Erasmus University Rotterdam

MSc in Maritime Economics and Logistics

2020/2021

The Impact of US Reshoring on Container Shipping Market

by

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Acknowledgments

This thesis would not have been completed without the guidance and support of Professor Ted Welten, to whom I would like to express my sincere gratitude.

A special thanks to StuNed Scholarship Program for giving me the opportunity to study in the Kingdom of the Netherlands.

I dedicate this thesis to my parents, Catharina Rita Kurniati and FX Denny Hermanto, and to my sister, Anastasia Faradina Srikandini.

My greatest gratitude goes to my father Jesus Christ for making all this possible.

"With man this is impossible, but with God all things are possible"
Matthew 19:26

The best view comes after the hardest climb.

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Abstract

Since the end of 2008 crisis, the United States (US) has begun to consider the value of reshoring some of its essential manufacturing industries. Rising labour wages and rapid developments in automation have slowly erased competitive advantages in low-cost manufacturing countries. Supply chain disruptions caused by COVID-19 further undermine the economic integration and reinforce relocation and reshoring trends. However, relocating the manufacturing back to the US will cause a significant change on the global supply chain. This will not only change the manufacturing location but also transform the maritime shipping. The scenario of US reshoring from China and other Asian countries will potentially reduce the trade of intermediate manufactured goods and demand for containership capacity in the Trans-Pacific route.

Therefore, this thesis identifies the implications of the US reshoring to the demand of containership capacity in Trans-Pacific route and how it affects the global container shipping market. The thesis produces a model to simulate the scenario of US reshoring and the response of the shipping market to the changing demand. In developing the model, we apply Stopford’s Shipping Market Model with the theory of Shipping Cycle and System Dynamics approach. We run the simulation over twenty years period with a set of independent and dependent variables based on 2018 container trade and active merchant fleet data as a basis point. The model simulation forecasts the development of four market segments of container ship: Feeder, Panamax, Neo-Panamax, and Ultra Large Container Vessels (ULCV).

The result of model simulation suggests that the reshoring scenario causes significant implications for the container shipping market. The simulation shows that container trade in the Trans-Pacific will decline, while other trade routes indicate positive growth, especially for intra-regional trade. The different trade developments on each route also influence the demand of containership capacity. The simulation demonstrates how shipping investors adjust their capacity to the changing demand. As a result of US reshoring, the simulation predicts that Feeder segment will overtake Neo-Panamax as the segment with the largest fleet size.

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List of Abbreviations

AI – Artificial Intelligence
CPS – Cyber Physical System
IoT – Internet of Things
MIR – Manufacturing Import Ratio
OECD – Organization for Economic Co-operation and Development
TEU – Twenty-Foot Equivalent Unit
ULCV – Ultra Large Container Vessel
UN – United Nations
UNCTAD – United Nations Conference on Trade and development
US – The United States of America

Chapter 1: Introduction

1.1. Background

Three decades ago, many US producers began manufacturing and sourcing in China to reduce costs (Bossche, 2020). Low labour cost became the main consideration for US manufacturers to offshore their production, not only in China but also to many other low-cost-countries in Asia. The development of global containerization has made the delivery of manufactured goods cheap and reliable, thus makes the total cost of offshoring more competitive than producing in US.

However, COVID-19 pandemic revealed the unprecedented weakness of global supply chain. During the first outbreak in China, countries all over the world were experiencing shortages of supply. China has become a primary producer of high value products in the global trade, any disruption in the country will directly lead to greater disruption in the global supply chain. Over the last decade, the global dependence on Chinese intermediate inputs has grown exponentially (Friedt, 2021). According to the US Census Bureau (2021) China shared the largest proportion of US total imports, accounted for 18.1 percent in 2019.

Supply chain disruptions caused by COVID-19 further undermine the economic integration and reinforce relocation and reshoring trends (Fortunato, 2021). Before COVID-19, industry 4.0 have also provided greater possibility of reshoring. Automation is expected to reduce the reliance on low skill labour in manufacturing and therefore reduce the benefits of offshoring. In addition, dramatic rising wages in China has also reduced the attractiveness of its labour advantage.

US-China trade war fuels the idea of bringing back manufacturing to US soil even further. Kearney's seventh annual reshoring index (2020) revealed the fell of US Manufacturing Import Ratio (MIR) from 13.1 percent in 2018 to 12.1 percent in 2019. This is the largest imports decline since 2011. The sum of all manufactured imports from Asia decreased by 7.0 percent, from 816 billion USD in 2018 to 757 billion USD in 2019 where China contributed the highest decline of 17 percent (Bossche, 2020).

The decline of US imports from Asia was also captured by the container trade data on Trans-Pacific route published by the United Nations Conference on Trade and Development (2021). The container trade in Trans-Pacific has dropped since 2018. From 28.2 million TEU, it decreased to 26.8 million TEU in 2019 and declined further to 25.1 million TEU in 2020. Nevertheless, the Trans-pacific remain the busiest trade route followed by the Asia–Europe and Transatlantic route.

The scenario of US reshoring influenced by the increasing tension of US-China trade war and a rising concern about protectionism and supply chain resilience as a result of COVID-19 crisis potentially affect the container trade in Trans-pacific route. Currently, the deployment of containerships in Trans-pacific route is dominated by Neo-Panamax vessels (Clarkson Research, 2020). According to Stopford (2009), "shipping is about sea transport, and the main purpose of the shipping cycle is to adjust the fleet to changes in the volume and composition" (p.170). Therefore, in the future, US reshoring scenario followed with the decreasing of US imports and exports volume will likely change the demand of fleet capacity and composition globally.

The thesis comes up with the aim to identify the implications of US reshoring to the demand of container fleet capacity in Trans-pacific route and how it would affect the global container shipping market considering the cyclicality behaviour of the market. The research will be a valuable input for shipowners as they need to assess the direction of shipping markets in both long and short term and to adjust their fleet size in order to avoid over-capacity in the future. Since there has not been any model developed for determining the impact of reshoring on the container shipping markets, this research would also be a contribution to academic learning.

1.2. Research Question

The objective of this thesis is to produce a model for identifying the implications of US reshoring on the global container shipping markets: supply, demand, and market equilibrium of four different segments of containership (Feeder, Panamax, Neo-Panamax, and ULCV). We expect the decrease of US imports and exports volume in intermediate manufactured good as a result of reshoring from China and other Asian countries will reduce the demand of containership capacity in the Trans-Pacific route and trigger changes in the fleet composition of global container shipping market.

This objective leads to the following research question:

"How does US reshoring scenario in relocating manufacturing from China and other Asian countries affect the four different market segments of containership?"

The sub-questions below provide details for the main research question:

1. How does the US identify potential manufacturing sectors to relocate from China and other Asian countries in their reshoring scenario?
2. What is the impact of US reshoring scenario to relocate manufacturing from China and other Asian countries to the change of US total imports and exports value?

3. How does the change in US imports and exports affect the deployment of four different segments of containership in Trans-pacific route?
4. How does the cyclicality of shipping market response to the change of seaborne container trade pattern in trans-pacific due to the scenario of US reshoring over the next twenty years?

1.3. Approach

Both qualitative and quantitative approach will be used to answer our main and sub-research questions. Economic analysis will be used to assess the impact of US reshoring on the US total imports and exports volume. We will first identify the list of potential manufacturing sectors based on the reshorability index from the previous studies on US reshoring scenario. Data research derived from the UN Comtrade and World Bank will be performed to determine the list of US trading partners from Asia and to analyse the implication of reshoring on the US trading value. Furthermore, the net effect on the US exports and imports container volume will be analysed, followed with a discussion on how the reshoring scenario will affect the deployment of containership in Trans-Pacific.

In order to answer the last sub research question, we will use Stopford's Shipping Market Model with the theory of Shipping Cycle and System Dynamics approach to model the response of shipping market to the reduced demand of containerships capacity in the Trans-Pacific route. The analysis is conducted based on the assumption of 5.0 percent annual reshoring scenario over the next twenty years. The model will forecast the market condition of four containership market segments: Feeder, Panamax, Neo-Panamax, and ULCV, based on data of active merchant fleet, orderbook, seaborne trade, and the scenario of US reshoring. Set of independent and dependent variables to be used in the model will be determined.

1.4. Structure

This thesis comprises eight chapters, i.e., Chapter 1 - Introduction, Chapter 2-4 - Literature Review, Chapter 5 - Theoretical Framework, Chapter 6 - Methodology, Chapter 7 - Analysis and Result, Chapter 8 - Discussion and Conclusion.

Chapter 1 explains the background and relevance of this thesis, lists out the research question and sub-research questions. It briefly describes what approach will be used to analyse the problem. This chapter also presents the overall structure of the thesis and the expected benefits of the research.

Chapter 2 contains relevant literature related to the reshoring phenomenon and factors that reinforce the trend. It discusses recent cases which support the idea of reshoring such as COVID-19 crisis, US-China trade war, industry 4.0, and rapid wage growth in China.

Chapter 3 provides answers for sub-research question 1 and 2 by assessing the scenario of US reshoring and the outcome on US total imports and exports. It discusses US reshoring initiatives and trade policy as well as the US government effort towards revitalization of its manufacturing industries. It also reviews the previous studies on reshoring index and the targeted manufacturing sectors. The economic analysis is conducted in order to estimate the net effect of reshoring on US total trades.

Chapter 4 explains how reshoring scenario will reduce the US exports and imports container volume and further affect the deployment of containership in Trans-pacific route, which answers sub-research question 3. This chapter discusses the current container shipping market including the fleet composition in major trade routes.

Chapter 5 presents the theoretical framework based on literature studies. This chapter discuses Stopford's Shipping Market Model and the characteristic of shipping cycles to explain the corelation between the US reshoring scenario and the implication on global container shipping market. It lists out the problem description and variables used to develop a model for identifying the implications of US reshoring to the four different segments of containership market. Furthermore, this chapter explores the system dynamics in shipping and how this approach can improve shipping market model.

Chapter 6 explain the methodology of the research. It presents the data collection used in the model, the determinants, and other necessary assumptions. By the end of this chapter, problem formulation and model equation will be presented.

Chapter 7 analyses the result arising from the model. The expected result from the model is the dynamic of container shipping market in the next twenty years which cover supply, demand, and market equilibrium of four different segments of containership.

Chapter 8 compares the market conditions among the different segments in order to draw conclusion about the overall container shipping market in the next twenty years. It discusses the main findings and applicability of this model from the theoretical and practical perspective. At the end, it summarizes the result of this study and provide directions for future research.

Chapter 2: The Shift towards Reshoring

2.1. Introduction

In this chapter, we explain the evolution of manufacturing and world trade, from Fordism to the emergence of the global value chain and trade in intermediate products. Furthermore, we discuss the phenomenon of reshoring and factors reinforcing the trend, detailing recent cases that support the idea of reshoring, such as rapid wage growth in China, industry 4.0, US-China trade war, and the COVID-19 crisis.

2.2. Global Value Chain

According to World Trade Statistical Review (2019), more than half of world trade in goods consists of intermediate products which are mostly exchanged within international production system of global value chain. The American economist, Wilfred Ethier, described this concept as part of intra-industry trades which are trade flows of intermediate manufactured goods from one producer to another (Marrewijk, 2012). This concept confirms David Ricardo classical theory of comparative advantage where each economy specializes in certain products, and then exchange those products. Intermediate goods, by definition, are semi-finished goods used as inputs in the production of final goods (O'Sullivan & Sheffrin, 2003). International trade in intermediate manufactured goods has emerged since 1970s and has grown strongly over the past decades (Franco-Bedoya & Frohm, 2020).

The rise of global value chain and intermediate manufactured goods trade were triggered by the adversity of the previous manufacturing system. In the early twentieth century, the world was introduced to the new system of mass production known as Fordism. American leading automobile manufacturer, Ford Motor Company, first popularized a tailored manufacturing system where standardized cars are assembled using moving assembly lines of dedicated machineries and semi-skilled labour in centralized factories (Jessop, 2021). The large profits were coming from the production of a high volume of standardized output. Ford made everything they needed for their cars from the raw materials. His mass production techniques help them achieve substantial economies of scale by producing everything themselves (Thompson, 2021).

However, Fordism had to enter crisis in 1970s when the price of primary commodities rose unfavourably along with the growth of total labour costs, resulting in the worsening of the capital per product ratio and the slow-down productivity (Lipietz, 1997). The inflexibility of Fordism manufacturing concept which rely on dedicated production line was no longer viable to address the uncertainty of demand and fluctuated input costs. Capitalist hesitated to invest in fixed-cost special purpose machineries that cannot sustain long production runs

(Pietrykowski, 1999). This triggered the evolution from Fordist mass production to Post-Fordist systems of flexible specialization. Since then, the popularism of Fordism has declined and the Post-Fordist approach to production organization has emerged.

Post-Fordist offers lean and high-performance production system focusing on flexibility. The search for economies of scale also introduced the internationalization of productive processes (Lipietz, 1997). This concept divides production processes into separate components that can be performed in various locations and by various entities, each specializing in a particular stage of production. Fordist countries also increasingly sought ways to overturn the growth of labour cost by sub-contracting production to non-Fordist countries, placing particular emphasis on the capital-labour relation. In these diversified production chains, the capital-intensive stage of production is conducted mainly in the industrialized, capital-rich economies, while the labour-intensive stage of the production process is conducted in the developing countries, where labour costs are lower (Kohler, 2004).

The production fragmentation provides an opportunity for producers in less developed countries to expand their market and supplying large firms abroad. Becoming part of the global production chains is an opportunity for developing countries to boost their economic growth by taking advantage of their natural resources, workforce, and specialized skills (World Trade Organization, 2019). There are two known types of participation in the global value chain: backward and forward participation (OECD, 2015). Backward participation means that the countries import intermediate goods as inputs to produce and export the final manufactured products. Meanwhile, forward participation applies when countries export intermediate goods to foreign partners that will involve in the later stages of production.

The development of sea transportation also play an important role in facilitating the trend of global value chain. Manufacturer must ensure that the costs of transporting intermediate manufactured goods and sending finished products back are lower enough to meet the expected profit. Therefore, shipping is considered as an integral part of the value generation process in the global production network (Rodrigue & Hesse, 2006). Rapid growth of containerization in early 1990s has changed the scale and scope of global freight which enabled greater velocity in freight distribution with larger quantity of space and at the same time, lower cost (Rodrigue & Notteboom, 2015). It has successfully helped boost offshoring and international production system even further.

As shown in the Figure 1, the value of intermediate goods trade within the global value chain has always been increasing from time to time since 1988. According to the World Trade Organization (2019), the value of intermediate goods exports has reached 57 percent of total world trade in 2015. Asian economies have become major players in global value chains showing the highest growth rate in the participation to the total value of intermediate goods trade.

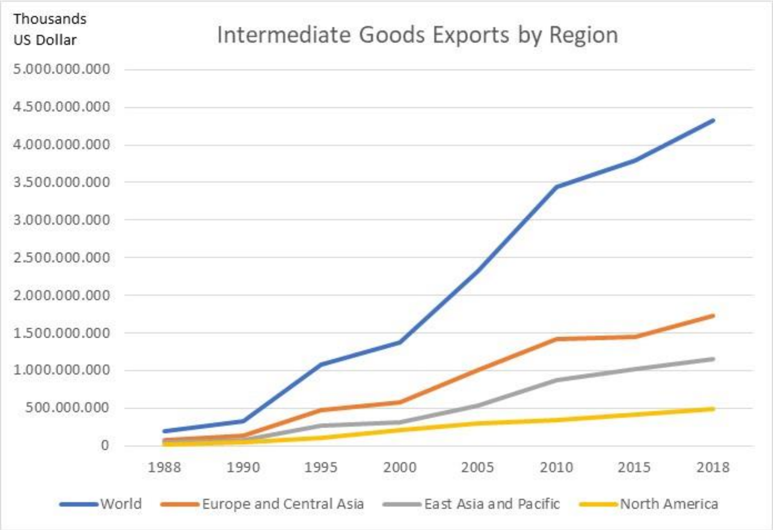

Figure 1. Intermediate goods exports by region from 1988 to 2018
Source: Compiled by author based on WITS, 2021.

China has become the primary destination for offshoring since it declared economic reform in 1978 (Morrison, 2019). China experienced a real boom in international trade and all the major multinational manufacturers turned their attention on the country, including the US. China's opening up provided the world with an offer of millions low-skilled labour, able to perform manufacturing jobs at a really low cost. The government incentivized foreign companies to invest in the country by granting them many facilitations. Countries from all around the world started to invest in China, mainly offshoring the low-value-added activities of their value chains (Ercolanetti, 2021). Having joined the World Trade Organization in late 2001, China demonstrated its commitment in facilitating free trade resulting in more of foreign direct investment coming to the country.

Figure 2 shows a comparison of China's share in the export and import of intermediate manufactured goods between 2000 and 2018. China’s contribution in the global value chain increased more than double in term of intermediate goods imports, rising from 4.1 percent to 9.4 percent. The shares of Chinesse intermediate goods exports also increased significantly from 5.49 percent to 9.7 percent. In contrast, the US shows the decrease of intermediate goods exports share, from 15.05 percent dropped to 11.19 percemt. The same happened to US intermediate goods imports share, decreased from 11.53 percent to 8.75 percent, placing US in the second position after China.

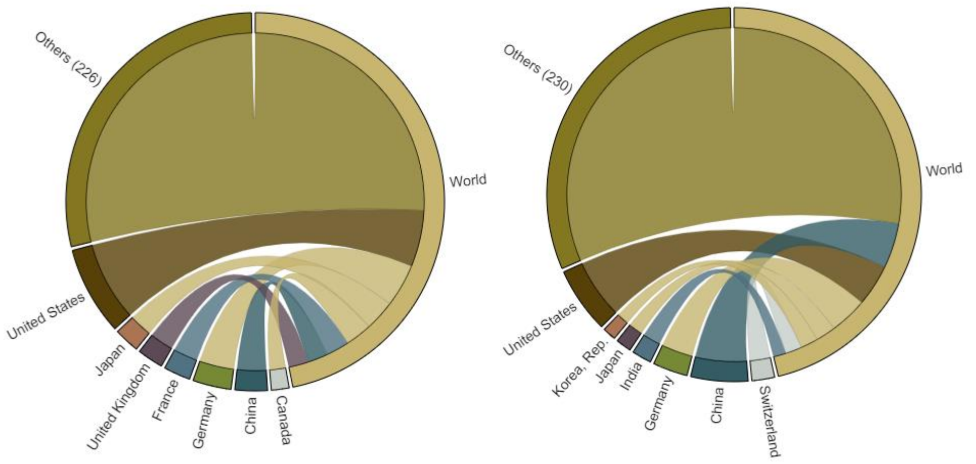

Figure 2. Country shares in intermediate goods trade in 2000 (left) and 2018 (right)
Source: WITS, 2021

Interestingly, most of China intermediate good exports are going to the US and most of China intermediate good imports are also coming from the US. Hence, It can be concluded that the US has involved China more and more in their global production network, where China has contributed both in backward and forward participation in the last three decades. Although Canada remain the US largest trading partner in intermediate goods, the share of China has been rapidly growing, while imports from Canada tend to slowly decrease.

The number of US imports of intermediate manufactured goods from China continued to increase significantly and steadily from 1991 to 2018. Along with the growth of imports from China, imports of intermediate manufactured goods from Mexico also shows a steady increase even though the acceleration pace was not as high as China. On the other hand, US imports of intermediate goods from Canada have been stagnant since 2005.

Figure 3. US Intermediate Goods Imports by Trading Partners
Source: Compiled by author based on WITS, 2021

2.3. Reshoring Phenomenon and Contributing Factors

Despite all of the advantages, there are also downsides from offshoring production to low cost countries like China. The main reason why US producers began manufacturing to China is certainly cost. However, the US-China Trade War exposed the second dimension into the equation, higher tarrifs imposed by both countries is increasing the risk of supply chain disruption. The latest, Covid-19 brings a third dimension into the equation, resilience (Bossche, 2020).

According to Thomas Survey (2021), many US companies begin to realize the risk of manufacturing overseas and are now considering to end their reliance on manufacturing abroad. The shifts toward reshoring is likely to accelerate rapidly in the coming months and year. Based on the survey, 49 percent agreed or strongly agreed that the benefits of onshore production outweigh the higher labour costs. As much as 47 percent said their company will strive to diversify its supply chain over the next three years to reduce dependence on a single country source or manufacturing location, while 41 percent said they will specifically strive to reduce dependence on China for manufacturing.

In line with the survey, UNCTAD (2021) also revealed data showing the total trade of intermediate manufactured goods in 2019 significantly declined, while the total trade of consumer products still grew. This confirms that the shift toward reshoring holds true. Intermediate products contributed close to 8 trillion USD in the total trade value, with consumer products accounted for 4.8 trillion USD. The total trade value between US in China has also dropped significantly from 683 billion USD in 2018 to 579 billion USD in 2019 according to UN Comtrade Database.

Figure 4. Trade in Goods by Stage of Processing and Broad Category
Source: UNCTAD, 2021

We might suggest that the rising tension of US-China trade war contributed to the decline of intermediate goods trade in 2019. However, there was already growing evidence that businesses themselves were reconfiguring supply chains long before US-China trade war and COVID-19 pandemic (Lund, et al., 2019). According to McKinsey (2019) the factors responsible for reinforcing the reshoring trends include rising wages in China and the advancement of technology in manufacturing. In 2014, Kearney published the survey regarding reasons for reshoring. According to the survey, the top reasons of reshoring are the improvement of delivery time, quality, and cost. Cost itself consists of total cost of ownership, freight cost, and wage cost (Bossche, 2014).

2.3.1. Rising Wage in China

Lower wage cost is the main determinant factor in company's decision to offshore their production from the US. However, according to Business Climate Survey conducted by The American Chamber of Commerce in China (2019), rising wages has now become a major challenge for businesses to keep investing in China. The decline in China’s working age population may have caused the rapid rising wages in the country. In each year from 2013 to 2015, businesses cited rising labour costs as their top priority issue. In the latest Business Climate Survey carried out in 2019, 56 percent of US firms in the survey still pointed out rising labour costs as their largest concern.

China’s average monthly wages rose by 263 percent from 2007 to 2018. The average monthly wages have dramatically increased from 55 USD in 1990 become 990 USD in 2018 (Morrison, 2019). According to data from China's Ministry of Labour and Social Security (2018), between 2000 and 2015, the average wage bill in China's manufacturing sector increased at a rate of 13.3 percent, almost six times the overall inflation rate. In contrast, wage of manufacturing workers in the US increased only at a 2.8 percent annual rate during the same period, or 0.6 percentage points faster than growth in consumer prices (Department of Commerce United States of America, 2018)

Moreover, there is also a continuously improving ratio of labour output per labour cost in the US, making it more attractive for US firms to reshore. In 2016, the unit labour costs in the US are 6.0 percent below their level 16 years ago (Department of Commerce United States of America, 2018). Before the recession, unit labour costs in US even decreased by nearly 20 percent, showing that productivity rose faster than labour costs. China, on the contrary, the wage increase has outpaced its labour productivity growth resulting unit labour costs in 2016 almost three-time times higher than in 2000.

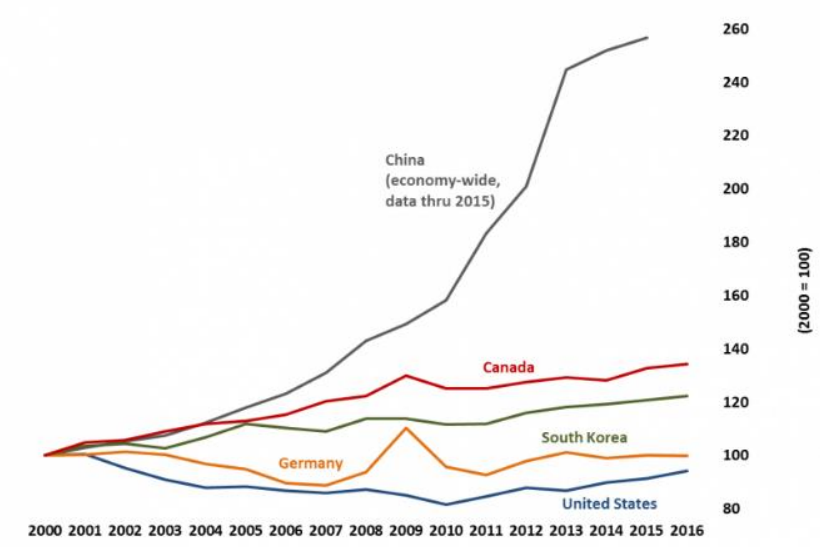

Figure 5. Unit Labor Costs in the Manufacturing Sector of Selected Countries, 2000-2016
Source: Department of Commerce United States of America, 2018

In addition to the increasing labour costs, there are several labour markets factors that also become important elements to reconsider reshoring. The Economist Intelligence Unit (2018) assess several labour-market factors that are likely to disrupt business operations, such as the power of labour unions, historical issues of labour strikes, restrictive labour laws, and the risk of finding skilled labour. The result of the assessment is presented into an overall score from 0 to 100, with 100 reflecting the highest risk to business profitability. As of April 2017, the US categorized within the lowest risk area together with Switzerland and Hong Kong with the score below 20. Japan and many European countries positioned in the second lowest risk category. Surprisingly, China came in relatively high in terms of labour risk, posting a score of 57.

Although the current labour costs in the US are still higher than China, the US Reshoring Initiative predicts that factors like lower transportation costs and quicker inventory turns can offset higher labour costs to make reshoring less expensive (Maul, 2020).

2.3.2. Industry 4.0

Industry 4.0 is the fourth industrial revolution which enables autonomous manufacturing cells to independently control and optimize production process using the combination of multiple technologies, such as Cyber Physical System (CPS), Internet of Things (IoT), Artificial Intelligence (AI), robotics/automation, big data analytics, and cloud computing (Thoben, Wiesner, & Wuest, 2017). Industry 4.0 is believed will improve the quality of manufacturing processes, products, and after production services (Souchet, 2021).

The main advantage of intelligent manufacturing processes is the ability to self-regulate and self-control without having much of human involvement (Mandal & Sarkar, 2012). Industry 4.0

provides the reliability of running various steps of production without requiring human analytics and intervention. Consequently, we will expect the dramatic reduce of labour demand in manufacturing when more firms are applying industry 4.0 in the future. Literature shows that industry 4.0 will lower the need for low-cost labour (Laseur, 2019).

According to McKinsey (2019), several renown global manufacturing firm have fully implemented industry 4.0 while around 70 percent of US companies have already started the pilot project. They agree that not only the technology has significantly reduced the need of labour time, but it is also increased the productivity. TATA co-developed an end-to-end visibility solution in two assembly plants of a Swedish industrial tools and equipment manufacturer. The results of this solution were a 30 percent efficiency gain in product planning and a reduction in subassembly work in progress time from three days to four hours.

Furthermore, full automation allows lean manufacturing concepts which generate less error and waste as automated processes will strictly follow the highly standardized manufacturing steps. Ford proves that the use of sensor-based quality control in industry 4.0 is creating better result than human inspection. The technology has also successfully reduced waste by minimizing the refining of defective parts by detecting defects early and enabling rework to happen even sooner. After introducing this completely automated vision-based inspection system, Ford saw a decrease in inspection time and 90 percent improvement in defect detection compared to human inspection (Mckinsey, 2019). Reduce inspection time also happen to Samsung which uses 3D vision scanning for LCD panels quality control. Changing to a sensor-based in-line inspection increased the speed of the inspection process from minutes to less than one second per screen. Samsung significantly reduce the number of quality issues also reduce the need for labour-intensive and inefficient rework areas.

The McKinsey report (2019) suggests, because of the higher utilization of manufacturing automation, labour cost was reduced by 80 percent and higher process efficiency and quality were reached. In addition to the reduced labour costs and higher productivity, industry 4.0 is also expected to generate lower energy consumption (Laseur, 2019) .Energy is one of the costs related drivers that contribute to reshoring. McKinsey’s recent research with the World Economic Forum (2019) estimates the implementation of industry 4.0 has possible value creation at around 3.7 trillion USD in 2025.

Therefore, Rapid developments in industry 4.0 have slowly erased competitive advantages in low-cost manufacturing countries and decrease the benefit of offshoring (Laseur, 2019). When labour costs are continuously rising in China and many developing countries, industry 4.0 will continuously reinforce the decision of reshoring by US manufacturers.

2.3.3. US-China Trade War

China is currently the largest trading partner of the US, it is the largest US merchandise trading partner, biggest source of imports, and third-largest US export market (Morrison, 2019). However, the trade relation between the two countries is recently being strained. It was all started in 2015 when the Chinese government announced to upgrade and modernize their manufacturing in several key sectors. Through some extensive government initiatives, China sets target to become a major global player in these sectors. US raised concerns that China intends to use industrial policies to decrease the country's reliance on foreign technology and eventually dominate global markets (Morrison, 2019).

In 2017, US under the Trump Administration launched a Section 301 investigation of China's innovation and intellectual property policies deemed harmful to US economy. In 2018, US started to increase tariffs by 25 percent on 250 billion USD worth of imports from China. China responded by raising tariffs vary from 5 to 25 percent on 124 billion USD worth of imports from the United States. US put another tariff on June and September 2019 and China responded with retaliation on some US products the following months. By January 2021, 66.1 percent of China total exports and 58.3 percent of US total exports are affected by the tariff war (Bown, 2021).

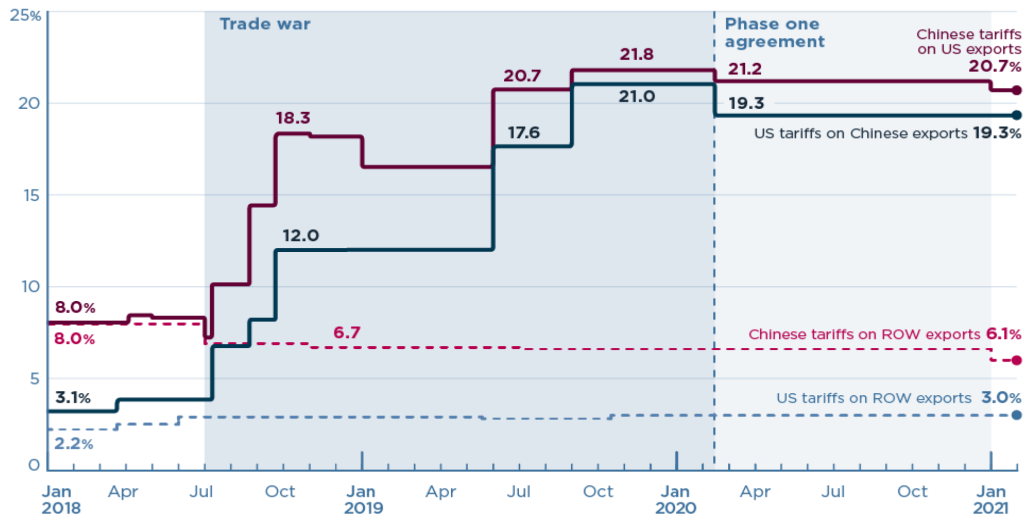

Figure 6. Tariffs imposed on US-China Trade War
Source: Peterson Institute for International Economics, 2021

As a result, trade between the two countries sharply decreased in 2019. The tariff imposed had strong negative effects on US imports of several targeted products from China. However, the study conducted by European Central Bank (2020) presents evidence that the US tariffs against China are mostly targeting imports of manufactured intermediate goods. Therefore, US-China Trade War creates a direct implication on US reshoring trends. US firms must adjust to the new environment and find alternative suppliers abroad or relocate production facilities to the US.

US manufacturers are much more reliant on Chinese intermediates than the other way around. According to the research conducted by Erken, Giesbergen, & Nauta (2019), electronics, computers, footwears, and textiles are the most vulnerable US sectors in the current trade war. Chinese intermediates contribute more than 20 percent in these industries. For example, the computers and electronic products produced in US depend on the supply of Chinese for the rare earth elements. In the other hand, US electronic producers also use China as a manufacturing hub for assembling their final products. Both scenarios, the increased tariff will likely increase the end price of these products. Other industries that show some vulnerabilities are transport equipment and printing products. There is a relatively large share of Chinese value added incorporated in the US export goods from these sectors.

Certainly, manufacturing in China has become more expensive due to tariffs. It goes with the rising labour wage in China over the past few years. Based on the current situation and the continuing trends, it is reasonable that US companies are considering relocation of their production out of China. In this scenario, apart from reshoring, the US manufacturers is also considering nearshoring and shift operations to other Asian countries such as Vietnam and India (Bossche, 2020). However, relocating production to other Asian countries does not guarantee that supply chain disruptions caused by tariffs and other trade barriers will not arise in the future. A report from McKinsey (2020) suggests that the severity and frequency of global supply chain disruptions are increasing as shown in Figure 7.

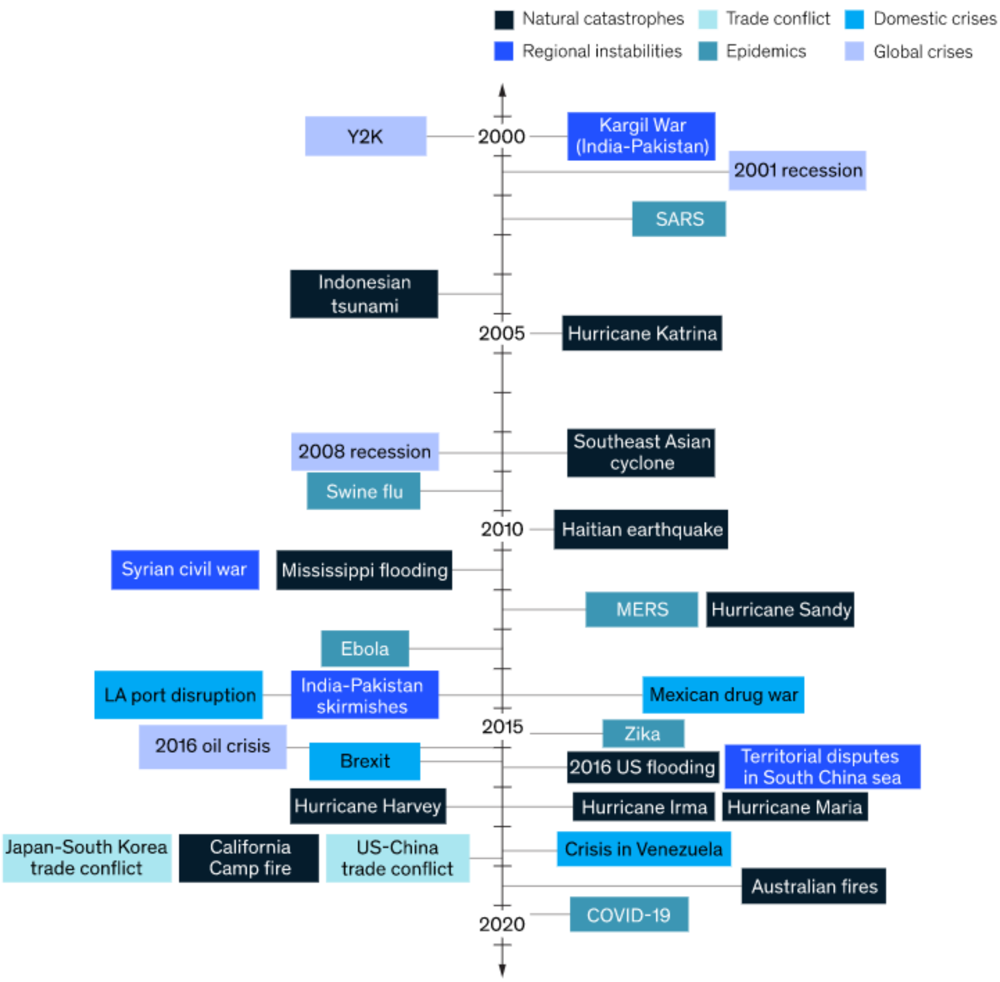

Figure 7. Historical revive of supply chain disruptions
Source: McKinsey & Company, 2020

2.3.4. COVID-19 Disruptions

The increasing US-China tensions in the trade war has created supply chain disruptions for many US manufacturers that largely rely on Chinese intermediates. COVID-19 exposed further the overdependence of US on foreign supplies. It results in the assessment that US over-reliance on global supply chain has become detrimental to a larger risk. The pandemic is prompting many US companies to place more attention on building resiliency (Shih, 2020). Many companies are starting to view reshoring and nearshoring of their production capabilities to prepare themselves to face the next potential disruption (Bossche, 2020).

The shortages of personal protective equipment (PPE) that happened in the first quarter of 2020 have led many policymakers to conclude that global supply chains are no longer fit for essential goods sectors (Evenett, 2020). When the coronavirus took the first outbreak in China, the Chinese government strictly imposed health protocol in the region resulting in the increase demand for PPE. The urgency to deal with its own crisis has reduced China's net exports of PPE and diminishing supplies available to the rest of the world.

China is the largest foreign supplier in PPE for the US. Local health care providers in the US were reporting significant and immediate supply shortages as the pandemic intensified (Fish & Spillane, 2020). The shortages include testing swabs, face shields, and other critical high-volume, low-price PPE commodity goods. According to Global Trade Alert (2020), from the total 99 products of PPE, China ships the 54 products mostly to the US. In addition to PPE, Chinese firms are said to supply more than 90 percent of US antibiotics, 70 percent of acetaminophen, and almost half of the anti-coagulant heparin (Evenett, 2020).

The challenges in sourcing PPE led to claims that US manufacturers have become too dependent on Chinese supplies. Fish & Spillane (2020) suggest that the same dependency also happen to other critical industries, including pharmaceuticals, medical devices, semiconductors, automotive, aerospace, textiles and chemicals, communications, and IT hardware manufacturing. This has brought into light the core weaknesses in a global supply chain that prioritizes more on costs reduction and just-in-time production that typically do not take major disruptions such as natural disasters, pandemics, or other geopolitical crises into consideration.

According to Kearney (2020), some executives signalled a strong intent to reduce dependence on manufactured imports from foreign countries, particularly China. Deloitte survey (2021) shows that 83 percent of companies are diversifying production in order to meet customer demands. One such adaptation involves repositioning manufacturing operations closer to home as part of the efforts to improve response. Ma (2020) indicates that 69 percent of companies across the manufacturing and industrial sectors are likely to bring manufacturing production and sourcing back to North America in the face of recent disruptions.

Supply chain resilience strategies that localize critical industries and their component supply chains will not only diminish the weaknesses uncovered during the COVID-19 pandemic. Brookings Institute (2020) suggest that reshoring will also increase employment growth and provide economic development opportunities for the US. It is predicted that the extensive reshoring of pharmaceuticals and medical supplies alone could potentially create more than one million new jobs in the US (Ferry, 2020).

2.4. Conclusion

The rise of the global value chain has increased trade in intermediate goods over the past three decades. The production fragmentation that divides the capital-intensive and labour-intensive stage of production has enabled developing countries with their low labour cost advantage to participate in both forward and backward participation. China has become the main destination for labour-intensive stage production, where most US-based companies offshore their production process. The number of US imports of intermediate goods from China increased significantly between 1991 and 2018.

However, many US companies are starting to realize the risk of offshoring their production overseas, particularly China, and are now considering moving their production back to the US. The factors responsible for this reshoring initiative are rising wages in developing countries and the advancement of technology in manufacturing, reducing the benefit of offshoring. Data shows that overall trade in intermediate goods declined significantly in 2019, with the trade war between the US and China also contributing to the decline. The latest, COVID-19, has further exposed the US's over-reliance on foreign supplies and prompted many US companies to pay more attention to the reshoring initiative.

Chapter 3: The US Reshoring Scenario

3.1. Introduction

In the previous chapter, we discuss the evidence of ongoing reshoring trends and factors that are driving the trends globally. In this chapter we will explain specifically about the US initiatives and trade policies towards reshoring. We further discuss the US reshoring scenario in more detail by assessing the selection of industries, the trading partners involved, and the net effect of reshoring on US export and import value.

3.2. US Reshoring Initiatives and Trade Policy

In the last few decades global production network and offshoring has changed the US manufacturing landscape. This has not only moved the manufacturing location out from the US but also transformed the competitiveness and economy structure of the country. The decline in the share of US manufacturing in the country's GDP has been one of the perceived disadvantages from the on-going offshoring practice (Sarder, et al., 2016). At the same time, it has also created millions of lost jobs in the manufacturing sector which recently came to the attention of the US government.

Therefore, after the great economic recession hit the US in 2008, the government further encouraged reshoring as an effort to create jobs in the manufacturing sector. The reshoring initiative is also expected to overcome several other problems from offshoring such as poor quality of outsourced products, increasing operating cost in the outsourced countries, social and environmental compliance, political instability, intellectual property loss and huge trade gaps (Sarder, et al., 2016).

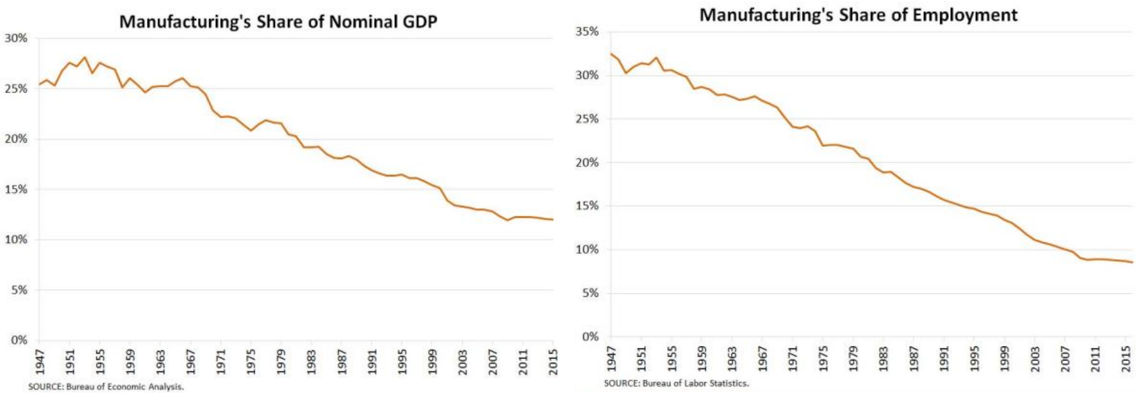

Figure 8. The US manufacturing's share of nominal GDP (left) and employment (right), 1947-2015
Source: Chien & Morris, 2017

As discussed in the previous chapter, surveys revealed that US companies are starting to realize that offshoring production to low-cost countries like China is not as profitable as it used to be. At the same time, the option of relocating production to other Asian countries, faces the same challenges related to rising wages (Sarder, et al., 2016). In addition, these countries also have constraints in terms of infrastructure, production quality, and the ability to achieve the scale of production needed to become a viable substitute. Many countries are still far behind China in factory standards, therefore, no country in Asia is capable of replacing China at the moment (Brooks, 2014).

Simchi-Levi (2012), based on their study, strongly indicates that the world is in the middle of a transformation from a global manufacturing strategy to a more regional strategy. The study states that this trend has accelerated in the last few years not only because of job loss in the US, but also because the economics that made offshoring attractive in the first place have changed, mainly due to labour costs, automation, and risk factors. US major firms like Apple, Google, and Ford have announced their plans to bring back part of their offshore production to the US, while the large retailer, Walmart, has committed to source more of the goods from manufacturers located in the US (Sarder, et al., 2016).

However, bringing back manufacturing to the US also has its own challenges. As a result of widespread offshoring over the decades, skilled workers required for manufacturing operations such as electrician and advanced machine operator are becoming scarce in the US (Bossche, 2014). 77 percent of manufacturers pointed out that they still need to fill certain skill gaps, while half of the companies surveyed said they were unable to fill several positions with skilled workers (Birand, 2021).

As it turns out, the lack of skilled labour in the manufacturing sector is also due to the diminishing interest of Americans to work in manufacturing. Hobson (2020) illustrates the perception of the average American toward manufacturing jobs as a “grimy black and white photo of some beleaguered person standing at a lathe”. In fact, the manufacturing nowadays is a high-tech production operation with robotics, artificial intelligent and advanced software. The misleading perception arises because not many people have access to industrial facilities, in contrast to some other types of work that they always see on a daily basis (Hobson, 2020).

In addition to the skills gap, US manufacturers also have to increase productivity and improve the efficiency of their workforce to compete effectively with low-cost manufacturing countries. Improved labour productivity is another key to accelerate reshoring (Bossche, 2020). Surveys and interviews conducted by Kearney with more than 100 plant managers leading US manufacturing facilities show a positive trend in labour productivity, with 80 percent of managers reporting increased productivity over the past three years.

In order to increase productivity, some companies also accelerate their investments by spending on equipment. Capital goods new orders for machinery shows large increase in the second half of 2020 (Mutikani, 2021). In fact, by January 2021, new orders for capital goods had reached historic levels. Capital goods new orders are an important leading indicator in assessing whether the climate is becoming more favourable for reshoring. Survey by The Manufacturing Institute found that investment in automation and technology was the top priority across manufacturers (Bossche, 2020). Prioritizing such investments is essential to improve productivity and making domestic manufacturing more competitive than offshoring options. Facility investments will make reshoring more feasible.

The US Government under Trump presidency has issued several protectionist policies which have a direct impact on the reshoring initiatives. These policies were made as an effort to reduce the trade deficit, save jobs, and enhance the economy (Clifford & Romaniuk, 2020). Some of Trump's protectionist policies that have also received a lot of criticism include the pulling out of the Trans-Pacific Partnership initiative and the renegotiations of North American Free Trade Agreement and the Korea-US Free Trade Agreement toward less openness (Noland, 2019). The US also imposed protection in steel and aluminium via a national security case (Section 232 of the Trade Expansion Act of 1962), started a trade war with China, and has threatened trade relations with other partners via a pending Section 232 case on trade in automobiles and parts (Noland, 2019).

Although less confrontational, economists suggest that Biden Administration has continued most of the Trump’s protectionist policies such as tariffs on metal imports and efforts to undermine free trade agreement (Anderson, 2021). Furthermore, Biden has added various other inward-looking policies such as establishing an executive order on American’s Supply Chains called as “Buy American” rules and proposing tax incentives for ordinary citizens to purchase American-made electric cars. According to White House press release (2021), the executive order signed in February 2021 aim to help insulate the US economy from future shortages of critical imported components by making the US less reliant on foreign supplies. The order is expected to make US supply chains more resilient, diverse, and secure. It will help revitalize US domestic manufacturing capacity and create good-paying jobs.

The executive order is trying to push several US essential industries to produce more domestically. The US government commits to support this policy with blend of incentives and directives. In addition, the Biden administration and congressional leaders are also proposing 10 percent offshoring tax on products US companies produce abroad to sell domestically (Bossche, Castaño, Blaesser, & Serraneau, 2021). Biden also make specific change in “Made in America” domestic content requirements, expecting US manufacturer to bring more of their operations home to earn the right to display the “Made in America” emblem on their brands. In sum, these policies directly and explicitly support reshoring.

All in all, the US government policy is now focused on making the US manufacturing more competitive. The US Government also address the shortage skilled labour issues through the National Apprenticeship Act of 2021. The House of Education and Labour Committee (2021) estimates that the National Apprenticeship Act could create nearly 1 million new apprenticeship opportunities. This will take direct aim at eliminating the shortage of skilled manufacturing labour in the US, which should in turn make it far more feasible for more US companies to reshore their manufacturing operations.

3.3. Net Effect of US Reshoring

3.3.1. Selection of Industries and Affected Trading Partners

Survey conducted by Kearney in March 2021 indicates that reshoring is already underway. According to the survey, 41 percent of respondents said their company has reshored at least a portion of their manufacturing operations to the US over the past three years (2020). The survey involves a range of company sizes from more than a dozen industry sectors, where almost half of respondents are company with more than 1 billion USD revenues.

Similarly, US import data shows that the production has shifted away from China. US imports from China fell by 88 billion USD in 2019, while imports from the rest of the world increased by 68 billion USD, which means 20 billion USD worth of production could have moved from China to the US (van der Veen, 2020). Moreover, the analysis shows that China’s market share in the US imports significantly dropped in 2019.

Some recent studies have identified several industrial sectors that should consider reshoring, taking into account macroeconomic factors and industry cost models. Most studies conclude that computers and electronics, electrical equipment, primary metals, machinery, furniture, plastics and rubber, paper, and fabricated metals are the most potential industries to be relocated back to the US (Bossche, 2014). In line with most studies, Rabobank's research identified that these industries also experienced the largest decline in US imports from China in 2019 (van der Veen, 2020). Computer and Electronic Products has the largest decline of 39.6 billion USD.

NAICS Code	Industry	Import Decline (billion USD)
	Manufacturing Total	-88.1
334	Computer and Electronic Products	-39.6
335	Appliances and Components	-7.4
337	Furniture and Related Products	-6.8
333	Machinery	-5.8
325	Chemical Products	-5.0
336	Transportation Equipment	-4.0
332	Fabricated Metal Products	-3.4
315	Apparel, Leather, and Allied Products	-2.9
327	Non-metallic Mineral Products	-2.1
326	Plastic and Rubber Products	-1.8

Table 1. US imports decline from China by industry sector
Source: RaboResearch calculations based on US Census Bureau, 2020

Considerations for relocating manufacturing operations to the US can vary significantly from sector to sector. Readiness factors must be weighed and evaluated rigorously to determine if reshoring is the right decision for each specific industry. McCutcheon, et al. (2012) suggest that there are seven factors that the industry should consider about reshoring production facilities back to the US. These factors include transportation and energy costs, exchange rates, labour cost, capital availability, skilled labour availability, domestic demand, tax, and climate arrangements.

In a broader perspective, the US government should consider the economic impact created by each industry before targeting strategic sectors to be relocated. Several other factors, such as infrastructure readiness, availability of regulations, and the suitability of the industrial ecosystem, can also be other considerations in determining which industrial sector to reshore. In addition, supply chain weaknesses exposed in the early days of the pandemic should be considered in targeting critical industries in the reshoring scenario. The US needs to strengthen their essential industries and their supply chains to be more resilient and able to adapt to global disruptions (Fish & Spillane, 2020).

RaboResearch (2019) summarizes list of US industrial sectors that rely heavily on intermediate inputs from China. Based on Trade in Value Added data from OECD, the top three industries with the largest share of Chinese intermediate inputs are electrical equipment, computers and electronic products, and textile and shoes. China's intermediate products account for more than 20 percent of the production of these three sectors.

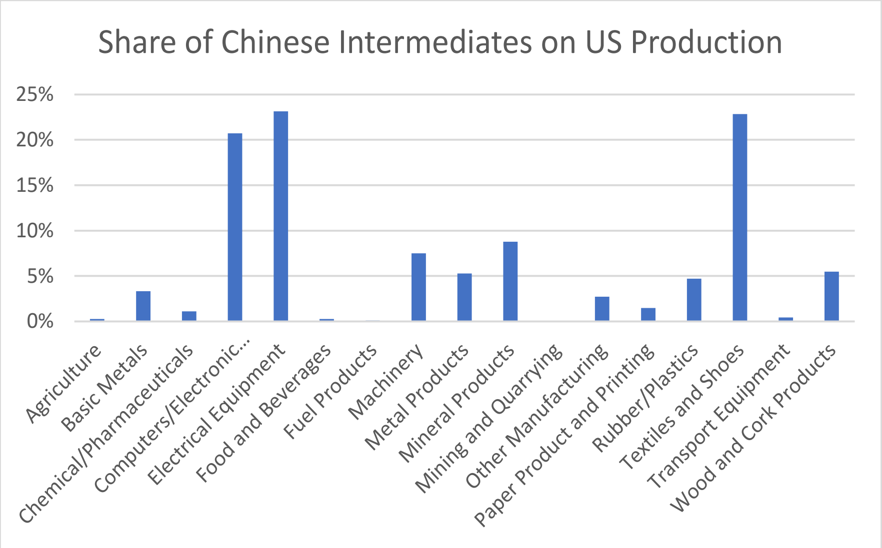

Figure 9. Shares of Chinese intermediates input in US production
Source: Compiled by author based on OECD TiVA database, RaboResearch, 2019

Furthermore, Sarder, et al. (2016) assessed the reshorability of the US Manufacturing Industry. In their study, they considered 9 different types of manufacturing industries based on the 3-digit NAICS code. The industry in this study represents 56 percent of total US imports from China. They investigate the industries reshorability index according to several reshoring factors such as the cost and availability of skilled labour, availability of natural resources, incentives, regulatory policies, proximity to customers, infrastructure, ease of doing business, and presence of suppliers and partners. The data used in this study is based on several indicators such as the Global Competitiveness Index by the Global Economic Forum, the Logistics Performance Index by the World Bank, the Global Energy Competitiveness Index by KPMG, and the Business Environment Index by the Economist Intelligence Unit.

The higher value on reshorability index indicates less benefits for reshoring, while the lower value on reshorability index indicates more benefits to reshore production. The result of the study suggests that the computer and electronic equipment industry has the lowest rehorability index, which means it has the highest benefits to reshore. Other industries that also have low reshorability index are Chemical Products and Electrical Equipment.

NAICS Code	Industry	Reshorability Index
334	Computer & Electronic Products	14.51
335	Electrical Equipment, Appliances and Component	18.83
325	Chemicals and Chemicals Products	19.56
311	Food and Kindred Products	23.51
312	Beverages & Tobacco Products	25.35
336	Motor Vehicle and Transport Equipment	24.08

331	Primary Metal	25.35
327	Non-metallic Mineral Products	33.23
321	Wood Products	30.16

Table 2. Reshorability Index from China to US
Source: Sarder et al., 2016

Based on various studies discussed, it appears that computers and electronic components are one of the most potential industrial sectors in the scenario of US reshoring. In 2018, according to Harvard Growth Lab (2020), China accounted for 37.26 percent of total US imports of electronic products. Asia as a whole accounts for about 211 billion USD from the total 329 billion USD of US electronic product imports. In a specific order, Asian countries that contributed to the supply of electronic products to the US besides China are Malaysia (9.26%), Japan (8.24%), South Korea (6.46%), Taiwan (5.33%), Vietnam (4.19%), Thailand (2.80%), Philippines (1.87%), Singapore (1.35%), and followed by India, Hong Kong, and Indonesia. The US decision to reshore the electronics industry sector will certainly have an impact on the trade volume between the US and Asian countries mentioned above.

Similarly, World Bank data (2021) shows that Asian countries has also dominated the share of US imports of intermediate goods across all industrial sectors. China, Japan, India, South Korea, and Singapore are some of the countries that have the largest share of the total US imports of intermediate goods from Asia. Therefore, these countries will be affected by the US reshoring scenario for various types of industries.

3.3.2. The Impact on US Trades

Globalization has driven the international fragmentation of production, leading to greater trade in intermediate goods (Boc & Lanz, 2013) .Therefore, the trade volume of intermediate goods will experience the most significant impact from the US reshoring scenario. In the previous chapter it was discussed that there are two different participations in global value chains, namely forward and backward participation. In the case of forward participation, foreign trading partners export intermediate goods to the US, conversely, in backward participation, the US exports intermediate goods to foreign trading partners. Thus, to find out the net effect of reshoring on US trade volume, we look at data on exports and imports of intermediate goods between the US and its trading partners in Asia. In 2018, according to World Bank Trade Statistic, the US largest trading partners for intermediate goods from Asia were China, Japan, South Korea, Singapore, Vietnam, Thailand, Malaysia, India, the Philippines, Hong Kong, and Indonesia. However, as this study focuses on the impact of reshoring on Trans-Pacific Trade, we will exclude India from our data assessment.

The UN Comtrade database provides the latest international trade statistics to help us assess the US trade with its trading partners. Under the classification of Board Economic Categories, the database presents a variable to help us analyse the global value chains. The new variable allows us to differentiate intermediate goods that are generic and consumed across a wide range of industries, and specific intermediate goods that typically consumed only in certain industries.

Based on the data in derived from UN Comtrade Database (2021), the value of intermediate goods imported to the US from its largest trading partner in Asia in 2018 is around 356 billion USD or 36.4 percent of the total import value, while the value of intermediate goods exported from the US to Asia is around 212 billion USD or around 56.8 percent of the total export value. These figures correspond to the characteristics of the US export and import structure presented by the World Bank. Lakatos and Ohnsorge (2017) provide a characteristic of US exports structure classified by arm's length and intra-firm trade, consisting of 53 and 59 percent of intermediate goods, respectively. As for the US import structure, intermediate goods accounted for 49 and 48 percent. Although the UN Comtrade figures in 2018 show that the share of imported intermediate goods is lower than the indicated characteristics, but if the value of unidentified goods is added to the value of intermediate goods, the percentage will correspond to this characteristic.

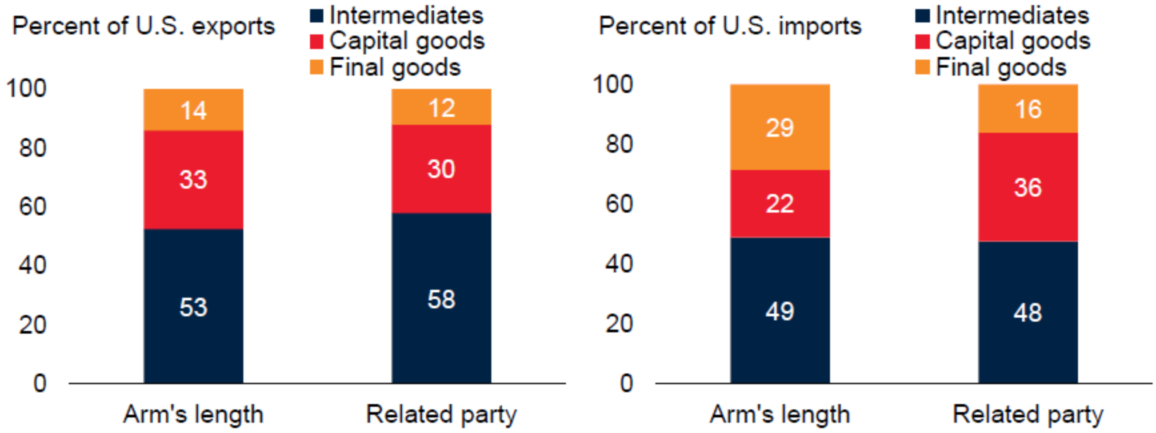

Figure 10. Characteristic of US exports and imports' structure
Source: Lakatos and Ohnsorge, 2017

Global value chains consist of two types of cross-border operations, intra-firm and arm's length. Intra-firm trade consists of cross-border transactions between firms linked by levels of control and ownership whereas arm-length is defined as cross-border transactions between unrelated firms. In practice, multinational companies use intra-firm and arm's length transactions to varying degrees. In 2015, intra-firm transactions were estimated to account for about a third of global exports. Unfortunately, the data on global intra-firm trade is not available. There is only one publicly available data set published by the US Census Bureau that distinguishes intra-firm transactions from arm's length trade. Lakatos & Ohnsorge (2017) show that approximately 30 percent of US exports and 50 percent of US imports are intra-firm. In the scenario of US reshoring, we can expect that the value of intermediate goods trade from both Arm’s length and Intra-Firm to decrease gradually over the next few years as many US based companies relocate their production back to the US.

3.4 Conclusion

In recent years, the US has enacted several protectionist policies that have a direct impact on reshoring initiatives. The main idea of these policies is to revive the US domestic production capacity, reduce the trade deficit and create high-paying jobs for Americans. The US government is committed to support these policies with a mix of incentives and guidelines, such as imposing higher tariffs on some imports, renegotiating free trade agreements, raising domestic content requirements and offshoring taxes, and providing incentives for US citizens to buy American made products. The US government is also addressing the skilled labour shortage in manufacturing through the National Apprenticeship Act.

If the effort of reshoring continues, most of the Asian countries that have so far dominated the share of US intermediate imports will be affected. Most studies conclude that computers and electronics, home appliances and electrical equipment, primary metals, machinery, furniture, plastics and rubber, paper and machined metals are the most potential industries to be relocated back to the US. According to the World Bank, the structure of US exports classified by Arm's length and Intra Firm trade, comprising 53 and 59 percent of intermediate goods, respectively. In terms of the US import structure, intermediate goods accounted for 49 and 48 percent respectively. These values of intermediate goods trade in both Arm's length and Intra-Firm will gradually decline in the coming years if the US Reshoring scenario persists.

Chapter 4: Container Shipping Market

4.1 Introduction

In this Chapter, we discuss the container shipping market and the implications of the US reshoring. First, we review the recent trends and performance of container trade. We compare the growth of container trade in major trade routes to presents an indication of reverse globalization. Further, we discuss how reshoring will likely affect the deployment of containership across various segments. Given the decline in trade between the US and Asia, in this chapter, we evaluate the containership supply and demand in Trans-Pacific.

4.2 Demand for Container Shipping Services

Previously we discussed the global shift towards reshoring and how the rise of protectionist sentiment has overtaken and enhanced the reshaping of globalization trends. Some suggest that the global production network based on low labour cost advantages may have reached its limit (UNCTAD, 2020). Containerized trade growth over the last three decades seem to capture the same trend direction. Maritime trade has been sustained by the aggressive containerization in the 2000s, coinciding with the wave of hyper globalization. However, in 2019, global containerized trade expanded at a slower rate of 1.1 percent, down from 3.8 percent in 2018, with the biggest contributor is the decline container volume in the Trans-Pacific route between the US and Asia (UNCTAD, 2020).

The decline in the value of US exports and imports provides a strong signal of continued US protectionist policies and reshoring initiatives. In addition, the US reshoring scenario in several potential industries will further reduce the value of trade because intermediate manufactured goods account for more than half of the total US trade (Lakatos & Ohnsorge, 2017). The statistic shows that the US Manufacturing Imports Ratio (MIR) fell from 13.1 percent in 2018 to 12.1 percent in 2019, which was the largest decline in imports since 2011 (Bossche, 2020). Total manufacturing imports from Asia fell from 816 billion USD in 2018 to 757 billion USD in 2019. According to the UN Comtrade Database (2021), the total value of trade between the US and China fell significantly from 683 billion USD in 2018 to 579 billion USD in 2019.

According to UNCTAD (2021), since 2018, the container volume in Trans-Pacific has experienced a significant decline. In 2019, the amount of container transported from East Asia to North America dropped from 20.8 million TEUs to 20 million TEUs, while from North America to Asia decreased from 7.4 million TEUs to 6.8 million TEUs. The overall container volume in Trans-Pacific contracted by 4.7 percent. Trade tensions and escalating tariffs between China and the United States are the main causes of the decline in the container volume in Trans-

Pacific (UNCTAD, 2020). Transatlantic also contracted a smaller 2.1 percent as a result of escalating trade tensions between the European Union and the US.

Main-lane's East–West container trade routes, namely Asia–Europe, Trans-Pacific and Transatlantic, accounted for 39.1 percent of worldwide container trade flows in 2019. Therefore, the decline in container volume in this route led to slower growth of the overall maritime trade, hitting their lowest level since the 2008–2009 global financial crisis (UNCTAD, 2020). In 2019, Main-lane’s East-West was contracted by 1.8 percent, compared with positive growth on other routes. This figure was saved by the Asia-Europe trade route which grew 1.8 percent. Volumes on the westbound leg expanded by 1.4 percent, and eastbound volumes from Europe to Asia rose by 2.9 percent.

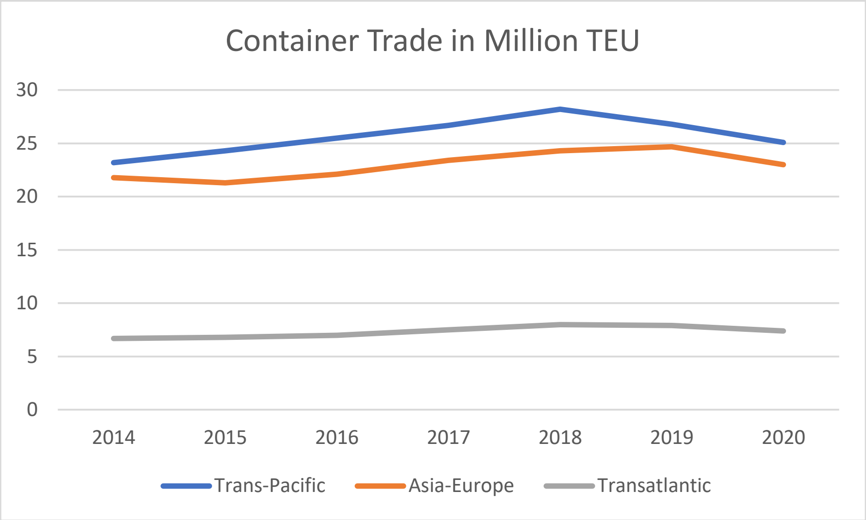

Figure 11. Container trade on major East-West trade routes
Source: Compiled by author based on UNCTAD, 2021

By comparing the decline in the value of imports and exports with the decrease in the number of containers transported, we can obtain the average value of TEU which will indicate whether the decline in trade occurs in high value or low value commodities. The decline in the value of imports of 59 billion USD from Asia to the US was reflected by a decrease of 800,000 TEUs. This means that the average value per TEU is approximately USD 73,540, which is double the estimated average TEU value from Asia to North America of USD 30,477 (Cowie, 2007). This indicates that most of the decrease in the number of containers was contributed by high value cargo. Based on IHS Markit (2017), the top three commodities with the highest value per TEU are Footwears, Textiles, and Machinery/Electrical. Therefore, the change in number of containers transported is directly related with the reshoring scenario of some potential commodities discussed in the previous chapter.

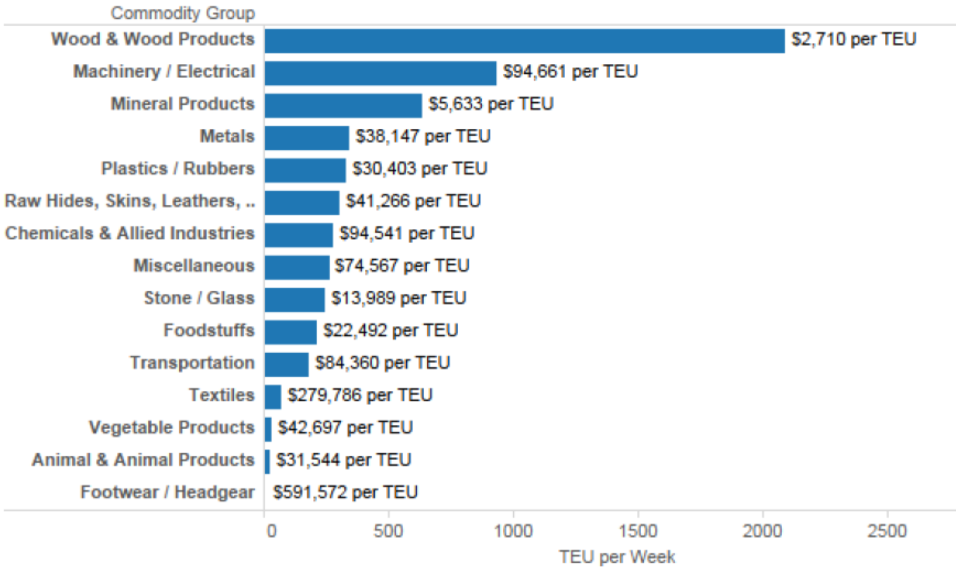

Figure 12. Cargo Value Estimation
Source: HIS Markit Vessel Accumulation and Cargo Value Estimation, 2017

4.3. Containership Capacity and Deployment

The global shift towards reshoring will likely shape the future of maritime trade and transportation (UNCTAD, 2020). The decline in exports and imports has a direct impact on the amount of container cargo being transported, thus affecting the fleet capacity and the deployment of containerships. Currently according to the data from Clarkson Research (2020), Trans-Pacific route is mostly served by Neo-Panamax 8000-11.999 TEUs and 12.000-14.999 TEUs. In total, both account for about 70 percent of the total fleet deployed in the Trans-Pacific. As expected, given the declining number of containers transported on that route, the orderbook and deliveries for Neo-Panamax has also been decreasing. From a total of 94 vessels delivered in 2015, it fell to only 20 vessels delivered in 2019. In contrast to ULCV 15,000+ TEUs, it increased from 13 ships delivered in 2016 to 30 ships in 2019. Around 90 percent of ULCV ships are deployed in Asia - Europe trade lane.

Over the past 20 years, vessel sizes have been increasing to optimize costs through economies of scale (UNCTAD, 2020). The average size of containerships has more than doubled compared with vessels built 20 years ago, with the average capacity four times greater. By October 2020, the containership fleet stood at 5,393 vessels with total capacity of 23.4 million TEUs, following growth of 4.0 percent in full year 2019. Cascading of tonnage remains a key part of liner companies' toolkit to manage capacity (Clarkson Research, 2020). Cascading means that shipping companies deploy larger containerships in key trade routes, while pushing medium-sized vessels into smaller sectors.

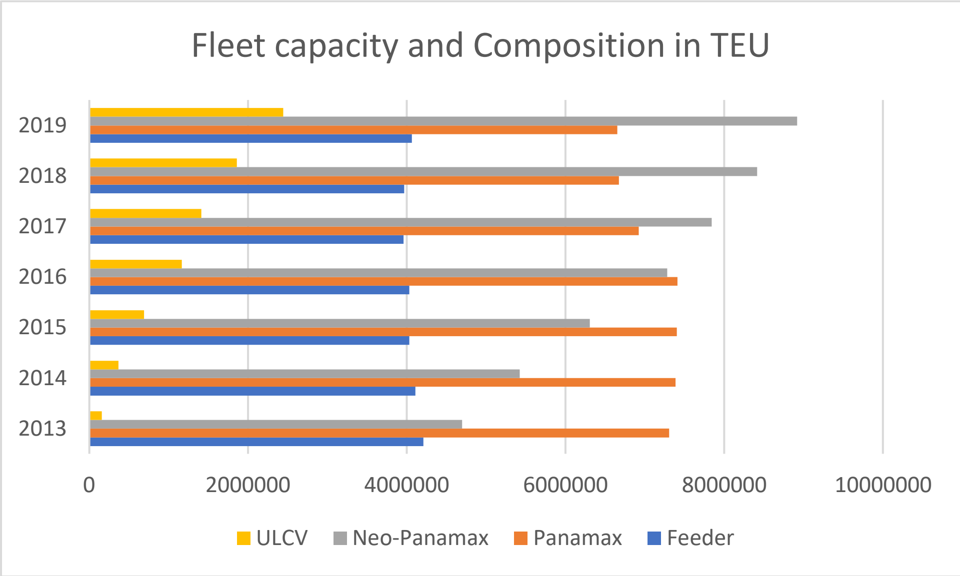

Figure 13. Fleet capacity and composition
Source: Complied by author based on Clarkson Research, 2020

Containerships can be divided into different classes based on their capacity, determined by the number of TEUs to carry on board. Containerships under 3,000 TEU are typically called Feeders. Some Feeders are equipped with cargo cranes. Feeder Class was first introduced in1970s, it has a maximum length of 215 meters. The next generation is Panamax Class, which was introduced in the 1980s. Ships in this class must have a maximum beam of 32.2m, and a maximum depth of 13.3 meters to be able to enter the Panama Canal. The first generation of Panamax has a capacity of up to 5,999 TEU with a length up to 305 meters. The second generation introduced in the 2000s can carry up to 7,999 TEU with a length up to 335 meters.

Neo Panamax was later introduced in 2006, the ship is much too big to fit through the Panama Canal's old locks but could easily fit through the new expansion. The capacity of Neo Panamax ranging from 12,000 to 14,500 TEU, with a length up to 366 meters. The biggest class with an intake capacity of more than 14,500 TEU is called Ultra Large Container Vessel (ULCV). The length of ULCV is 366 meters and above, the beam is 49 meters and wider, and the draft is 15.2 meters and deeper. This class of vessels is able to transit at Suez Canal.

Fleet capacity in the ULCV 15.000+ TEU sector increased by 11.4 percent during Q1-Q3 2020, to reach 176 units of 3.40 million TEU. This growth was contributed largely by deliveries of the ULCV 20,000+ TEU sector. In the Neo-Panamax 12.000-14.999 TEU sector, fleet capacity grew by 3.3 percent, to total 258 vessels of 3.53 million TEU. Meanwhile in the Neo-Panamax 8,000-11,999 TEU size range, the level of capacity was up by just 0.4 percent. In the Panamax 3,000-7,999 TEU sector, fleet capacity contracted by -1.3 percent while the fleet capacity in the sub-3,000 TEU Feeder sector increased by 1.3 percent.

Some observers argue the evaluation of the existing supply-chain patterns and strategies to shift away from the model that had been promoted by hyper globalization will also introduce near-shoring and eliminate single-country centric supply chains (UNCTAD, 2020). The developments of both reshoring and nearshoring will prompt further regionalization of supply chains and growth in intra-regional container flows. The changing trade patterns and a redirection of flows away from China towards intra-regional trade, thereby promoting the deployment of smaller vessels (Clarkson Research, 2020). This is also shown by the increase in orderbooks and deliveries for the container feeder segment below 3000 TEUs. Deliveries increased from 67 ships in 2015 to 104 ships in 2019.

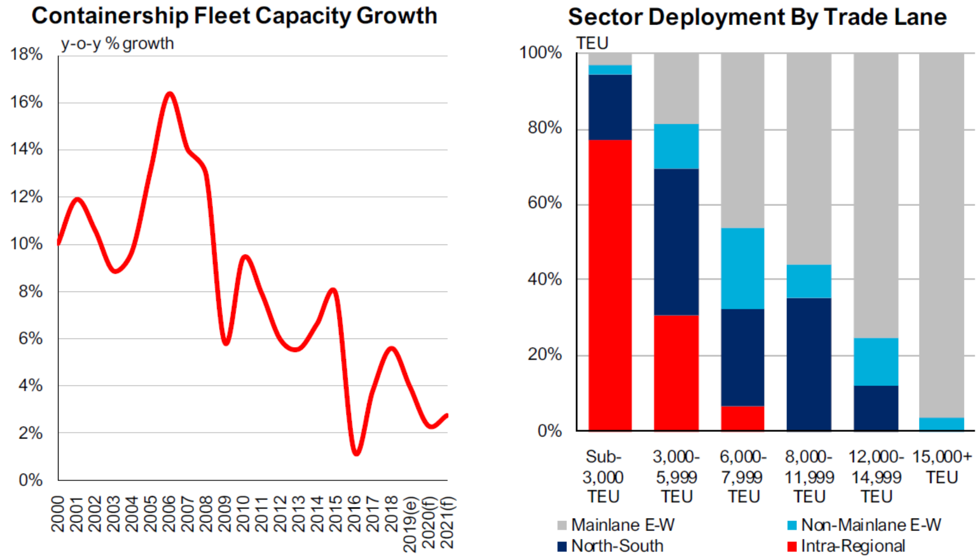

Figure 14. Fleet capacity growth (left) and deployment by trade lane (right)
Source: Clarkson Research, 2020

Shipowners need to adjust their fleet capacity to match the fluctuated demand levels. Declining demands far below the capacity will create a negative impact on the charter rates. During the first six months of 2020, for example, operators increased idling and blank sailing to maintain freight rates amid declining demand due to the COVID-19 crisis. 11 percent of the container fleet was estimated to be idle during the first half of 2020 (UNCTAD, 2020). Container trade on the main lanes shows the steepest declines, with Asia-Europe trade down 18 percent in February-May, and peak leg Trans-Pacific trade down 13 percent amid major impacts on European and North American economies. As a result, the ConTex charter rate decreased to an average of 368 points, compared with an annual average of 407 points in 2019 (UNCTAD, 2020).

Containership fleet growth has been limited in 2020, with deliveries slowing substantially and the pace of scrapping accelerating compared to 2019. In summary, the shifts in globalization patterns, supply-chain configuration and production models have created implications for transport and inventory decisions, which are of strategic importance for shipping. They have the potential to reshape the operational landscape, especially for container shipping, which affects capacity deployed and operations. For example, greater regionalization would lead to the increased fragmentation of trade flows which, in turn, would make the use of larger vessels more challenging.

4.4. Containership Supply and Demand in Trans-Pacific

Container shipping routes can be divided into three main lane, namely East-West, linking the major industrial centres of North America, Western Europe and Asia; North-South, connecting major production and consumption centres of Europe, Asia and North America, and developing countries in the Southern Hemisphere; Intra-Regional trades operating in shorter hauls and with smaller ships. Of all those mentioned, the largest deep sea shipping route is the Trans-Pacific trade between Asia and North America.

Most of Trans-Pacific services operate between the North American ports on the East Coast, the Gulf and the West Coast and the industrial centres of Asian countries, with some services extending to the Middle East. According the data from Clarkson Research (2020), there are at least 73 services served by 547 ships in Trans-Pacific route. The total capacity deployed is about 4.3 million TEU, providing more than 24 million TEU annual capacity. From the total capacity deployed, 81 percent is served by Neo-Panamax vessels, while only 18 percent by Panamax, and the rest is served by Feeder and ULCV. More larger vessels were introduced on this route, reducing the number of ships deployed but increasing the total TEU capacity. In 2015, there were 597 ships deployed with 3.6 million TEU capacity, while in 2019, the number of ships reduced to 547, but the TEU capacity increased to 4.3 million.

The number of containers transported on this route has been increasing from year to year since 2012 but began to show a decline in 2019. However, the Trans-Pacific trade growth has been very unbalanced, with strong growth in the eastbound trade coinciding with a deep and extended slump in westbound volumes. Container flows on the dominant leg, Asia to North America, reached 20.8 million TEU in 2018, while in the opposite, the flow of westbound stood at 7.4 million TEU (UNCTAD, 2020). As the imbalance of container flows is expected to continue, repositioning of empty containers will remain a major concern for carriers operating on the Trans-Pacific route.

Clarkson Research (2020) has also calculated the demand and supply index of containerships on the Trans-Pacific Route. The index measures an annual factor that calculates the increase in demand divided by the average increase in supply. Using 1996 data as a basis, the index results tell us, if the index value goes up then demand grows faster than supply, and if the index value goes down then supply grows faster than demand. The demand and supply index for the Trans-Pacific east-bound leg showed a decline from 134.3 in 2012 to 128.1 in 2018, indicating an excess of supply to demand. In contrast, the demand and supply index in the westbound leg of Far East - Europe, its value rose from 121.9 in 2012 to 129.7 in 2018.

Year	Trans-Pacific			Far-East - Europe		
	Running Capacity	Container Trade	Demand/Supply Index	Running Capacity	Container Trade	Demand/Supply Index
2012	18,032	14,865	134.3	19,939	13,620	121.9
2013	19,171	15,133	128.6	19,914	14,326	128.4
2014	20,101	15,492	125.5	20,649	15,246	131.7
2015	20,982	16,394	127.3	21,745	14,750	121.0
2016	21,107	17,218	132.9	20,587	15,179	131.5
2017	22,640	18,045	129.8	20,658	15,865	137.0
2018	24,461	19,244	128.1	22,274	16,187	129.7

Table 3. Container Shipping Demand and Supply Index on Trans-Pacific and Far East Europe
Source: Compiled by author based on Clarkson Research, 2020

4.5. Conclusion

The performance of containerized trade in recent years has not been very impressive as indicated by slower growth in 2019, down 1.1 percent from 2018. As expected, the largest contributor to the low performance was the decline in container trade on Trans-Pacific routes between the US and Asia. Container volume in the Trans-Pacific and Transatlantic are contracted 4.7 percent and 2.7 percent, respectively, indicating the negative implications of the US trade protectionist policies.

Recent data shows that the Demand and Supply Index of containership in Trans-Pacific has been declining since 2012. Currently, from the total capacity deployed in Trans-Pacific route, 81 percent is served by Neo-Panamax vessels, while only 18 percent served by Panamax, and the rest is served by Feeder and ULCV. Some argued that regionalization will make the use of larger vessels more challenging, thereby encouraging deployment of smaller vessels. The orderbook and deliveries trends in recent years confirm this projection.

Chapter 5: Theoretical Framework

5.1. Introduction

In Chapter 3, we discussed the anticipated decline in trade value between the US and its trading partners in Asia as a net effect of the ongoing reshoring trend. Furthermore, in Chapter 4, we provide evidence that the decline in trade between the US and Asia has a direct impact on container trade in trans-Pacific route, resulting in changing trends in supply and demand index for containerships in the region. In this chapter, we will examine the theoretical framework, explaining the relationship between the development of the world economy and the container shipping market from several different perspectives. Based on previous studies on the same subject, we will determine which theory is most suitable to be used to analyse the effect of US reshoring on the container shipping market.

5.2. Shipping Market Supply and Demand Model

Stopford (2009) introduced a model to explain the dynamic relationship between supply and demand in the shipping market. There are three main parts involved in this model, namely the demand module, the supply module, and the freight market. In this model, sea transport demand is measured in tons-miles as it takes into account the tonnage of cargo shipped and the average distance transported. Therefore, the quantity of freight supplied is also measured in ton-miles which reflects not only the capacity of fleets available in the market, but also the efficiency and productivity of the fleet.

In the demand module, the world economy, influenced by business cycles and growth trends, determines the volume of goods traded by sea, while trade developments in certain commodities change the average haulage distance of cargo transported. The cargo shippers are the main actor of the demand module. Their decisions over the source of raw materials and the location of processing plants determine how trade develops.

In the supply module, the world merchant fleet provides a fixed stock of transport capacity. The fleet can be increased by newbuilding and reduced by scrapping. In addition, economic policies also have an impact on how the supply side of the market develops. Shipping investors, which are mainly private shipowners or shipping companies, are the central part of this module. They have the important task of ordering new ships and scrapping old ones.

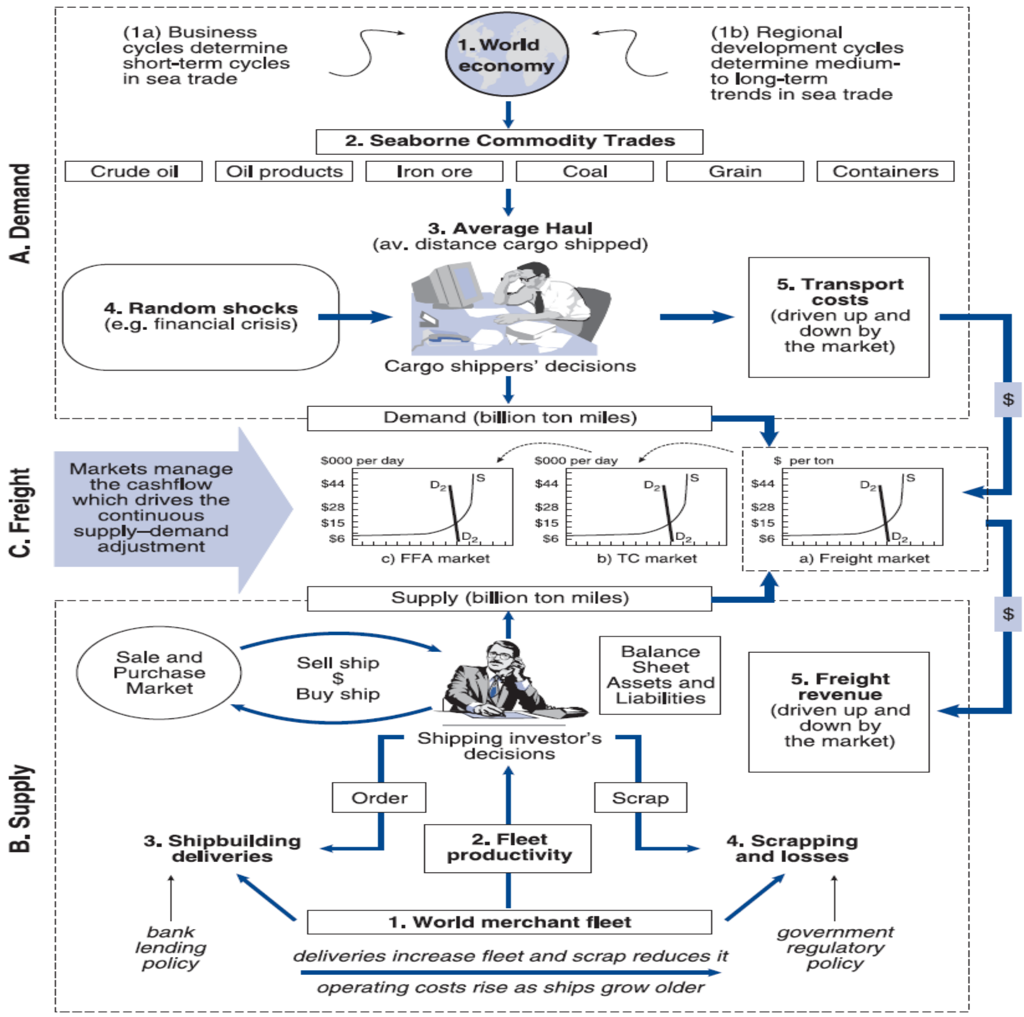

Figure 15. Shipping Market Model
Source: Stopford, 2009

The dynamic link in this model lies in the freight market where the imbalance between supply and demand converges. As a result, freight rates continue to adjust in response to changes in the supply and demand balance. When vessels are in short supply, freight rates increase and encourage shipping investors to buy more second-hand vessels. When the price of second-hand ships became too expensive, they switched to ordering new ships which led to an expansion of the total world fleet.

Too many vessels in the market lower the freight rates and increase the lay-up of the vessels and thus reverse the adjustment process. Shipowners struggling to pay the fixed costs were forced to sell the ship to raise cash. If the downturn continues, eventually the price of old ships will drop to a level where selling the ship to the demolition market is better than to the second-hand market. Thus, the total capacity of the world's fleet will decrease gradually.

Stopford (2009) argues that the most important single influence on ship demand is the world economy. This is in line with several data showing a close relationship between the growth rate of sea trade and GDP. Fluctuations in the rate of economic growth work through into seaborne trade, creating a cyclical pattern of demand for ships. The second influence is the ability of local resources to meet local demand. Trade boosts when domestic demand is met by foreign suppliers and decreases when the opposite occurs.

However, the economic structure of the countries that generate seaborne trade is likely to change over time. Therefore, Stopford (2009) suggests looking at four types of changes in order to better anticipate fluctuations in sea transport demand. The four types of changes are changes in demand for commodity, changes in the source from which supplies of the commodity are obtain, changes due to a relocation of processing plant which changes the trade pattern, and finally changes in the shipper's transport policy.

This approach fits the reshoring problem discussed in this thesis. In the US Reshoring scenario, there will be changes in the demand for intermediate goods. This change will occur in trade between the US and countries in Asia. The reason for the trade volume change is because US producers will relocate their production from Asia back to the US. Thus, it can be concluded, based on Stopford's shipping market model, the US reshoring scenario will create demand change for sea transport.

Furthermore, Stopford (2009) describes the supply-side relationships in the shipping model are behavioural. The high freight rates stimulated newbuilding orders in the past has no guarantee for demand in future. The problem is the pace of adjustment in supply to the changes in demand is very slow. It takes 2-3 years to build a merchant ships, and once the ship is delivered, it has a physical lifespan of 15-30 years before the ship usually enters the demolition market (Stopford, 2009). Scrapping depends on the balance of several factors. The main considerations are age, technical obsolescence, scrap prices, current earnings and market expectations. Therefore, in the case of fall in demand and there is a large surplus to be removed, the adjustment of supply will take years.

A key feature of the shipping market model is the mechanism by which supply adjusts when ship demand does not turn out as expected. In the short term, supply responds to freight rates by adjusting vessel operating speed and considering lay-up. In the longer term, freight rates contribute to the investment decisions which result in scrapping and ordering of ships. The longer-term adjustment mechanism balances supply and demand through the three other markets: the second-hand market, the newbuilding market and the demolition market.

The adjustment mechanism also results in decisions about what types of ships are built or scrapped. From the point of view of the shipping industry, the type of ship built or scrapped in the capacity adjustment mechanism is important because peaks and troughs in the deliveries of specific ship types have an impact on their market prospects. Based on this concept, it is reasonable that changes in demand due to the US Reshoring scenario will have a different impact on each market segment of containership size, and the adjustment mechanism of each market segment will give a different response.

5.3. The Theory of Shipping Cycle

The primary goal of the market mechanism is to coordinate the growth of supply and demand for sea transport. Previously, we discussed the behaviour in shipping market model, when ships are in short supply freight rates increase and stimulate ordering. Conversely, when there is a surplus, rates fall and remain low until enough ships have been scrapped to bring the market into balance. This behaviour gives shipping market a typical cycle with characteristic pattern driven by volatile demand and slow-response supply. As long as there are fluctuations in supply or demand there will be cycles, and these cycles are called as shipping cycles. The theory of shipping cycles so far has been shaped primarily by two models, the Tinbergen–Koopmans model and the Beenstock–Vergottis model.

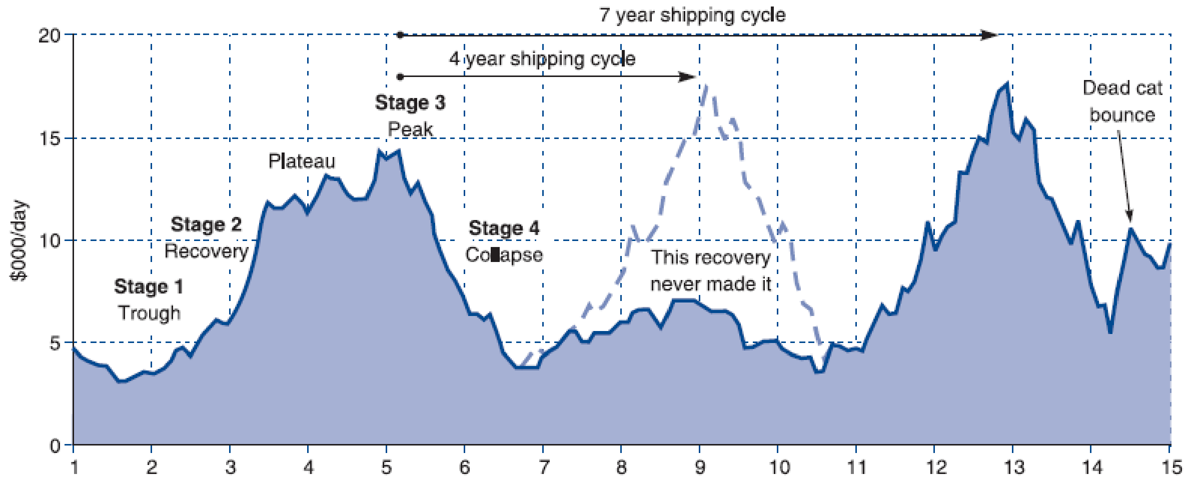

Figure 16. Theory of Shipping Cycle
Source: Stopford, 2009.

The fundamental concept of the Tinbergen–Koopmans model (1939) is that shipping cycles occur even if the demand for shipping services is not cyclical. This model is formulated based on the understanding that the shipping cycles are solely caused by the cyclical behaviour of the supply, due to the lag between placing orders for ships and the ability of shipyards to deliver. This behaviour then creates fluctuations in the supply of vessels and the world's total fleet, thereby creating an imbalance of supply and demand in the freight market. The evolution in the fleet size changes the supply of shipping services almost proportionately.

To investigate the dynamic evolution of the fleet size, this model assumes the size of order book to be a positive function of freight rates. The demand for vessels increases when freight rates improve and therefore change in the orderbook is equal to the change demand for vessels. In this model, orderbook is assumed without cancelations. This model is interested only in the dynamic evolution of the fleet with everything else being unchanged. Under these simplifying assumptions, the net fleet is equal to the accumulation of fleet deliveries.

Karakitsos-Varnavides (2014) argue that the Tinbergen–Koopmans model may be rudimentary because the demand for shipping services is assumed to be perfectly inelastic to freight rates. However, according to Stopford's Model, Freight rates do not have any influence on demand of shipping services. The demand of shipping services is determined by world economy, seaborne commodity trade, average haul, and random shocks. Despite all the oversimplified assumptions, the Tinbergen-Koopmans model captures a very important aspect of the shipping cycle, namely newbuilding delivery delays. The model links the shipbuilding market and freight markets in explaining shipping cycles by taking into account the delivery lag between orders for new ships and the delivery time. In this model, even when the demand for shipping services is constant, the fleet and freight rates will oscillate.

The Beenstock–Vergottis (1985) introduces more complex approach to explain the interaction of the freight, time charter, second-hand, newbuilding and scrap markets in their model. This model takes into account variables besides demand for shipping services, such as interest rates and bunker fees, to also trigger fluctuations in the fleet. This model applies rational expectations to calculate the impact of expected and unexpected changes in its variables. In this model, owner adjusts his actual fleet to the optimal capacity on a monthly basis by considering whether to buy or sell additional vessels in the second-hand market or scrap existing vessels according to the principle of short-term profit maximisation. Therefore, the major asset market in this model is the second-hand market. The importance of the newbuilding market is downgraded as being less important to the second-hand market.

The basic concept of maximizing short-term profits makes Beenstock–Vergottis ignore the long-term consequences of shipowner's decisions despite forming rational expectations. Karakitsos-Varnavides disagree with this concept, they believe the appropriate framework for a fleet expansion strategy is long-term profit maximisation. Therefore, they integrate the Tinbergen–Koopmans model with the Beenstock–Vergottis model. In this integrated model, Karakitsos-Varnavides consider demand for shipping services as endogenous variable. In Beenstock-Vergottis model, this variable is exogenous, which is determined outside the model and is imposed on the model. As the freight rate is endogenous, the dynamics of the newbuilding price and the net fleet are analysed for a given freight rate. A fleet capacity expansion strategy involves expectations of future freight rates, newbuilding, second-hand and scrap prices, which are jointly determined.

The demand for new vessels is derived from the first-order condition for long-run maximum profits. It is a function of the demand for shipping services, relative prices - which is the freight rate relative to the user cost of capital, and technological factors. However, in this model, the demand for shipping services is more important than the relative prices. The demand for shipping services is determined by the real GDP, which acts as a representation of the world economy. For simplicity, it is assumed that the demand for shipping services is a constant multiple of real GDP. Demand shocks in the economy, such as a temporary drop in aggregate demand, cause cyclical fluctuations in the economy, and recession triggers a fall in the demand for shipping services.

Demolition expressed as a proportion of the existing total fleet is a function of the scrap price relative to the second-hand price and the age of the fleet. Therefore, the rate of demolition is a positive function of the rate of scrap prices, and a negative function of the rate of second-hand prices. The total fleet is determined by the interaction of new-building market and demolition market. The change of the total fleet between two consecutive periods is equal to the deliveries less the demolition in the same period.

Similarly, the fleet expansion decision in this model is predetermined by past expectations of current demand. The shipping cycles are generated by overly optimistic demand expectations in the past, which results in lower utilization of fleet capacity. Freight rates, newbuilding and second-hand prices fall on impact. However, the economy would tend to return to long-run equilibrium. The actual demand for shipping services rebounds in response to the recovery of the economy, thereby triggering improvements in the fleet capacity utilisation rate. The actual and expected developments reverse the decline in freight rates, newbuilding and second-hand prices. After some time, all shipping markets return to long-run equilibrium.

Overall, the integrated model of Karakitsos-Varnavides is suitable for use in modelling the behaviour of shipping cycle in response to demand changes due to US reshoring. Not only this model considers the cyclical behaviour from the supply side, but it also takes into account fluctuations in the demand for shipping services triggered by the world economy, which the Tinbergen-Koopmans model does not provide. Moreover, this model also applies rational expectations with long-term profit maximization in determining the fleet adjustment strategy, which is more realistic than the concept offered by the Beenstock–Vergottis model. However, the complexity of the variables considered in this model such as bunker price and interest rates needs to be simplified to focus only on the capacity model.

5.4. System Dynamics

Stopford breakdowns the dynamic adjustment process in shipping model into four stages. First, the orders placed at the top of the cycle, when rates are very profitable. Second, demand changes in a direction which investors did not anticipate during the shipbuilding time-lag, therefore, by the time the new ships delivered to the market, they create market imbalance and encourage owners to reduce order. Third, a tendency for investors to react to the violent and often unexpected swings in freight rates. Fourth, in most cases, a major crisis requires greater adjustment in the supply, which is more than minor adjustments in the tonnage of ships delivered or scrapped.

Sterman (2002) explains dynamic complexity mostly arises in systems with certain characteristics. The main attribute is that the system is constantly changing and the actors in the system interact strongly. Moreover, because the actors are tightly coupled, their action create feedback on themselves. This feedback triggers another action, giving rise to a new situation that then influences subsequent decisions that generate dynamics.

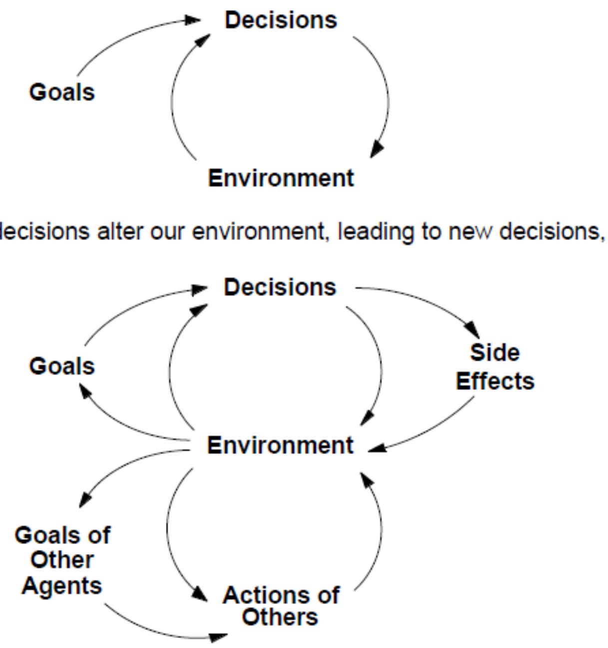

Figure 17. Feedback loops in system dynamics
Source: Sterman, 2002

In the shipping market model, shipping investors and cargo shippers are closely related, and thus their actions create feedback on each other and trigger subsequent decisions. The other characteristic highlighted by Sterman (2002) is also time delays between taking a decision and its effects on the state of the system. Delays in feedback loops create instability and increase the tendency of systems to oscillates.

Taylor (1976) applies system dynamics in shipping industry to identify its dynamic characteristics and formative mechanisms. In this case, mechanism is interpreted as the organization and policies applied to the system. Examples of mechanisms in production models, such as how much production starts at any time and how many warehouse orders, are used to determine the behaviour of the system. Taylor further describes system dynamics as time-varying fluctuations which comprises inter-dependent feedback loops. He argues that the fluctuations in a system dynamic are brought by the internal workings or mechanisms of the system itself. Therefore, similar with Tinbergen–Koopmans model, Taylor suggests that these fluctuations in shipping industry are not produced by random effects but by factors working within the system.

According to Taylor (1976), the mechanisms in the systems will produce two types of feedback loops. Positive feedback promotes growth and negative feedback tends to move the system towards a desired level of operation. Besides identifying all the relevant feedback processes, it also needs to determine the values and types of delays which operate in the system. For example, in shipping industry, delay occurs between placing order and the delivery of the new ships. When all the sufficient detail of the system is available, it is then possible to construct a model for system dynamics. In addition, it is also necessary to define factors such as system-boundaries, use of the model, and primary objectives.

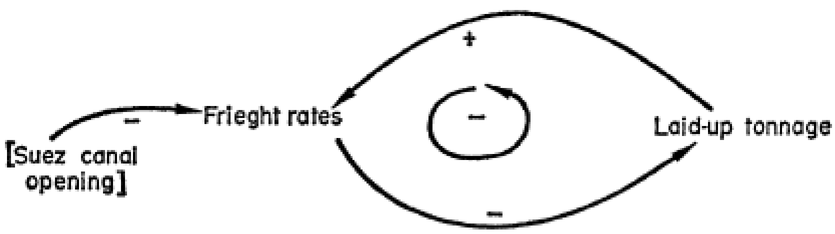

Figure 18. Two types feedback loops in shipping
Source: Taylor,1976

Taylor (1976) asserts that for each of these types of vessel there is a separate, but not independent, sub-system operating within the whole system of shipping. Shipping companies that own and operate several types of ships often place orders for new buildings only for certain types based on various market factors and company policies. An industry-wide model could therefore consist of inter-linking sub-models based upon vessel types. As well as dynamic processes operating within individual sub-models there are similar processes which operate to link the sub-models together. This approach can be used to model the impact of US reshoring on the overall shipping market consisting of several inter-linking sub-markets of each containership size.

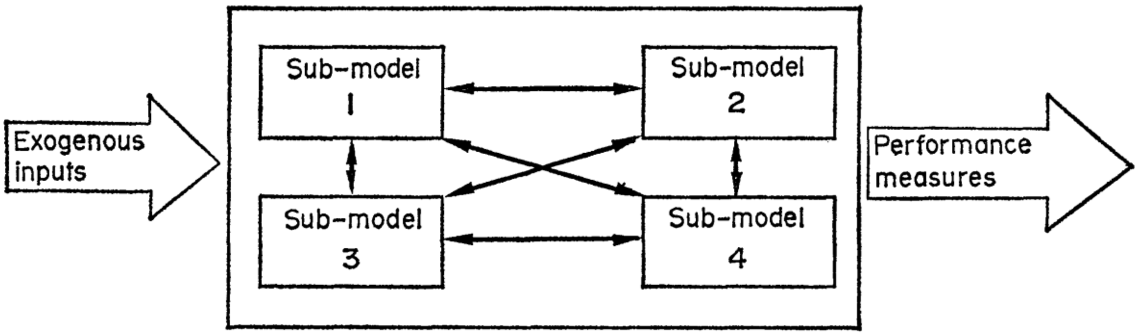

Figure 19. Industry-wide model consist of inter-linking sub models
Source: Taylor, 1976

Dimitrious (2016) used this approach to construct the dynamic inter-relationships among the variables affecting the crude tanker market. Dimitrious examines three sub-markets, VLCC, Suezmax, and Aframax, and predicts the performance of each market over the period of 2016-2026. In this study, Dimitrious sets a projected increase in demand over a period time that is set as the basis for owner expectations. He constructed a simple system dynamics model to forecast the crude oil tanker market in the foreseeable future examining the capacity demanded and supplied. However, since it is difficult to estimate the average haul and the fleet productivity, the study concentrated on the tonnage capacity instead of ton-miles.

Dimitrious argues system dynamics is appropriate because it considers delays in the balance between supply and demand, changes in exogenous variables as well as the cause and causality relations that shape the market over time. System dynamics models are formulated with equations portraying the decision rules of the agents, natural processes, and physical structures relevant to the purpose of the model. However, according to Sterman (2002) it is not the mathematics that distinguish system dynamics models from many other dynamic models, but the specification of the equation and the modelling process. He suggests that good system dynamics models have a broad model boundary but there should be few exogenous variables.

5.5. Conclusion

In conclusion, Stopford's Shipping Market Model fits the problem discussed in this thesis. In this model, the world economy, influenced by business cycles and growth trends, determines the volume of goods traded by sea and decisions over the source of supplies and the location of production determine how trade develops, which perfectly describes the scenario of US Reshoring. The changes in demand are causing an imbalance in the freight market, prompting shipping investors to adjust the existing fleet capacity presented through newbuilding and scrapping.

Karakitsos-Varnavides (2014) provides comprehensive and realistic approach for the capacity adjustment strategy. Therefore, this concept can be used to complete the behaviour of the supply module in Stopford's Shipping Market Model. This concept applies rational expectations with long-term profit maximization in determining the fleet capacity adjustment, which is more realistic than the concept offered by the Beenstock–Vergottis model. The strategy involves expectations of future freight rates, newbuilding, second-hand, and scrap prices, which are jointly determined to challenge the oversimplified assumption of Tinbergen-Koopman model.

Therefore, in this thesis, we will use the Stopford shipping market model with the integration of shipping cycle theory from Karakitsos-Varnavides to model the response of the shipping market to the change in demand for shipping services as a result of the US reshoring scenario. Overall, demand for shipping services will follow the projection of real GDP growth. However, as discussed in Chapter 3, the US Reshoring scenario assumes that trade in intermediate goods from both Arm's Length and Intra-Firm between the US and its largest trading partners in Asia will gradually decline. The proportion of intermediate goods will follow the characteristic of US export and import structure provided by the World Bank.

Since the US reshoring scenario will only affect trade between the US and its main trading partner in Asia, namely China, Japan, South Korea, Singapore, Vietnam, Thailand, Malaysia, the Philippines, Hong Kong and Indonesia, thus, it will mainly affect container trade on the Trans-Pacific Route. As discussed in Chapter 4, of the total capacity deployed on the Trans-Pacific Route, 81% is served by Neo-Panamax vessels, 18% by Panamax and the remaining is served by Feeder and ULCV. The change in demand for shipping services on this route will therefore have a different effect on each type of container vessel. Hence, in the supply module, we will model the fleet capacity adjustment strategy separately for each market segment of container vessel size.

The adjustment of the fleet capacity on each segment of containership is done by means of newbuilding and demolition. As we will be using the Karakitsos-Varnavides approach, the decision to order new vessels in this model is described as a function of the demand for shipping services and the existing capacity, which is the supply and demand ratio in the freight market. Demolition, on the other hand, is a function of scrap prices relative to second-hand prices and fleet age, expressed as a share of the existing total fleet. In summary, the change in the total fleet between two successive periods is equal to the deliveries minus the scrapping in the same period.

We will also create a System Dynamics mechanism in the model based on positive and negative feedback loops proposed by Taylor. Positive feedback promotes growth and negative feedback tends to drive the system to a desired business level. In addition to identifying all relevant feedback processes, we will also determine the values and types of delays operating in the system, such as delay between placing the order and delivery of the new vessels.

Chapter 6: Methodology

6.1. Introduction

In the previous chapter, we discussed the theoretical framework to model the response of the shipping market to the reduced demand for containership capacity on the Trans-Pacific route as a result of US reshoring scenario. In this chapter, we further elaborate Stopford's shipping market model with the shipping cycle theory and the systems dynamics approach, specific to our problem. We will present the model in a flowchart with system dynamics and feedback loops, as well as equations we use to develop the framework of our model.

6.2. Model Description

The aim of our model is to simulate the changing demand for container shipping services over the next twenty years, taking into account forecasted economic growth and the US reshoring scenario. The model assesses the changes in demand on each of the major trade routes. In addition, based on the deployment characteristics of containership, the model will then simulate the demand of running capacity of each containership size over the time period.

The model calculates the equilibrium based on the available running capacity of the containership in the market and the predicted demand. According to this market equilibrium, the model simulates the behaviour of shipping investors to adjust their capacity. When ships are in short supply, freight rates rise and encourage shipping investors to buy more ships, while when there are too many ships in the market, it lowers freight rates, reversing the adjustment process. In the long run, we would like to obtain the trend and fluctuation of supply and demand of each containership size, as well as the oscillating shipping cycle generated by this behaviour.

6.2.1. The Application of Shipping Market Model

We apply the Stopford's Shipping Market Model to our problem as shown in Figure 1. Our exogenous variables in the demand module are forecasted trade growth based on GDP and the US Reshoring scenario. Our model incorporates these variables into the demand for container shipping services on each trade route, expressed as $D_{i,t}$. Where i stands for trade route and t stands for time or year. Provided the deployment characteristic of containership on each route, the model will generate demand of containership running capacity, expressed as $D_{j,t}$, where j stands for each containership size.

In the supply module, our exogenous variable is the current fleet capacity, expressed as $C_{j,t}$. Given the productivity, the model calculates the running capacity and the market equilibrium which is the ratio between supply and demand of containership running capacity expressed as $E_{j,t}$. Market equilibrium is the objective of our model. Therefore, we formulate capacity adjustment strategy to maintain the balance between demand and supply in the market. The capacity adjustment strategy will generate two decision variable, fleet expansion as positive feedback and fleet adjustment as negative feedback. These decision variables influence output parameters in this model, which are orderbook $O_{j,t}$ and Scrapping $S_{j,t}$.

We will run the model for twenty years. We expect that market equilibrium, $E_{j,t}$ to fluctuate as the demand of shipping services changes over time and the shipping investors attempt to balance the capacity. The delay in response of the capacity adjustment strategy also leads to more fluctuations in the market equilibrium and total fleet capacity.

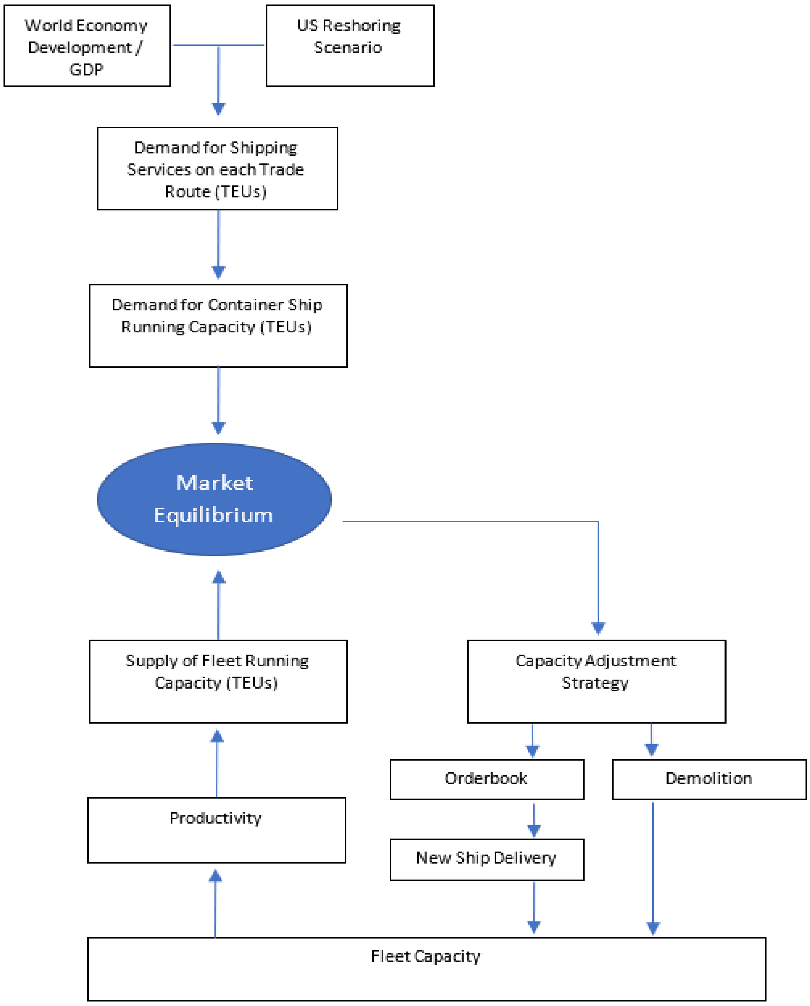

Figure 20. Flowchart of Shipping Market Model

In summary, our main parameters in the model are as follow:

Input Parameters:

$D_{i,t}$ = Demand of container shipping services on each trade route in year t

$D_{j,t}$ = Demand of containership running capacity in year t

$C_{j,t}$ = Capacity of containership in year t

Objective:

$E_{j,t}$ = Market equilibrium of demand and supply of containership capacity in year t

Decision variable:

u = Capacity expansion decision, based on market equilibrium

v = Capacity adjustment decision, based on market equilibrium

Output Parameters:

$O_{j,t}$ = Orderbook of containership

$S_{j,t}$ = Demolition of containership

6.2.2. The Application of System Dynamic

We also apply system dynamics approach in our model. The system dynamics apply in the relationship between Market Equilibrium, Capacity Adjustment Decision, and Fleet Capacity. In general, figure 2 explains how system dynamics work in our model. Changing demand has a positive effect on the market equilibrium. From the shipping investor's point of view, positive market equilibrium means that demand for container shipping services exceeds the available running capacity. This situation also generates positive expectation on capacity adjustment decision, resulting in positive feedback to expand the fleet capacity by ordering more new ships and reduce demolition. The capacity adjustment decision also takes into account the current size of fleet capacity and the age of fleet.

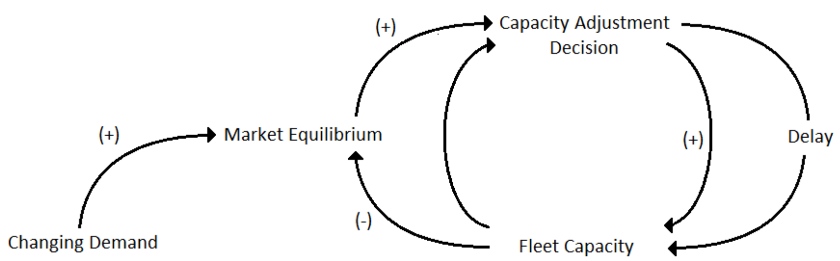

Figure 21. Model's System Dynamic

However, capacity adjustment decision also creates a side effect, which is a delay caused by the delivery lead time of the new ships. The expansion of fleet capacity based on the earlier expectation will create negative effect on market equilibrium because it increases the supply/demand ratio. Given another change in demand, it triggers the next capacity adjustment decision. When the market equilibrium is not favourable for the shipping investors, the capacity adjustment decision is now changed to reduce the orderbook to correct the oversupply. Therefore, our system dynamics in the model has two different feedback loops. Positive feedback promotes growth and negative feedback tends to move the system towards a desired level.

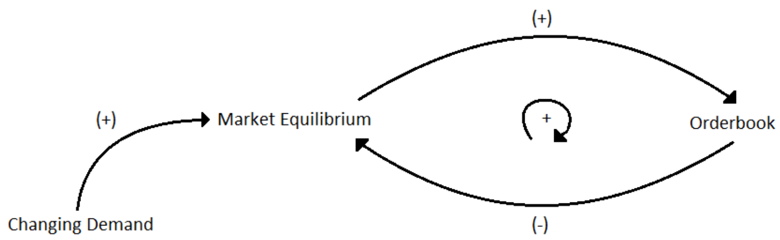

Figure 22. Positive Feedback Loop

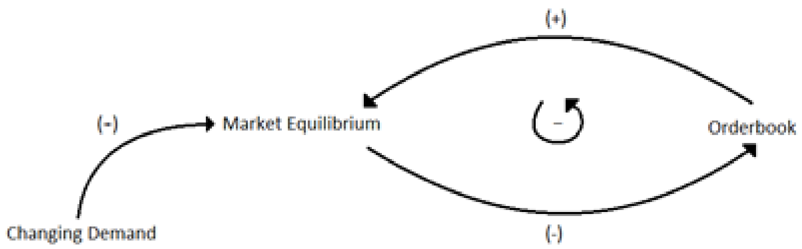

Figure 23. Negative Feedback Loop

The capacity adjustment decision based on these feedback loops is expressed with a different value of u and v. Positive market equilibrium will promote a higher value of u and a lower value of v, resulting in more orderbook and less demolition. However, when the market equilibrium is negative, the model generates a lower value of u and a higher value of v, which reduces or even stops the orderbook, and favours more scrapping.

6.3. Data Collection

In order to formulate our model equations and run the model, we need to collect various data according to the main parameters discussed in 6.2.1. First, we need to define the value of our exogenous variables, these values that are determined outside the model and imposed on the model. As explained earlier, our exogenous variables from the demand module are forecasted trade growth based on GDP and the US Reshoring scenario. According to our study literature, container trade growth in general has always followed the development of GDP. In 2017, DNV-

GL (2017) forecast annual GDP growth of 2.4 percent on average until 2050 and container trade growth of 2.6 percent on average. We will use this projection as our input parameters because the forecast period fits our model time frame. The other required data will be discussed in the following sections.

6.3.1. US Exports and Imports Structure

The net effect of reshoring scenario on the US trade value is one of the variables to be determined outside the model. In previous discussion, we have concluded that if the ongoing reshoring effort continues, most Asian countries that have so far dominated the share of US intermediate imports and exports will be affected. These countries are China, Japan, South Korea, Singapore, Vietnam, Thailand, Malaysia, the Philippines, Hong Kong and Indonesia. As discussed in Chapter 3, Lakatos and Ohnsorge (2017) provide a characteristic of US import and export structure classified by arm's length and intra-firm trade. They suggest that 30 percent of US exports and 50 percent of US imports are intra-firm.

The share of intermediate goods in US export respectively for arm's length and intra-firm trade are 53 and 59 percent. As for the US import structure, intermediate goods accounted for 49 and 48 percent. Therefore, based on this structure, we collect the data of actual trade between the US and its largest trading partners in Asia in order to find out if this characteristic applies and can be used in our model. We obtain the data from UN Comtrade database under the broad economic categories as shown in table 1 and 2. The latest available data is in 2018, thus, we use this data as a basis point of our model.

Trading Partner	US Capital Goods Import	US Consumption Goods Import	US Intermediate Goods Import	Not specified Import
China	208,644,100,921	153,424,898,768	181,010,614,667	20,123,505,184
Japan	30,733,133,335	5,097,261,398	60,274,639,538	49,797,218,271
South Korea	13,568,303,090	3,678,839,254	39,243,604,069	19,709,840,706
Singapore	4,352,824,582	2,846,630,405	12,664,674,467	7,015,007,822
Vietnam	10,382,599,880	27,400,951,483	9,701,149,590	3,792,788,536
Thailand	11,785,434,168	5,176,617,703	11,810,992,685	4,253,575,387
Malaysia	10,121,628,638	4,388,228,730	24,329,406,719	1,292,162,599
Indonesia	1,261,260,112	8,934,041,692	8,955,097,471	2,681,555,202
Philippines	3,212,492,278	2,035,304,392	6,717,212,498	974,339,419
Hong Kong	944,054,237	1,208,553,049	1,638,019,784	2,639,875,314

Table 4. US imports value from Asia
Source: Compiled by author based on UN Comtrade Database, 2021

Trading Partner	US Capital Goods Export	US Consumption Goods Export	US Intermediate Goods Export	Not specified Export
China	18,202,078,658	4,725,474,445	67,436,179,001	29,784,133,619
Japan	11,311,387,849	5,932,829,549	41,284,629,566	16,697,238,659
South Korea	8,305,269,736	2,346,904,867	34,409,569,677	11,442,787,806
Singapore	6,430,826,552	1,663,661,381	14,352,246,808	10,283,017,963
Vietnam	843,743,098	435,310,906	6,936,479,940	1,459,760,370
Thailand	1,564,193,820	472,654,241	9,870,003,326	540,615,850
Malaysia	1,702,268,329	335,204,529	9,185,360,447	1,789,112,970
Indonesia	633,949,637	237,820,685	6,054,202,591	1,245,573,253
Philippines	801,962,971	332,441,953	6,196,934,829	1,388,732,884
Hong Kong	7,542,974,381	6,877,322,744	16,791,701,813	6,072,154,876

Table 5. US exports value to Asia
Source: Compiled by author based on UN Comtrade Database, 2021

According to the data, the value of intermediate goods imported to the US from its largest trading partner in Asia in 2018 is around 356 billion USD or 36.4 percent of the total import value, while the value of intermediate goods exported from the US to Asia is around 212 billion USD or around 56.8 percent of the total export value. Although the UN Comtrade figures show that the share of imported intermediate goods is lower than the indicated characteristics, but if the value of not-specified goods is added to the value of intermediate goods, the share will correspond to the characteristics of the US export and import structure presented. Therefore, we will use this structure and characteristic for our model to distinguish the trade of intermediate goods from other goods in order to simulate the reshoring scenario.

6.3.2. Demand for Container Shipping Services

As explained in the model description, our model requires exogenous variables determined outside the system to generate demand for container shipping services on each trade route over the next twenty years. Therefore, it requires data of actual demand for container shipping services in 2018 as a starting point. The demand for container transport services is expressed in TEU and we obtain this data from Clarkson Research. Originally, the data is grouped under four major trade routes, but we split this data into six trade routes to better simulate the net effect of the US reshoring scenario specifically on the Trans-Pacific route. As discussed in Chapter 4, the US reshoring scenario will mainly affect container volume in Trans-Pacific. Thus, the six grouped trade routes used in this model are Trans-Pacific, Far East - Europe, Transatlantic, E-W Non-Main Lane, North-South, and Intra-Regional.

Year	Trans-Pacific					
	Asia-North America			North America-Asia		
	Intermediates (TEU)	Others (TEU)	Total (TEU)	Intermediates (TEU)	Others (TEU)	Total (TEU)
2018	9312000	9888000	19200000	4087500	3412500	7500000

Table 6. Demand for Container Shipping Services in Trans-Pacific in 2018
(Clarkson Research, 2020)

Year	Far East – Europe (TEU)	Transatlantic (TEU)	E-W Non-Main Lane (TEU)	North-South (TEU)	Intra-Regional (TEU)
2018	24800000	7900000	20500000	32300000	81900000

Table 7. Demand for Container Shipping Services other trade routes in 2018
(Clarkson Research, 2020)

6.3.3. Containership Deployment Share

Based on the demand for shipping services on each trade route, our model generates demand for running capacity for each containership size. As discussed in Chapter 4, we classified containership size into four segments, namely Feeder, Panamax, Neo-Panamax, and ULCV. In order to calculate demand for each containership size, our model requires data on the share of containership deployment on each trade route. The data is obtained from Clarkson Research (2020). Similar with the export and import structure in the US, we assume that this deployment share characteristic will remain constant over the time frame of the model.

Containership Deployment Share = k					
Trade Route (i)	Containership size (j)				
	Feeder	Panamax	Neo-Panamax	ULCV	Total
Trans-Pacific	0.01	0.18	0.80	0.01	1
Far East – Europe	0	0.02	0.26	0.72	1
Transatlantic	0.05	0.57	0.38	0	1
EW Non-Main lane	0.04	0.42	0.48	0.6	1
North-South	0.1	0.42	0.48	0	1
Intra-Regional	0.62	0.38	0	0	1

Table 8. Containership Deployment Share
(Clarkson Research, 2020)

6.3.4. Historical Fleet Capacity and Productivity

From the supply module, our exogenous variable is the current fleet capacity. We could get this data from Clarkson Research (2020), where this data is also available for each containership size. As previously described, given the productivity, our model calculates the running capacity that will be used in the market equilibrium. Therefore, we also have to determine the value of the average productivity, expressed in TEU cargo/TEU capacity. To determine this value, we collect the historical data of the total number of containers transported and the total fleet capacity from 2014 to 2018. According to the data, the average productivity is 9.24 TEU cargo/TEU capacity. We will use this value of average productivity to run our model.

Year	Capacity by Containership Size (TEU)				
	Feeder	Panamax	Neo-Panamax	ULCV	Total
2014	4107600	7386300	5422700	367400	17284000
2015	4034300	7400800	6307500	692200	18434800
2016	4033700	7411100	7282300	1166700	19893800
2017	3961000	6924300	7843300	1412100	20140700
2018	3966400	6671000	8413300	1859400	20910100

Table 9. The fleet capacity by each containership size
(Clarkson Research, 2020)

Year	Total Fleet Capacity (TEU)	Total Cargo (TEU)	Productivity (TEU Cargo/TEU Capacity)
2014	17284000	164400000	9.57
2015	18434800	167900000	9.51
2016	19893800	175500000	9.11
2017	20140700	185300000	8.82
2018	20910100	194100000	9.20
	Average		9.24

Table 10. The historical data of total fleet capacity and total cargo
(Clarkson, 2020)

6.3.5. Historical Market Equilibrium

The aim of our capacity adjustment strategy is to maintain the balance between demand and supply in the market. The capacity adjustment strategy generates decision variable u and v that determine the value of orderbook and scrapping. Therefore, we need to evaluate the historical value of market equilibrium and compare this value with orderbook and demolition in the following years in order to define the range value of u and v. As shown in Table 8, the market equilibrium of each vessel changes from time to time, with a value range between 0.9 and 1. In some cases the value goes below 0.9 and above 1. The data is derived from the total fleet capacity multiplied by the average productivity calculated from Table 7 and the total container transported as reported by Clarkson Research (2020) from 2014 to 2019. If the value of the market equilibrium is greater than 1, it shows that the supply is greater than the demand, conversely, if the value is less than 1, the demand is greater than the supply.

Supply/Demand Ratio					
Year	Feeder	Panamax	Neo-Panamax	ULCV	Total
2014	1.19	1.20	0.77	0.28	0.97
2015	1.13	1.17	0.88	0.52	1.01
2016	1.08	1.12	0.97	0.85	1.05
2017	0.99	0.99	1.00	0.98	1.00
2018	0.94	0.91	1.03	1.24	1.00

Table 11. The historical data of market equilibrium
(Clarkson Research, 2020)

6.3.6. Historical Deliveries

Since there is not enough data for the orderbook, we are collecting historical data on new ship deliveries from Clarkson Research, assuming no orderbook has been cancelled. We collect the data from 2015 to 2019 for each containership size. Furthermore, we calculate the percentage between deliveries and fleet capacity two years before to find the correlation between supply/demand ratio and the decision of ordering new vessels. As shown in Table 10, the average percentage of the estimated orderbook is 0.07, with the lowest value of 0, which means no orderbook. Some vessels, such as ULCV, show a high percentage of the orderbook because this specific vessel size was introduced in 2014 in which the existing capacity in the market was very minimum.

Year	Deliveries (TEU)				
	Feeder	Panamax	Neo-Panamax	ULCV	Total
2015	99600	112000	974800	474400	1660800
2016	98300	8100	561000	245400	912800
2017	128700	30700	570000	447400	1176800
2018	168600	37400	506100	586400	1298500
2019	160900	24800	270900	606700	1063300

Table 12. The historical data of new ship deliveries
(Clarkson Research, 2020)

Year	Deliveries per total TEU Capacity t-2 (%)				
	Feeder	Panamax	Neo-Panamax	ULCV	Total
2015	0.02	0.02	0.21	2.99	0.10
2016	0.02	0.00	0.10	0.67	0.05
2017	0.03	0.00	0.09	0.65	0.06
2018	0.04	0.01	0.07	0.50	0.07
2019	0.04	0.00	0.03	0.43	0.05
Average					0.07

Table 13. The percentage of estimated orderbook to the capacity

6.3.7. Historical Demolition

Similarly, we collect the historical data for demolition to find the correlation between supply/demand ratio and the decision of scrapping ships. As shown in Table 12, the average demolition percentage varies in total from 0.01 to 0.03, and in extreme cases even to 0.05. The average age of scrapped vessels is 25 years. According to this data, there is no scrapping for Neo-Panamax and ULCV so far as there is no ship of either size older than 25 years. Comparing Table 15 and Table 11, we can summarize that when the supply/demand ratio decreases, the percentage of ships went to demolition market also decreases.

Year	Demolition (TEU)				
	Feeder	Panamax	Neo-Panamax	ULCV	Total
2015	95200	101600	0	0	196800
2016	164100	491600	0	0	655700
2017	120800	284000	0	0	404800
2018	63600	53800	0	0	117400
2019	102100	80700	0	0	182800

Table 14. The historical data of ships demolition
(Clarkson Research, 2020)

Year	Demolition per total TEU Capacity t-1 + deliveries (TEU)				
	Feeder	Panamax	Neo-Panamax	ULCV	Average
2015	0.02	0.01	0	0	0.02
2016	0.04	0.07	0	0	0.05
2017	0.03	0.04	0	0	0.03
2018	0.02	0.01	0	0	0.01
2019	0.02	0.01	0	0	0.02

Table 15. The percentage of demolition to the capacity
(Clarkson Research, 2020)

6.4. Model equations

Provided the description of the model and all the data required, now we formulate the model equations. These equations will generate value from time to time within the set timeframe. The values generated by these equations called as endogenous variables, which are variables changed or determined by its relationship with other variables within the model. In other words, these values are dependent variables which correlate with other factors within the system being studied.

First, we formulate equations to determine the demand for shipping services on each trade route. We previously identified six trade routes for our research. The US reshoring scenario affects only the development of demand for shipping services in the Trans-Pacific, while on other trade routes the development of demand is determined solely by forecasts of global trade growth. Therefore, we formulate two different equations, one specific to the demand in Trans-Pacific (1), and another equation for the other trade routes (5).

Demand for Shipping Services on Trans-Pacific (TEU/year)

$$D_{i,t} = DMI_t + DMO_t + DXI_t + DXO_t \tag{1}$$

Where:

$i = trade\ route \qquad\qquad i = 1\ (Trans - Pacific)$

$t = year$

$DMI = container\ trade\ of\ US\ intermediate\ imports$

$DMO = container\ trade\ of\ US\ other\ imports$

$DXI = container\ trade\ of\ US\ intermediate\ exports$

$DXO = container\ trade\ of\ US\ other\ exports$

The demand of shipping services in Trans-Pacific are divided into two segments. The demand related to the trade in intermediate goods, and the demand related to the trade of all other goods. Further, we divide this trade into east-bound trade from Asia to the US, and west-bound trade from the US to Asia. In other words, east bound trade represents the US imports, and the westbound trade represents the US exports. As explained in the data collection, we use 2018 trade data as our basis point. Therefore, we simulate the reshoring scenario based on the trade value of intermediate goods in 2018, reducing 5 percent every year for the next 20 years. We name the 5 percent reduction in the trade for intermediate goods as annual reshoring proportion, r. Other goods will follow the forecast of global container trade growth of 2.6 percent, g.

$$DMI_t = DMI_{t-1} - (DMI_{2018} * r) \qquad\qquad DXI_t = DXI_{t-1} - (DXI_{2018} * r) \tag{2}$$

$$DMO_t = DMO_{t-1} * g \qquad\qquad DXO_t = DXO_{t-1} * g \tag{3}$$

Where:

$r = annual\ reshoring\ proportion = 0.05$

$g = global\ container\ trade\ growth = 0.026$

$DMI_{2018} = container\ trade\ of\ US\ intermediate\ imports\ in\ 2018$

$DXI_{2018} = container\ trade\ of\ US\ intermediate\ exports\ in\ 2018$

In order to determine the value of intermediate goods, we use the World Bank characteristic of US export and import structure discussed in the previous section. From the total US import, 50 percent is categorized as Arm's Length trade, m_1, where 49 percent of this trade is intermediate goods, m_2. Another 50 percent of US total import categorized under Intrafirm trade, m_3, where 48 percent of this trade consist of intermediate goods, m_4. Similarly, From the total US export, 70 percent is categorized as Arm's Length trade, x_1, where 49 percent of this trade is intermediate goods, x_2. Another 30 percent of US total export categorized under Intrafirm trade, m_3, where 58 percent of this trade consist of intermediate goods, m_4.

$$DMI_{2018} = DM_{2018} * (m_1 m_2 + m_3 m_4)\, DXI_{2018} = DX_{2018} * (x_1 x_2 + x_3 x_4) \quad (4)$$

Where:

$DM_{2018} = container\ trade\ of\ US\ total\ imports$
$DX_{2018} = container\ trade\ of\ US\ total\ exports$

$m_1 = arm's\ length\ US\ imports\ trade\ ratio = 0.5$
$m_2 = intermediate\ ratio\ for\ US\ arm's\ length\ imports = 0.49$
$m_3 = intrafirm\ US\ imports\ trade\ ratio = 0.5$
$m_4 = intermediate\ ratio\ for\ US\ intrafirm\ imports = 0.48$

$x_1 = arm's\ length\ US\ exports\ trade\ ratio = 0.7$
$x_2 = intermediate\ ratio\ for\ US\ arm's\ length\ exports = 0.53$
$x_3 = intrafirm\ US\ exports\ trade\ ratio = 0.3$
$x_4 = intermediate\ ratio\ for\ US\ intrafirm\ exports = 0.58$

The trade development in other trade routes, namely Far East – Europe, Transatlantic, E-W Non-Main Lane, North-South, and Intra-Regional are assumed to be driven only by the forecast of global economic growth. Therefore, the development for shipping services on these routes consider only the forecast of annual global container trade growth of 2.6 percent as shown in the equation below.

Demand for Shipping Services on Other Trade Routes (TEU/year)

$$D_{i,t} = D_{i,t-1} * g \quad (5)$$

Where:

$i = trade\ route$ $\qquad i = 2\ (Far\ East - Europe)$
$3\ (Transatlantic)$
$4\ (E - W\ Non\ Main\ Lane)$
$5\ (North - South)$
$6\ (Intra\ Regional)$

The next formulation is to determine the demand for fleet running capacity for each of the size of containerships (6). In previous discussion, we defined 4 different sizes of containerships for our research, namely Feeder, Panamax, Neo-Panamax and ULCV. In order to calculate the demand for fleet running capacity, we have to calculate all demand for shipping services on all routes, D_j and multiply it by the deployment share of each size of containership, k. The characteristic of deployment share refers to table 5 discussed in sub-section 6.3.3. The demand of fleet running capacity is the outcome of the demand module in our shipping market model. This value will later determine the market equilibrium.

Demand for Fleet Running Capacity (TEU/year) (6)

$$D_{j,t} = \sum_{i=1}^{n} D_{i,t} k_{ij}$$

Where:

$j = container\ ship\ size \qquad j = 1\ (Feeder)$
$2\ (Panamax)$
$3\ (Neo - Panamax)$
$4\ (ULCV)$

$t = year$

$i = trade\ route$

$k = containership\ deployment\ share$

From the supply module, we formulate equations to calculate the fleet capacity for each containership size, C_j expressed in TEU (7). In the formulation we apply the Karakitsos-Varnavides integrated shipping cycle theory, where the change in the total fleet between two successive periods is equal to the deliveries, N_j minus the scrapping, S_j in the same period. In other words, the total fleet capacity is calculated annually at the end period on the basis of the fleet capacity of the previous year, the deliveries and scrapping in the same period added together.

Total Fleet Capacity (TEU)

$$C_{j,t} = C_{j,t-1} + N_{j,t} - S_{j,t} \qquad (7)$$

Where:

$j = container\ ship\ size \qquad j = 1\ (Feeder)$
$2\ (Panamax)$
$3\ (Neo - Panamax)$
$4\ (ULCV)$

$t = year$

$N = delivery\ of\ new\ vessel$

$S = scrapped\ vessel$

As discussed in the previous chapter, Stopford suggests that it takes 2-3 years to build a merchant ship. In our model we assume that the average delivery time of a new ship is 2 years. The deliveries of new ships are therefore equal to the order book created 2 years earlier, assuming there is no cancellation from the order book.

New Vessel Deliveries (TEU) (8)

$$N_{j,t} = O_{j,t-2}$$

Where:

$O = Orderbook$

$L = delivery\ lead\ time = 2\ years$

According to Karakitsos-Varnavides, the orderbook for new vessels is derived from the first-order condition for long-run maximum profits. It is a function of the demand for shipping services, relative prices - which is the freight rate relative to the user cost of capital, and technological factors. It is difficult to quantify such as technological factor into the equation. Therefore, we formulate the equation for orderbook (9) based on the fleet capacity from the first-order condition multiplied by fleet expansion decision variable, u, which is determined by all the above factors.

Orderbook (TEU) (9)

$$O_{j,t} = C_{j,t} * u$$

Where:

$u = capacity\ expansion\ decision\ based\ on\ market\ equilibrium,\ E_t$

Karakitsos-Varnavides describes Demolition as a function of the scrap price relative to the second-hand price and the age of the fleet. The number of ships scrapped is the share of the existing total fleet. In our model, we present the fleet adjustment decision variable, v, as a function of the scrap price to the second-hand price. We assume that the decision to scrap ships, S_j, will be made at the end of period, based on the fleet capacity from the previous year, $C_{j,t-1}$, the delivery of new ships in the same period $N_{j,t}$, and the market condition. We also take age of the fleet into account when deciding whether to scrap ships. Stopford (2009) states that ship has a physical lifespan of 15-30 years before it usually enters the demolition market. Therefore, we apply a policy on our model that the ship must be scraped at the maximum age of 25 years. For this reason, the model requires the data from the delivery of ships from 1992 to 2013.

Demolition (TEU) (10)

$$S_{j,t} = (C_{j,t-1} + N_{j,t}) * v, \qquad S_{j,t} > N_{j,t-25}$$

Where:

$v = Capacity\ adjustment\ decision\ based\ on\ previous\ year\ market\ equilibrium,\ E_{t-1}$

$L = ship's\ lifetime = 25\ years$

Both the orderbook and scrapping are driven by capacity expansion and adjustment decision variables. These variables are made based on the market equilibrium. Market equilibrium, E_j is a function of total fleet capacity, C_j multiplied by average productivity, p and divided by the demand for ship running capacity, D_j. We calculated the average productivity in section 6.3.4 as 9.24 TEU cargo / TEU capacity.

Market Equilibrium

$$E_{j,t} = C_{j,t} * p \,/\, D_{j,t} \qquad (11)$$

Where:

p = productivity (TEU cargo/TEU Capacity) = 9.24

The value of the market equilibrium is the basis for determining the decision variable, both for fleet expansion and adjustment decision. In this model, we define the range value of u and v according to our observation in table 11, 13, and 15. When the market equilibrium shows value below 0.9, it indicates that vessels are in short supply, which increases freight rates and encourages shipping investors to buy ships. Due to the increasing demand, the price of second-hand ships become too expensive, so that the shipowner order new ships, which lead to an expansion of the total world fleet. Therefore, in this state we formulate the highest value of of u and the lowest value of v.

However, when the value of the market equilibrium is greater than 1, it indicates that there are too many ships in the market, causing the freight rates to drop and the ships to lay-up. Shipowners struggling to pay the fixed costs were forced to sell the ship to raise money. If the downturn continues, the price of old ships will eventually fall to a level where it is better to sell the ship to the scrapyard than to the second-hand market. Therefore, in this situation, we set the lowest value of of u and the highest value of v. Overall, the desired value of market equilibrium is between 0.9 to 1. In this condition, the shipowners still have room to expand the fleet while they simultaneously send the older ship to the demolition market.

Capacity Expansion Decision (12)

IF $E_{j,t} < 0.9$ then $u = 0.15$

IF $0.9 < E_{j,t} < 1$ then $u = 0.10$

IF $E_{j,t} > 1$ then $u = 0$

Capacity Adjustment Decision (13)

IF $E_{j,t-1} < 0.9$ then $v = 0{,}01$

IF $0.9 < E_{j,t-1} < 1$ then $v = 0.02$

IF $E_{j,t-1} > 1$ then $v = 0.03$

6.5. Conclusion

At this stage, we have developed and formulated all the required equations to run our model. We apply the Stopford Shipping Market Model to our problem and define the input parameters, objective, decision variables, and output parameters. We also apply the system dynamics approach in the relationship of market equilibrium, capacity adjustment decision and fleet capacity in our model. We determine positive and negative feedback loops expressed in different value of decision variables u and v. Finally, we formulated 13 equations for our model, according to our theoretical framework, data set, and assumptions. The aim of our model is to simulate the changing demand for container shipping services over the next twenty years, taking into account the forecasted economic growth and the US reshoring scenario. We will obtain from the model the trend and fluctuation of supply and demand of each containership size, namely Feeder, Panamax, Neo-Panamax and ULCV, as well as the oscillating shipping cycle generated by the behaviour of shipping market.

Chapter 7: Analysis and Result

In this chapter, we present the result of running the model based on the framework, formulated equations, and data collection explained in the previous chapter. The first part of the model simulates the changing demand for containership running capacity over the next twenty years, taking into account the predicted economic growth and the US reshoring scenario. The second part of the model simulates the response of the container shipping market and shows the fluctuation of supply and demand of each market segment for container ships, namely Feeder, Panamax, Neo-Panamax and ULCV. Based on this result, we analyse trends and fluctuations by market segment and discuss how the US reshoring scenario affects the container shipping market in general.

7.1. Demand for Container Shipping Services over the next 20 years

We compute equation 1-4 and run the model in Microsoft Excel to simulate the change in demand for container shipping services on the Trans-Pacific route for 20 years period. In this model, we assume an annual reshoring of 5 percent. That means the container trade value of intermediate goods between the US and its trading partners in Asia is decreasing by 5 percent each year from our starting point in 2018, while the trade value of capital and consumer goods is growing by 2.6 percent following the global container trade growth. In this scenario, the result of our model shows that the total container trade in Trans-Pacific is decreasing from year to year. It falls from 26.7 million TEU in 2018 to 22.2 million in 2038.

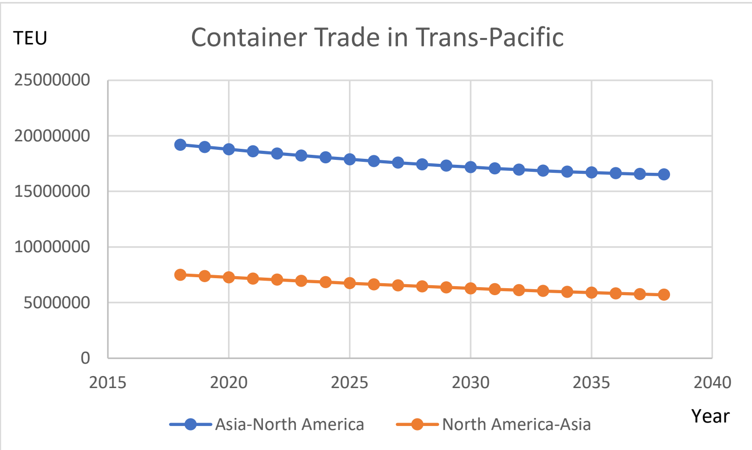

Figure 24. Model result of container trade in Trans-Pacific 2018-2038

We then compute equation 5 and simulate the trade development in other trade routes: Far East – Europe, Transatlantic, E-W Non-Main Lane, North-South and Intra-regional. We assume that the trade development in these trade routes is not directly affected by the US reshoring scenario. Demand for shipping services on these trade routes is driven by the forecast of annual global container trade growth of 2.6 percent.

As a result, figure 25 shows the comparison of the trade development of all trade routes. The intra-regional shows the highest increase of demand for containership running capacity, from 81.9 million TEU in 2018 to 136.8 million TEU in 2038. Other trade routes except Trans-Pacific are showing moderate growth. The only declining demand is Trans-Pacific, starting in 2018 over the Far East - Europe and EW Non-Main Lane, but ending under these two trade routes in 2038.

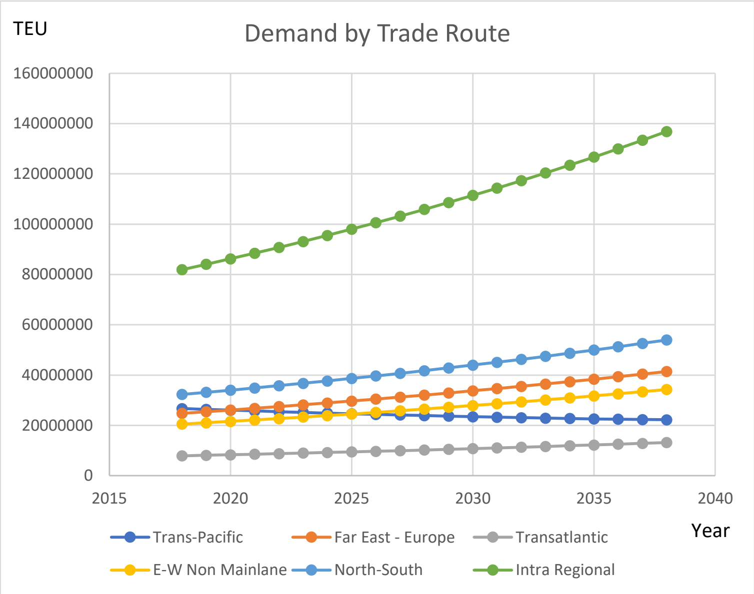

Figure 25. Model result of demand for containership running capacity by trade route 2018-2038

In order to determine the demand for each containership size, we calculate Equation 6 as described in the previous chapter. In this model, we defined 4 segments of container vessel size, namely Feeder, Panamax, Neo-Panamax and ULCV. We run this model based on the containership deployment characteristic of each route assessed by Clarkson Research. In this simulation we assume that the deployment share remains constant over the time period of the model.

The result of running the model shows that the demand for Feeder and Panamax is increasing significantly. In terms of running capacity, the demand for Panamax vessels increases from 63.1 million TEU in 2018 to 101.4 million TEU in 2038, while the demand for feeder vessels increases from 55.5 million TEU to 92.5 million TEU. In contrast, demand growth for Neo-Panamax and ULCV is at a somewhat slower pace. The demand for Neo-Panamax increases from 56.1 million TEU in 2018 to only 75.9 million TEU in 2038, while the demand for ULCV increases from 19.3 million TEU to 32.1 million TEU.

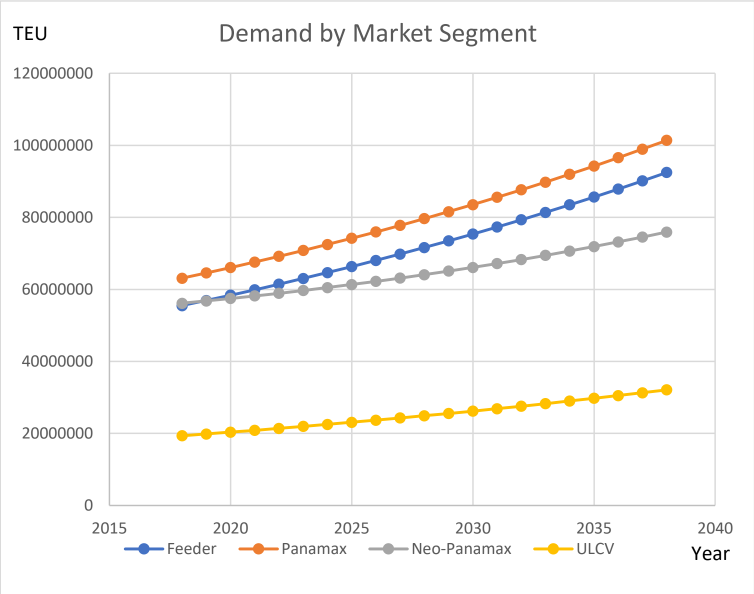

Figure 26. Model result of demand for containership running capacity by market segment 2018-2038

7.2. Container Shipping Market Model Simulation

In the second part of the simulation, we run the model to describe the response of the shipping investors to the changing demand simulated in the previous section. We run the model for each market segment separately based on the existing fleet capacity, historical data of deliveries and scraps, and assumption of capacity adjustment strategy to maintain the desired range of supply and demand ratio. In this model, we assume that each segment of the containership is required to meet the pre-determined average productivity, calculated from the historical data of the total number of containers transported and the total fleet capacity from 2014 to 2018.

7.2.1. Feeder

Driven by the changing demand for feeder vessels as shown in Figure 27, we compute equation 7-13 simultaneously to run a systems dynamics model to simulate the response of the shipping market. As can be seen in figure 28, the shipping investors in the feeder market are trying to adapt the capacity to the increasing demand. However, the graph also shows that a constant increase in demand does not necessarily correspond to a constant increase in capacity. Instead, the model simulation shows that shipping investors reduce the capacity from 2028 before increasing capacity again in 2033.

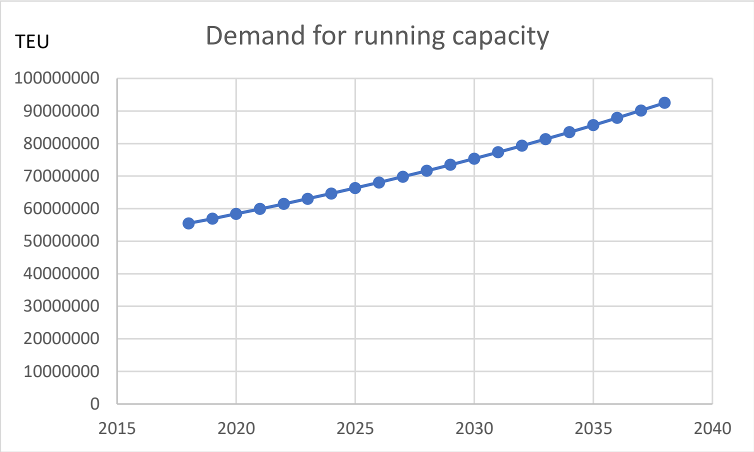

Figure 27. Model result of demand for Feeder 2018-2038

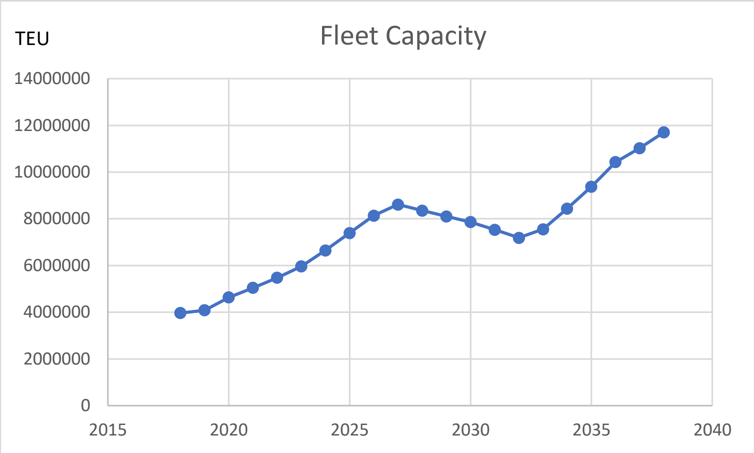

Figure 28. Model result of capacity adjustment for Feeder 2018-2038

The fluctuation in the fleet capacity corresponds to the market equilibrium of the feeder size as shown in figure 29. The simulation starts in 2018 with the ratio of the supply far below the demanded running capacity. Therefore, the shipping investors in feeder market expand the capacity to keep up with the increasing demand. However, over-optimistic expectations and the delay in response cause the capacity to reach a point where it exceeds demand, resulting in oversupply. Consequently, shipping investors have to reduce the capacity to keep the market balance at the desired level.

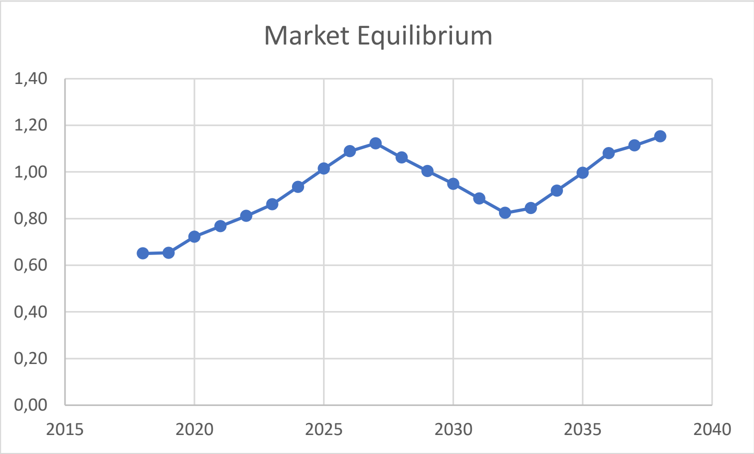

Figure 29. Model result of market equilibrium for Feeder 2018-2038

Figure 30 shows how our model generates the capacity adjustment decision by demolition. Normally ships are scrapped at the age of 25 as indicated by the yellow plots on the graph. However, the graphs shows that between the year 2025-2030, the number of ships scrapped is greater than the number of ships with an age of 25 years. These appear with blue plots in the graph. It implies that the situation is forcing the shipping investors to scrap younger ships in order to maintain the desired market balance. The same situation also occurs between the year 2035-2038.

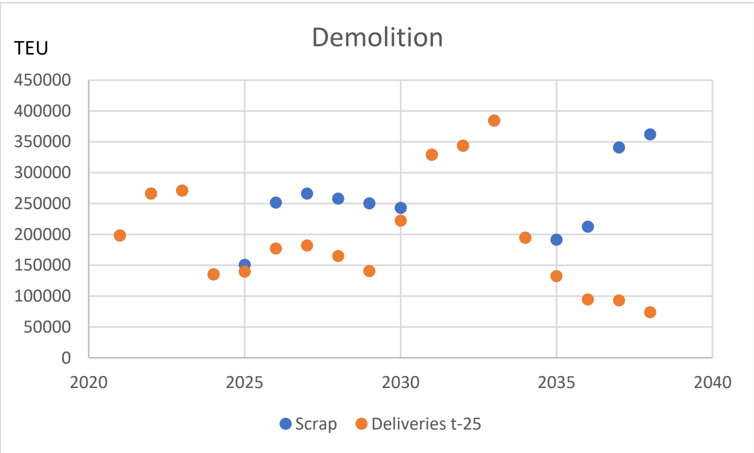

Figure 30. Model result of demolition for Feeder 2018-2038

On the other hand, the capacity expansion decision generated by our model is shown in Figure 31. The high number of orderbook between the year 2018-2024 indicates the over-expectation from the shipping investors. In contrast, the number of orderbook between 2026-2030 indicates the effort of the shipping investors to reduce the capacity, this behaviour also corresponds to the high number of demolitions as shown in Figure 25.

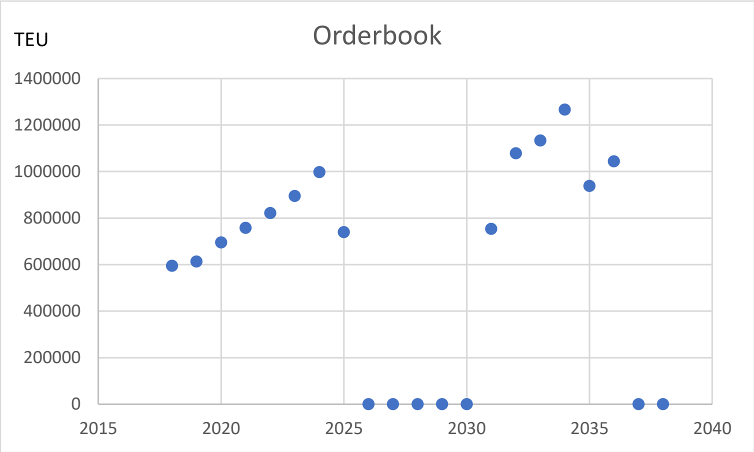

Figure 31. Model result of orderbook for Feeder 2018-2038

7.2.2. Panamax

Similarly, we run the same model for the Panamax market. The changing demand is shown in Figure 32. Then, we compute equation 7-13 simultaneously to run a systems dynamics model to simulate the response of the shipping market.

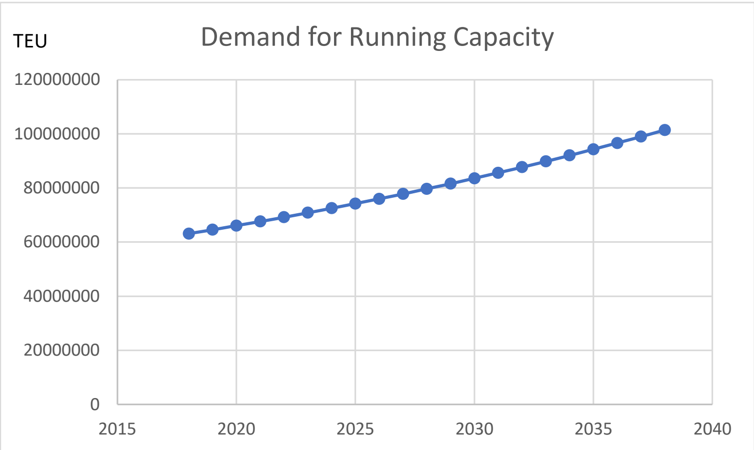

Figure 32. Model result of demand for Panamax 2018-2038

As Figure 33 shows, the shipping investors in the Panamax market are trying to match the capacity with the increasing demand. Similar to what we have seen on Feeder market, a constant increase in demand does not necessarily correspond to a constant increase in capacity. The model simulation shows that shipping investors in Panamax market also reduce the capacity in some periods.

The fluctuation in the fleet capacity corresponds to the market equilibrium of the Panamax size as shown in figure 34. The simulation starts with the balanced supply and demand, and as demand increases, the shipping investors in the Panamax market are trying to increase capacity to keep the balance. In 2023, the supply will start to exceed the demand and therefore the shipping investors are working to reduce the capacity. However, due to the delay in response, the capacity will continue to increase until it returns to the desired level in 2027.

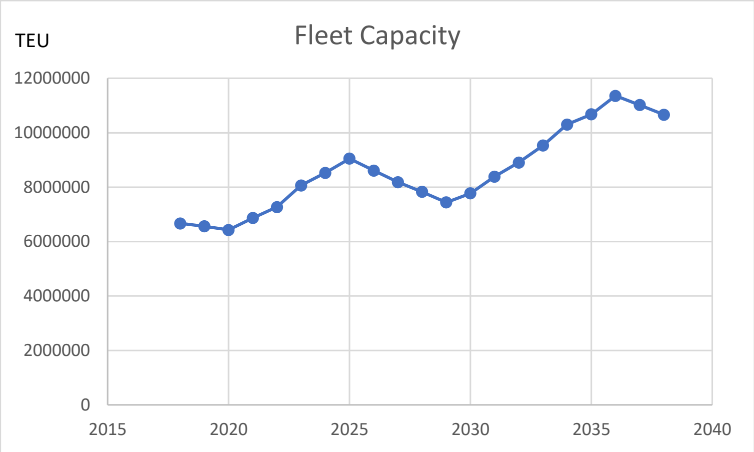

Figure 33. Model result of capacity adjustment for Panamax 2018-2038

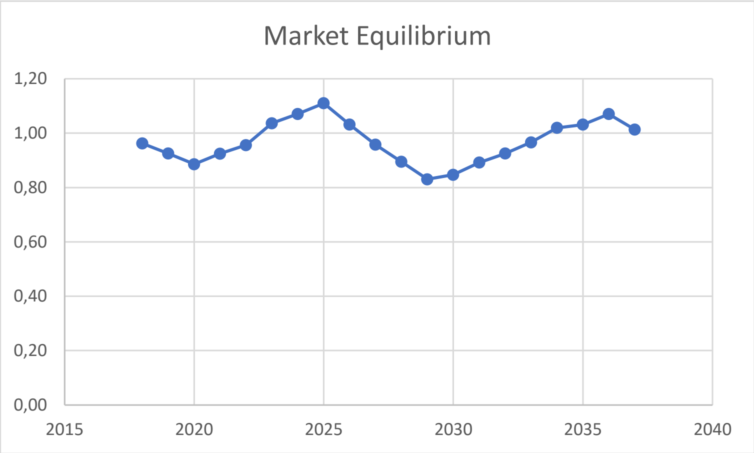

Figure 34. Model result of market equilibrium for Panamax 2018-2038

Figure 35 shows how shipping investors in the model adjust the capacity of the Panamax fleet through scrapping. In general, the number of scrapped ships in the Panamax market is high because there is a large population of old ships in this market segment. Although, in some periods, the market situation also puts pressure on shipping investors to send more younger ships to the scrapping market. As indicated by blue plots in the graph, this happens in 2024, 2036. And 2037.

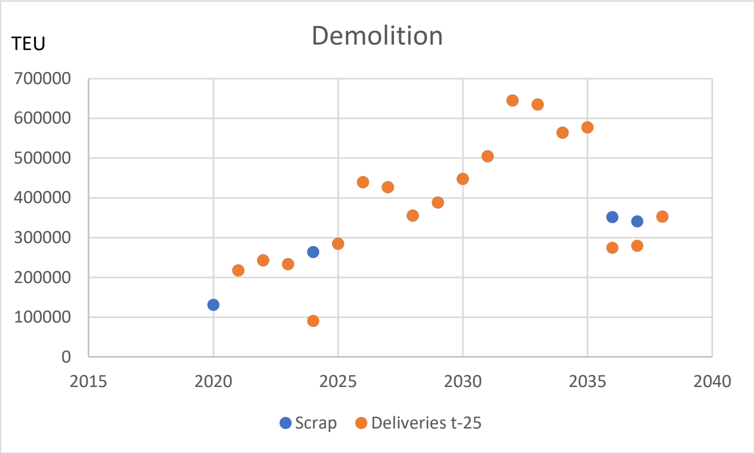

Figure 35. Model result of demolition for Panamax 2018-2038

The capacity expansion decision generated by our model is shown in Figure 36. There are some periods when shipping investors place orderbook to expand fleet capacity. As can be seen from the graph, it happens between the year 2020-2023, also between the year 2028-2034. In another scenario, when there is an oversupply, the shipping investors do not place order for newbuilding, as shown by blue plots between the year 2024-2027 and between the year 2035-2038.

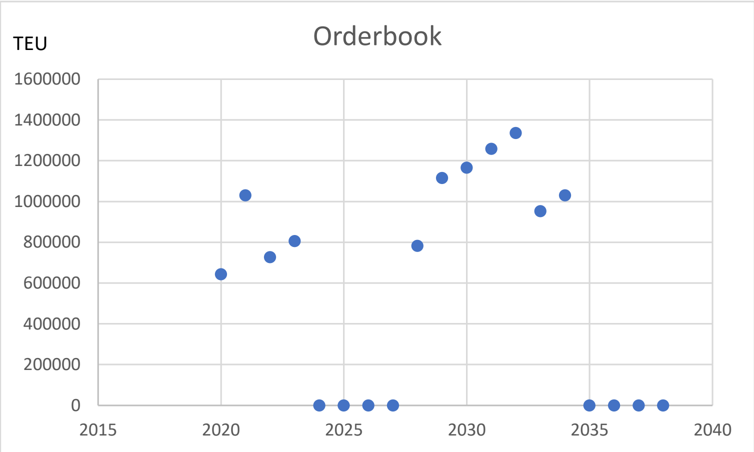

Figure 36. Model result of orderbook for Panamax 2018-2038

7.2.3. Neo-Panamax

As discussed in the previous section, Neo-Panamax is the most affected market segment from the US reshoring scenario. Neo-Panamax shares the largest fleet deployment on the Trans-Pacific Route, which our model predicts will see trade decline over the next 20 years. Therefore, the Neo-Panamax market shows a different dynamics of market equilibrium compared to the other markets discussed earlier. Overall, our model tells us that there is still growing demand for Neo-Panamax vessels, although it is growing much slower compared to Feeder and Panamax. The predicted growth in demand for Panamax is shown in Figure 37.

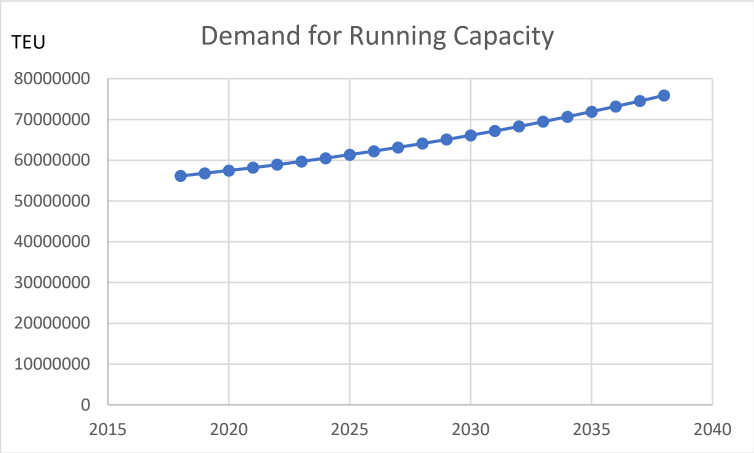

Figure 37. Model result of demand for Neo-Panamax 2018-2038

As a result, shipping investors are trying to reduce the capacity to adapt to the slow-growing demand of this market segment. Figure 38 shows that the capacity of the Neo-Panamax fleet will continue to decrease until 2028, reaching its lowest level at 6.5 million TEU. At the end of our simulation, the total fleet capacity stands at 8.3 million TEU, slightly lower than the capacity in 2018.

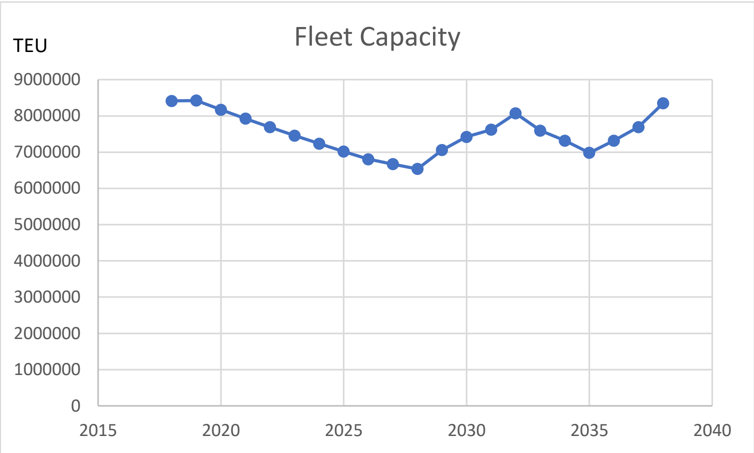

Figure 38. Model result of capacity adjustment for Neo-Panamax 2018-2038

Figure 39 shows the dynamics of the market equilibrium of the Panamax size. The simulation starts with too many Neo-Panamax ships on the market. This is happening because according to the actual data, the ship investors placed a huge order for Neo-Panamax vessels between 2015-2017, indicating that they do not predict the scenario of US reshoring and the declining trade on the Trans-Pacific route. As a result, the shipping investors have to reduce capacity to achieve the desired level of market balance. However, this corrective action will take time as the graph shows, the market imbalance will last until 2025.

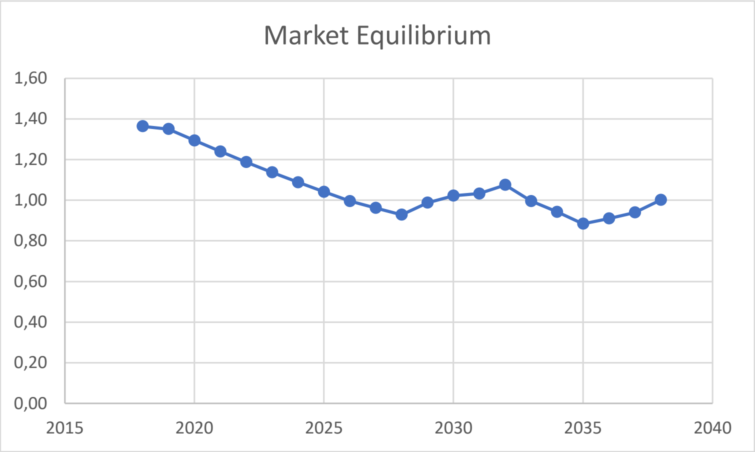

Figure 39. Model result of market equilibrium for Neo-Panamax 2018-2038

In order to reduce capacity, our model shows that the shipping investors will send many vessels under 25 years old to the scrapping market. As can be seen in figure 40, this occur between 2020-2028. According to our data, the oldest Neo-Panamax ships were delivered in 1997. The model therefore suggests that ships in this segment will be sent for scrap at age 22 and younger. During the same period, shipping investors in the Neo-Panamax market will also stop ordering new ships. As figure 41 shows, shipping investors will start ordering new ships in 2027. According to the result of our model, the highest order book will occur in 2036.

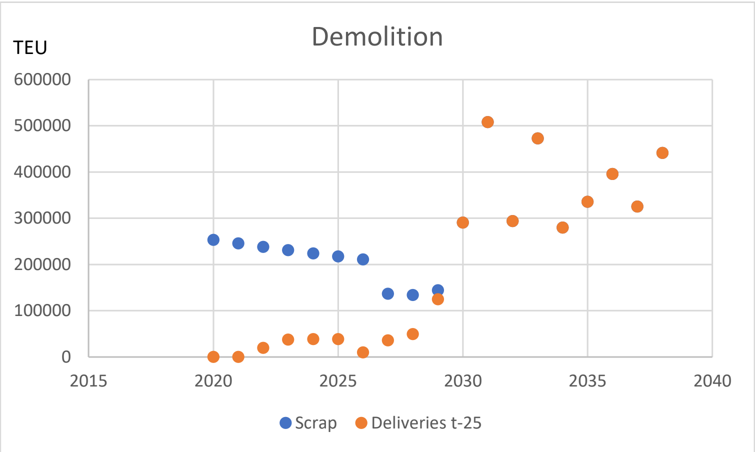

Figure 40. Model result of demolition for Neo-Panamax 2018-2038

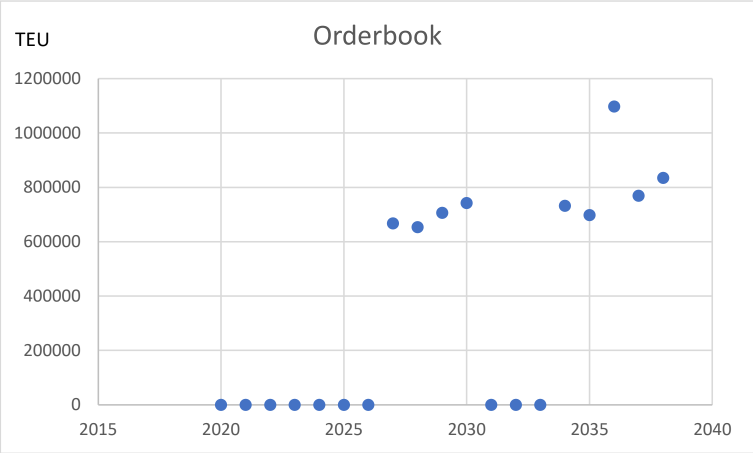

Figure 41. Model result of orderbook for Neo-Panamax 2018-2038

7.2.4. Ultra Large Container Vessel

We also run the model to simulate the dynamics of ULCV market. As shown in Figure 42, our model predicts that the demand for running capacity of ULCV will increase, from 19.3 million TEU in 2018 to 32.1 million TEU in 2038. In response, the shipping investor in this market will increase the fleet capacity to serve the increasing demand. Similar with the other segments, the fleet capacity development of ULCV is also non-linear.

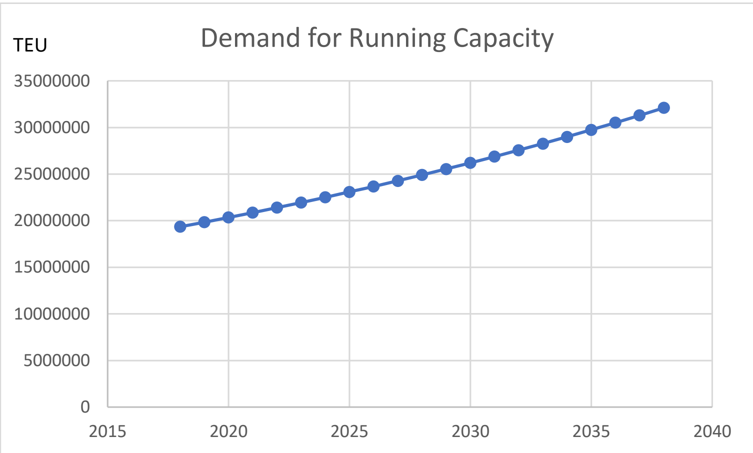

Figure 42. Model result of demand for ULCV 2018-2038

As can be seen from the graph in Figure 43, the simulation shows that, despite a constant increase in demand, the fleet capacity of ULCV decreases between the year 2022-2028 and is followed by another decrease between the year 2034-3038. This fluctuation also corresponds to the market equilibrium as shown in figure 44. The simulation starts with the ideal ratio of supply and demand. However, similar with Post-Panamax, there are too many orderbooks ware made between 2015-2017, indicating the over-expectation of the shipping investors.

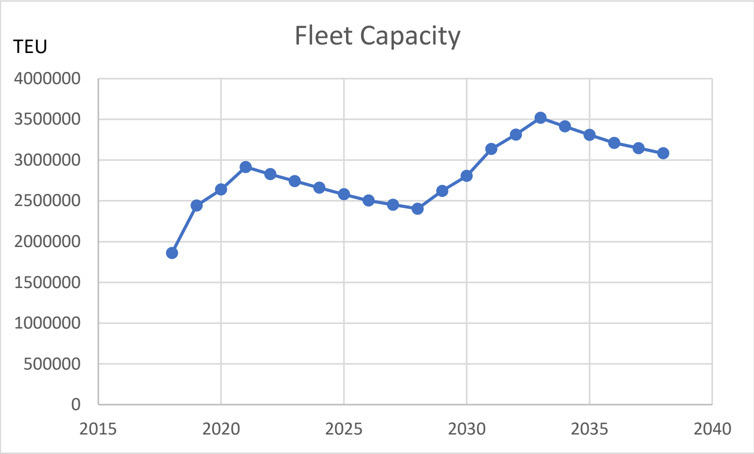

Figure 43. Model result of capacity adjustment for ULCV 2018-2038

When these new ships are delivered between 2019-2021, in such a short time, the fleet capacity therefore increase sharply and cause an imbalance of supply and demand in the market. The capacity adjustment strategy to correct the market equilibrium is then demonstrated by the shipping investors. As Figure 44 shows, the market will return to balance in 2025.

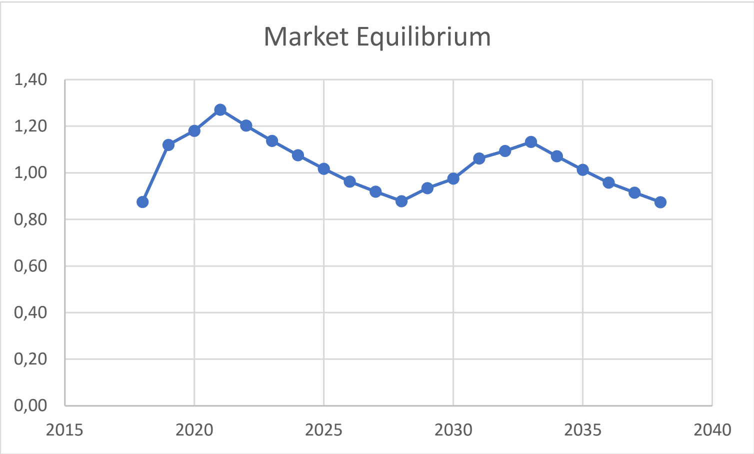

Figure 44. Model result of market equilibrium for Neo-Panamax 2018-2038

In order to achieve market equilibrium, our model simulates the capacity adjustment decision to reduce the capacity through demolition. As can be seen in Figure 45, the number of ships that are sent to the demolition market annually is always greater than the population of the old ships, which we determine in this model as age of 25 years. Although the number of scrapped capacities is low, less than 100.000 TEU, the simulation indicates that the ship of this segment will enter the demolition market too early. According to our data, the first ULCV was delivered in 2006. In this scenario, the ships are therefore scraped at age below 14 years. The capacity expansion decision generated by our model is shown in Figure 46. As a result of over-capacity, the shipping investors are no longer placing order until 2026.

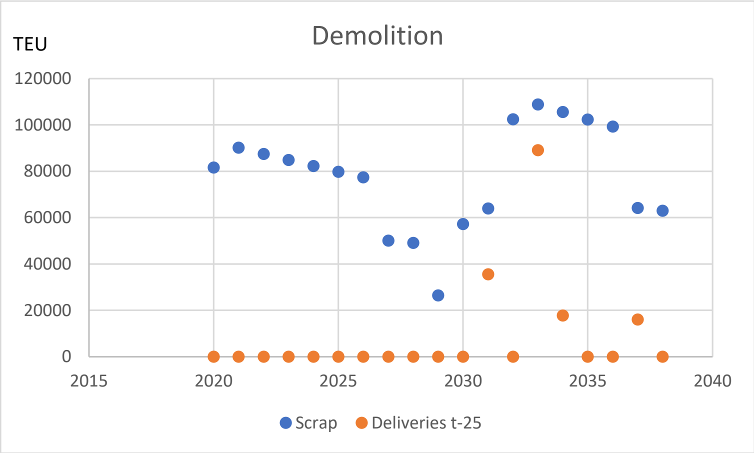

Figure 45. Model result of demolition for ULCV 2018-2038

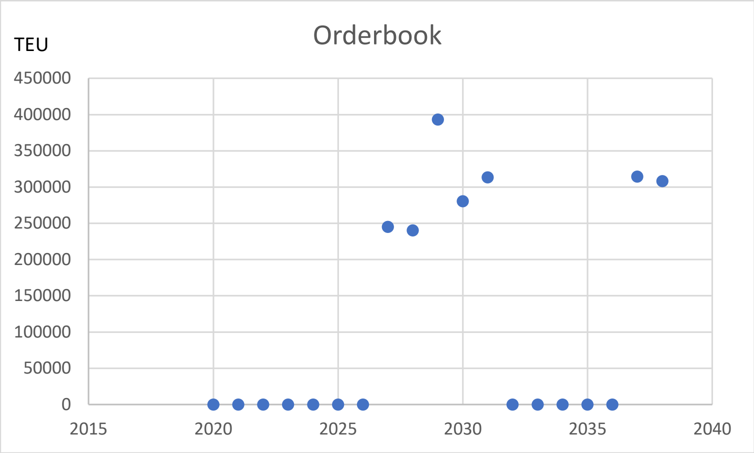

Figure 46. Model result of orderbook for ULCV 2018-2038

7.3. Conclusion

The result of our simulation suggests that the reshoring scenario in the US has significant implications for the container shipping market. The model simulation predicts that as a result of US reshoring, container trade in the Trans-Pacific will decrease from 26.7 million TEU in 2018 to 22.2 million TEU in 2038, while other trade routes show positive growth. In this scenario, intra-regional trade is expected to dominate global container trade, accounting for 136.8 million TEU in 2038.

Furthermore, our simulation shows that the different trade developments on each route influence the demand for capacity for container ships. Assuming the deployment characteristics remain constant over the simulation period, the US reshoring scenario has a different impact on each containership market segment. The annual demand for Feeder capacity increases significantly from 55.5 million TEU in 2018 to 92.5 million TEU in 2038.

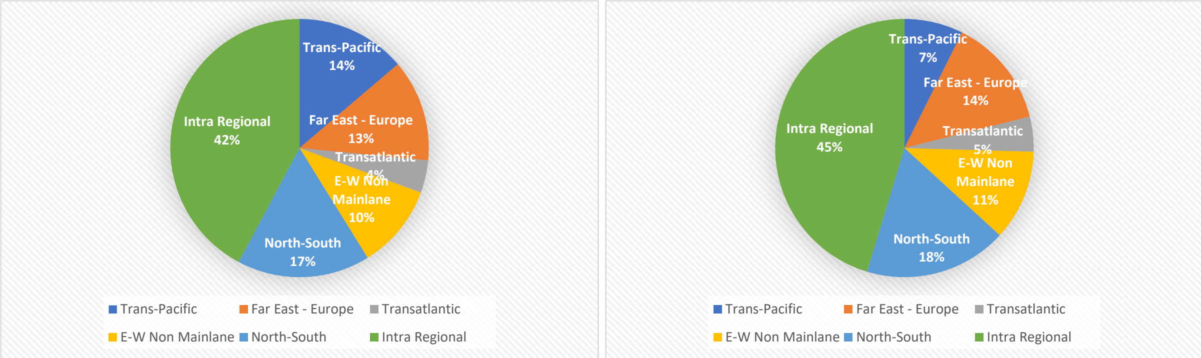

Figure 47. The comparison of global container trade shares by in 2018 (left) and 2038 (right)

Similarly, the demand for Panamax vessels increases from 63.1 million TEU in 2018 to 101.4 million TEU in 2038. Also, the demand for ULCV is increasing from 19.3 million TEU to 32.1 million TEU between the same period. However, the demand for Neo-Panamax vessels is growing at a much slower pace. It increases from 56.1 million TEU in 2018 to only 75.9 million TEU in 2038. This segment shares the largest deployment on the Trans-Pacific route.

The system dynamics simulation in our model shows how the shipping investors adapt their capacity to changing demand, based on the principle of Stopford Shipping Market Model and the theory of Shipping Cycle. The result of our simulation shows that the fleet capacity for Feeder will increase from 3.9 million TEU in 2018 to 11.7 million TEU in 2038. The simulation starts with a shortage of supply and the shipping investors will continue to order new vessels until 2024. The capacity for Panamax is also increasing, from 6.7 million TEU in 2018 to 10.6 million TEU in 2038. The simulation indicates a large number of scrapping activities due to the large population of old ships in this market segment. The simulation predicts that the highest order book will be made between the year 2029-2032.

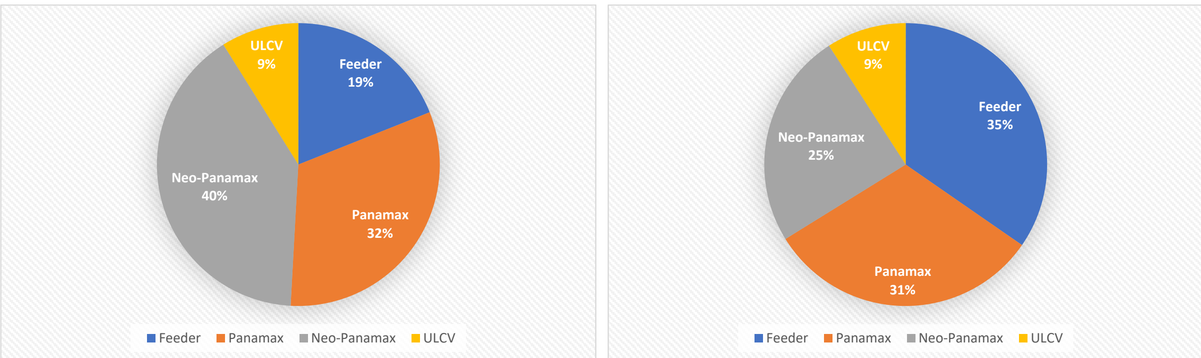

Figure 48. The comparison of containership fleet capacity shares in 2018 (left) and 2038 (right)

Neo-Panamax is the only segment with a declining capacity. It drops from 8.4 million TEU in 2018 to 8.3 million TEU in 2038. The simulation also starts with an oversupply due to high orderbook between 2015-2017. As a result, our simulation shows that the shipping investors do not place an order for a new ship until 2026 and that many ships under 25 are sent to the demolition market. Similarly, we also see a high orderbook for ULCV in the same period. Our simulation suggests that the new ships being delivered will significantly increase capacity and create an imbalance between supply and demand. As a result, shipping investors will reduce capacity by not placing orders for new ships until 2026 and sending younger ships to scrap.

Chapter 8: Conclusion and Discussion

As explained in the previous chapter, the result of our simulation shows that the reshoring scenario in the US certainly has an impact on the container shipping market. It predicts that container trade on the Trans-Pacific route will decline and further affect the demand for containership running capacity. Our simulation suggests that Neo-Panamax will suffer the most negative impact from this scenario. In this chapter we take a closer look at the result of our simulation, in relation to the theoretical and practical perspective. We investigate whether our simulation reflects the theory and practice of the shipping market and which aspects of the model can be improved to increase its applicability.

8.1. Concluding Remarks

In recent years, the US has imposed several protectionist policies that have a direct impact on reshoring initiatives. If the continued effort of reshoring continues, most of the Asian countries that have so far dominated the share of US intermediate exports and imports will be affected. The scenario of US reshoring influenced by the increasing tension of US-China trade war and a rising concern about protectionism and supply chain resilience as a result of COVID-19 crisis will affect the container trade and the shipping market. Therefore, we develop our main research question of "How does US reshoring scenario in relocating manufacturing from China and other Asian countries affect the four different market segments of containership?".

In order to answer our main research question, we had to address four sub-research questions. The first sub-research question is how the US identifies potential manufacturing sectors to relocate from China and other Asian countries in their reshoring scenario. In Chapter 3, we discuss some recent studies that identified several industrial sectors that should consider reshoring, taking into account macroeconomic factors and industry cost models. Most studies conclude that computers and electronics, electrical equipment, primary metals, machinery, furniture, plastics and rubber, paper, and fabricated metals are the most potential industries to be relocated back to the US. These industries also experienced the largest decline in US imports from China in 2019.

The second sub-research question discuss about the impact of US reshoring scenario to relocate manufacturing from China and other Asian countries to the change of US total imports and exports value. In our discussion we conclude that the value of intermediate goods trade will decrease gradually over the next twenty years as many US manufacturers relocate their production back to the US. US exports structure classified by arm's length and intra-firm trade, consisting of 53 and 59 percent of intermediate goods, respectively. As for the US import structure, intermediate goods accounted for 49 and 48 percent. Based on the data derived from UN Comtrade Database, the value of intermediate goods imported to the US from its largest trading partner in Asia in 2018 was around 356 billion USD while the value of intermediate goods exported from the US to Asia was about 212 billion USD.

Furthermore, we discuss in Chapter 4 the answer of our third research question about how the change in US imports and exports value affects the deployment of four different segments of containership in Trans-pacific route. Our data assessment reveals that the container volume in Trans-Pacific has experienced a significant decline. In 2019, the amount of container transported from East Asia to North America dropped from 20.8 million TEUs to 20 million TEUs, while from North America to Asia decreased from 7.4 million TEUs to 6.8 million TEUs. The overall container volume in Trans-Pacific contracted by 4.7 percent. Currently, 81 percent from the total capacity in Trans-Pacific route is served by Neo-Panamax vessels, while only 18 percent served by Panamax, and the rest is served by Feeder and ULCV. Our study suggests that regionalization will make the use of larger vessels more challenging, thereby encouraging deployment of smaller vessels.

We also address the last sub-research question which leads to our main research question. We develop the model to explain how the cyclicality of global containership market responds to the change of container trade according to Stopford's Shipping Market Model and the theory of shipping cycle. In developing our model, we compared several shipping cycle theories and we found Karakitsos-Varnavides provides more comprehensive and realistic approach. Therefore, to model the response of the shipping market to the change in demand for shipping services as a result of the US reshoring scenario, we use the Stopford's shipping market model with the integration of shipping cycle theory from Karakitsos-Varnavides. We also apply system dynamic to our model. The model framework and equations are formulated in Chapter 6.

Finally, we run the model for twenty years period in order to answer our main research question. As a result of US reshoring, the model simulation predicts that container trade in the Trans-Pacific will decrease from 26.7 million TEU in 2018 to 22.2 million TEU in 2038, while other trade routes show positive growth and therefore change the demand for capacity for containerships in the coming years. The annual demand for Feeder capacity increases significantly from 55.5 million TEU in 2018 to 92.5 million TEU in 2038. Similarly, the demand for Panamax vessels increases from 63.1 million TEU in 2018 to 101.4 million TEU in 2038, and the demand for ULCV is increasing from 19.3 million TEU to 32.1 million TEU. The demand for Neo-Panamax vessels, however, is growing at a much slower pace as this segment shares the largest deployment on the Trans-Pacific route. It increases from 56.1 million TEU in 2018 to only 75.9 million TEU in 2038.

The model framework and equations we develop have successfully demonstrated the dynamic relationship between supply and demand according to the concept of Stopford's shipping market model. Our model shows how the shipping investors adapt their capacity to the changing demand. The result of our simulation shows that the fleet capacity for Feeder will increase from 3.9 million TEU in 2018 to 11.7 million TEU in 2038. The capacity for Panamax is also increasing, from 6.6 million TEU in 2018 to 10.6 million TEU in 2038, while the capacity for ULCV increases from 1.9 million TEU to 3.1 million TEU. Neo-Panamax is the only segment with a declining capacity. It drops from 8.4 million TEU in 2018 to 8.3 million TEU in 2038

Our simulation confirms that shipping cycles occur even when the demand for shipping services is not cyclical. These cycles are driven by the cyclical behaviour of the supply-side, due to the lag between ship orders and shipyards' ability to deliver. The over-expectation of shipping investors and inability to predict the future market situation is also a contributing factor. In extreme cases, our simulation shows that the shipping investors would not place an order for the new vessel and would send younger vessels for scrapping to adjust their capacity.

8.2. Theoretical Implications

The result of our simulation proves the theory that world economy determines the volume of goods traded by sea and the decisions over the source of materials and the location of production plants determine how trade develops. The result suggests that the US reshoring scenario will significantly reduce the share of container trade in Trans-Pacific route and promote higher share of intra-regional container trade.

The result of our simulation also shows that the model framework and equations we develop have successfully demonstrated the dynamic relationship between supply and demand according to the concept of Stopford's shipping market model. These dynamic relationships are reflected in the market equilibrium of each containership market segment. The result confirms the theory that the dynamic link in the shipping market lies in the freight market where the imbalance between supply and demand converges. Although the reshoring scenario in the US affects each containership market segment differently, but all segments exhibit the typical cycle and fluctuations in their market equilibriums.

Stopford argues that this typical cycle is generated by the relationship behaviour of the supply-side in the shipping market model. When ships are in short supply freight rates increase and stimulate ordering. Conversely, when there is a surplus, rates fall and remain low until enough ships have been scrapped to bring the market into balance. The fluctuations in the market equilibrium, as shown by the simulation, indicate that shipping investors are trying to maintain the market equilibrium according to this behaviour. We also observe that in some market segments, the over-expectation and inability to predict the future market situation has caused an oversupply in the market balance.

Our simulation confirms Tinbergen-Koopmans' fundamental concept that shipping cycles occur even when the demand for shipping services is not cyclical. Our model simulates the change in demand is linear because it is driven by constant container trade growth and a constant reshoring scenario. However, instead of linear, the market equilibrium of all market segments from our simulation shows a typical cycle.

In developing our model, we adopt the Karakitsos-Varnavides integrated concept, in which the fleet capacity adjustment strategy is influenced by the expectations of future freight rates, new building, second-hand, and scrap prices, which are determined collectively. Therefore, our decision to order new vessels and scrap from existing capacity continues to change each time, depending on the situation of the freight market. This approach is different from the simulation developed by Dimitriou which assumes that freight rates will not affect scrapping activity. In his model, Dimitriou runs the simulation with a constant amount of demolition per year. However, our simulation presents more clearly define cyclicality and shows more similar pattern with the typical shipping market cycle discussed by Stopford.

We also apply System Dynamic in our model. We formulate the model to produce two types of feedback loops. Positive feedback promotes growth and negative feedback tends to move the system towards a desired level of market balance. We also impose time delays between taking a decision and its effects on the state of the system. From the result of our simulation, delays in feedback loops certainly create instability and increase the tendency of systems to oscillates more.

8.3. Practical Implications

Using container trade data from Clarkson Research in 2018 as our starting point, the simulation results suggest that the US reshoring scenario will reduce container trade in the Trans-Pacific for several years to come. We compare our results with the actual data calculated by Clarkson Research and UNCTAD, which we can only compare for the container trade in 2019 and 2020. As shown in Table 16, our simulation results do not differ significantly from the actual calculations. Therefore, we can expect that our simulation results represent the true trend of the container trade.

Year	Clarkson and UNCTAD Calculations*			Our Simulations		
	Eastbound	Westbound	Trans-Pacific	Eastbound	Westbound	Trans-Pacific
2018	19.2	7.5	26.7	19.2	7.5	26.7
2019	18.8	7.4	26.2	19.0	7.4	26.4
2020	18.1	7.0	26.1	18.8	7.3	26.1

Table 16. Comparison of container trade simulation with the actual calculation in million TEU

From the supply side, in response to changing demand due to reshoring in the US, Neo-Panamax's share will fall from 40 percent in 2018 to only 25 percent by 2038. The Feeder, on the other hand, will have the largest fleet by 2038. The share increases from 15 percent in 2018 to 35 percent in 2038. This result confirms the projection from Clarkson Research that the changing trade patterns towards intra-regional trade will promote the deployment of smaller vessels. Similarly, UNCTAD also predicts that the shifts in globalization patterns to greater regionalization would make the use of larger vessels more challenging.

We also find an interesting finding from our simulation. In our model, we apply a capacity adjustment strategy that creates a decision variable to determine the amount of orderbook and scrapping. In extreme cases, our simulation shows that the shipping investors would not place an order for the new vessel and would also send younger vessels for scrapping to adjust their capacity. Based on the result, some Neo-Panamax ships will be scrapped at the age of 22 and some ULCVs will be scrapped at the earliest age of 14. Stopford states that merchant ships have a physical lifespan of 15-30 years before the ship usually ends up at scrap.

In practice, the absence of new ship deliveries for some type of ship has happened in the history of this industry. For example, according to historical data from Clarkson Research, Panamax vessel with a size of 6000 TEU and more was not delivered in 2016, 2018 and 2019. The same happened with Neo-Panamax with a size of less than 12,000 TEU, there was no contract for a newbuilding signed in 2016 and 2017. Interestingly, in the case of the scrapping of younger ships, this trend has actually increased with the container fleet in recent years. In 2016, the first 10-year-old Panamax vessel was scrapped due to deteriorating employment prospects. In 2017, the 7-year-old containership of 3,100 TEU was also scrapped, breaking the record for the youngest scrapping of a containership. Drewry suggests that scrapping for young age containership are now being considered to help balance the supply and demand.

8.4 Limitation

Given the limited time to complete our research, this thesis is subject to a number of limitations. Our model only considers constant container trade growth and reshoring scenario without taking into account trade diversions and other random shocks that could possibly occur during our simulation timeframe. In fact, there are always fluctuations in world real GDP that affect the development of the container trade. For example, in our simulations, we do not consider the impact of COVID-19 on the calculation of container trade growth. Predicting random shocks in the economy and estimating the implications they might have is very challenging and we therefore excluded them from our model.

The result of our simulation suggests that as an impact of the reshoring scenario in the US, the demand for Neo-Panamax vessels will decrease and therefore the shipping investors will adapt the capacity to the changing demand. However, this result assumes that the deployment characteristic remains constant until the end of the simulation. In practice, knowing that economies of scale favour the use of larger ships, this deployment characteristic may change in the future. For example, the share of Neo-Panamax could exceed the share of Panamax vessels in the coming years, not only for Trans-Pacific but also for other trade routes. Nevertheless, since we don't have sufficient basis to predict the trends of deployment characteristics in the future, we only use the current deployment share for our simulation.

The other assumption we use in the model is that all segment of containership has the same productivity. The concept of productivity is useful because it measures overall cargo carrying performance, including operational performance in terms of speed and the amount of cargo transported. According to Stopford, the productivity is determined by the distance the vessel travels in 24 hours, the number of days it spends loaded at sea in a year, and the extent to which it travels with a full cargo. In practice, the productivity of each type of vessel is different and to obtain a precise estimation required further examination. In addition, Clarkson Research suggests that the fleet productivity is also different on each route, determined by the number of ships serving the route, the number of services, also the frequency of each service.

8.5. Recommendation for Future Research

Since the development of the global economy and container trade is very dynamic, the main obstacle in designing the model arose during data collection to construct a realistic scenario. Therefore, further research may be needed to validate some of the assumptions used in this model, such as assessing the scenario of US reshoring not only with Asian countries but also with other trading partners. It is also important for the following research to consider the potential of trade diversions and other random shocks that could potentially occur during the simulation timeframe. In addition, the trend of using larger containerships may change the deployment share characteristic in the future. Therefore, the next study is expected to analyse this change and incorporate it into the model.

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