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Competition Between Chinese Railways and Traditional Shipping in China-Europe transportation under the BRI

by

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Acknowledgements

In the process of writing this paper, I have received a lot of support and assistance.

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Abstract

With the increasing volume of trade between China and Europe, transport plays a crucial role, especially during the special times of the pandemic and the Russia-Ukraine war, and the choice of transport mode has become a topic of discussion. Maritime transport has always dominated the trade between China and Europe, however, since China's Belt and Road project, the China-Europe railway has started to develop rapidly and has become a strong competitor to maritime transport with its faster speed and lower transport costs than air transport. In this study, we discuss the competitiveness of sea and rail transport through two case studies.

We begin by introducing the study's objectives and research questions, followed by a brief history of the Belt and Road initiative and the growth of its railway network. The benefits and drawbacks of shipping and rail transportation are then covered, followed by an investigation of the effects of the COVID-19 pandemic and the invasion of Ukraine by Russia on each, in the context of the existing external environment. Then, using two case studies involving varying values of goods being transported by long-distance rail and deepsea container shipping on the China-Europe trade route, we summarize some of the literature reviews and analyze the findings. However, we developed a sensitivity analysis to examine if the cost and time competitiveness of the two modes of transport changes by changing the average price of ocean freight to a pre-pandemic level and then removing the government subsidy for rail transport. The results show that railways are much less competitive and less competitive for the transport of low-value commodities after leaving subsidies, in which case maritime transport, with its high carrying capacity and relatively low rates, significantly increases its competitiveness between the European and Chinese transport market.

This study has several real-world applications that can assist shippers in selecting the best mode of transportation for different types of goods and quantities.

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List of Abbreviations

BRI	Belt and Road Initiative
MoU	Memorandum of Understanding
CGE	Computable General Equilibrium
CPEC	China–Pakistan Economic Corridor
FEM	Fixed Effects Model
LSTSB	Land and Sea Transport Spatial
NSR	North Sea Route
SCR	Suez Canal Route
CER	China Europe Express
CSERE	Chongqing Western Europe Express
FEU	Forty-foot Container
CAF	Currency Adjustment Factor
BAF	Bunker Adjustment Fee
THC	Terminal Handling Fee

Chapter 1. Introduction

1.1 Research Objective

According to the World Bank (1994), the level of infrastructure development largely determines the success or failure of developing countries in diversifying production, promoting trade, reducing transaction costs, coping with population growth, reducing poverty, or improving environmental conditions, and is the "wheels" of their economic activity. Transportation is the cornerstone of development in infrastructure construction, and its impact on economic growth is significant, not only creating a large number of jobs and bringing employment opportunities but also reducing operating time and costs and improving economic efficiency by improving transportation conditions. Economic globalization has acted as a powerful force for global economic expansion, fostering the exchange of commodities and capital, the advancement of science, technology, and culture, as well as cross-national engagement. Having a sound transportation infrastructure is crucial for any country to compete internationally in the global market (Lin et al., 2021).

China proposed the BRI (Belt and Road Initiative) strategy in 2013 to expand global connectivity, particularly through the development of transportation infrastructure. At the same time, the BRI wants to stimulate the trade between China and other countries and establishes the Eurasian economy as a whole (HERRERO and XU, 2016). As we can see from Figure 1, from 2015 to 2021, trade between China and Europe has shown a consistent upward trend. The growth in transactions is accompanied by an increase in demand for logistics.

The distance between the two geographic areas of Europe and China means that the main available modes of transport are sea, air, and rail. Air transportation's carrying capacity is substantially lower than other transportation modes and that it is much more expensive (Solistica, 2022). While some level of competition can be observed between air freight and long-distance rail transport on the China-Europe trade route (Zhou et al., 2021), this study only concentrates on maritime shipping and rail transportation.

Maritime transport has long remained the dominant mode and more mature means of transport between China and Europe. The maritime route connects the large container ports in the Chinese coastal areas of the Bohai Bay (Dalian, Yingkou, Tianjin), Shandong province (Yantai, Qingdao, Rizhao), the Yangtze River Delta (Shanghai, Ningbo, Taicang), the Taiwan Straits (Xiamen, Fuzhou) and the Pearl River Delta (Guangzhou, Shenzhen and Hong Kong) with Europe passing via the Malacca Strait, the Suez Canal and the Mediterranean Sea. Following the "Belt and Road" policy, the rapid development of so-called Eurasian land-bridges via rail has become an emerging option, vigorously promoting the development of trade inland, making freight transport between China and Europe more effective, significantly reducing transit times and reducing the impact of the external natural environment on transport, which also achieved significant growth during the pandemic (Zhang, Y., 2021a). How is the emerging competition from rail affecting the historically dominant position of maritime transport? With this question in mind, in this paper, we analyze and compare the competitiveness of rail and sea transport between China and Europe to explore the results.

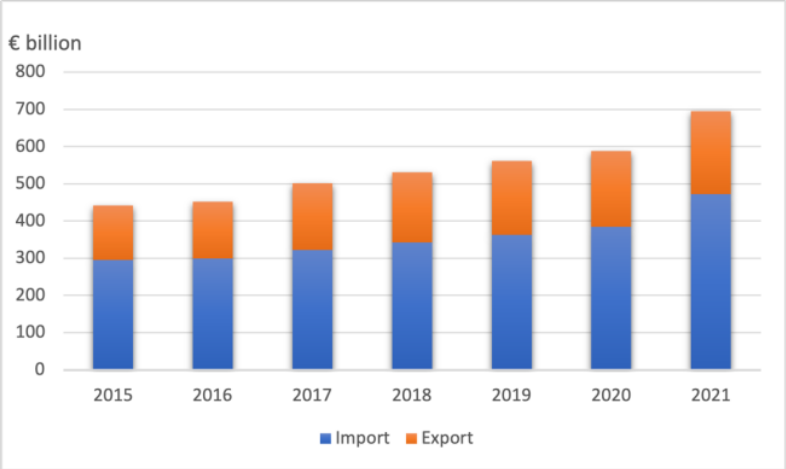

Figure 1: Total trade between China and Europe from 2015 to 2021

Source : Eurostat

1.2 Research Question and Sub Research Questions

The main research question in this paper is defined as :

"How will China-Europe rail services compete with traditional maritime shipping in China-Europe transportation under the Belt and Road Initiative? "

The following sub research questions have been established in order to address the primary research question :

1) what is the background of maritime and railway transport between Europe and China?
2) what is the BRI? What is the intent of this strategy? How has it stimulated China's railway development?
3) what are the advantages and disadvantages of shipping?
4) what are the advantages and disadvantages of railway transportation?
5) What is the current state of railway and marine transportation in Sino-European trade? (Considering the impact of Covid-19 and the invasion of Ukraine by Russia)
6) What will be the future of railway and shipping transportation?

1.3 Research structure

Overall, this paper compares the competitiveness of rail and sea transport in the context of the BRI using quantitative and qualitative analysis. The detailed structure of the research is presented below :

Chapter 1 provides an overview of the entire paper, outlining the objectives, research questions, and structure of the study.

Chapter 2 introduces the history of the Belt and Road policy, the participating nations and areas, the development trajectory, and the evolution of China's train construction under the impact of the strategy.

Chapter 3 presents the respective characteristics of the two modes of transportation, rail, and sea, and briefly discusses the impact of the Covid-19 pandemic and the Russian-Ukrainian war on these two modes of transportation, taking into account the actual situation.

Chapter 4 collects a literature review on previous comparisons of the two modes of transportation, rail, and sea, as well as the impact of the Belt and Road Policy on transportation.

Chapter 5 is the methodology of this paper. We used the case study approach as the main research method. We have selected a total of two examples of rail and sea transport, one for high value goods and one for low value goods, to compare the two modes of transport, and in this chapter, we also show the data collection process.

Chapter 6 presents a data analysis of the two selected cases from different perspectives, followed by conclusions. To test the relative validity of the conclusions, a sensitivity analysis is also conducted.

Chapter 7 presents the conclusions of the entire article and some limitations of this study.

Chapter 2. The Belt and Road Initiative

2.1 The characteristics of the BRI

The first Silk Road, which crossed Central Asian nations and stretched thousands of miles into Europe, existed between 206 and 220 B.C. during the Han Dynasty of China's westward expansion (Frese, 2019). Given this history of development, during official visits to Indonesia and Kazakhstan in 2013, Xi Jinping, the president of the People's Republic of China, proposed "the Belt and Road Initiative" idea for the first time (Alexandrovna). The "Silk Road Economic Belt" is represented by the term "belt," which refers to the development of overland transportation networks for road and rail. Sea routes that link Southeast Asia with Africa, the Middle East, Europe, South Asia, and Middle East are known as the "21st Century Maritime Silk Road" (Ghiasy et al., 2018). This long-term policy is aiming to establish and reinforce the relationships between nations along the "Belt and Road", push for the connectivity of the Eurasian continent and the waterways surrounding it, build a comprehensive, multi-level, complex interconnection network, eliminate trade bottlenecks, make the logistic system more effective and increases demand for freight transportation (Lee, Yang et al., 2018). According to European Commission, 80% of world GDP is generated in coastal areas within 100 kilometers from the seashore (2021), and landlocked regions find it difficult to conduct trade and business. The BRI, in this scenario, connects also interior places to the rest of the world by building rail and road infrastructure.

In addition to promoting the development of transportation facilities mentioned above, according to the research of Cosentino et al., from China's standpoint, they also have other objectives as followed (2018):

- Firstly, with the increasing labor cost in the coastal areas and decline of export demand, China wants to transfer part of the industrial centers to inland areas through the development of a railroad system under BRI and stimulate the economic growth in inland areas.

- Secondly, China wants to control the supply chains to lower the transport cost thus increasing its competitiveness during trade.

- Thirdly, China intends to solve the problem of the uneven development of provinces through the Belt and Road project. Due to its geographical disadvantage, the northwest has not been successfully developed, while the southeast has long been a preferred investment location. China can connect its northwest region to the rest of the globe and advance its economic growth by building railways.

- Fourthly, the BRI project involves constructing a lot of infrastructures, which uses a lot of raw materials such as steel, thus addressing the issue of China's steel production overcapacity.

- Finally, the BRI has the potential to increase RMB usage and strengthen China's position as a global power.

Of course, other countries including those in the EU can undoubtedly benefit from the BRI project, and quite a few have signed a Memorandum of Understanding (MoU) with China. As shown in Figure 2, more and more nations are discovering the value of building transportation infrastructure, increasing participation from less than 20 in 2013 to 147 by 2022.
Including 18 countries within the European Union makes it considerably easier for European countries to access Asian markets. According to STALOGISTIC, moving goods from Europe to China used to take at least one month per ship, but now it only takes 16 to 20 days by rail. In addition, China has begun the China-Europe express. The China Railway Express takes three-quarters less time to operate than shipping and costs much less than air freight, according to DFH Logistics, the cost to transport a container through China Express Railways from Chongqing to Duisburg is only 20% of the price of air transport (2022). The BRI aims to bring the world closer together and makes it more global and integrated.

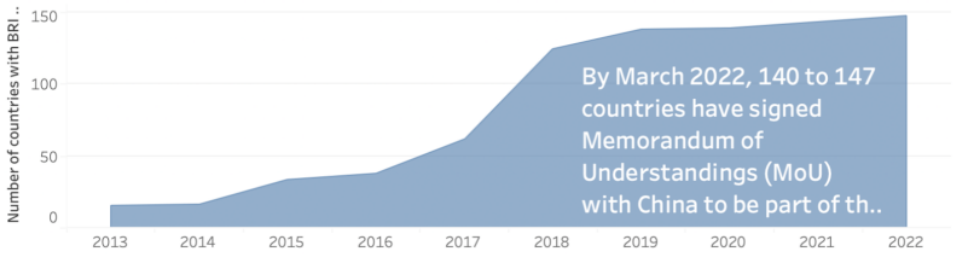

Figure 2: Number of countries joined the BRI from 2013 to 2022
Source : Green Finance & Development Center

2.2 The development of Sino-European Railway under BRI

The growth of the rail network, both inside Asia and connecting Asia to Europe, is aligned with a large portion of the investment connected to the BRI. China hopes to use it to better connect itself to the world. For China-EU trade, one of the most important is railroad construction. The China Railway Express now travels through 185 cities in 23 different European countries. In the west, middle, and east, three significant railroad corridors have developed, and they are as follows (Du and Zhao, 2022):

The "Middle corridor" connects Inner Mongolia's Erlianhot port exit with European nations via Mongolia and the Russian Siberian Railway. Beijing-Guangzhou set two, and other train trunk lines transport the primary source of cargo attraction area for North China, Central China, South China, and other places.

The "Western corridor" which enters the Russian Siberian Railway on the way out of the Inner Mongolian Manzhouli port, provides access to European nations. The primary source of goods for the northeast, central, and eastern parts of China, as well as for other regions, is transported via the Beijing-Shanghai, Hada, and other train trunk lines.

The "Eastern corridor" mainly attracts import and export cargo from East China, South China, and Northeast China, and is connected to the Russian railroad via Beijing-Shanghai, Beijing-Harbin, and Binzhou lines at Manzhouli railroad port in Inner Mongolia and Suifenhe railroad

port in Heilongjiang, and to other European countries via Belarus, Poland, and other national railroads.

Figure 3: China- Europe 3 main rail corridor (bule-Eastern corridor, green-Middle corridor, red-Western corridor)
Source: Fobwiki

In 2011, a train left Chongqing for Duisburg, Germany, which kicked off the prelude of the China-Europe train. In this decade of development, China-Europe train freight has grown from less than 20 trains to more than 12,400 trains in 2020, an increase of 108%. By 2021, more than three million standard containers with a total product value of 23 billion euros have been transported by train between China and Europe (China Train Guide, 2021).

In 2021, China has already decided to spend more money on a number of foreign stations, and Zhengzhou has added 12 new stations to the China-Europe railway, including Kaliningrad in Russia (Nulimaimaiti, 2021). Until April 2022, China has 73 routes through this network, including Spain, France, Poland, Germany, the Czech Republic, and Poland in Europe. According to official Chinese sources, freight trains traveling along these routes conducted 3,630 runs in the first quarter of this year (Dasgupta, 2022).

Figure 4 shows all routes from China to Europe by train and table 1 lists the starting locations, final destinations, and trip distances for 12 main train routes between inland China and Europe. We can see that many of the routes start from inland cities, which is one of the objectives of the Belt and Road construction program, to reduce the economic differences between inland cities and coastal areas. Many inland areas, such as Chongqing, have a high population density and labor is available and less expensive than in coastal cities, which will encourage more companies to build factories in these inland cities, further boosting inland economic development.

Figure 4: Rail transport routes between Europe and China

Source : DSV (2022)

	Origin	Destination	Countries on the route	Length of the journey (km)
1	Chongqing	Duisburg	China, Kazakhstan, Russia, Belarus, Poland, and Germany	11000
2	Chengdu	Lodz	China, Kazakhstan, Russia, Belarus, and Poland	9965
3	Zhengzhou	Warsaw	China, Kazakhstan, Russia, Belarus, and Poland	9048
4	Zhengzhou	Hamburg	China, Kazakhstan, Russia, Belarus, Poland, and Germany	10245
5	Wuhan	The Czech Republic	China, Kazakhstan, Russia, Belarus, Poland, and The Czech Republic	10700
6	Suzhou	Warsaw	China, Belarus, and Poland	11200
7	Changsha	Duisburg	China, Kazakhstan, Russia, Belarus, Poland, and Germany	11808
8	Yiwu	Madrid	China, Kazakhstan, Russia, Belarus, Poland, Germany, France, and Spain	13052
9	Harbin	Russia	China and Russia	5574
10	Harbin	Hamburg	China, Russia, and Germany	9820
11	Lanzhou	Hamburg	China, Kazakhstan, Russia, Belarus, Poland, and Germany	8027
12	Urumqi	Duisburg	China, Kazakhstan, Russia, Belarus, Poland, and Germany	8000

Table 1: List of some China Europe Railway Express

Source: Own compilation' based on the "China Train Guide"

Chapter 3. The characteristics of shipping and rail transportation

3.1 The characteristics of shipping

In a century of global trade history, sea transport was the most popular mode of transportation chosen. According to China Power, shipping accounts for 80% of global trade in terms of volume, and the foundation of international trade and the world economy is maritime transportation (2021). Sea freight occupies such an important position in global trade, mainly because of the following advantages :

- The first is the **cost**. In normal economic conditions, sea freight has a significant price advantage over rail and air freight, allowing even small suppliers to afford shipping costs, but this advantage seems less pronounced after the pandemic due to the supply chain crisis, as we will discuss in more detail in subsequent sections.

- Second, ships can transport delicate cargo, such as hazardous goods and toxic materials more **safely**. To ensure the safety of the cargo, ship, and crew, the majority of vessels are well-designed for this specific cargo. China prohibits the transport by rail of most dangerous goods on the Chinese part of the Eurasian rail network.

- Third, shipping is almost completely **worldwide**. Due to the ports' rapid development, it is now possible to ship products practically everywhere by sea because a port of entry is almost always close by (Hillebrand, 2022).

- Fourth, shipping is considered more **environmentally friendly** per ton or container carried. In relative terms, maritime transport has less harmful emissions and carbon footprint than other modes of transport, coupled with some policy and regulatory restrictions, such as the IMO organization's sulfur emission restrictions on ships, which require all ships to use fuel with no more than 0.50% sulfur on board to reduce sulfur emissions starting in 2020. This will lead to more clean energy development and utilization in maritime transport, which is expected to achieve true zero-emission transport (Crowley, 2018). The decarbonization of maritime shipping is high on the

political agenda and is part of the strategies of shipping lines, involving the search and future large-scale use of green ship fuel such as hydrogen, ammonia, methanol and alike.

- Lastly, **large and heavy** cargo can be transported via sea freight. The carrying **capacity** increases as the size of the ship improves. The Ever Ace, one of the largest container ships, has a carrying capacity of up to 24,000 TEU (Nita, 2021), while a wagon combination of a typical rail service on the China-Europe route has a capacity of 30 to 84 TEU (Woodburn, 2011).

However, there are a number of drawbacks to sea freight that limit further expansion :

- Maritime shipping is **time consuming**. For example, shipping items from China to Europe typically takes 5-7 weeks under normal circumstances. Shipping is not a good option if your goods are perishable.

- **Shipping is not very reliable**. The volatility of the maritime environment can leave you with the possibility of delays in your cargo, such as the blockage of the Suez Canal in March 2021 that left at least 30 ships stuck there, causing serious economic impact (Leggett, 2021). As shown in Figure 5, it indicates that the global average schedule reliability of container shipping (measured as the on-time arrival of ships, this is on the day they are supposed to arrive in port) used to be around 65 to 80% in pre-pandemic times, while it has dropped to less than 40% since the Summer of 2020.

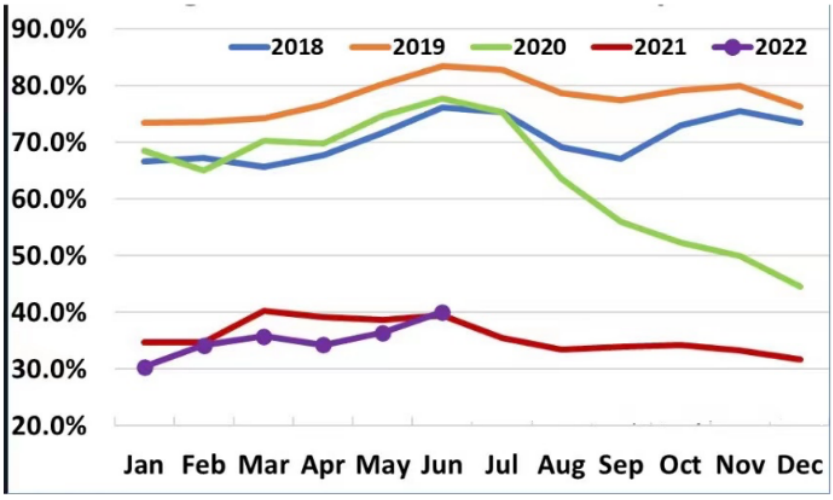

Figure 5: Global schedule reliability

Source : (Sea-Intelligence, 2022)

- Maritime shipping may face some **port of call problems**. Ships are getting bigger and bigger as the need for maritime transportation grows, but not all ports have the draught depth and equipment to handle large ships. As a result, congestion in ports where large ships can dock and an increase in the need for transshipment may result, making maritime transportation more and more unreliable (Rodrigue, 2015).

In general, shipping can carry large and heavy goods, and freight costs are lower than air and rail transport, but the delivery time is relatively long, so shippers need to consider whether to choose this mode of transport according to their own commodity characteristics.

3.2 The characteristics of railroad

The first railroads strengthened the form of transportation that had evolved hundreds of years before. The bulkiest or heaviest objects were typically transported by water throughout the Middle Ages. Trade gaps could increase if there were no natural links among navigable rivers. Rail transportation began as a result of a strategy that was proposed in the late medieval period to make steam-powered land transportation practical. From then on, railroad transportation

started to enter people's life. With the advancement of technology, the many benefits of railroad transportation have increased its popularity with the general population (Allen and Shedd, 2022), including:

- **Short transportation time**. Rail freight is currently the fastest mode of transportation on land. Taking China to Europe as an example, it usually takes only 16-20 days, which is much faster than sea transportation (Sino Shipping, 2022).

- Rail freight is **more reliable**. In comparison to ocean and air freight, rail freight travels on a set track that is less impacted by weather and avoids clogged roads, allowing goods to arrive at their destination on schedule (Agarwal). Still, the total transit time can be negatively affected by delays at container transfer terminals on the Polish/Belarus border and the China/Kazakhstan border. At these locations containers need to be transloaded from one train to another given differences in rail gauge between the rail network of former Soviet nations and the rail networks in the EU and China.

- Rail transport is **well organized**. Compared to maritime freight, it follows a set timetable and itinerary which makes its services more precise, consistent, and regular (The Economic Times, 2022).

- The railway is considered a **cost-efficient** mode of transportation. Rail transport is much cheaper than air transport, although more expensive than sea transport, but the transport time is short, which improves the economic efficiency.

- **Big capacity**. Like shipping, rail can also transport heavy bulk commodities. Moreover, the capacity of rail can easily be expanded by adding additional wagons (Prasanna, 2022).

- The **development of the hinterland** may be facilitated by rail. Railway transportation can assist manufacturers to relocate, lower land use costs, and resolve issues with difficult water transportation in inland places as well as with insufficient land availability in coastal areas.

Railroads are without a doubt the foundation of the global transportation network. Railroads do, however, have a lot of drawbacks on the other hand :

- Requires **huge financial support.** The railway is a capital-intensive industry that needs a large amount of money for infrastructure construction, maintenance, and operating costs. Many countries don't have the ability to build railroads, which can create a disconnect in rail links.

- Sometimes **not flexible**. As we have already mentioned, rail freight has its own schedule and routes, which are difficult to modify or adapt to suit specific requests, thus lack of flexibility compared to other transportation modes.

- **Monopolies** may develop. Because railroads are a high capital requirement, a monopoly may be formed. Even if it is governed by the government, it can cause high prices or inefficiencies due to a lack of competition (Agarwal).

Overall, the railroad is an indispensable part of modern transportation, with high efficiency and large capacity, but also requires large capital investment and is relatively less flexible.

3.3 The current state of the railway and marine transportation

3.3.1 The Impact of the Covid-19 pandemic

The coronavirus (Covid -19) spreads throughout the world by late 2019 or early. According to the Worldmeter, there were 544 million confirmed cases of the disease globally as of June 20, 2022, with 6 million deaths (2022). Many people are sick and isolated at home and unable to work, which has seriously affected the operation of all industries including transportation. Many manufacturing plants are temporarily closed, and shipping lines were canceled, therefore,

demand for most cargoes is declining, and many ships and rails are underloaded, causing significant losses to the transportation industry.

However, since November 2020, when most people were vaccinated, the market has reopened and demand began to grow rapidly, but supply could not keep up, for example, many containers were stacked on the docks and there were not enough workers to load and unload them. In addition, the imbalance in container trade volumes between East Asia and the rest of the world has exacerbated the shortage of containers, causing shipping prices to skyrocket (LaRocca, 2021).

Taking Shanghai to Rotterdam as an example, as we can see in Figure 6, from 2019 to November 2020, the price of shipping containers was almost stable at around $2,500, but from December 2020, container prices soared up to $14,600 (September 2021), setting a record high price, and in 2022, container prices fell back a little bit to around $9,800, but still increased by almost 300 percent over the price in 2019 which is quite impressive (Placek, 2022).

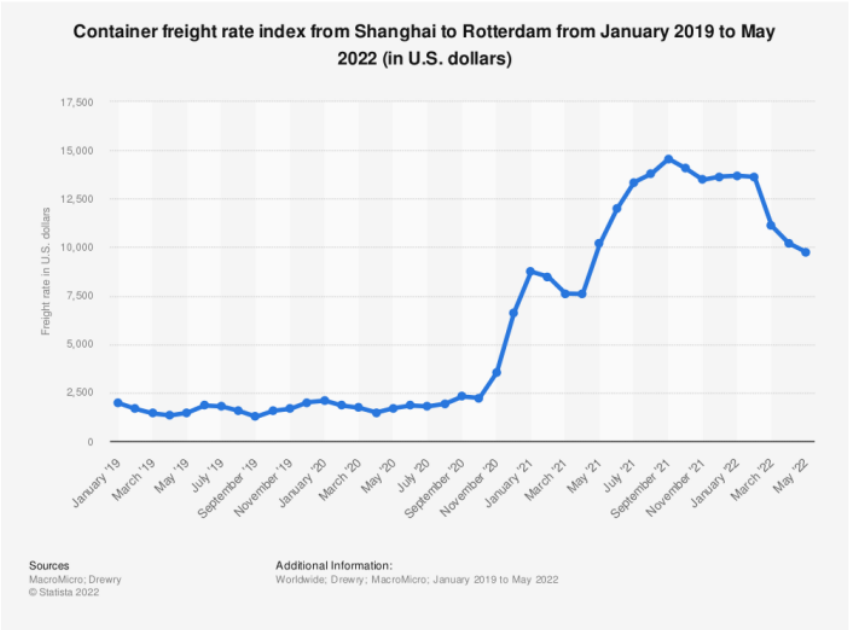

Figure 6: price changes for shipping fright rate from Shanghai to Rotterdam (2019-2022)
Source: Statista

The pandemic not only drove up the cost of shipping goods by sea but also prolonged the amount of time it took to ship goods by sea. According to Figure 7, it takes an average of 60 days to carry a container from China to Europe at the beginning of 2020, mainly caused by port congestion and equipment availability issues (vessels, containers, and trucks). After that, the number of transportation days grew steadily until it reached 116 days in March 2022. Due to the concurrent changes in price and transit time, the advantages of sea transportation in international transportation between China and Europe have steadily decreased.

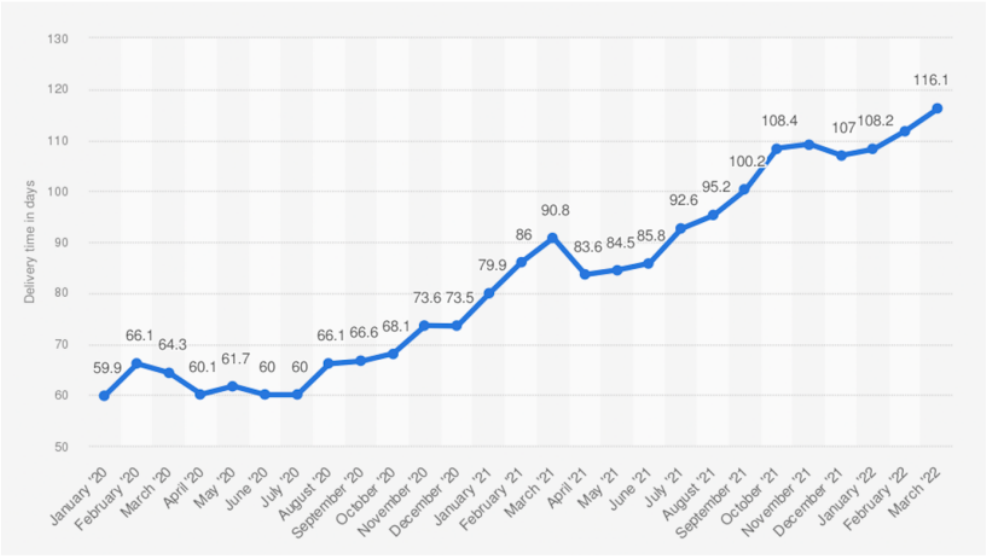

Figure 7: Days needed from January 2020 to March 2022 for a shipping container to arrive from China to Europe

Source: Statista 2022

However, it appears that rail transport has a new opportunity. After the pandemic had a significant impact on sea transportation and led prices to rise to levels comparable to those of the railroad, and because the train is much timelier than sea transportation, this virtually increased the railroad's competitiveness. The labor shortage has less effect on the railroads because international rail transport requires less labor over large distances and requires fewer quarantine checks. As can be seen in Figure 8, freight volumes on the China-Europe route

increased significantly in 2020, rising by 56% from 2019 to 1,135,000 TEUs, and continuing to rise gradually to 1,460,000 TEUs in 2021.

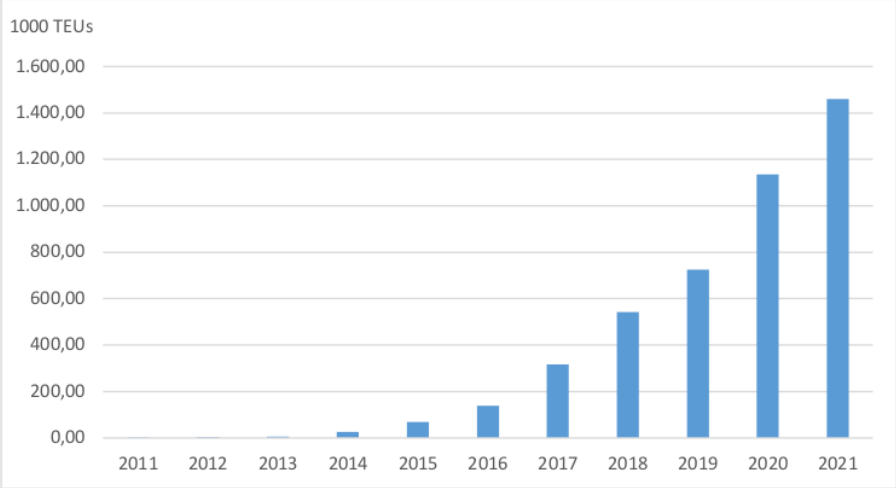

Figure 8: Freight volume transported by China Railway Express to Europe 2011-2021
Source: China State Railway Group

3.3.2 The Impact of the invasion of Ukraine by Russia

On February 24, 2022, Russia declared a full-scale war with Ukraine, a war that resulted in the death of almost 3,000 citizens and the displacement of millions of people. There is no doubt that this war also seriously disrupted maritime transport in the region, as the military control of maritime transport made parts of the Black Sea impassable which will lead to more congestion, and the blocked routes affected the efficiency of maritime transport to some extent. In addition, due to the world sanctions against Russia and the cessation of Russian exports as a major fuel country, the supply of bunker fuel was insufficient. Prices rise when demand outpaces supply and increases in fuel prices drive up shipping costs. Shipping becomes less reliable because of these factors (Tan, 2022).

Under the significant impact of the Covid-19 pandemic on maritime transportation, China-Europe railway transportation has gained opportunities for development. In 2021, 1.46 million containers of goods have been transported between China and Europe, an increase of 30% over

2020. However, the outbreak of the Russia and Ukraine War has put the railway from China to Europe at risk. Although only 2% of the China-Europe railway passes through Ukraine, as Europe begins to impose sanctions on Russia, once Europe begins to boycott the goods passing through Russia, the China-Europe railway is at risk of suspension, because most of the routes of the China-Europe railway must pass through Russia (Dasgupta, 2022).

Although the Western Corridor of the Central European Railway avoids Russia and instead travels through Turkey and Kazakhstan to reach Europe, it can be an alternative route, but the capacity of this route is very limited and also takes more time, which will increase the price of rail transport and reduce competitiveness (Dasgupta, 2022).

In conclusion, the sudden outbreak of the COVID-19 pandemic and the war between Russia and Ukraine had a profound impact on the transportation between China and Europe, and under these abnormal conditions, the characteristics of each mode of transportation changed, for example, the price of sea transport, which was known for its low price, shot up by 300%, and the railroad transportation, which was known for its reliability, became unstable because of the war, but the goods still needed to be transported, so in the later chapter we compare the competitiveness of sea and railroad transportation in China and Europe in this particular background.

Chapter 4. Literature review

4.1 Research on the impact of the BRI on Transportation

Shao et al. (2018) stated that transportation is the core of China's BRI, and shipping and railways play an important role in promoting international logistics connections. The primary factor influencing and directing the economic spatial pattern is transportation. However, many countries face serious problems in transportation facilities, especially railways, such as lack of capital and technology. Under the BRI policy, China has solved these problems and vigorously promoted the construction of railways in the countries along the route. The construction of a high-speed rail line has been proposed as a way to better boost "land power", but the feasibility and urgency of such a project are unclear. Accordingly, the authors used the LT-HSRCEP model to assess and fully take into account the political characteristics of policy stability, international cooperation, and other political factors. They came to the conclusion that the conditions in the countries along the route are suitable and essential for the construction of high-speed rail. A speedy connection to the road will be promoted by this decision, which will also quickly open international logistical channels.

Prodi and Fardella (2018) investigate how the One Belt One Road policy will affect the development of railroads and ports in Europe. Railways and ports are, in their opinion, Europe's most important BRI infrastructure investments. Railway construction may reduce transportation time, which is advantageous for goods with high value or those that need quick and swift delivery. Overall, though, port growth has the biggest economic benefit for Europe because it promotes healthy competition and improves connectivity between Europe and Asia. The BRI has led to a considerable rise in investment in Europe, which is advantageous for the economies of the crisis-affected nations. By tightly tying up the European and Asian markets, it also strengthens healthy competition inside Europe.

De Soyres et al (2019) look at the changes in shipping time to determine how much trade costs can be reduced through the Belt and Road Initiative. The method introduced by Hummels and Schaur (2013) is used by the authors to convert changes in shipping time to changes in trade costs after first calculating the time savings in shipping using a GIS network analysis. Trade expenses will decrease as the BRI matures and traders are able to select the best shipping routes.

Transportation efficiency will also increase as infrastructure advances. Due to the development of the BRI, shipping times and trade costs both fell by 2,5% and 2,2%, respectively.

Wang et al (2020) studied how the development of transportation infrastructure construction under the BRI policy affected the countries along the route. They first analyze the data from 65 nations along the Belt and Road Initiative from 2007 to 2016 and then apply the "spatial econometric approaches" to investigate the impact on economic growth from the improvement of the infrastructure. The result reveals that the impact of transportation infrastructure varies by region. The countries with advanced domestic transportation systems will benefit a lot while those who have poor domestic infrastructure will have negative economic growth due to the strong competitiveness around.

Chen and Li (2021) examined how the investment in transportation infrastructure from BRI policy has impacted the regional economic activities in different countries through lowering trade costs. The Computable General Equilibrium (CGE) model is used in the study to first estimate trade costs and then to examine the economic impact by looking at how trade evolves in various regions. The results showed that while 32 countries' welfare increased with time, others, like Thailand and Vietnam, experienced a decline. Furthermore, the welfare effect is not necessarily consistent with GDP growth in some countries (Estonia, Saudi Arabia, etc.). The majority of the countries along the Belt and Road benefit considerably from the investments made in transportation, with central and west Asian nations benefiting the most and central and western European nations benefiting the least.

Yang et al (2018) pointed out that the development of the new Eurasian Land Bridge train service and the Budapest-Piraeus line under BRI has had a significant impact on service networks in China and Europe. Improving transport networks is also a significant component of the Belt and Road project. This study used a bi-level programming approach to reconstruct China's shipping service network connecting two significant railway networks with the goal of maximizing total profit and minimizing total cost (taking COSCO as an example). The results show that COSCO has increased its profits by 6% through the new shipping network. If he expands the Piraeus port by increasing the number of port calls, COSCO can achieve a more significant profit increase, which is also a good way to expand its presence in Eastern Europe.

However, due to its high cost, railroad transportation has a far lower utilization rate than shipping, thus the government should think about offering suitable subsidies to support the regular operation of railway transportation.

Lee, Hu et al (2018) analyze the One Belt One Road policy by evaluating economic transportation routes, infrastructure, ports, and China's inland development. Through a series of academic meetings in China, Korea, Taiwan, and Australia, the results indicate that the creation of economic corridors will accelerate the growth of China's hinterland and create strong competition with port cities. Additionally, the development of China–Pakistan Economic Corridor (CPEC) can significantly reduce the congestion of LNG ships at the Malacca Straits. The benefits of the Singapore port will also be diminished by this expansion, which will also encourage the relocation of other industrial plants.

Jennings (2022) analyzes why China wants to strengthen high-speed rail connections across Eurasia in its Belt and Road project. High-speed rail transport could keep trains running in the event of a war in Ukraine and provide an alternative to sea routes that have been hampered by shipping backlogs during the pandemic. China has well-balanced its relations with Russia and the European Union through a solid supply chain, and these ties will help to further promote railway development.

Nulimaimaiti (2021) provided some specific data on railway development under the BRI project. As one of the important BRI development projects, China Development Bank decides to continue to provide financial support to upgrade the China Railway Express, connecting 89 Chinese cities and 23 European countries. In November 2021, DB cargo, the largest freight train enterprise in Europe, set up a company in Shanghai in order to increase the volume of freight moving between Europe and China over time.

Yii et al. (2018) investigated the importance of the BRI project's transportation infrastructure in Asian countries. The data from 2000 to 2015 were analyzed using the fixed effects model(FEM). The results demonstrate that the growth of local GDP is significantly influenced by the development of transportation infrastructure, particularly the railway network. Economic growth is fueled by the development of the transportation infrastructure, which

boosts output and investment performance. All participating nations in the BRI project should work together to improve the transportation infrastructure and connectivity.

Hillman (2018) pointed out the fast development and challenges of the China- EU railway under the BRI. Data show that from 2006 to 2017, the cost of air transport increased by 33%, and the transit time of shipping increased by 22% in the same period, but the transit time of rail transport has been reduced from 36 days in the beginning to about 16 days with almost no change in cost which has greatly increased the competitiveness of rail freight. However, railways also face some challenges. Firstly, with the large capacity and low cost, maritime shipping still dominates the trade between China to Europe. Secondly, the railway operation relies heavily on government subsidies which are uncertain in the future. Thirdly, the trade imbalance results in masses of empty containers and lower demand from Europe to China, which will restrain future growth in the years to come. In general, railways have achieved rapid development under the Belt and Road project. However, compared with shipping with a long history of trade, it still lacks certain competitiveness, especially in terms of carrying capacity. It is also possible to improve railway terminals and increase frequency, but it will be a long process to achieve.

4.2 Research on previous studies about the comparison between railway and shipping

According to UNECEU, only 7% of container trade in 2018 took place on land; 62% of it occurred at sea. Lu et al. (2019) want to know if the train service should be stopped. In order to determine the variables impacting the choice of transport modes, they used a land and sea transport spatial (LSTSB) model, from which they concluded that the locations, transport costs, and time costs are the most crucial factors. Furthermore, they use four different scenarios with various influencing circumstances to examine the competition between rail and maritime transportation. The findings indicated that rail transportation has long been underrated and is substantially more competitive than maritime transportation. However, different geographical areas may favor different modes of freight transportation, and this is affected by both economic development and regional preferences.

Zeng et al (2020) analyzed the development potential of the North Sea Route (NSR) in China-EU trade. A route competition has developed between the Suez Canal Route (SCR), NSR, and railroads as a result of the BRI's rapid development of rail transport between China and Europe. In order to estimate the prospective market share of these three modes of transportation, the authors first used a bootstrapped multinomial logit (MNL) model to assess the shippers' purchasing behavior and then employed case studies to observe the development of various transport routes in various areas. The findings showed that the NSR had relatively little appeal, despite the absence of significant competition, primarily due to the limitations of a challenging natural environment. The market share of NSR will now continue to decline as a result of the rapid escalation of competition in the railway system brought on by the development of BRI.

Lian et al.(2020) studied the competition between China Europe Express (CER) and liner shipping in the Sulphur emissions limited environment. After the IMO regulation was implemented, the price of fuel skyrocketed, which drove up transportation costs. To analyze the effects of shipping lines passing on additional fuel costs to shippers, a calibrated model was utilized. The findings show that passing all additional costs onto shippers would not be feasible, and the suggested ratio is between 30 and 40 percent. To boost its own competitiveness, CER should simultaneously boost frequency and cut waiting times. The IMO 2020 Sulphur law and the growth of the CER as a whole will increase its competitiveness and play a significant role in commerce between China and Europe.

The Best-Worst Approach (BWM) method and 63 customer surveys on customers from various regions of China were used by the authors to examine the customers' preferences for CER service. The results demonstrated that lowering costs, shortening turnaround times, and enhancing reliability can all increase customer satisfaction. Additionally, offering a tracking service will boost customer interest in CER. Finally, a distinctive pricing approach that takes into account the variety of needs can help to enhance profit management (Li et al., 2020).

In terms of travel time, expense, and dependability, the authors compared the service quality of Eurasian rail freight with other modes of transportation (air, sea) between China and Europe trade from a shipper's point of view. A trade off model was employed to assess market share and preference. Shanghai and Hamburg were used as examples for the comparison

investigation. The findings revealed that the cost of rail freight is roughly 20% less than that of air and that its transit time is 50% less than that of sea cargo. Additionally, rail fright is an excellent choice for time-sensitive products while having a low value. Finally, rail freight offers a cost-effective alternative for lead times for freight related to production, as opposed to competing with other forms of transportation (Zhang, X. and Schramm, 2020).

Zhang, Y (2021) stated that rail freight is an alternative transportation mode from China to the EU. The rail mode still makes up a small percentage of the trade in comparison to shipping, but its trade volume and value have been growing quickly recently. During the Covid-19 pandemic, Europe's foreign trade declined, and China became Europe's largest trading partner for the first time. Although maritime transport still dominated trade, the shortage of containers caused shipping prices to soar, making rail a good alternative mode of transport.

Yang, Z. et al (2020) compare two modes of transportation, rail, and sea, for exporting containerized cargo from Chongqing to Europe to examine the ease of international transportation, changes in trade volumes, and the impact of the Chongqing Western Europe Express (CSERE) on the development of international logistics centers. The study shows that CSERE has increased the accessibility of trade shipments and that more and more high-value products are being exported to Europe. In order to create an international logistics center, Chongqing needs to attract more high-value factories and inland connections.

VALENTINE (2017) pointed out that maritime and rail transport are often connected in parallel. The railroad has the characteristics of fast timeliness but high price. Although it can sometimes be used for direct transportation, sea freight still occupies a major position due to its low price. Additionally, there are situations when these two forms of transportation work together. A hybrid mode of transportation is used in many places. For instance, the East Coast of the United States needs containers from China delivered faster, so the containers are first transported by railroad to the East Coast, and then by ship to the ports on the West Coast. In general, both modes of transportation have their own characteristics and serve different markets with different needs.

Bínová et al. (2018) compare two different ways of transporting containers by sea and rail between the Czech Republic and China. With a relatively low cost of roughly 3000-4000USD/TEU and a quick connection to seashore places, maritime shipping can offer large capacity, but because of the longer route, the leading time is also longer. Rail freight is a fast means of transportation that can visit many cities simultaneously along the route, but the cost is considerable (about 6000–7000 USD/TEU) and there are significant infrastructure needs in the transit countries.

Using a multi-criteria analysis, Neumann (2021) looks at how different modes of transportation (railway and maritime) affect shipping between China and Poland in terms of cost, duration, number of containers transported, and environmental impact. According to the findings, rail freight may travel more quickly since its routes are shorter; on average, it takes 12 days by railway and 45 days by ship to transport goods from central China to the port of Gdansk. Because the cost of transportation is inversely proportional to the amount of advance time, maritime transportation is more cost-effective. Additionally, sea transportation has the highest capacity of all the modes of transportation. For instance, a container ship from China to Gdansk can carry a maximum of about 25000TEU, which is significantly higher than the capacity of the rail. While at sea, container ships emitted a lot of harmful gases, but this problem can be fixed by using clean fuel instead. Rail is regarded as an eco-friendly mode of transportation, although its capacity is constrained. Despite the qualities of these two modes of transportation, they currently face certain threats. Pirate attacks are a possibility for maritime shipping, and port congestion is another constraint. Due to the involvement of so many nations in the infrastructure, geopolitics poses a serious issue for rail freight.

The author analyzes the competition between rail and sea freight on the Eurasian Continent. As a traditional mode of transportation, ocean shipping has an absolutely dominant position, but because it is extremely sensitive to changes in the external environment, such as typhoons, it will lead to the inability to transport goods in time. In addition to this, maritime transport faces many challenges. For example, if the freight demand of large ships is not matched, the advantage of a lower unit freight rate will be lost. Moreover, the efficiency of loading and unloading will affect the economics of the scale of ships. Rail transport is more reliable but has a very high holding cost. Furthermore, since it passes through many different countries,

different customs clearance methods and charging systems can affect the timeliness of the railroad. In addition to addressing the challenges they face, as market demands continue to change, different modes of transportation must also be changed to better fit the market (SinLessZero, 2018).

Desk News (2018) studied the features of freight railroads and their impact on shipping. The China-Europe freight train is the heart of China's Silk Road and a major component of the Chinese government's BRI. Under the strong support of the government, railway transportation has occupied a market between China and Europe. Although the transportation volume is not as big as that of sea transportation, still provides customers with the option of multimodal shipping. In fact, customers will really benefit from this competition between rail and sea since it will give them more options. Customers transporting high-value and time-sensitive cargo may choose the rail approach, while customers with high volumes may choose the slower but less expensive ocean shipping option. Of course, sea transportation cannot reach the speed of railway transportation, and railway transportation cannot catch up with the carrying capacity of sea transportation. Each of them has particular benefits and drawbacks. In a short period of time, sea transportation will still be the dominant mode of transportation for Sino-European trade. However, in the future, with technological development and progress, rail transport has the potential to pose a real danger to shipping.

4.3 Conclusion of the literature review

Overall, railway infrastructure is a core component of the BRI, which China hopes to use to address domestic steel overcapacity and enhance the RMB's position in the world monetary system, drive inland city development, increase employment, and strengthen ties with the world. For other countries, railroads are capital concentrated and technically supported construction, and without the support of mature domestic inland rail facilities, there will be negative economic impacts due to the gradually increasing competitiveness of their surroundings. Furthermore, maritime shipping also develops in BRI. For example, the "Maritime Silk Road" initiative reduces travel distances and expedites travel times by linking China with Southeast Asia, the Gulf States, North Africa, and Europe.

Shipping was considered the only way to transport large volumes over long distances for centuries (Stopford, 2009). With its high carrying capacity and low price per unit, it has been a transportation leader in the past and even now, however, there are many challenges in sea transportation, firstly it is largely affected by the external environment, for example, last year the Suez Canal was blocked, and many ships were forced to stay for almost a week, leading to serious delays. Secondly, the long shipping time by sea is very unfriendly for some perishable or time sensitive commodities.

Railroad transportation has grown at an incredible rate since the BRI's implementation, providing another option for international trade transit. Rail travel takes almost half as long as sea travel and is less impacted by the outside environment, but because it crosses so many political boundaries, certain processes, like customs clearance, can become more challenging. Additionally, the cost of railroad transportation is high despite the fact that there are already significant government subsidies; however, because of its much lower carrying capacity than that of sea transport, the unit price is relatively high and is better suited for goods with a high value or those that need to be delivered quickly.

Chapter 5. Methodology

5.1 Case study: An integrated cost approach

The case study approach is especially well suited for the adoption of descriptions of pertinent problems, occurrences, or events in their authentic real-life settings when thorough knowledge is required (Crowe et al., 2011).

According to Yin, when "how" and "why" questions are raised, and the discussion questions reflect current events and are applicable to real-world situations, case studies are generally the preferred approach (2003).

In this paper, our research question is about “How will China-Europe rail services compete with traditional maritime shipping in China-Europe transportation under the BRI?” this subject is highly relevant to the real world, therefore, we adopt the case study method here.

Previously, we have discussed the characteristics of shipping and rail transportation, they both have benefits and drawbacks. For a closer comparison of these two transportation methods, we adopt the integrated logistic cost approach to compare shipping and rail transportation through the case studies.

To demonstrate a thorough comparison of the logistics costs of two different means of transportation, rail, and sea, we have chosen to use a forty-foot container (FEU) for the shipping of different values of finished goods from China to Europe as examples in this section.

The selected case studies are shown below:

Case 1. **Zhengzhou – Hamburg**

Transport low value products of $40000

Transportation methods	**Routes**
Shipping	Zhengzhou – Qingdao – Hamburg
Railway	Zhengzhou – Hamburg

Referring to the optimal solution given by the transport company, the cargo is first transported by rail from Zhengzhou to Qingdao and then by deep sea to Hamburg for the shipping method.

Case 2. **Chengdu – Rotterdam**

Transport high value products of $210000

Transportation methods	**Routes**
Shipping	Chengdu – Shanghai – Rotterdam
Railway	Chengdu– Tilburg – Rotterdam

In the maritime freight option, rail travel from Chengdu to Shanghai, and then a vessel travels from Shanghai to Rotterdam. The rail option involves a truck trip from Tilburg to Rotterdam and a rail trip from Chengdu to Tilburg.

5.2 Data Collection

We take into account three aspects of the logistics cost structure of the case studies.

Firstly, the delivery time, including transit time, transport time, and dwell time.

The second category is transportation and handling fees, which include those for pre- and post-haulage, export service fees, freight charges (including BAF and CAF), departure and arrival port handling fees, and customs clearance of paperwork.

Lastly is the time cost of the goods, which includes interest cost, technical and economic depreciation, insurance expenses, container rental fees, and depreciation costs.

We used the average shipment time from Maersk and Shining Ocean, two separate shipping firms, to determine the data for the first portion of the shipping delivery time.

We consulted shipping service provider Cross Ocean and obtained quotes for the second phase of the logistics operation of the shipping for June 2022. (See details in Appendix 1 and 2). The following methods were used to get the remaining data:

- **Technical economic depreciation of goods**

Based on research by Van de Voorde and Blauwens (1988) on the relationship between commodities and the value of time in commodity shipping, we set the Technical Economic Depreciation Goods at 10% of the value of the goods per year.

- **Insurance**

The cost of the insurance was calculated by the agent base on the value of the goods.

- **Leasing cost of a container**

The price for renting a 40ft container is taken from the container leasing company called " TARGET BOX " and set at 4.67 USD per day.

- **Interest rate**

The interest rate was determined by the " Interest calculator " on the European Union website.

Rail has a considerably more straightforward logistic cost structure than shipping when it comes to "transport and handling costs," which include the freight rate, terminal handling fees (THC) for both departure and arrival, the rail fuel surcharge, and custom clearance fees.
All the data for railway transportation in the case studies were provided by a China-European Express Agency in RMB, we converted at an exchange rate of 1 USD equals 6.4 RMB.

Since the value of the commodities will determine the cost of time, we chose a **low-value** cargo shipment of $40,000 for case study 1 and a **high-value** cargo shipment of $210,000 for case

study 2 to analyze the impact of varying commodity prices on the comparison of ocean and rail transport modes.

In the end, we obtained the following complete data as shown in table 2 and 3.

	Shipping(Zhengzhou-Qingdao-Hamburg)	**Railway**(Zhengzhou-Hamburg)
Value container content($)	40000	40000
Time variables (days)		
Transit time to Qingdao	3	0
Transport time to Hamburg	55	25
Dwell time at Qingdao	1	0
End-haulage(including pick-up and delivery)	1	1
Total transit time	60	26
Transport and handling cost (USD per TEU)		
Pre-haulage Qingdao(by train)	668	0
Export service	15	0
Freight rate	10250	9500
THC origin	128	313
THC destination	266	
BAF	Included	0
CAF	Included	0
Rail fuel surcharge($0.1 per km)	0	1021
ISPS surcharge Hamburg	20	0
Documentation fee	110	0
Customs clearance	59	45
Administration fee	20	0

End-haulage by truck(port to warehouse)	201	201
Total transport and handling costs	11737	11080
Time costs goods(USD per TEU)		
Technical economic depreciation goods(10% per year)	658	285
Insurance	157	57
Leasing costs container(4.67 USD per day)	280	500(fixed)
Interest costs(8% per year)	526	228
Total time costs goods	1621	1070
Overall total costs	13358	12150
Percentage of value of goods	33.40%	30.38%

Table 2: Cost comparison for shipping and railway in case study 1

Source : Own compilation

	Shipping(Chengdu-Shanghai-Rotterdam)	**Railway**(Chengdu-Tilburg-Rotterdam)
Value container content($)	210000	210000
Time variables (days)		
Transit time to Shanghai	2.5	0
Transit time to Tilburg	0	23
Transport time to Rotterdam	36	0.5
Dwell time at transit point	1	1
End-haulage(including pick-up and delivery)	1	1
Total transit time	41	25.5
Transport and handling cost (USD per TEU)		
Pre-haulage Shanghai(by truck)	1500	0
Export service	50	0
Freight rate	10030	9500
THC Shanghai	255	313
THC Rotterdam	65	
BAF	included	0
CAF	included	0
Rail fuel surcharge($0.1 per km)	0	1100
ISPS surcharge Rotterdam	20	0
Documentation fee	140	0
Customs clearance	125	45
Administration fee	20	0
End-haulage by truck	201	1211
Total transport and handling costs	12406	12169
Time costs goods(USD per TEU)		

Technical / economic depreciation goods(10% per year)	2359	1467
Insurance	600	293
Leasing costs container(4.67 USD per day)	191	500(fixed)
Interest costs(8% per year)	1887	1174
Total time costs goods	5037	3434
Overall total costs	17443	15603
Percentage of value of goods	8.31%	7.43%

Table 3: Cost comparison for shipping and railway in case study 2

Source : Own compilation

Chapter 6. Case analysis

6.1 Data analysis

6.11 Case 1

Price is the main factor influencing the choice of transportation method for commodities with a relatively low value. The profit margin increases as the cost of logistics decreases. This viewpoint allows us to contrast the costs of railroads and ships. The case in example 1 is depicted in Figure 9. When comparing the costs of the two different modes of transportation, as we can see, there is only a $657 difference between shipping and rail freight in terms of transit and handling costs. For the overall cost, these two modes of transportation account for 33.4% and 30.38% of the total value of the goods respectively, the difference between the two is only 3.02%, but the difference in time costs of goods has reached 51.5%. According to *Statista*, in the normal situation before Covid-19, sea freight is about a quarter of the price of rail, however, the Covid-19 crisis has driven up container shipping prices, eliminating shipping's former low-price advantage. At the same time, there is still a demand for transportation, and the railroad is unable to keep up with the backlog. Container shipping is still in high demand and is hard to come by. To better select an appropriate transport option in the case of such a little difference in transit prices, we need to incorporate other comparison factors.

Figure 9: Comparison of total cost(USD) in case study 1

Source : Own compilation

Another crucial component of the transportation process is the amount of time spent. Saving travel time is valued for maximizing business utility, saving extra time attached to labor, fuel, etc., which is an important way to reduce total expense transportation costs. In addition, for some perishable goods, time is life, and failure to transport to the destination within the shelf life can cause huge losses.

Figure 10 displays the overall time cost of transporting products by both modes and their transit times. First of all, we can clearly see that the total transportation time by rail is about 43% of that by sea and considering the possibility of canal blockage and the impact of the pandemic, this time difference could be even greater. In addition, because of the rail's quick transit time, the total time cost of goods, which includes leasing payments, insurance premiums, and interest costs, is $551 cheaper by rail than by sea. Because of this, rail freight is generally a better option than sea freight for delivering low-value goods that are more sensitive to logistical costs because rail prices are relatively low and the transportation time is short.

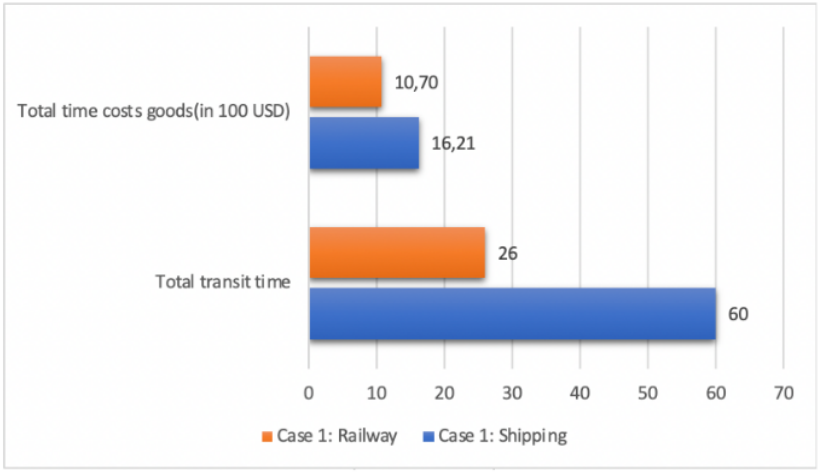

Figure 10: Comparison of total transit time(days) in case study 1
Source : Own compilation

In general, in case 1, the pandemic era is very unfriendly to the transportation of relatively low-value items, because the transportation price accounts for more than 30% of the total value of the items, and shipping, which has always been dominated by the low-price advantage,

gradually losing it, the uncertain external environment also creates the possibility of shipping delays. Given the current circumstances, the railway's competitiveness in the European-Chinese transportation sector has quickly increased due to its relatively cheaper price and quicker transit times than maritime shipping.

6.11 Case 2

In case 2, we take the example of transporting goods valued at around $210,000 to consider which one is more competitive, sea or rail. For higher-value goods, the transportation price may not be the most important element, but it is also a reference indicator that cannot be ignored.

In Figure 11, the cost of shipping by rail and by maritime shipping is shown to be virtually identical (there is only a difference of $237), and the difference between the two modes of transportation in terms of time and products cost has also decreased to 46.68% from 51.5 % in case 1. It is clear that when it comes to higher value goods, the price difference between rail and sea transport is relatively small.

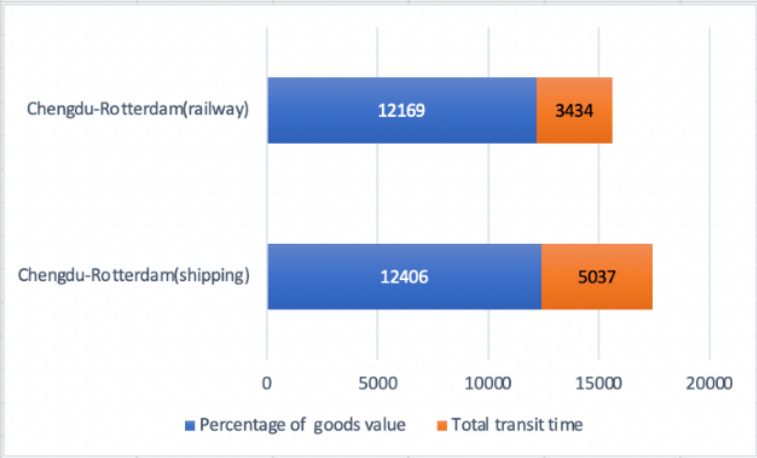

Figure 11: Comparison of total cost(USD) in case study 2
Source : Own compilation

In the case where the shipping price is not significantly different, the shorter shipment time will become a very prominent advantage. We can see from figure 12, that although the time difference between the railway and the sea is not as great as that of Case 1, it has nevertheless reached 60.78%, indicating that the railway is significantly faster than the sea in terms of transportation time.

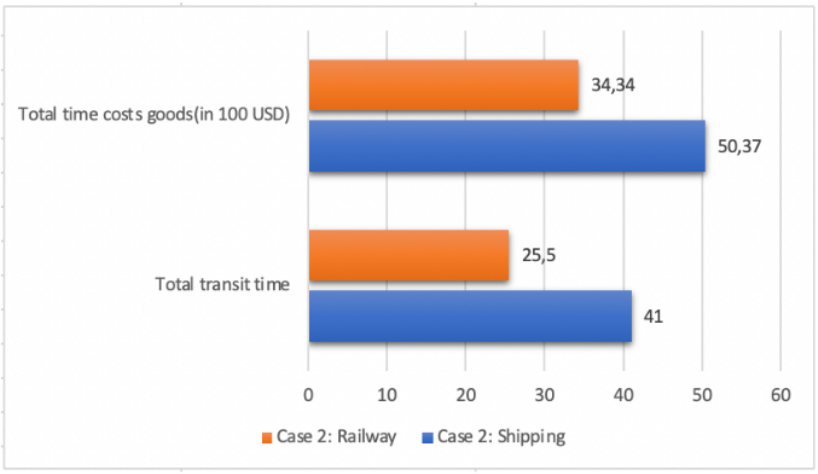

Figure 12: Comparison of total transit time(days) in case study 2
Source : Own compilation

In fact, when we combine the two case studies together, as shown in Figure 13, there is not a significant difference in total freight costs as a percentage of the value of the goods between sea and rail transportation in the current environment of the pandemic and the invasion of Ukraine by Russia, whether it is in the shipment of low-value or high-value commodities. Even in case 2, there is only a 0.88% difference. The benefit of reduced prices of maritime transport is diminishing with time.

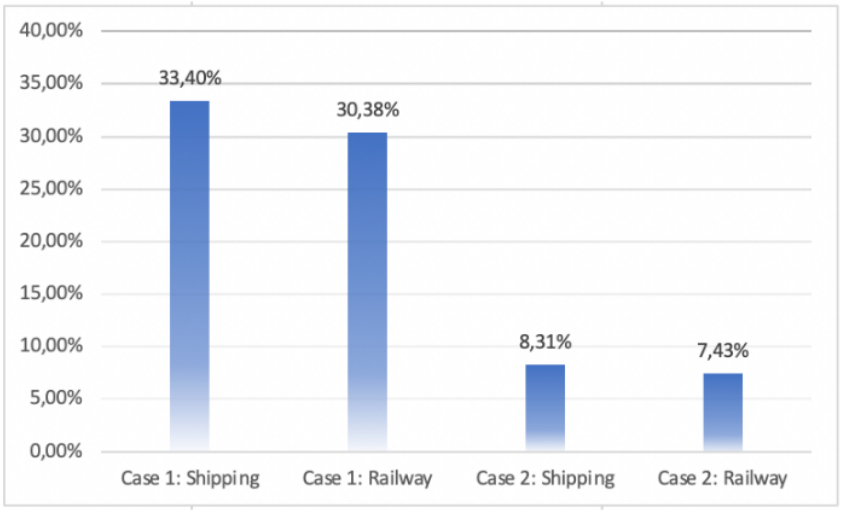

Figure 13: Comparison of logistics costs as a percentage of cargo value in case studies
Source : Own compilation

6.2 Sensitivity analysis

Sensitivity analysis is a mathematical technique used to examine how the level of uncertainty in one part of a model affects the level of uncertainty in the entire model (Indeed Editorial Team, 2021).

Because of covid-19, many things have changed dramatically, as we discussed in Chapter 3, before the pandemic, container ocean freight prices were almost stable at around $2500, including terminal handling fees and surcharges, so the current situation of sea freight rates have been far from the normal track. Similar scenarios apply to rail freight, which is also impacted by outside influences, such as the Chinese government's strong support. In an effort to boost demand and lower operating costs for freight forwarders to raise the likelihood of a rail network connecting Asia with Europe, the Chinese government began financing China-European railways in 2016 (Knowler Greg, 2022). However, according to Railway Supply, the Chinese government will stop subsidizing rail freight to Europe in 2023; as a result, 2022 will be the final year that such subsidies are provided (2022). If it is true as the Railway Supply said, it will have a significant impact on the shipping and rail freight. For this reason, we conduct a

sensitivity analysis on the above two cases here to see the changes in the results when the shipping price drops back to the pre-pandemic level and railway transportation loses government subsidies.

We maintain the current parameters in our shipment scenario and adjust the shipping cost to $2500 in cases 1 and 2. All other parameters were left unchanged for rail freight, but government subsidies were taken out and rail fees were increased. The route subsidies described in the case studies are shown in Table 4. For the two case studies, we increased the rail freight prices by $7,400 and $7,000, respectively. The final data are shown in Table 5 and Table 6.

Routes	Freight Rate(USD/FEU)	Subsidy(USD/FEU)
Zhengzhou-Hamburg	9500	7400
Chengdu-Tilburg	9500	7000

Table 4: Subsidy of routes in case studies

Source: RailFreight

	Shipping(Zhengzhou-Qingdao-Hamburg)	**Railway**(Zhengzhou-Hamburg)
Value container content($)	40000	40000
Time variables (days)		
Transit time to Qingdao	3	0
Transport time to Hamburg	55	25
Dwell time at Qingdao	1	0
End-haulage(including pick-up and delivery)	1	1
Total transit time	60	26
Transport and handling cost (USD per TEU)		
Pre-haulage Qingdao(by train)	668	0

Export service	15	0
Freight rate	**2500**	**16900**
THC origin	Included	313
THC destination	Included	
BAF	Included	0
CAF	Included	0
Rail fuel surcharge($0.1 per km)	0	1021
ISPS surcharge Hamburg	20	0
Documentation fee	110	0
Customs clearance	59	45
Administration fee	20	0
End-haulage by truck(port to warehouse)	201	201
Total transport and handling costs	3593	18480
Time costs goods(USD per TEU)		
Technical economic depreciation goods(10% per year)	658	285
Insurance	157	57
Leasing costs container(4.67 USD per day)	280	500(fixed)
Interest costs(8% per year)	526	228
Total time costs goods	1621	1070
Overall total costs	**5214**	**19550**
Percentage of value of goods	13.0%	48.88%

Table 5: Cost comparison for shipping and railway in sensitivity analysis case study 1s

Source : Own compilation

	Shipping(Chengdu-Shanghai-Rotterdam)	**Railway**(Chengdu-Tilburg-Rotterdam)
Value container content($)	210000	210000
Time variables (days)		
Transit time to Shanghai	2.5	0
Transit time to Tilburg	0	23
Transport time to Rotterdam	36	0.5
Dwell time at transit point	1	1
End-haulage(including pick-up and delivery)	1	1
Total transit time	41	25.5
Transport and handling cost (USD per TEU)		
Pre-haulage Shanghai(by truck)	1500	0
Export service	50	0
Freight rate	**2500**	**16500**
THC Shanghai	Included	313
THC Rotterdam	Included	
BAF	Included	0
CAF	Included	0
Rail fuel surcharge($0.1 per km)	0	1100
ISPS surcharge Rotterdam	20	0
Documentation fee	140	0
Customs clearance	125	45
Administration fee	20	0
End-haulage by truck	201	1211
Total transport and handling costs	4556	19169
Time costs goods(USD per TEU)		

Technical / economic depreciation goods(10% per year)	2359	1467
Insurance	600	293
Leasing costs container(4.67 USD per day)	191	500(fixed)
Interest costs(8% per year)	1887	1174
Total time costs goods	5037	3434
Overall total costs	**9593**	**22603**
Percentage of value of goods	4.6%	10.76%

Table 6: Cost comparison for shipping and railway in sensitivity analysis case study 2s

Source : Own compilation

When we modified the shipping and rail freight rates, we observed a significant difference in the overall costs of the two modes of transportation, as shown in Figure 14. For the transportation of low-value goods, the total shipping cost was only 26.7% of that of rail, and for high-priced goods, sea freight will be slightly more expensive, but it is still significantly less than the railway. In this situation, trains are unfavorable to moving lesser value goods, and as we can see in Figure 15, rail transport costs account for almost half of their own value, which will drive some of the low-value products out of the market because they can't sustain a higher price. For high value goods, however, freight charges for the two modes of transportation are 10.8% and 4.6% of the good's value, respectively. While there is a difference, because of the high value of the product, the effect is not as noticeable as it is with low-value goods.

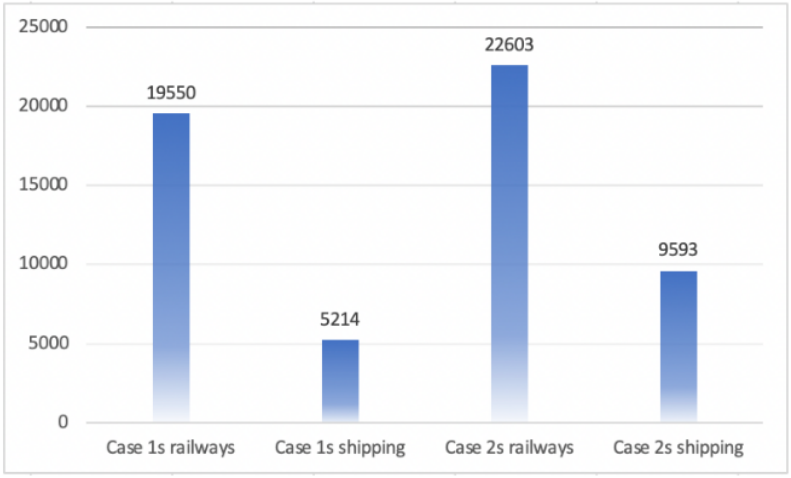

Figure 14: Comparison of total cost(USD) for sensitivity analysis case study 1s and 2s

Source : Own compilation

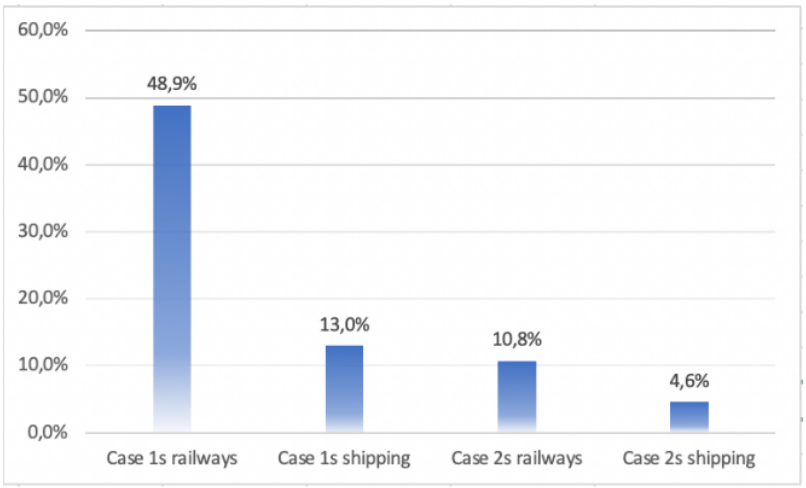

Figure 15: Comparison of percentage of goods value for sensitivity analysis case study 1s and 2s

Source : Own compilation

Shippers of low-value goods will have very few options if the Chinese government does decide to end its support for the China-Europe railway, and the majority will choose sea shipping even though it takes longer to deliver. The vast price disparity between them will affect their competition as well. When carrying items that are not time-sensitive, shippers would most likely go for inexpensive ocean freight, and rail transport can only stay in business by attracting high-value and time-sensitive goods.

In addition to transport costs, shipping is much higher than rail transport in terms of transport volume. According to Sohu News, the annual container throughput of Chinese ports in 2020 was 264.3 million TEUs, and the China-European Liner sent 1.135 million TEUs of cargo, which is only four-thousandths of the port's container throughput, so in the case of transporting a large number of commodities, maritime transport may be more competitive (Mei, 2021).

Chapter 7. Conclusion and future research

7.1 Research conclusion

In this study, we assessed the competitiveness of rail and sea transport between China and Europe by comparing the logistics costs of these two modes of transport in the context of the Belt and Road initiative through a case study. Two goods of different values were chosen to see how the value of the goods affected the results. In the end, we arrive at the following conclusions:

A. In the present environment, following the pandemic and with sea freight prices at an all-time high, rail transport can provide twice as quick delivery times as sea freight and at prices that are comparable to sea freight. In this situation, rail appears to be more competitive than sea freight on the market.

B. Due to a number of external factors, marine pricing has seen remarkable variations, while government subsidies have helped rail transit expand so quickly. We wanted to know how competitive maritime, and rail are under normal conditions, so we conducted a sensitivity analysis of two cases. The findings indicate that under normal conditions, the low-cost advantage of sea freight is very apparent, whereas when the railway loses government subsidies, the high-cost will exclude many low and medium-value items and can only attract some high-value or more time-demanding items, so the advantage of sea freight will be more noticeable in such situations.

C. Since the implementation of the Belt and Road project, it has indeed greatly facilitated rail transport between China and Europe, especially during the special period of the pandemic, the railway has leaped to become a strong competitor to maritime transport, however, in terms of carrying capacity, maritime transport still has an unshakable position, perhaps the railway will gradually increase its carrying capacity afterward, but for the time being, it still cannot compete with maritime transport.

D. In the long run, sea freight prices will not remain so high, and when things return to normal, they should fall, thus further strengthening the competitiveness of sea freight in Central Europe.

7.2 Limitations of this study

Through this study, we have seen the respective competitiveness of sea and rail in China-Europe container transportation, and at the same time, we have also seen some limitations of this paper.

Firstly, because of the length of the article, we only chose two cases for analysis, which could result in limited results evaluation. Additionally, the data selection in the case analysis might differ depending on the commodities and shipping service providers, which haven't been taken into consideration.

Secondly, we discussed the case of railways without government subsidies in the sensitivity analysis, but we did not take into account the potential of other investment subsidies, which may also have limitations in the interpretation of the results.

Lastly, although we changed the freight factor for the sensitivity analysis, it might be meaningful to conduct additional analysis by changing other variables, such as the transport time, which is affected by outside factors. Investigating how this affects the outcomes when the time factor is uncertain is a worthwhile direction to take.

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Appendix

Appendix 1 : Shipping data for case 1

Cheapest | Direct Carrier Booking

Ocean | Est.**55 days** (55 days port-to-port)

Est. Arrival: Aug 03, 2022 | 11:00 PM (UTC) → Est. Departure: Jun 09, 2022 | 06:00 AM (UTC)

CNTAO — — DEHAM

twill Twill by Maersk ★★★★★(4)

$10,986[19]

Book on Twill

Cut Off: Jun 07, 2022 03:00 PM (UTC)

Origin charges

Fee code	Fee name	Comment	Units	Unit price	Amount
ODF	Documentation Fee Origin	-	1	$67.44 USD	**$67.44**
OHC	Terminal Handling Service - Origin	-	1	$128.29 USD	**$128.29**
EXP	Export Service	-	1	$14.99 USD	**$14.99**

CNTAO > DEHAM

Fee code	Fee name	Comment	Units	Unit price	Amount
PSS	Peak Season Surcharge	-	1	$2,000.00 USD	**$2,000.00**
EFF	Environmental Fuel Fee	-	1	$653.00 USD	**$653.00**
LSS	Low Sulphur Surcharge	-	1	$15.00 USD	**$15.00**
BAS	Basic Ocean Freight	-	1	$7,582.00 USD	**$7,582.00**

Subtotal: $10,250.00 USD

Destination charges

Fee code	Fee name	Comment	Units	Unit price	Amount
DDF	Documentation fee - Destination	-	1	$42.63 USD	**$42.63**
DHC	Terminal Handling Service - Destination	-	1	$266.44 USD	**$266.44**

Customs Brokerage

twill

Fee name	Comment	Amount
Import Customs Clearance	Per Bill of Lading	**$59.24**

Subtotal: $59.24 USD

Insurance

XCOVER.COM

Fee name	Comment	Amount
Transport Insurance (based on goods value of USD 40000 and initial freight costs)	-	**$157.16**

Appendix 2 : Shipping data for case 2

Best value

Ocean | Est.**31-37 days** (25-35 days port-to-port)

CNSHA — — NLRTM

Shining Ocean ★★★½☆(117)

$11,730[52]

Select

Gate-in by: May 31, 2022

Origin charges

Fee code	Fee name	Comment	Units	Unit price	Amount
ODOC	Documentation Charges at Origin	Flat Fee	1	$75.00 USD	**$75.00**
OCCF	Export Customs Clearance	Flat Fee	1	$50.00 USD	**$50.00**
OTHC 40'	Terminal Handling Charge at Origin	Per Container	1	$255.00 USD	**$255.00**
AMS	Automated Manifest System	Flat Fee	1	$30.00 USD	**$30.00**

CNSHA > NLRTM

Fee code	Fee name	Comment	Units	Unit price	Amount
OCEAN 40'	Ocean Freight Cost	Per Container	1	$10,000.00 USD	**$10,000.00**
HDL 40'	Handling Charges	Per Container	1	$30.00 USD	**$30.00**

Subtotal: $10,030.00 USD

Destination charges

Fee code	Fee name	Comment	Units	Unit price	Amount
D-LOCAL 40'	Local Charges at Destination	Per Container	1	$350.00 USD	**$350.00**
DDOC	Documentation Charges at Destination	Flat Fee	1	$65.00 USD	**$65.00**
DTHC 40'	Terminal Handling Charge at Destination	Per Container	1	$65.00 USD	**$65.00**

Customs Brokerage

Fee name	Comment	Amount
Import Customs Clearance	Flat Fee.	**$125.00**

Subtotal: $125.00 USD

Insurance

XCOVER.COM

Fee name	Comment	Amount
Transport Insurance (based on goods value of USD 210000 and initial freight costs)	-	**$599.72**