



## SUEZ CANAL: AN EXPLORATORY STUDY ON ALTERNATIVE TRADE ROUTES

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### ABSTRACT

**Objective:** This research aimed to analyze the main alternative routes to Suez Canal Route (SCR): North Sea Route (NSR) and Trans-Siberian Route (TSR). **Method:** A systematic literature review (SLR) was carried out using the Web of Science (WoS) database. Forty-eight related articles were found, of which 16 remained for further analysis after refinement. **Main Results:** It was identified that the TSR and NSR routes are economically viable compared to the SCR, given certain specific conditions, and that the railway mode is less studied in relation to the maritime mode. **Relevance / Originality:** Possible alternative trade routes for the transportation of goods, both via maritime and railway modes, were identified, with the highlighting of advantages and disadvantages. **Theoretical / Methodological Contributions:** The study is relevant for the international logistics field, since, by analyzing each transport mode, it was possible to highlight issues that need to be further explored in relation to existing routes. **Social / Management Contributions:** This study contributed to determining TSR as the most cost-effective route according to the articles analyzed in the SLR. It also clarified issues such as prices, costs, distances, advantages and disadvantages, sustainability issues, as well as updated data from other studies.

**Keywords:** International logistics, Supply chain, International maritime and railway transport, Systematic literature review.

## CANAL DE SUEZ: UM ESTUDO EXPLORATÓRIO SOBRE ROTAS COMERCIAIS ALTERNATIVAS

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### RESUMO

**Objetivo:** Este estudo teve como objetivo analisar as principais rotas alternativas para o Canal de Suez (SCR): Rota do Mar do Norte (NSR) e Rota Transiberiana (TSR). **Método:** Uma revisão sistemática da literatura (RSL) foi realizada utilizando a base de dados Web of Science (WoS). Foram encontrados 48 artigos relacionados, dos quais 16 permaneceram para análise aprofundada após refinamento. **Principais Resultados:** Foi identificado que as rotas TSR e NSR são economicamente viáveis em comparação com o SCR, dadas certas condições específicas, além de haver menos estudos do modo ferroviário em relação ao modo marítimo. **Relevância / Originalidade:** Foram identificadas possíveis rotas comerciais alternativas para o transporte de mercadorias, tanto por via marítima quanto ferroviária, destacando-se vantagens e desvantagens. **Contribuições Teóricas / Metodológicas:** O estudo é relevante para o campo da logística internacional, uma vez que, ao se analisar cada modo de transporte, foi possível destacar questões que precisam ser exploradas mais profundamente em relação às rotas existentes. **Contribuições Sociais / Gerenciais:** Este estudo contribuiu para determinar a TSR como a rota mais econômica, de acordo com os artigos analisados na RSL. Também esclareceu questões como preços, custos, distâncias, vantagens e desvantagens, sustentabilidade, além de dados atualizados de outros estudos.

**Palavras-chave:** Logística internacional, Cadeia de suprimentos, Transporte marítimo e ferroviário internacional, Revisão sistemática da literatura.

### INTRODUCTION

Maritime trade between Asia and Europe comprises a large portion of global trade. The Suez Canal Route (SCR) stands out as the main maritime route

for trade between the continents. Currently, 12% of global cargo transportation and 30% of container trade pass through the SCR (Guo, Guo, & Lv, 2022), making it vitally important for supply chains (SC), not just in Europe and Asia, but all around the world (Wan

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et al., 2023). It is important to highlight the growing congestion crisis that the canal faces due to its limited capacity. This situation is projected to worsen due to an estimated increase of 73% in the volume of international trade between continents by 2030, and 300% by 2050 (OECD, 2016), as well as to the increase in piracy in the Gulf of Aden region, which holds the SCR route. According to Martínez-Zarzoso (2013), the effect of maritime piracy on the price of transport shows that an additional hijacked ship results in a 1.2% increase in maritime transport costs between Europe and Asia.

Other factors of pressure on these costs are exorbitant taxes and the monopoly that the Egyptian government charges for use of the canal (Appendix 1), a fact that motivates shipping companies to opt for other routes to avoid such fees (Alphaliner, 2020). One example is the land railway modality through the Trans-Siberian Route, which moves about 97,400 containers per year between continents (Zeng, Lu, Lin, Yuen, & Li, 2020). Another is avoidance of the canal as a protest due to the fees charged by the SCR authorities (Contessi, 2021).

An example of the importance of the SCR was the impact of the stranding of the container ship *Ever Given* at the route in March 2021. The ship blocked the canal for six days (Appendix 2), resulting in a reduction of global trade growth between 0.2 and 0.4 percentage points, with around USD 57.6 billion in damage to international trade (Allianz SE, 2021). Besides that, more than 300 ships waited to pass through the canal during the period. When the flow returned to normal, a loss of around 17 billion dollars was estimated (Duerr, 2021).

The recent route issue as well as the aforementioned finite capacity create, by themselves, the opportunity and motivation to explore other trade routes (Bulis & Skapars, 2014), heightened by the need to search for safer and economically viable alternatives. Empirically, new modalities and route diversification in an era of connectivity, where alternative options are increasingly available for this bottleneck, are increasingly pressing (Contessi, 2021). Additionally, Unescap (2022) brings infrastructure gaps and bottlenecks, inconsistency of rules and regulations, and different technical standards and operating procedures as challenges that Asia and Europe are facing in the international trade scope.

Theoretically, various methodological approaches are used to evaluate the Asia/Europe foreign trade routes and to determine the North Sea Route (NSR) and Trans-Siberian Route (TSR) as alternatives to SCR (Gleb & Jin, 2021; Hermann, Lin, Lebel, & Kovalenko, 2022; Theocharis, Pettit, Rodrigues, & Haider, 2018). NSR passes through northern Russia, crossing the entire Arctic Ocean (Appendix 3), and TSR is mainly formed by a railway that connects western Russia (Moscow) to the country's far east region (Vladivostok, close to the border with China). Also, there are two complementary branches of this route: one is the Trans-Mongolian Railway line and another is the Trans-Manchurian Railway line, both connecting Moscow to Beijing, China.

Despite the emphasis on the NSR and TSR routes, there is no clear definition of the decision-making factors involving them. In this regard, this paper provides a pioneering systematic review of the existing literature on alternative routes to SCR and serves as the starting point for developing decision-making regarding the choice of route, which evidences the relevant contribution this paper can bring.

Given these factors and motivated by the scarcity of research dedicated to analyzing trade routes in the international logistics field, this research aimed to analyze the main alternative routes to SCR: NSR and TSR. This objective sought to answer the question that guided this research: "What are the advantages and disadvantages of the alternative routes to the SCR?" The research used a systematic literature review (SLR) with the following specific objectives:

- to contextualize the Asia/Europe foreign trade, specifically through the SCR;
- to present the NSR and TSR as alternative routes to the SCR;
- to analyze the extent to which these routes are economically viable (or not) as substitute or additional routes to the SCR.

In addition to this introduction, the article is organized into four sections. The literature review is presented in the second section, while the research method is described in the third. Results and discussion follow in section four. Final considerations close the article.

## 1. THEORETICAL BACKGROUND

### 1.1. International maritime and rail transport

According to Rodrigue (2020), transport is the act of transferring a load, using some transportation modality (air, waterway or land), from one place to another. The air mode plays a crucial role in transporting high-value goods (Sahoo, Pasayat, Bhowmick, Fernandes, & Tiwari, 2022). At the same time, perishable, time-sensitive, or items needed quickly in SC are often sent by air too, despite this being an expensive mode of transportation. Hence, uncertainties arise about operating expenses when making decisions for cargo airlines (Wen, Xu, Choi, & Chung, 2019).

This research was limited to analyzing two commercial routes that use different international transport modes: the maritime transport that belongs to the waterway mode (NSR) and the rail transport that belongs to the land mode (TSR). Therefore, a brief explanation of each is provided in order to contextualize the study.

The waterway mode uses ships or barges for cargo transport, and is designated as lacustrine, fluvial, or maritime according to the mode used, whether lakes, rivers, or the ocean, respectively. Regardless of the mode, docking ports exist, whether between the same country or several different countries (Ghosh, 2022). Ports play an important role in the development of international trade, contributing to increasing global competition and opening new markets (David, 2017; Rodrigue & Notteboom, 2009).

It is estimated that maritime transport (liner shipping) is the most common modality, comprising more than 80% of the “world’s total merchandise trade and confirming that this kind of transport plays a crucial role in international trade in the context of supply chain globalization” (Unctad, 2023). This modality can be divided into four trade groups: east-west, north-south, south-south, and intraregional. These represent, respectively, 50.7, 9.2, 12.5 and 27.6% of maritime trade, with the largest share of trade being east-west, including the maritime routes between Europe and Asia (Unctad, 2023). Furthermore, maritime transport is characterized by its greater economy and large capacity for cargo transport, the limit of which is ship size.

Currently, one way to distinguish the size of ships is using the parameter of capability to pass through the Panama Canal. According to David (2017), a Panamax ship has a maximum size equivalent to the canal’s gates. These measures are equivalent to 304.8 meters in length and 33.53 meters in width, additionally a maximum of 75 thousand tons of cargo. All ships with a width greater than that are classified as post-Panamax. We may mention the reference used by oil tankers in the SCR, the Suezmax. This refers to tankers with a loading capacity in the range of 160,000 deadweight tons, with a beam around 48 and 68 meters high, given that the SCR bridge is suspended at 70 meters. This parameter is due to the SCR having a depth that allows a maximum of 17 meters of draft<sup>1</sup> (Stott, 2012).

Adzija and Kukhta (2022) highlight the different types of ships used in this process, such as general cargo ships, container ships, tankers, roll-on/roll-off, and bulk carriers. General cargo ships carry a wide variety of cargo such as vehicles, paper reels, bars, bags etc. Tankers are specialized in the transport of crude oil and its derivatives. Roll-on/roll-off ships allow loading and unloading of wheeled loads. Bulk carriers are used to transport bulk cargo such as commodities. Finally, there are container ships, which have a loading area of practically the entire deck, in addition to the interior of the ship. Container carriers have cell compartments where the containers are perfectly stowed and locked on the floor or between them.

The use of the container in terms of grouped cargo stands out, as it is responsible for the transport of approximately 19% of world trade. In addition, the growing volume of container<sup>2</sup> transport is estimated to vary between 3.2 and 2.9% until 2028 (Unctad, 2023). Containers can be classified as 20 or 40 feet (dry) or HC (high cube) containers, which entails an additional foot added to their height. Furthermore, they are also distinguished according to their purpose, such as reefer (refrigerator) and tank, for transporting liquids, among others. A 20-foot container is equivalent

<sup>1</sup> Draft is the measurement of the submerged part of the ship. Technically, it is the distance from the water depth to the keel of the ship (Menon, 2020).

<sup>2</sup> According to the International Organization for Standardization (ISO), a container is a mobile cargo safe made of steel, designed for multimodal transport.

to one Twenty Foot Equivalent Unit (TEU)<sup>3</sup>. The advantage of this container is that it can be used in any mode of transport, representing the best and most modern form of cargo unitization (Adzija & Kukhta, 2022). Furthermore, maritime transport between Asia and Europe, for the most part, occurs through the Suez Canal. According to the Suez Canal Authority (SCA), in 2019, 53% of the total cargo transported through the canal was done by container ships. In that regard, maritime trade on the continents route had an increase of 31.1% from 2017 to 2022 (Unctad, 2023).

Various studies focus on maritime transportation connecting Asia and Europe (Lee, Oduor, Farahmand, & Tolliver, 2014; Notteboom, 2012; Verny & Grigentin, 2009; Wang & Meng, 2011; Yercan & Sogut, 2023). Over the last five decades, the modernization of the Suez Canal challenged alternative routes between Asia and Europe due to its efficiency.

The land mode is also relevant in international trade. In this modality, transport occurs via highways or railroads. Although road transport is most often utilized for internal transport within a country, it can also be used for international trade, usually in neighboring countries, and, in most cases, for the connection of production sources to other export modes (Adzija & Kukhta, 2022). Yet, rail transport offers many advantages over road transport, such as a large capacity for cargo transport; greater economy; a variety of options (steam, diesel, electricity); and consistent delivery times (David, 2017).

The use of rail transport is mainly characterized by being specialized in transporting low value-added goods over long distances, in large quantities and at constant speed (Adzija & Kukhta, 2022). Compared with the maritime mode, intercontinental railroads significantly reduce the time needed for transport; compared to air, the cost is reduced by 40%; and, compared to road transport, productivity is increased by 50% (Li, Bolton, and Westphal, 2018; Wagener, Aritua, & Zhu, 2020). Despite the benefits mentioned in relation to other modes, one reservation is limitation of traffic to established tracks, without flexibility and serving fixed routes. In addition, different types of gauges<sup>4</sup> in different countries make international rail transport difficult (David, 2017).

With regard to Europe and Asia trade, recent traffic in the Suez Canal and piracy in areas like the Gulf of Aden are elevating its importance (Bulis & Skapars, 2014). The Economic and Social Commission for Asia and the Pacific — ESCAP<sup>5</sup> (Unescap, 2022) states that the growth of rail transport between Asia and Europe had increased by 500% from 2014 to 2016, considering the economic growth in fast-developing countries such as China, India, and Turkey. In view of this growth, the global technological expansion of railways should also advance (Maró & Török, 2022); for example, new large-capacity railroad cars that can hold 100 tons of goods stand out. In addition to these, there are double-deck container wagons, which support two containers per wagon (Pruyn & Van Hassel, 2022). Currently, rail trade between Asia and Europe represents approximately 1% of the total intercontinental trade in volume and 2% in value. This means that the majority, 95% volume and 70% value trade between the two continents occurs through maritime transportation (Unescap, 2022), the main route being through the SCR.

## 1.2. Suez Canal

The Suez Canal is one of the most important artificial waterways in the world. It was built in 1869 in Egypt, then a British colony. The canal is at sea level and connects the Mediterranean Sea with the Red Sea (Gulf of Suez), and then the Indian Ocean. Being 193 km long and 365 meters wide, it allows for an efficient maritime connection between the European and Asian continents (Lutmar & Rubinovitz, 2023; Spagna, 2021). However, it is also at the crossroads of the African continent (Lutmar & Rubinovitz, 2023) (Appendix 1).

The purpose of its construction was to drastically reduce shipping time, making it unnecessary to go around the African continent as ships had to do before its construction, a journey that currently takes an average of ten days. The estimated time for traversing the canal is 11 to 18 hours. For Verny and Grigentin (2009), the SCR is the predominant

<sup>3</sup> Standard measurement for measuring container capacity on ships, trains, etc. (Szymonik, 2014).

<sup>4</sup> The width is determined by the distance between two tracks on a railway track.

<sup>5</sup> ESCAP is an intergovernmental platform, part of the United Nations (UN). It promotes cooperation among its 53 member States and nine associate members for solutions to sustainable development (Unescap, 2022).

route between Asia and Europe (Appendix 3), with particular benefits for container traffic, such as the outflow of production from major manufacturing centers in the world.

During its more than one hundred years of operation, the canal has been modified to meet the growth of ships and product flows in an increasingly globalized economy. In 1956, the Egyptian government, having been independent since 1922, nationalized the SCR (Martín Borda, 2011). This decision culminated in a war between Egypt on one side and, on the other, France, the United Kingdom, and Israel. The friction ended only in 1975 when Egypt reopened the canal. Since then, the canal has been maintained by the SCA, which belongs to Egypt's government, and is used by companies around the world that pay tariffs to do so (Martín Borda, 2011).

Currently, shipping companies consider the fees abusive. The canal's monopoly on maritime trade between Asia and Europe is an important factor in these fees charged (Martín Borda, 2011), since 2% of Egypt's Gross Domestic Product (GDP) comes from canal tariffs. According to the Reuters website (2020), the canal's revenue in 2019 stood at USD \$5.72 billion and the transit traffic was 18,880 ships, equivalent to an average of USD \$302,000 per ship for passage. A steep increase in Suez Canal transit fees has been introduced (approximately 15% in 2022, for example, a 20,000 TEU container ship pays approximately USD \$700,000 for a single transit) (Lutmar & Rubinovitz, 2023).

In this context, it should be emphasized that maritime trade is a fundamental element of world trade and involves a number of agreed norms and principles (Talley & Ng, 2013). Since the 2008 crisis, several changes have taken place: the most industrialized countries (the G7)<sup>6</sup> sought to regain their strength through new forms of economic development. This development has generated an expansion in the size of ships. In this regard, important achievements have been made in the realm of huge ships: Emma Maersk, a 15,500 TEU ship, in 2006; Maersk Triple E-class, 18,000 TEU ship in 2013; and in 2019, MSC

Gülsün, with a capacity of 23,756 TEU. An example of these super ships is the Ever Given itself, one of the largest container ships ever built (the latest one reaches 24,000 containers and belongs to the Evergreen Company) (Lutmar & Rubinovitz, 2023). Wan et al. (2023) researched, in a quantitative way, the consequences of the Suez Canal blockage on worldwide maritime transport networks. The findings indicated that the blockage had a distinct impact on the global maritime transport network, surpassing the expectations of most experts. Repercussions varied across continents, with Asia and Europe being relatively less affected. Also, container ships and oil tankers were the most affected, resulting in container transport being the most impacted.

Another issue regarding the SCR is maritime piracy in the Gulf of Aden, off the coast of Somalia. This region is a threat to the commercial shipping, mainly due to the absence of a state to intervene and provide security to the ships that use the route. Fu, Ng and Lau (2010) show that if piracy increased ten times, SCR traffic would drop by 30%, 18% of which would be redirected to the Cape Route, causing losses of USD \$30 billion per year. On the other hand, a decrease in the piracy success rate of 10% would increase exports by around 5.4% in the canal (Martínez-Zarzoso, 2013).

Added to these aspects, the climate issue is worth mentioning, reinforcing the need for more sustainable alternatives. While global warming affects many aspects of the ocean, the impact of shipping and transport is of particular importance in predicting climate change as an indirect effect. Global warming is one of the factors that is leading to the emergence of new alternative maritime transport routes between Asia and Europe (Bayirhan & Gazioğlu, 2021; Yercan & Sogut, 2023). CO<sub>2</sub> emissions are estimated to be 14 to 35% less than in other shipping routes, due to a reduced navigation distance, assuming the use of a 4,000 TEU ship (Furuichi & Otsuka, 2015). The International Panel on Climate Change's Work Group has conducted studies on the potential impacts of greenhouse gas emissions on the atmosphere and global warming (Pörtner et al., 2022). "According to some of the scenarios outlined by the Group, the Earth by 2100 could experience a global warming of 1.8–4 C<sub>0</sub>. This warming could have several impacts on the planet, including changes in the Gulf Stream warm water

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<sup>6</sup>The G7 is an abbreviation for the Group of Seven, an organization of leaders from some of the world's largest economies: Canada, France, Germany, Italy, Japan, the United Kingdom and the United States.

current, an increase in temperature up to 11°, and a melting of the Arctic region's ice by 22–33%" (Yercan & Sogut, 2023, pp. 103707).

### 1.3. Analysis of alternatives to the Suez Canal

Presently, large companies concentrate production in countries where labor is cheaper, such as European companies manufacturing their products in Asian countries (Martín Borda, 2011). Therefore, this intercontinental movement of goods generates a huge amount of traffic, which raises the need for new routes when the current ones become saturated or blocked — as in the case of Ever Given in March 2021 — or the consideration of issues related to cargo and individuals' security, piracy, or global climate change, so that there are alternative options for transporting goods (Bayirhan & Gazioğlu, 2021). Among them the NSR and TSR stand out. Other possible routes, such as the Panama Canal, the Cape of Good Hope or northern Canada, the latter through the Arctic ocean, have been ruled out due to economic unviability.

#### 1.3.1. Northern Sea Route

The NSR is an alternative route to SCR (Bayirhan & Gazioğlu, 2021; Martínez-Zarzoso, 2013; Solvang, Karamperidis, Valantis-Kanellos, & Song, 2018), and the shockwave from the temporary blockage of the Suez Canal makes it more likely for the NSR to become a prominent alternative. This route passes through northern Russia, crossing the entire Arctic Ocean (Appendix 3). Recently, the NSR has attracted increasing global attention, and the reduction in the ice layer, as well as Russia's interest in boosting traffic, have opened up opportunities for companies to navigate between the Pacific and the Atlantic using the route (Gunnarsson & Moe, 2021).

According to Serreze and Barry (2011), the region had a temperature increase twice that of the rest of the Earth, a phenomenon caused by global warming. In addition, predictions suggest that the Arctic Ocean, warming at an average of 2.5°C since 2000, will likely be entirely ice-free by 2035, especially during the summer months (Bayirhan & Gazioğlu, 2021). The average annual extent of Russian Arctic Sea ice has been reduced at an accelerating rate over the past 40 years (Vizcarra et al., 2017). From these changes, the NSR

appears as an alternative for maritime trade between Asia and Europe, with regard to cost reduction and shorter distances, compared to SCR (Lasserre, 2014; Schøyen & Bråthen, 2011; Zhang, Meng, & Ng, 2016).

According to Martínez-Zarzoso (2013), the International Maritime Organization (IMO) has issued guidelines for ships seeking to operate in this region, guidelines that will promote a reduction in time and distance for the delivery of goods between Europe and Asia. In the case of distance, sailing through the Arctic reduces this factor by 40% in relation to SCR. This is reinforced by Lasserre (2014), who points out the possibility of a greater number of trips and, consequently, a greater amount of transported goods, due to the shorter distance between the regions. If melting in the Arctic continues at its current rate, NSR will account for 8% of trade between Asia and Europe by 2030, and approximately 10% of all traffic by 2050 (Peters et al., 2011).

In the period of 2016 to 2019, traffic on the NSR had an increase due to Russian incentives with project cargo related to development (Gunnarsson & Moe, 2021). This period consequently saw an increase in the number of destination voyages in the route, of 1,232 in total: 1,108 between the NSR and European ports, and 124 between the NSR and Asian ports, which added up to 525,846 tons on cargo transported (Gunnarsson & Moe, 2021). On the other hand, only 51 international transits passed through NSR during the same period, carrying cargo totaling 980,676 tons. In that regard, The Arctic Economic Council expects the volume of transported cargo will reach 100 million tons by 2025 on the NSR (AEC, 2019). Despite this, Gunnarsson and Moe (2021) state that the growth of international transit shipping depends on favorable international market conditions and supportive Russian policies.

Studies indicate that traveling on the NSR consumes less fuel (Liu & Kronbak, 2010; Schøyen and Bråthen, 2011), but the infrastructure in the region is not well developed, which limits the services of ships and possibilities of occasional repairs (Ho, 2010; Zhu, Fu, Ng, Luo, & Ge, 2018). Lee and Song (2014) and Zhao and Hu (2016) point out that, due to the reduction of ice in the Arctic and the increase in the volume of maritime trade resulting from globalization, the opening of the NSR will reach a level of continuous navigation with lower risks in the near future.

### 1.3.2. *Trans-Siberian Route*

International transport using the Trans-Siberian railway and marine transport to connect Europe and Asia through Russia (Moscow and Vladivostok port) is called the TSR Route, or the TSR transportation route. On this route, cargo is transported from ports in Asia to the eastern extremity of the railway route, Vladivostok port in Russia, and goes to the west (Moscow) (Tsuji, 2007) where there are railway connections to European Union countries. Also, China (Beijing port) and Europe can be connected only by railway through the Trans-Mongolian Railway or Trans-Manchurian Railway lines. This paper considered the TSR (Appendix 3) for both cases, international multimodal (railway and marine) or unimodal (railway) transport between Asia and Europe.

The TSR is over 10,000 kilometers long and is considered to play a leading role in a sustainable, flexible, and secure SC (Wang, Wang, Li, & Yuen, 2020). According to Unctad (2021), exports from developed economies, such as France, Germany and the United Kingdom, to countries with developing economies in Asia, specially China, have experienced an increase of 29,43%. Specifically on the TSR, from 2008 to 2019, there was a 33.5% growth in traffic, reaching 26 million TEU, assuming 10 tons per TEU (Hilmola, Li, & Panova, 2021). This increased logistic capacity and the investment of USD 4–8 trillion strengthens the TSR as a cross-border routing alternative (Menhas, Mahmood, Tanchangya, Safdar, & Hussain, 2019; Wang et al., 2020).

Indeed, the railway in Russia comprises 80% of the country's transport matrix, whereas in China it corresponds to 8% of the total transported (David, 2017). Most of China's international transport is carried out by maritime mode; for instance, 77% of its imported oil uses the Strait of Malacca (BP, 2020), crossing the Indian and Pacific Oceans.

However, geopolitical issues and congestion on the Strait of Malacca as well as in the Suez Canal have made these locations less attractive for China and have motivated the development of infrastructure for efficient logistics.

In 2013, China's President Xi Jinping proposed the Belt and Road Initiative (BRI) (hereafter referred to as the OBOR), with the aim of expanding Chinese influence on global economy and politics. The project con-

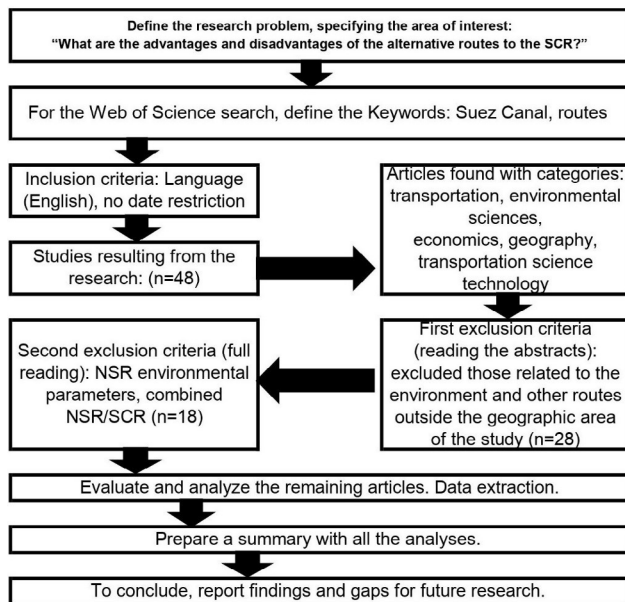
sists of two elements: the Silk Road Economic Belt, which focuses on the development of land-based connections between China and Europe; and the 21<sup>st</sup> Century Maritime Silk Road, which involves sea transport routes and maritime infrastructure connecting China's East Coast to South Asia, Europe, and Africa (Mau & Seuren, 2023). According to Martín Borda (2011), among the railway alternatives considered on the OBOR project, TSR stood out due to its potential to compete with current maritime services (Islam, Zunder, Jackson, Nesterova, & Burgess, 2013; Moon, Kim, & Lee, 2015). In line with it, Li et al. (2018) researched the prospective consequences of railway infrastructure on international freight and suggested that the OBOR railways, encompassing the TSR, facilitate trade between China and Europe. Additionally, the railways have a favorable impact on China's exports to its European trade partners.

In fact, the railway between the Far East and Europe would shorten transit time between regions and relieve congestion in the ports of southern China (Biondo, 2008). For example, a trip from China to Germany (Beijing and Hamburg city, respectively), through the Trans-Siberian railway takes on average 15 days (Martín Borda, 2011; Pruyn & Van Hassel, 2022). A sea trip (from Tianjin, near Beijing, to Hamburg), through the SCR takes 36 days on average (Sea Rates, 2021).

In general, the TSR cost is higher than that of maritime transport: it is equivalent to EUR 2800/ TEU, while approximate costs of SCR and NSR are 2,400 euros/TEU (Pruyn & Van Hassel, 2022). However, SCR transit time between Asia and Europe is shorter than that of maritime options.

## 2. METHOD

This article proposes, from the definition of the problem and objectives, to carry out two stages of research: an exploratory study that uses the qualitative strategy of a SLR based on content analysis (Figure 1), and, after the selection of materials, a second step in which the articles are evaluated through a quantitative descriptive analysis (Qian, Seuring, & Wagner, 2020). The review followed the methodology of Tranfield, Denyer and Smart (2003), which includes planning the review, conducting the RSL, reporting and disseminating it. The planning and conduction phase



Source: Adapted from Tranfield et al. (2003).

**Figure 1.** Systematic literature review: research design.

was constructed according to the objective of the study and its research question, in addition to the use of a protocol by the assumptions of Shamseer et al. (2015). Therefore, the relevance of using a protocol to carry out the RSL stands out, that is, definitions of eligibility criteria for the material, which assists in the transparency and integrity of the investigation (Shamseer et al., 2015). This protocol is important for several reasons, such as: it allows planning of the steps taken, and therefore anticipating potential problems; it generates comparisons between the protocol and the completed review and replication of the review methods used; it prevents arbitrary decision-making regarding data inclusion and exclusion criteria, among others (Shamseer et al., 2015).

## 2.1. Research strategy and search terms

As a first step of the SLR, data collection was carried out on July 16<sup>th</sup>, 2021, in search of patterns in the published articles. This was carried out in the Web of Science (WoS) database, using the English keywords "Suez Canal" and "routes", without date restriction. As a result, 48 articles related to the keywords were found, in categories such as 'transportation', 'environmental sciences', 'economics', 'transportation science technology', and 'geography.' WoS is a well-known electronic database, with rigorous independent edi-

torial processes to maintain journal quality (Clarivate, 2021; Maior, Oliveira Jr., Ribeiro, & Fernandes, 2022; Sauer & Seuring, 2017). The search was limited to the research process timeline, allowing us to capture all pertinent literature regardless of publication date, and encompassing all papers published in academic journals up to July 2021.

## 2.2. Selection criteria and data search

After reading the abstracts of these 48 articles, it was found that 20 of them did not match the study objectives. Some of the excluded articles discussed environmental issues, like Abril and Abdel-Aal (2000), El-Magd, Zakzouk, Abdulaziz, and Ali (2020) and Ibrahim and Mosaad (2021). Others were limited to searching routes outside the geographic area covered by this study, such as Chen, Zeng and Deng (2016) and Pham, Kim, and Yeo (2018). After the abstract reading stage, a second filtering process was performed based on a full reading of the articles. Of the 28 remaining articles, 12 were discarded because they did not address the main objective of the review, leaving 16 for further analysis. Articles by Gleb and Jin (2021) and Valsson and Ulfarsson (2009) were discarded because they did not address the economic viability of the route. The article by Xu, Yang and Wang (2018) was also ruled out, as it examines the NSR and SCR routes combined, deviating from the objective which is to seek alternative routes, not partially usable ones. The study by Yuan, Hsieh and Su (2020) was also excluded because it dealt with carriers' resilience in relation to the NSR and the Kra Canal<sup>7</sup>. Figure 1 summarizes the research design.

## 2.3. Descriptive analysis

In the second stage of the research, the content of the studies was evaluated through a descriptive quantitative analysis. This analysis provides a fruitful basis for the interpretation applied in the subsequent

<sup>7</sup> The Kra Canal, in Thailand, is a project to connect the Gulf of Thailand with the Bay of Bengal. It would integrate with China's BRI and the Maritime Silk Route. The canal could reduce shipping distances and times between East Asia and Europe, bypassing the congested Malacca Straits (Yuan et al., 2020).



content analysis of the selected articles (Qian et al., 2020). The sample of articles in this research derives from a total of eight journals. Most of the articles were published in journals related to maritime transport, in the time period between 2010 and 2021.

Table 1 shows the relationship of the routes studied by the authors in the 16 analyzed articles. Based on

**Table 1.** Studies reviewing the academic literature on the routes chosen.

Study Author	Routes		
	SCR	NSR	TSR
Liu and Kronbak (2010)	X	X	
Khon et al. (2010)		X	
Schøyen and Bråthen (2011)	X	X	
Moon et al. (2015)	X	X	X
Pierre and Olivier (2015)	X	X	
Fauray and Cariou (2016)	X	X	
Zhao and Hu (2016)	X	X	
Zhang et al. (2016)	X	X	
Solvang et al. (2018)		X	
Wang et al. (2018)	X	X	
Zhu et al. (2018)	X	X	
Cariou et al. (2019)	X	X	X
Sur and Kim (2020)		X	
Zeng et al. (2020)	X	X	X
Tseng et al. (2021)	X	X	
Xu and Yin (2021)	X	X	

SCR: Suez Canal Route; NSR: North Sea Route; TSR: Trans-Siberian Route.

Source: based on systematic literature review (2021).

the studies, the following citations of the routes are pointed out: NSR (16), SCR (14) and TSR (3).

### 3. DATA ANALYSIS AND DISCUSSIONS

The SCR route issue, the finite capacity, the need to search for safer and economically viable alternatives (Bulis & Skapars, 2014), as well as an inconsistency in rules and regulations and different operating procedures (Unescap, 2022) for this bottleneck between Asia and Europe, are increasingly pressing in the international merchandise trade scope.

Given the above, regarding descriptive quantitative analysis, the journals that published the most relevant articles were: *Transportation Research Part A-Policy and Practice* (4), *Maritime Policy & Management* (3), and *Journal of Transport Geography* (3). Table 2 was prepared with the impact factors and citations of journals in the area of international operations.

Table 2 also highlights some relevant data about the journals. The parameters selected were: International Standard Serial Number (ISSN); total publications; sum of the number of citations; average number of citations per item; and h-index, which is a metric to assess the cumulative impact of an author's academic production and performance, that measures quantity and quality by comparing publications with citations (Fassin, 2023). These parameters were chosen because they combine publication and citation counts, the most widely used proxies for productivity and impact, as well as an easily computable and concise metric with traditional elements for evaluating researchers (Fassin, 2023).

**Table 2.** Journals by their impact factor and quotes.

Journal	ISSN	Total publications	Sum of No. of quotes	Average of quotes per item	h-index
Transportation Research Part A-Policy and Practice	0965-8564	4.018	109.328	27.21	132
Maritime Policy & Management	0308-8839	3.538	42.367	11.97	73
Journal of Transport Geography	0966-6923	3.262	69.410	21.28	105
Asian Journal of Shipping and Logistics	2092-5212	301	1.571	5.22	21
Maritime Economics & Logistics	1479-2931	516	6.997	13.56	38
<b>Total</b>	-	11.635	229.673	-	-

Source: Web of Science (2021).

Regarding the total number of publications, the *Transportation Research Part A-Policy and Practice* journal has the highest number. It is also the one with the most citations, around 47.6% of the total. Consequently, it also presents the highest average of citations per item and H-index, and it can be considered that the journal's level in terms of productivity and the citation impact of publications is higher than the others'.

Following the analyses, Figure 2 shows the number of citations of the main articles of journals found in SLR:

The Figure 2 highlights the growth in the number of citations in the period between 2000 and 2021. From the analysis of the Figure 2, it is possible to see that the journal *Transportation Research Part A-Policy and Practice* was the one with the highest number of citations. However, it is also possible to note that the *Journal of Transport Geography* is showing significant growth and will reach first place in the next few years if this trend continues. In the years 2020 and 2021, Figure 2 had an atypical behavior due to the COVID-19 pandemic, which affected the number of articles and citations.

### 3.1. The Asia/Europe foreign trade

Schøyen and Bråthen (2011), Wang, Zheng, and Meng (2018) and Xu and Yin (2021) described concepts related to the niche market, reinforcing the opportunity of bulk transport in alternative maritime routes. Unlike liner ships<sup>8</sup>, tramp ships<sup>9</sup>, such as bulk carriers and oil tankers, are described in studies by Schøyen and Bråthen (2011) and Xu and Yin (2021) as those that do not have predetermined routes, a determining factor for traveling through the NSR, for example. A third modality, the industrial one, consists of industrial operators that own the shipped loads and control the ships used to transport them, in search of an alternative to minimize the cost of sending their loads. Such operations fit in high-volume liquid and dry bulk businesses, such as oil, chemicals and ores

(Christiansen, Fagerholt, Nygreen, & Ronen, 2007). Yet, Faury and Cariou (2016) and Zhao and Hu (2016) described the transport costs in the mode, contrasting travel costs and total costs.

Still on the maritime matter, the SLR authors also proposed to conceptualize issues such as: fuel costs (Zhao & Hu, 2016); choice of route as directly linked to product aspects (Schøyen & Bråthen, 2011); transportation of refrigerated and fresh goods (Zeng et al., 2020); and multimodalism as it relates to increased international trade (Moon et al., 2015). At the same time, Schøyen and Bråthen (2011) highlighted the risks that exist in the SC and their interference in transport. The need for new routes for more agile and flexible chains was underlined as well, such as in studies by Schøyen and Bråthen (2011), Solvang et al. (2018), and Sur and Kim (2020).

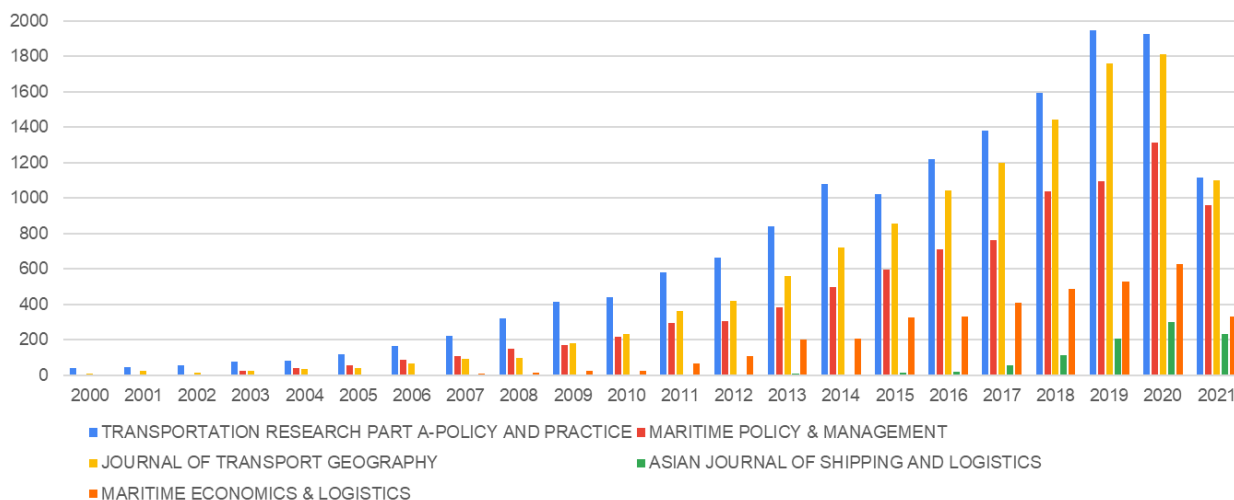
Due to the recent navigational problems of traditional waterways, affected by factors such as waiting time for canal passage, canal tolls, and capacity limitations, shipping companies are seeking new routes to replace traditional ones (Sun, Zhang, & Zhu, 2022). In reaction to increasing clogging and shrinking ocean capacity, Maersk has launched the first train intermodal service between Europe and China (Port Technology International, 2021). Moreover, this new route has been able to stand by its schedule, delivery times and swift transit clearance, creating a robust ground for further expansion of transcontinental transit.

It is also important to approach legal instruments and standards. An example is the European Agreement on Important International Combined Transport Lines and related installations (AGTC). Implementing AGTC minimum standards is expected to strengthen critical Euro-Asian railway routes that can connect Central Asian landlocked to international markets.

Alternatively, Zeng et al. (2020) show that the railway route has increased from 2011 to 2015 in terms of market share compared to NSR and SCR, corresponding to an average of 4,51% of transport between China and Germany in 2015. This market share is more significant for routes departing from East China (8,69%) and Northeast China (7,66%). The authors also state that, due to economic prosperity in the Northeast China region, this will increase cargo supply in East China, an adjacent region, as well. The advantages of the railway in terms of speed and safety will result in an increase of market share compared to

<sup>8</sup> Liner ships are goods and cargo transport vessels that move on regular routes at fixed times.

<sup>9</sup> Tramp ships means independent ships without a regular line of navigation, ships for freight. These are appropriate to the transport of bulk goods.



Source: Web of Science (2021).

**Figure 2.** Comparison of the number of citations of the main articles in journals.

SCR in the near future too. At the same time, if compared to NSR, the railway route is more advanced in terms of infrastructure.

### 3.2. The North Sea Route and Trans-Siberian Route as alternatives to the Suez Canal Route

Regarding the comparison between routes, all articles seek to identify the problems of the NSR route, mainly by economic parameters. Only three of them have the TSR as a study objective. First, Moon *et al.* (2015) show the TSR is the most competitive route, NSR the second and SCR the less competitive. The criteria used to measure competitiveness were: transport distance, transport time, transport cost, transport service, safety and awareness. Yet, when comparing both quantitative (distance, time and costs) and qualitative factors (service, safety and awareness), the TSR is ranked first. Quantitative factors were transport distance, transport time and transport cost, and qualitative factors such as transport service, safety and awareness. Second, Cariou, Cheaitou, Fauray, and Hamdan's (2019) results show the railway option relates mostly to shorter transit times, which gives competitiveness to high-value cargos. For instance, the results of Zeng *et al.* (2020) show a rapid development of the railway and increasing competition. Taking competition into account, the projected share of the NSR is even smaller. As the market share of the NSR increases, the SCR decreases, while the TSR stays constant.

According to the SLR, Table 3 presents a comparison between the NSR, SCR, and TSR routes in the categories: location; mode of transport; statistical data; advantages; and disadvantages.

Table 3 organizes the advantages and disadvantages of one route over another and highlights the NSR route as being the most advantageous. Authors Liu and Kronbak (2010), Pierre and Olivier (2015), Sur and Kim (2020), and Tseng, Zhou and Hwang (2021) have identified the best chances of developing transport in the NSR as depending on the costs of ice-breaker ships to decrease, as rates are currently high. Another aspect highlighted by Solvang *et al.* (2018), Zeng *et al.* (2020) and Zhu *et al.* (2018) is that the Northern Europe and Asia regions are the ones with the best chances of developing using the NSR, as both are closer to that route, which makes them more competitive than countries such as, for example, Indonesia, in South Asia.

### 3.3. Analysis of the economic viability of the North Sea and Trans-Siberian routes to the Suez Canal Route

The NSR was addressed in all SLR articles (Table 1). Several of the studies claimed that the route is unfeasible, such as those stating that the NSR is not viable if the ice-breaking rate remains at current levels (Liu & Kronbak, 2010; Pierre & Olivier, 2015) and rates currently equate to two times SCR rates (Tseng *et al.*, 2021). In contrast, some articles argue that the NSR is a viable and

**Table 3.** Comparative table of routes.

	<b>Northern Sea Route (NSR)</b>	<b>Suez Canal Route (SCR)</b>	<b>Trans-Siberian Route (TSR)</b>
Location	Arctic Ocean Pacific Ocean	Pacific Ocean Atlantic Ocean Indian Ocean Mediterranean Sea	Asia Europe
Mode	Maritime	Maritime	Rail
Statistical data	Extension: approximately 6,660 km Transit time: 19 days (Martínez-Zarzoso, 2013)	Extension: 8,320 – 10,820 km Transit time: 38 days (Martínez-Zarzoso, 2013)	Extension: 8,040 – 9,250 km Transit time: 15 – 21 days (Martínez-Zarzoso, 2013)
Benefits	Reduced transit time Fewer stops required Less CO <sup>2</sup> emissions Shortest route Fuel economy Government subsidy i.e. South Korea Economy of scale Cost savings 15 to 50% No piracy Advised route for tramp ships	Advised route for liner ships	Reduced transit time
Disadvantages	Navigable for 3 months only More risks No container ship data on route Reduced speed in icy parts High rate of icebreaker ship Lack of infrastructure along the routes Russian government obstacles Larger ships cannot be used High insurance	Piracy More stops along the way Traffic limitation High fees for the Suez Canal Blockages on the Suez Canal	Reduced capacity Different Gauges Higher CO <sup>2</sup> emissions

Source: Own editing based on the theoretical framework and systematic literature review (2021).

prosperous alternative, such as Schøyen and Bråthen (2011), with reduced transit time and fuel efficiency; Faury and Cariou (2016) consider transit time and transit cost linked to the monthly ice thickness on NSR. The findings show the route is viable from July to November, months where ice thickness is lower or nonexistent, with savings of up to USD 1,64 million. Likewise, Pierre and Olivier (2015) point out that the cost differential for the SCR and NSR goes from US\$470 to US\$7,512 considering a speed increase from 8 kts<sup>10</sup> to 16 kts in the SCR. Finally, Solvang et al. (2018) describe that despite, all the risks of sailing on the NSR, the results demonstrate more benefits on this route,

<sup>10</sup> Knot (often abbreviated to kts) is a unit of measurement of speed, with 1 knot equal to 1 nautical mile per hour (Privatefly, 2020).

such as shorter distance, reduced fuel costs, and increased productivity.

The NSR can become a viable alternative after the ice-free sea increases and the route becomes marketable for the entire year (Martínez-Zarzoso, 2013). It should be noted that the route's viability has not been supported by a consensus among authors, although some conclude that it will be economically viable in a few years, when there is no more ice in the region: using the ice-free NSR reduces days at sea and doubles fuel efficiency (Schøyen & Bråthen, 2011), and the average cost of an NSR trip will be lower than that of an SCR trip, which makes the NSR a profitable alternative route (Zhao & Hu, 2016). Yet, Russia is seeking to promote the NSR as a more reliable alternative, creating a Special Economic Zone (SEZ) that is integrated with an industrial and transport corridor

to deliver products extracted or manufactured there (Contessi, 2021).

The results achieved by the authors about the SCR were mostly positive, economically speaking. Data obtained on the SLR show that large companies are too conservative to replace the SCR with another route (Wang et al., 2018). However, if it is shown to them that they can reduce costs by avoiding the SCR, this may be a reason for them to move to the NSR. Still, transport of containers by the SCR is that with the highest chances and profit margin (Wang et al., 2018; Zhang et al., 2016). On the other hand, of the three routes under comparison, the SCR ranked as the least economically attractive (Moon et al., 2015). From the results achieved with the authors of the theoretical background, compared to other routes, the rates applied to those traveling through the SCR are equivalent to costs with other routes (Alphaliner, 2020). The viability of the SCR was weakened when SCA, after a drop in transit volumes, applied a 6% discount exclusively for container crossings (Contessi, 2021). Thus, it is clear that, for container ships, the SCR is currently the most economically viable compared to the NSR. For the NSR, bulk transport may be a thriving market given current conditions (Schøyen & Bråthen, 2011).

Regarding the TSR route, despite fewer studies addressing it, it is possible to verify that SLR authors also classify it as a promising route. Moon et al. (2015) consider this railway route the most competitive of those studied. Also, other studies have concluded that it is an economically viable route: the success of the TSR depends on the facilitation of customs clearance, with the adoption of trade agreements with Poland, Russia, and Kazakhstan (Do Nascimento & Maynetto, 2019). Improvements in speed, cost and reliability make the TSR faster than sea, cheaper than air, leading many to see it as a substitute for the ocean option (Contessi, 2021). Only one of the studies points to the route as an unviable alternative since TSR costs are considered three times higher than maritime costs by the SCR (Martín Borda, 2011).

Given the above, it can be concluded that the alternative routes presented here are economically viable, given some factors that need to be weighed into the choice. The NSR is currently only viable for bulk carriers. The TSR route, on the other hand, is a good replacement for SCR for all types of loads. Thus, of the alternative routes, the TSR is the most economi-

cally viable, given its implementation progress, which is already advanced, and its flexibility in relation to the types of cargo that can be transported.

For future studies, authors such as Pierre and Olivier (2015), Tseng et al. (2021) and Zeng et al. (2020) recommend further research into the risks that shipping companies would face when using the NSR. Others advise an assessment of the conditions of Arctic ice and weather in more detail, such as Khon, Mokhov, Semenov, Latif and Park (2010), Schøyen and Bråthen (2011) and Tseng et al. (2021). Additionally, future studies are suggested regarding the use of liner ships by the authors Liu and Kronbak (2010), Solvang et al. (2018) and Xu and Yin (2021), transport of valuable and higher value-added cargo by Cariou et al. (2019) and Solvang et al. (2018), and route diversification both by sea — by Tseng et al. (2021) — and by rail — by Moon et al. (2015).

## FINAL CONSIDERATIONS

Bearing in mind the research problem — the advantages and disadvantages of alternative routes to the SCR —, it is possible, from the data of the selected articles, to highlight some ideas. Some authors consider the NSR to be economically unfeasible for liner ships given the current conditions of the route and the instability of itineraries (Wang et al., 2018; Zhang et al., 2016). On the other hand, studies indicate that the route is a good option for ships carrying oil and bulk (Tramp Ships), as they do not follow fixed paths (Schøyen & Bråthen, 2011; Zhang et al., 2016).

One of the main caveats of the studies on the unfeasibility of the NSR is the question of the fees charged by icebreakers, which are currently considered too high (Liu & Kronbak, 2010; Pierre & Olivier, 2015; Tseng et al., 2021; Xu and Yin, 2021). Fuel economy is an important factor, which can cover for icebreaker expenses, since the NSR can double fuel efficiency (Schøyen & Bråthen, 2011). In addition, amplifying commercial traffic through the NSR depends on necessary investments in infrastructure in the region, such as ports and relief areas (Sur and Kim, 2020; Zhu et al., 2018).

Regarding the studied routes, it was observed that the economic viability of the NSR depends on changing some factors such, as the high fee charged by the Russian government and government incen-

tives for cost reduction in icebreaker assistance. In addition, the route would be favorable for container ships if there were more navigable times (estimated to occur in the next few years). The OBOR project, which includes the TSR, needs improvement regarding navigating multiple borders and differing gauge types for transport on the route. It is necessary for governments to reach a consensus to speed up these customs processes and make the route even more competitive. It is worth mentioning that some countries already have these agreements, and two presidents, Mirziyoyev of Uzbekistan and Xi Jinping of China, spoke positively about future collaboration in advancing the BRI. During these meetings, the “two countries signed 115 agreements worth more than USD \$23 billion to increase their cooperation in transport and infrastructure” (Xinhua, 2018).

As a theoretical contribution, the study presents itself as relevant to the area of international logistics, since the explanation of each transport modality and the concepts regarding logistics made it possible to highlight the necessary issues to be addressed in relation to the existing routes. Still, few SLR studies were dedicated to the railway mode, most of them treating the maritime option, an aspect that can be viewed as a contribution to the field.

The study advanced the work of Moon *et al.* (2015), updating the data presented in their research. In addition, their study focused on transport between South Korea and Europe, which includes trade between Asia and Europe. This SLR also built on the ideas of Faury and Cariou (2016) with regard to their suggestion of studying the competitiveness of the NSR, as well as on the work by Tseng *et al.* (2021), with regard to the consideration of other navigable routes between Europe and Asia and the emphasis on the importance of derived costs (risks, navigational safety and political issues).

The research findings, in addition to contributing to the advancement of studies on trade routes between Asia and Europe, are also important for managerial practices. The study contributes to elucidating issues such as prices, costs, distances, advantages and disadvantages, and sustainability issues, which both transport companies and import and export organizations must observe when choosing a route, in addition to updating data from other studies.

For the area of logistics in general, especially for international logistics, this work contributes by discussing a current research problem, the use of alternative routes, which has been frequently debated over the years, mainly due to the thriving trade between continents and global warming. The research used the blockade of the Ever Given Ship as an illustrative case highlighting the importance of integrating members into the SC and the efficiency of distribution logistics in international trade in order to minimize negative impacts on operations.

Regarding the limitations of the research, the examined articles of the SLR do not use a theoretical framework, which should be underscored as a limitation because none presented an analytical model. Another limitation is the issue of sustainability, which was not addressed here due to the focus being restricted to the economic issue, but this is an important topic and is suggested for future studies.

In terms of future studies, further research is suggested that considers the SC, with an emphasis on logistics, since little data was found. Particularly, studies on rail transport for alternative routes are recommended, as most SLR articles focus on international maritime transport. Furthermore, it is necessary to delve deeper into the lack of safety in itineraries for the NSR. Studies are also needed on the post-COVID-19 pandemic's impact on international maritime trade, emphasizing the effects of high freight rates and lack of containers on bilateral Asia/Europe foreign trade. The implications that these studies can bring to Brazil's foreign trade are another factor to be analyzed in the future. Finally, and in view of the above, a complementary way to approach some of the issues here is to address how the rail modality benefits from the rise in sea freight prices in trade between Asia and Europe.

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## APPENDIX



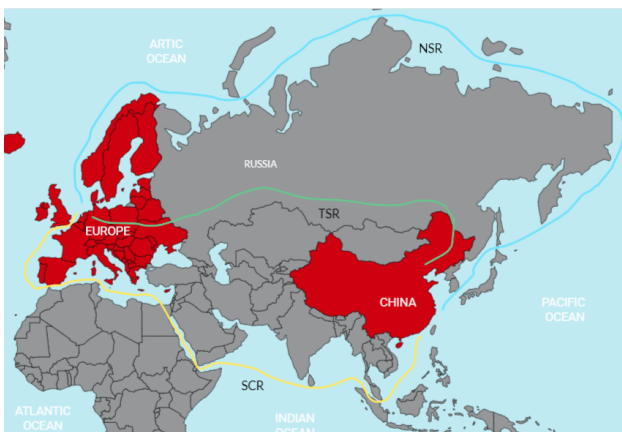
Source: Google Maps (2021).

**Appendix 1.** Map of the Suez Canal.



Source: Getty Images (2021).

**Appendix 2.** Blockade of the Ever Given.



**Appendix 3.** Routes map.