1	3	1	7	3	9	7	7	5	5	1	9	7	1	9	5	5	1	9	7	6	9	1	2	7	9	1
Average Weights		*3,75*	*7,50*	*1,00*	*4,25*	*2,75*	*6,00*	*4,75*	*3,75*	*6,25*	*6,25*	*3,25*	*4,25*	*3,25*	*3,00*	*4,50*	*4,50*	*5,00*	*2,50*	*4,00*	*2,00*	*3,50*	*5,50*	*4,75*	*7,00*	*1,50*	*3,75*	*4,00*	*5,50*	*3,50*
Average Weights		***4,68***	***5,18***	***2,39***	***3,79***	***3,96***	***5,25***	***4,07***	***2,93***	***6,25***	***6,18***	***4,68***	***3,14***	***3,68***	***3,86***	***4,36***	***4,93***	***4,07***	***2,54***	***3,29***	***3,21***	***3,21***	***3,75***	***4,18***	***4,75***	***2,82***	***3,75***	***2,71***	***3,79***	***3,86***

Appendix 13. Local Weights of BWM

	Dimension	Cost					Time					Service							Hinterland					Environment					Safety & Security					Social			
	Criteria	*C11*	*C12*	*C13*	*C14*	*ξ*	*C21*	*C22*	*C23*	*C24*	*ξ*	*C31*	*C32*	*C33*	*C34*	*C35*	*C36*	*ξ*	*C41*	*C42*	*C43*	*C44*	*ξ*	*C51*	*C52*	*C53*	*C54*	*ξ*	*C61*	*C62*	*C63*	*C64*	*ξ*	*C71*	*C72*	*C73*	*ξ*
	Respondent																																				
Carrier	R1	0,59	0,04	0,26	0,11	**0,19**	0,65	0,12	0,17	0,05	**0,22**	0,09	0,46	0,12	0,20	0,03	0,09	**0,15**	0,71	0,05	0,11	0,14	**0,25**	0,13	0,69	0,13	0,05	**0,23**	0,05	0,64	0,13	0,18	**0,26**	0,09	0,74	0,17	**0,10**
	R2	0,50	0,29	0,06	0,15	**0,08**	0,14	0,07	0,23	0,56	**0,13**	0,18	0,45	0,04	0,08	0,14	0,11	**0,10**	0,15	0,13	0,66	0,06	**0,10**	0,07	0,19	0,28	0,46	**0,10**	0,14	0,58	0,05	0,23	**0,10**	0,08	0,33	0,60	**0,06**
	R3	0,20	0,20	0,07	0,52	**0,09**	0,14	0,49	0,29	0,08	**0,09**	0,37	0,21	0,08	0,04	0,21	0,08	**0,06**	0,15	0,56	0,20	0,08	**0,05**	0,27	0,47	0,18	0,08	**0,07**	0,47	0,26	0,10	0,17	**0,05**	0,17	0,54	0,29	**0,04**
	R4	0,06	0,56	0,14	0,24	**0,16**	0,12	0,07	0,62	0,18	**0,11**	0,14	0,34	0,06	0,03	0,34	0,09	**0,08**	0,44	0,44	0,04	0,08	**0,11**	0,16	0,40	0,40	0,05	**0,07**	0,36	0,45	0,09	0,09	**0,09**	0,18	0,72	0,10	**0,02**
	R5	0,22	0,62	0,09	0,07	**0,04**	0,21	0,50	0,07	0,21	**0,14**	0,31	0,31	0,11	0,11	0,04	0,11	**0,02**	0,05	0,43	0,17	0,34	**0,09**	0,52	0,21	0,21	0,06	**0,10**	0,09	0,22	0,13	0,55	**0,12**	0,08	0,67	0,25	**0,08**
	R6	0,11	0,07	0,22	0,59	**0,07**	0,15	0,15	0,07	0,63	**0,13**	0,30	0,38	0,13	0,04	0,08	0,08	**0,08**	0,65	0,10	0,19	0,06	**0,11**	0,52	0,20	0,20	0,09	**0,07**	0,19	0,64	0,11	0,06	**0,14**	0,10	0,68	0,22	**0,02**
	R7	0,12	0,06	0,69	0,13	**0,12**	0,11	0,63	0,19	0,07	**0,15**	0,09	0,11	0,51	0,13	0,13	0,04	**0,13**	0,11	0,65	0,07	0,16	**0,14**	0,12	0,31	0,51	0,06	**0,11**	0,13	0,16	0,64	0,07	**0,13**	0,08	0,14	0,78	**0,09**
	R8	0,46	0,19	0,28	0,07	**0,10**	0,59	0,23	0,07	0,12	**0,11**	0,35	0,15	0,05	0,15	0,15	0,15	**0,10**	0,30	0,10	0,30	0,30	**0,00**	0,28	0,28	0,11	0,33	**0,06**	0,06	0,61	0,10	0,23	**0,07**	0,44	0,39	0,17	**0,06**
	R9	0,70	0,12	0,06	0,12	**0,13**	0,57	0,22	0,13	0,08	**0,10**	0,46	0,09	0,09	0,20	0,05	0,12	**0,14**	0,07	0,65	0,11	0,16	**0,14**	0,07	0,16	0,11	0,65	**0,14**	0,32	0,32	0,05	0,32	**0,00**	0,10	0,12	0,78	**0,08**
	R10	0,44	0,44	0,04	0,07	**0,06**	0,53	0,21	0,21	0,05	**0,09**	0,12	0,07	0,48	0,09	0,04	0,20	**0,12**	0,23	0,14	0,57	0,06	**0,14**	0,15	0,06	0,36	0,44	**0,08**	0,62	0,06	0,08	0,24	**0,10**	0,12	0,08	0,80	**0,05**
	R11	0,43	0,43	0,05	0,10	**0,06**	0,52	0,20	0,20	0,07	**0,09**	0,07	0,07	0,54	0,13	0,05	0,13	**0,12**	0,23	0,60	0,10	0,08	**0,08**	0,07	0,10	0,23	0,60	**0,11**	0,58	0,13	0,07	0,22	**0,08**	0,16	0,71	0,13	**0,09**
	R12	0,15	0,41	0,37	0,07	**0,04**	0,22	0,51	0,22	0,05	**0,15**	0,14	0,35	0,35	0,06	0,06	0,03	**0,07**	0,24	0,62	0,06	0,08	**0,10**	0,25	0,25	0,25	0,25	**0,00**	0,36	0,43	0,07	0,14	**0,07**	0,33	0,33	0,33	**0,00**
	Average Weights	*0,33*	*0,29*	*0,20*	*0,19*	***0,09***	*0,33*	*0,28*	*0,21*	*0,18*	***0,13***	*0,22*	*0,25*	*0,21*	*0,11*	*0,11*	*0,10*	***0,10***	*0,28*	*0,37*	*0,21*	*0,13*	***0,11***	*0,22*	*0,27*	*0,25*	*0,26*	***0,09***	*0,28*	*0,38*	*0,14*	*0,21*	***0,10***	*0,16*	*0,45*	*0,38*	***0,06***
3PL	R13	0,14	0,23	0,06	0,57	**0,14**	0,08	0,34	0,44	0,15	**0,10**	0,36	0,36	0,09	0,09	0,09	0,03	**0,07**	0,51	0,31	0,12	0,06	**0,11**	0,38	0,08	0,42	0,12	**0,03**	0,56	0,10	0,21	0,13	**0,08**	0,09	0,74	0,17	**0,10**
	R14	0,43	0,34	0,05	0,17	**0,09**	0,23	0,58	0,05	0,14	**0,10**	0,17	0,17	0,42	0,05	0,09	0,10	**0,09**	0,07	0,23	0,57	0,14	**0,11**	0,51	0,31	0,06	0,12	**0,11**	0,09	0,54	0,05	0,32	**0,11**	0,24	0,11	0,64	**0,09**
	R15	0,57	0,23	0,07	0,14	**0,11**	0,04	0,42	0,42	0,11	**0,11**	0,21	0,21	0,21	0,07	0,21	0,07	**0,00**	0,25	0,25	0,25	0,25	**0,00**	0,11	0,24	0,24	0,41	**0,08**	0,32	0,28	0,28	0,12	**0,04**	0,33	0,33	0,33	**0,00**
	R16	0,06	0,11	0,15	0,67	**0,10**	0,06	0,55	0,22	0,16	**0,10**	0,26	0,43	0,09	0,08	0,11	0,04	**0,10**	0,19	0,28	0,48	0,04	**0,08**	0,11	0,23	0,59	0,07	**0,10**	0,11	0,19	0,63	0,07	**0,11**	0,16	0,76	0,08	**0,07**
	R17	0,57	0,14	0,23	0,06	**0,12**	0,67	0,15	0,11	0,06	**0,10**	0,48	0,09	0,12	0,07	0,04	0,21	**0,14**	0,69	0,08	0,15	0,07	**0,06**	0,07	0,11	0,15	0,67	**0,09**	0,11	0,05	0,20	0,64	**0,15**	0,13	0,08	0,79	**0,10**
	R18	0,15	0,65	0,12	0,08	**0,09**	0,22	0,58	0,13	0,07	**0,08**	0,19	0,47	0,08	0,04	0,11	0,11	**0,10**	0,12	0,69	0,06	0,13	**0,12**	0,21	0,21	0,51	0,08	**0,11**	0,14	0,14	0,63	0,08	**0,09**	0,74	0,17	0,09	**0,10**
	Average Weights	*0,32*	*0,28*	*0,11*	*0,28*	***0,11***	*0,22*	*0,44*	*0,23*	*0,11*	***0,10***	*0,28*	*0,29*	*0,17*	*0,06*	*0,11*	*0,09*	***0,08***	*0,30*	*0,31*	*0,27*	*0,12*	***0,08***	*0,23*	*0,20*	*0,33*	*0,24*	***0,09***	*0,22*	*0,22*	*0,33*	*0,23*	***0,10***	*0,28*	*0,36*	*0,35*	***0,08***
BCO	R19	0,38	0,47	0,09	0,06	**0,08**	0,39	0,39	0,07	0,15	**0,05**	0,31	0,31	0,13	0,03	0,08	0,13	**0,08**	0,30	0,11	0,26	0,33	**0,04**	0,19	0,19	0,07	0,54	**0,03**	0,07	0,15	0,19	0,60	**0,14**	0,08	0,26	0,66	**0,12**
	R20	0,65	0,09	0,15	0,11	**0,11**	0,15	0,64	0,06	0,15	**0,10**	0,32	0,03	0,08	0,32	0,13	0,13	**0,07**	0,23	0,58	0,14	0,05	**0,12**	0,29	0,14	0,14	0,43	**0,14**	0,06	0,37	0,14	0,43	**0,06**	0,71	0,13	0,16	**0,09**
	R21	0,21	0,13	0,10	0,56	**0,08**	0,18	0,47	0,27	0,08	**0,07**	0,07	0,16	0,26	0,10	0,16	0,26	**0,05**	0,25	0,17	0,48	0,09	**0,02**	0,13	0,42	0,23	0,23	**0,03**	0,63	0,14	0,14	0,08	**0,09**	0,43	0,14	0,43	**0,00**
	R22	0,11	0,15	0,08	0,66	**0,09**	0,14	0,14	0,63	0,08	**0,09**	0,08	0,31	0,13	0,02	0,13	0,31	**0,09**	0,16	0,68	0,06	0,10	**0,14**	0,14	0,11	0,14	0,62	**0,08**	0,63	0,14	0,08	0,14	**0,09**	0,43	0,07	0,50	**0,07**
	R23	0,52	0,30	0,06	0,12	**0,08**	0,11	0,06	0,64	0,19	**0,11**	0,09	0,34	0,03	0,06	0,34	0,15	**0,10**	0,31	0,55	0,05	0,09	**0,07**	0,13	0,21	0,10	0,56	**0,08**	0,13	0,07	0,58	0,22	**0,08**	0,35	0,07	0,58	**0,12**
	R24	0,08	0,58	0,23	0,11	**0,10**	0,08	0,65	0,12	0,15	**0,09**	0,50	0,10	0,12	0,06	0,10	0,12	**0,10**	0,16	0,54	0,09	0,21	**0,10**	0,13	0,15	0,09	0,64	**0,11**	0,48	0,30	0,15	0,07	**0,13**	0,56	0,31	0,13	**0,06**
	Average Weights	*0,33*	*0,29*	*0,12*	*0,27*	***0,09***	*0,18*	*0,39*	*0,30*	*0,13*	***0,08***	*0,23*	*0,21*	*0,13*	*0,10*	*0,16*	*0,18*	***0,08***	*0,24*	*0,44*	*0,18*	*0,15*	***0,08***	*0,17*	*0,20*	*0,13*	*0,50*	***0,08***	*0,33*	*0,20*	*0,21*	*0,26*	***0,10***	*0,43*	*0,16*	*0,41*	***0,08***
Expert	R25	0,13	0,65	0,06	0,16	**0,13**	0,32	0,54	0,09	0,05	**0,10**	0,12	0,48	0,08	0,08	0,19	0,05	**0,10**	0,24	0,60	0,10	0,05	**0,13**	0,08	0,08	0,08	0,75	**0,00**	0,07	0,59	0,12	0,23	**0,11**	0,08	0,76	0,16	**0,18**
	R26	0,21	0,21	0,06	0,52	**0,10**	0,08	0,21	0,51	0,21	**0,11**	0,42	0,17	0,05	0,17	0,10	0,10	**0,08**	0,08	0,15	0,66	0,11	**0,09**	0,21	0,10	0,13	0,56	**0,08**	0,53	0,21	0,05	0,21	**0,11**	0,60	0,08	0,33	**0,06**
	R27	0,13	0,58	0,07	0,22	**0,08**	0,13	0,22	0,58	0,07	**0,07**	0,21	0,35	0,11	0,08	0,21	0,04	**0,07**	0,20	0,52	0,09	0,20	**0,07**	0,49	0,29	0,15	0,08	**0,10**	0,20	0,52	0,09	0,20	**0,07**	0,10	0,58	0,33	**0,08**
	R28	0,15	0,67	0,06	0,11	**0,10**	0,05	0,30	0,12	0,53	**0,06**	0,15	0,15	0,15	0,15	0,03	0,37	**0,08**	0,31	0,05	0,52	0,12	**0,10**	0,14	0,05	0,58	0,23	**0,12**	0,30	0,56	0,06	0,09	**0,04**	0,25	0,68	0,07	**0,08**
	Average Weights	*0,16*	*0,53*	*0,06*	*0,25*	***0,10***	*0,15*	*0,32*	*0,32*	*0,21*	***0,09***	*0,22*	*0,29*	*0,10*	*0,12*	*0,13*	*0,14*	***0,08***	*0,21*	*0,33*	*0,34*	*0,12*	***0,10***	*0,23*	*0,13*	*0,23*	*0,41*	***0,07***	*0,27*	*0,47*	*0,08*	*0,18*	***0,08***	*0,26*	*0,52*	*0,22*	***0,10***
	Average Weights	*0,30*	*0,32*	*0,14*	*0,23*	***0,10***	*0,25*	*0,35*	*0,25*	*0,16*	***0,11***	*0,23*	*0,25*	*0,17*	*0,10*	*0,12*	*0,12*	***0,09***	*0,26*	*0,37*	*0,24*	*0,13*	***0,09***	*0,21*	*0,22*	*0,24*	*0,33*	***0,09***	*0,28*	*0,32*	*0,19*	*0,22*	***0,10***	*0,26*	*0,38*	*0,36*	***0,07***

Appendix 14. Normalized Local Weights of BWM

	Dimension	Cost				Time				Service						Hinterland				Environment				Safety & Security				Social		
	Criteria	*C11*	*C12*	*C13*	*C14*	*C21*	*C22*	*C23*	*C24*	*C31*	*C32*	*C33*	*C34*	*C35*	*C36*	*C41*	*C42*	*C43*	*C44*	*C51*	*C52*	*C53*	*C54*	*C61*	*C62*	*C63*	*C64*	*C71*	*C72*	*C73*
	Respondent																													
Carrier	R1	0,84	0,06	0,38	0,17	0,97	0,19	0,27	0,08	0,18	0,97	0,23	0,64	0,10	0,24	1,00	0,07	0,16	0,40	0,25	1,00	0,22	0,07	0,09	1,00	0,20	0,28	0,12	0,97	0,21
	R2	0,72	0,43	0,09	0,22	0,21	0,11	0,36	0,89	0,37	0,95	0,07	0,25	0,40	0,30	0,21	0,18	1,00	0,18	0,14	0,27	0,48	0,61	0,21	0,91	0,08	0,36	0,10	0,43	0,75
	R3	0,29	0,30	0,11	0,78	0,22	0,75	0,45	0,13	0,73	0,44	0,16	0,14	0,62	0,23	0,22	0,81	0,31	0,25	0,51	0,69	0,30	0,11	0,74	0,40	0,16	0,27	0,23	0,71	0,37
	R4	0,08	0,83	0,21	0,36	0,18	0,11	0,97	0,29	0,28	0,72	0,11	0,09	1,00	0,23	0,63	0,64	0,06	0,23	0,30	0,58	0,68	0,06	0,57	0,71	0,14	0,14	0,25	0,94	0,13
	R5	0,31	0,93	0,14	0,10	0,32	0,77	0,11	0,34	0,63	0,66	0,20	0,35	0,12	0,30	0,07	0,63	0,26	1,00	1,00	0,30	0,35	0,08	0,14	0,35	0,21	0,87	0,11	0,88	0,31
	R6	0,16	0,11	0,32	0,88	0,23	0,23	0,11	1,00	0,59	0,80	0,23	0,13	0,22	0,21	0,92	0,14	0,29	0,17	0,99	0,29	0,33	0,12	0,31	1,00	0,17	0,09	0,14	0,89	0,28
	R7	0,16	0,09	1,00	0,20	0,16	0,97	0,30	0,11	0,18	0,22	0,94	0,40	0,37	0,11	0,16	0,95	0,11	0,46	0,24	0,45	0,87	0,08	0,20	0,24	1,00	0,11	0,10	0,19	0,98
	R8	0,66	0,28	0,41	0,11	0,87	0,36	0,11	0,18	0,70	0,32	0,09	0,47	0,44	0,41	0,42	0,15	0,45	0,87	0,53	0,40	0,19	0,44	0,09	0,96	0,15	0,36	0,60	0,51	0,21
	R9	1,00	0,18	0,09	0,18	0,84	0,34	0,21	0,12	0,92	0,18	0,16	0,63	0,13	0,33	0,10	0,95	0,17	0,46	0,14	0,23	0,19	0,87	0,50	0,50	0,07	0,50	0,14	0,16	0,98
	R10	0,63	0,66	0,06	0,11	0,80	0,32	0,32	0,08	0,24	0,14	0,89	0,27	0,12	0,54	0,33	0,20	0,86	0,18	0,28	0,08	0,61	0,58	0,98	0,09	0,13	0,38	0,16	0,11	1,00
	R11	0,61	0,63	0,08	0,14	0,78	0,31	0,31	0,12	0,15	0,15	1,00	0,41	0,14	0,36	0,32	0,88	0,15	0,22	0,13	0,15	0,40	0,79	0,91	0,21	0,11	0,35	0,22	0,94	0,16
	R12	0,22	0,61	0,54	0,10	0,33	0,79	0,34	0,08	0,28	0,74	0,65	0,19	0,18	0,08	0,34	0,90	0,09	0,23	0,48	0,36	0,43	0,33	0,56	0,67	0,11	0,22	0,45	0,44	0,42
Average Weights		*0,47*	*0,43*	*0,28*	*0,28*	*0,49*	*0,44*	*0,32*	*0,29*	*0,44*	*0,53*	*0,39*	*0,33*	*0,32*	*0,28*	*0,39*	*0,54*	*0,32*	*0,39*	*0,41*	*0,40*	*0,42*	*0,35*	*0,44*	*0,59*	*0,21*	*0,33*	*0,22*	*0,60*	*0,48*
3PL	R13	0,20	0,35	0,09	0,84	0,12	0,52	0,68	0,23	0,71	0,75	0,16	0,27	0,25	0,09	0,72	0,45	0,19	0,17	0,73	0,12	0,71	0,16	0,89	0,15	0,33	0,20	0,12	0,97	0,21
	R14	0,62	0,51	0,08	0,26	0,34	0,90	0,08	0,22	0,34	0,36	0,78	0,15	0,25	0,28	0,09	0,33	0,87	0,39	0,97	0,45	0,10	0,16	0,15	0,84	0,07	0,51	0,33	0,15	0,81
	R15	0,82	0,34	0,10	0,20	0,07	0,65	0,66	0,17	0,43	0,45	0,39	0,22	0,63	0,19	0,35	0,36	0,38	0,73	0,21	0,35	0,41	0,54	0,51	0,44	0,44	0,19	0,45	0,44	0,42
	R16	0,09	0,16	0,22	1,00	0,10	0,85	0,34	0,26	0,53	0,91	0,16	0,24	0,31	0,10	0,27	0,41	0,73	0,13	0,22	0,33	1,00	0,09	0,17	0,29	0,99	0,12	0,22	1,00	0,10
	R17	0,81	0,20	0,33	0,10	1,00	0,24	0,17	0,10	0,95	0,19	0,23	0,21	0,11	0,56	0,98	0,12	0,23	0,20	0,12	0,16	0,26	0,90	0,18	0,08	0,31	1,00	0,17	0,10	1,00
	R18	0,21	0,97	0,18	0,12	0,33	0,89	0,20	0,11	0,38	0,98	0,15	0,13	0,33	0,30	0,16	1,00	0,10	0,39	0,39	0,30	0,86	0,11	0,23	0,23	0,99	0,12	1,00	0,22	0,11
Average Weights		*0,46*	*0,42*	*0,17*	*0,42*	*0,32*	*0,68*	*0,36*	*0,18*	*0,56*	*0,60*	*0,31*	*0,20*	*0,31*	*0,25*	*0,43*	*0,45*	*0,41*	*0,33*	*0,44*	*0,29*	*0,56*	*0,33*	*0,35*	*0,34*	*0,52*	*0,36*	*0,38*	*0,48*	*0,44*
BCO	R19	0,55	0,69	0,14	0,09	0,58	0,60	0,10	0,24	0,62	0,66	0,24	0,10	0,23	0,36	0,42	0,16	0,39	0,97	0,36	0,28	0,13	0,73	0,10	0,23	0,29	0,94	0,10	0,34	0,83
	R20	0,93	0,13	0,22	0,16	0,22	0,99	0,09	0,24	0,64	0,06	0,14	1,00	0,38	0,35	0,33	0,84	0,21	0,15	0,54	0,21	0,24	0,57	0,10	0,57	0,22	0,67	0,96	0,16	0,20
	R21	0,30	0,19	0,14	0,84	0,27	0,73	0,42	0,13	0,14	0,33	0,48	0,32	0,45	0,70	0,36	0,25	0,73	0,27	0,25	0,61	0,38	0,30	1,00	0,23	0,22	0,12	0,58	0,19	0,54
	R22	0,15	0,22	0,12	0,98	0,21	0,22	0,98	0,12	0,16	0,66	0,25	0,08	0,39	0,84	0,23	0,98	0,09	0,29	0,26	0,16	0,24	0,82	1,00	0,23	0,12	0,23	0,58	0,09	0,63
	R23	0,74	0,44	0,09	0,18	0,16	0,09	1,00	0,30	0,18	0,71	0,05	0,20	0,99	0,39	0,44	0,80	0,08	0,26	0,24	0,31	0,16	0,75	0,21	0,11	0,90	0,35	0,47	0,09	0,73
	R24	0,12	0,86	0,33	0,17	0,12	1,00	0,19	0,24	1,00	0,21	0,22	0,18	0,29	0,33	0,23	0,78	0,13	0,62	0,24	0,22	0,15	0,85	0,75	0,47	0,24	0,11	0,76	0,41	0,16
Average Weights		*0,46*	*0,42*	*0,17*	*0,40*	*0,26*	*0,61*	*0,46*	*0,21*	*0,46*	*0,44*	*0,23*	*0,31*	*0,46*	*0,49*	*0,33*	*0,64*	*0,27*	*0,43*	*0,32*	*0,30*	*0,22*	*0,67*	*0,53*	*0,31*	*0,33*	*0,40*	*0,58*	*0,21*	*0,51*
Expert	R25	0,19	0,97	0,08	0,23	0,48	0,83	0,14	0,08	0,23	1,00	0,15	0,26	0,56	0,15	0,34	0,87	0,16	0,15	0,16	0,12	0,14	1,00	0,11	0,92	0,18	0,36	0,11	1,00	0,20
	R26	0,30	0,31	0,09	0,78	0,12	0,32	0,79	0,33	0,84	0,35	0,09	0,52	0,29	0,27	0,11	0,22	1,00	0,31	0,41	0,14	0,22	0,75	0,83	0,33	0,07	0,33	0,81	0,10	0,41
	R27	0,19	0,86	0,10	0,33	0,19	0,33	0,90	0,12	0,42	0,74	0,19	0,27	0,62	0,10	0,28	0,75	0,14	0,57	0,93	0,42	0,25	0,10	0,31	0,81	0,14	0,31	0,14	0,76	0,41
	R28	0,22	1,00	0,09	0,16	0,08	0,46	0,18	0,85	0,30	0,31	0,28	0,47	0,09	1,00	0,44	0,07	0,78	0,36	0,27	0,07	0,98	0,31	0,47	0,87	0,09	0,13	0,34	0,89	0,08
Average Weights		*0,22*	*0,79*	*0,09*	*0,38*	*0,22*	*0,49*	*0,50*	*0,34*	*0,45*	*0,60*	*0,18*	*0,38*	*0,39*	*0,38*	*0,29*	*0,48*	*0,52*	*0,35*	*0,44*	*0,19*	*0,40*	*0,54*	*0,43*	*0,73*	*0,12*	*0,29*	*0,35*	*0,69*	*0,27*
Average Weights		*0,43*	*0,48*	*0,21*	*0,35*	*0,37*	*0,53*	*0,39*	*0,26*	*0,47*	*0,53*	*0,31*	*0,31*	*0,36*	*0,33*	*0,37*	*0,53*	*0,36*	*0,38*	*0,40*	*0,32*	*0,40*	*0,44*	*0,44*	*0,49*	*0,29*	*0,34*	*0,35*	*0,50*	*0,45*