MT44070 Shipping Management Group Assignment

Group 15

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1 Introduction

The cost structure of vessels is a fundamental aspect of maritime logistics, influencing economic efficiency, operational sustainability, and competitive positioning within the shipping industry. Vessel size is a primary determinant of cost composition, affecting voyage expenses, port handling charges, and fixed operational expenditures. Understanding the correlation between vessel size and cost structure is critical for shipowners, port authorities, and policymakers seeking to optimize fleet management strategies. Beyond the direct cost implications for vessels, the impact of vessel size extends to the broader logistics chain. While larger vessels benefit from economies of scale, reducing transport costs per unit, they may introduce challenges such as increased port handling expenses, infrastructure limitations, and logistical inefficiencies. Balancing these factors is crucial for achieving cost optimization across the containerized shipping network.

Existing literature highlights both the benefits and challenges of vessel size expansion. Jansson and Shneerson emphasized the importance of queuing theory in analyzing port congestion and cost functions, which directly affect the cost structure of larger vessels[1]. Cullinane and Khanna examined economies of scale in container shipping but noted the difficulty of extrapolating cost benefits for ships beyond 8,000 TEU[2]. Similarly, Sys et al. determined that economies of scale are achievable up to approximately 12,500 TEU, though factors like circulation frequency and port calls influence the optimal vessel size[3]. Paz, Orive, and Cancelas highlighted that further vessel size growth is constrained by physical port characteristics, emphasizing the need for integrated port and maritime models[4]. Additionally, Moon and Woo showed that reducing port dwell times improves ship efficiency, reinforcing the importance of port operations in cost structures[5]. These studies underscore the complex relationship between vessel size, port infrastructure, and logistics efficiency.

In addition to cost considerations, environmental regulations play an increasingly critical role in shaping operational strategies within the shipping industry. In 2018, shipping accounted for 2.89% of global human-made emissions (IMO). Ships also emit large amounts of SOx and NOx during long port stays, contributing to seawater acidification. Without control measures, emissions could double by 2050 compared to 2007 levels. To address this, the IMO and governments have implemented various emission-reduction strategies.

Previous studies have analyzed how Emission Control Area (ECA) policies affect ship emissions. Wan et al. studied ships in the Port of Shanghai and found that emission reductions vary depending on ship type and size. Oil/chemical tankers and container ships had the largest reductions in SOx emissions. In addition, when ships use low-sulfur fuel while docked, SOx and PM10 emissions can be reduced by up to 94.4% and 78.3%, respectively[6]. Weng et al. investigated how ECA policies influence ship routes and emissions. Their results show that stricter ECA policies reduced SOx emissions by 31.24%–42.67% for merchant ships. Some ships chose to sail outside ECA areas to avoid using expensive low-sulfur fuel. Moreover, when the fuel price difference is more than USD 450 per ton, most ships tend to avoid ECAs[7].

Currently, there are several ways to comply with ECA regulations, such as using LNG as fuel, switching to MDO, or installing scrubbers. Mohseni et al. found that LNG is the most cost-effective option. It performs better than MDO and scrubbers in terms of both shipowner costs and total supply chain costs. Their study also showed that switching from MDO to LNG can reduce total port emissions by about 76%, especially CO, SO, NOx, and PM[8]. Zis et al. compared the use of MGO fuel with installing scrubbers to continue using HFO.

Their results show that when the fuel price gap between MGO and HFO is large, installing scrubbers becomes more economically attractive and has a shorter payback period. If a ship operates for a long time and spends many days at sea, investing in scrubbers is more cost-efficient[9].

In this context, this study offers a comprehensive perspective on the evolving economic and environmental landscape of global shipping by systematically analyzing vessel cost structures, logistics chain cost implications, and regulatory compliance strategies. The findings contribute to ongoing discussions on cost efficiency, regulatory adaptation, and sustainable maritime operations.

2 Approach and Main Results

2.1 The impact of vessel size on the cost structure of the vessels

This section discusses the impact of vessel size on vessel cost structure. Simulations were conducted using the Antwerp Port Model Program to calculate vessel costs of different vessel sizes. A 23,964 TEU vessel was selected as the baseline, alongside six smaller vessels, including one LNG vessel.

The initial cost analysis is based on a single loop voyage, starting from Ningbo Port, traveling west to deliver goods to Western Europe, and eventually returning to China. The total cost per loop is calculated by summing the total variable cost (including running costs, voyage costs, and port charges), port handling costs, and fixed costs. Figure 1 and Figure 2 illustrate the total cost per loop and the cost structure. Apart from the 14,800 TEU LNG vessel, total loop costs exhibit an almost linear increase with vessel size. The cost components follow a similar trend. Not like other vessels, the LNG vessel has higher costs due to a substantial rise in voyage costs, which will be discussed in the next section. Other cost components follow a growth pattern similar to the 14,990 TEU vessel, which has a comparable weight.

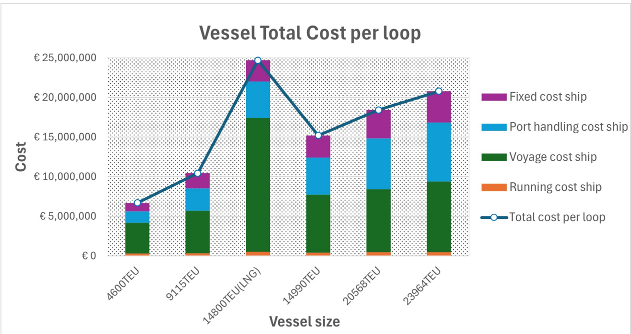

Figure 1: Vessel total cost per loop

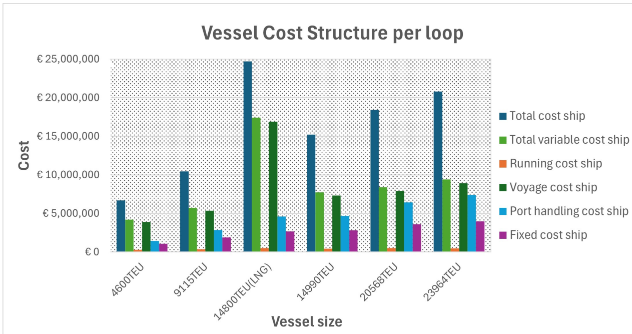

Figure 2: Vessel cost structure per loop

Since variations in vessel size affect cruising speed, port time, and other operational factors, the number of loops completed per year varies across vessel sizes. Therefore, the annual total cost and cost structure were also analyzed. As shown in Figure 3, the annual cost follows a similar pattern to the per-loop cost. With increasing vessel size, the proportion of voyage costs in the total cost slightly decreases, offset by a minor increase in port handling costs.

Figure 4 illustrates the total cost per TEU. Excluding the LNG vessel, the cost per TEU decreases as vessel size increases, with the rate of decline slowing as size grows. This reduction is primarily driven by a sharp drop in voyage cost per TEU, along with slight decreases in running and fixed costs. In contrast, port handling costs remain stable.

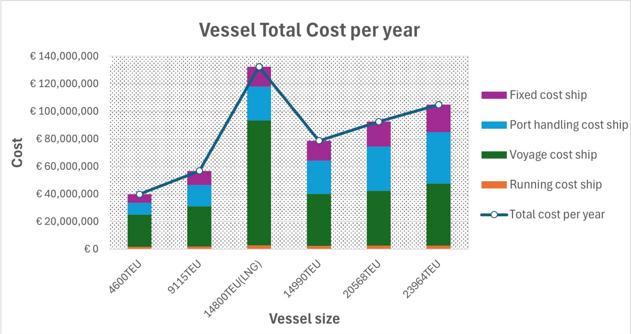

Figure 3: Vessel total cost per year

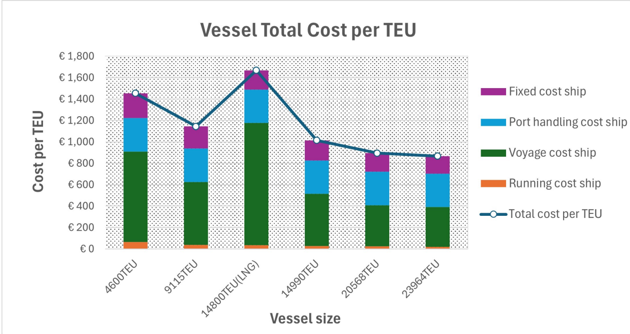

Figure 4: Vessel total cost per TEU

Beyond total cost variations, running and voyage costs were examined to identify cost patterns. Running costs consist of management, repair and maintenance, insurance, stores, and manning costs. As shown in Figure 5, insurance and manning costs account for the largest share of running costs. Insurance costs increase steadily with vessel size, while crew and management costs decrease. Voyage costs include fuel costs (in port, ECA, and non-ECA zones), lubricant oil costs, external costs, ETS costs, and cannel costs. Figure 6 highlights that cannel costs and non-ECA fuel costs are the most prominent contributors. As vessel size increases, cannel costs rise while non-ECA fuel costs decline. Additionally, the exceptionally high non-ECA fuel cost is the primary driver of the LNG vessel's elevated voyage cost.

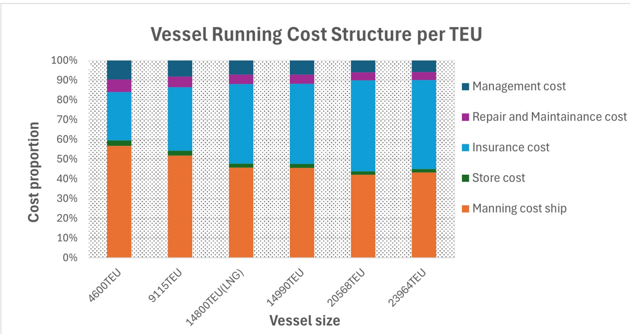

Figure 5: Vessel running cost structure per TEU

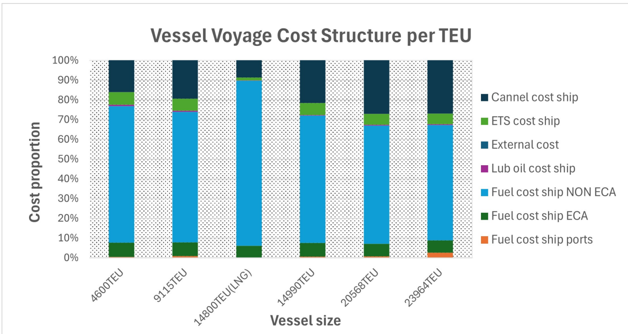

Figure 6: Vessel voyage cost structure per TEU

2.2 The impact of vessel size on the cost structure of the logistics chain

In this section, the impact of vessel size on the cost structure of the logistics chain is evaluated. First, we run simulations for all routes from Chongqing, China, to Düsseldorf, Germany, using the base vessel of 23,964 TEU to select the route with the lowest cost for further analysis. This step aligns with the core objective of logistics service providers in real-world business, which consistently focus on enhancing shipping quality in terms of cost and performance. Based on the summary in Table 1, the route from Xiamen to Zeebrugge is considered the optimal choice for the base vessel of 23,964 TEU, as it offers the lowest total generalized chain cost of 2,595.44 EUR/TEU. This route is thus selected for subsequent analyses of the impact of vessel size on cost structure.

Next, we examine the impact of vessel size on the logistics chain cost structure for the Xiamen–Zeebrugge route. Calculations are performed for six different vessel sizes, ranging from 4,600 TEU to 23,964 TEU, including one LNG-powered vessel of 14,800 TEU. The costs analyzed include hinterland costs (both from and to the port), port costs, maritime costs, and the total generalized chain cost. The results are summarized in Table 2.

The cost breakdown clearly shows that both "From" and "To" hinterland costs remain constant across all vessel sizes, indicating that hinterland logistics are not affected by vessel size variation. This is because hinterland transport primarily relies on land-based modes, such as trucks or trains, rather than vessels. In contrast, vessel size significantly impacts shipping activities that take place at ports and at sea. The proportion of each cost component and the trends of fluctuating costs are respectively illustrated in Figure 7 and Figure 8.

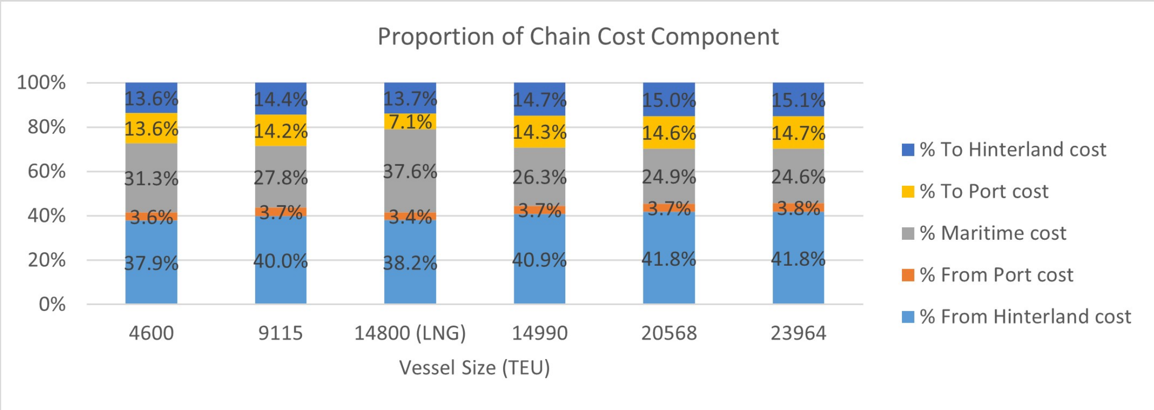

Figure 7: Proportion of chain cost component for all vessel options for Xiamen - Zeebrugge route

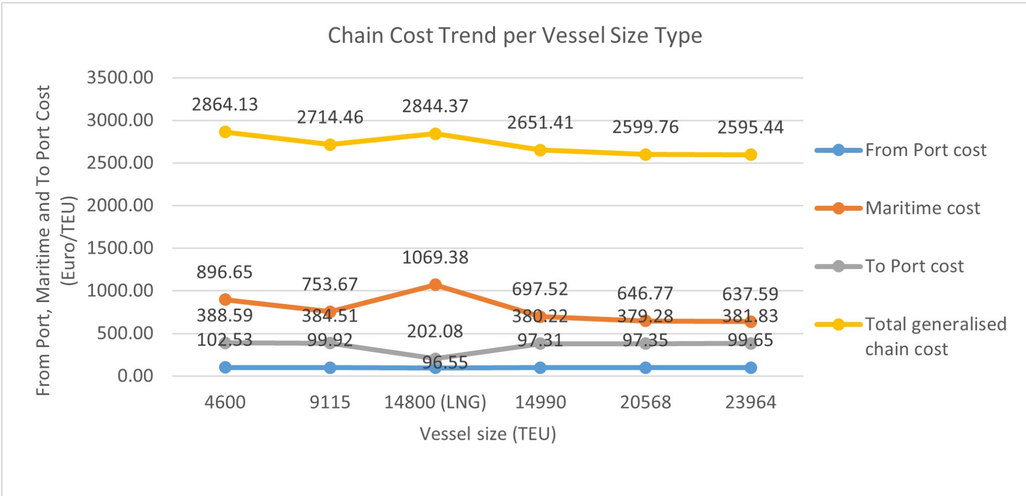

Figure 8: Chain cost component trend for all vessel options for Xiamen - Zeebrugge route

The results indicate that the generalized chain cost generally decreases with increasing vessel size, demonstrating the economies of scale achieved by deploying larger vessels. The smallest vessel of 4,600 TEU incurs the highest total cost of 2,864.13 EUR/TEU, while the largest vessel size of 23,964 TEU achieves the lowest cost of 2,595.44 EUR/TEU, representing a cost reduction of approximately 9.4%. The second-largest vessel of 20,568 TEU also exhibits a comparable total cost of 2,599.76 EUR/TEU, suggesting that the marginal cost reduction from 20,568 TEU to 23,964 TEU is relatively small. An interesting exception to this trend is the LNG-powered vessel of 14,800 TEU, which shows a higher total cost (2,844.37 EUR/TEU) than both smaller and larger vessels. This is mainly due to its significantly higher maritime cost of 1,069.38 EUR/TEU, reflecting the increased operating expenses associated with LNG technology despite its potential environmental benefits, which will be discussed further in the next section.

The overall downward trend in total chain cost is driven by the concurrent reduction of both maritime and port costs. Among cost components, maritime cost consistently decreases as vessel size increases, driven by economies of scale. Larger vessels are equipped with more efficient engines and greater capacity, resulting in lower fuel and operational costs per TEU when distributed over more containers in one trip. Port costs, although relatively minor in the overall cost structure, also show a slight decline with increasing vessel size, with only a marginal rise for the 23,964 TEU vessel. This trend likely results from more efficient port handling procedures for larger vessels.

In conclusion, vessel size plays a pivotal role in determining the cost structure of logistics chains, with larger vessels generally offering lower costs due to economies of scale. Furthermore, the decrease in maritime costs with increasing vessel size is the most influential factor in achieving overall cost reductions. It is also noteworthy that, while hinterland costs remain constant in absolute terms, their relative importance within the total logistics chain cost increases as other cost components decline.

2.3 The impact of using a scrubber or an LNG engine to comply to the ECA zones

2.3.1 Scrubber

One way to reduce emissions and comply with ECA regulations is to install scrubber technology. Scrubbers allow ships to continue using traditional heavy fuel oil (HFO) within ECAs, avoiding the extra cost of switching to low-sulfur fuel (MGO). In a scrubber system, before ship exhaust gases are released into the air, SOx are removed by being sprayed with liquid. Scrubbers can remove up to 95% of SOx, reduce particulate matter (PM) emissions, and meet IMO sulfur emission limits. However, installing scrubbers may also increase fuel and power consumption[10].

To analyze its impact on vessel costs, the installation of scrubber is used as a substitute in the calculation. The result of chain cost calculation can be seen in Table 3. It shows that the marine time cost decreased 0.8% after the installation of scrubber, while other related costs did not change; therefore, total generalised chain cost decreased 0.2%.

According to the calculation model, the only vessel cost component affected by the scrubber installation is fuel cost ship ECA as stated in Table 4. It refers to the expenses incurred when buying fuel that complies with ECA regulations for ships operating in SECA or NECA zones. The fuel cost ship ECA decreases by 33.3%, from €19.76 to €13.18 /TEU, because of scrubber installation, because vessels equipped with scrubbers can continue using HFO instead of MGO, which costs €325 per tonne more than HFO. Although scrubber operation increases power and fuel consumption, the additional cost is generally lower than the price difference between HFO and MGO. As a result, the overall fuel cost ship ECA decreases.

2.3.2 LNG

LNG (Liquefied Natural Gas) is considered an alternative fuel for shipping, because it has very low sulfur content and produces less NOx, PM, and CO_2 compared to traditional fuels. This helps reduce pollution and lower the environmental impact of shipping. Additionally, in some markets, LNG is more cost-competitive than MGO and HFO. However, since LNG bunkering facilities are limited, refueling can be inconvenient, thus reducing operational flexibility for shipping companies.

To analyze its impact on vessel costs, LNG fuel is used as a substitute in the calculation. The result of chain cost calculation can be seen in Table 5. As shown in the table, LNG significantly increases maritime costs by up to 85%, leading to a total generalized chain cost of 3138, which is 1.2 times higher than using MDO.

Furthermore, according to the calculation model, LNG fuel has a substantial impact on vessel costs, particularly voyage costs, which now account for 84% to 94% of the total variable cost per loop. As shown in Table 6, the fuel cost in ECA zones increased by 265%, while in Non-ECA zones, it rose by 447%, and in ports, it increased by 7%. This indicates that the primary cost increase comes from fuel expenses, as LNG (3564 EUR/ tonne) is significantly more expensive than HFO(651 EUR/ tonne) and MDO (976 EUR/ tonne), leading to a sharp rise in overall costs.

2.4 The extra cost due to the implementation of FuelEU directive

FuelEU Maritime establishes maximum limits on the annual average greenhouse gas (GHG) intensity of energy used by ships, which exceed 5,000 gross tonnage that call at European ports, regardless of their flag. The regulation aims to ensure a gradual reduction in the GHG intensity of fuels used in the maritime sector, and the target of FuelEU starts with a 2% decrease by 2025 and reaches an 80% reduction by 2050. In the model, FuelEU Maritime is considered within the framework of the Emissions Trading System (ETS), as its impact on fuel choices and emissions indirectly influences ETS-related costs. In the model, ETS costs are set to zero when FuelEU Maritime is not applied because, in this scenario, ships are not required to comply with the EU Emissions Trading System (ETS). In other words, without FuelEU, there is no obligation to purchase carbon allowances (EUAs), and vessels can continue using conventional fuels without incurring ETS-related expenses.

The chain cost calculation, presented in Table 7, shows that FuelEU implementation impacts maritime and port-related costs. Specifically, if FuelEU is not implemented, maritime costs decrease by 0.4%, and to-port costs decrease by 0.3%. This cost reduction may be due to ships using cheaper fuels and the absence of additional administrative costs in ports related to FuelEU compliance. Overall, the total generalized cost decreases by 0.1%.

The implementation of FuelEU directives mainly affects the ETS cost of ships in the calculation model, as shown in Table 8. The results indicate that the total annual ship cost decreases by 2% if FuelEU is not implemented. To reduce ETS cost of ship, the shippers can choose shorter to reduce fuel consumption and emissions. Avoiding congested areas where ships may have to slow down or idle, can also decrease fuel use, this leading to a decrease in ETS cost of ship. Additionally, planning ship arrivals efficiently can also reduce waiting time at ports, thus avoiding unnecessary fuel use and cutting ETS costs.

3 Conclusion

The analysis of vessel cost structures reveals a nearly linear relationship between vessel size and total cost per loop, with larger vessels generally benefiting from economies of scale. Excluding LNG vessels, the cost per TEU decreases as vessel size increases, primarily due to reduced voyage costs per unit. While port handling costs remain relatively stable, the proportion of voyage costs decreases with increasing vessel size, partially offset by a marginal rise in port handling expenses. A breakdown of operational expenditures indicates that insurance and manning costs constitute a significant share of running costs, while non-ECA fuel costs considerably influence voyage cost trends. However, LNG vessels face higher voyage costs due to elevated fuel prices, raising concerns about their economic feasibility. These findings emphasize the importance of vessel size optimization in achieving cost-efficient shipping operations and highlight the need for further research into alternative fuel strategies and cost mitigation measures.

The impact of vessel size on logistics costs confirms that larger vessels contribute to reduced per-unit transport costs through economies of scale, with the 23,964 TEU vessel demonstrating the lowest cost per TEU. However, the diminishing cost savings beyond a certain size suggest that efficiency gains must be carefully weighed against infrastructure constraints and logistical challenges. These findings offer valuable insights for shipping companies and policymakers in refining cost-effective fleet and supply chain management strategies. Future research should investigate the long-term economic and environmental implications of increasing vessel size, the potential of automation in further cost reductions, and the integration of hinterland transport to enhance overall logistics efficiency. As global trade continues to evolve, ongoing assessment of vessel size and logistics chain interactions remains critical to ensuring sustainable and cost-effective maritime transport solutions.

Regarding environmental compliance, this study finds that installing a scrubber can effectively reduce fuel and maritime costs, resulting in a slight decrease of 0.206% in the overall supply chain cost. Although LNG offers strong environmental benefits, its high fuel price significantly increases the total cost, leading to an increase of up to 102% in the total cost per ship loop. However, the findings of Mohseni et al. (2019) differ from those of this study. Their research suggests that, under conditions considering different routes (e.g., Asia–Europe, US–Europe), engine types, and future emission costs, LNG is the most economical option, with a total chain cost lower than that of using MDO or installing scrubbers. The study also points out that, in most cases, the scrubber option results in higher overall costs. This difference may be due to the assumptions made about fuel prices. In this study, LNG is assumed to be significantly more expensive than MDO and HFO, while Mohseni et al. considered several fuel price sensitivity scenarios, including cases where LNG prices are relatively lower. While this study considers a fixed ETS cost per tonne of $\mathrm{CO_2}$, future research could simulate varying carbon prices to assess the robustness of each alternative under carbon market volatility.

A

References

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B

List of Tables

No.	From port	To port	Total generalised chain cost	Notes
1	Ningbo	Hamburg	2780.32	
2	Ningbo	Bremerhaven	2737.97	
3	Ningbo	Zeebrugge	2700.63	
4	Ningbo	Rotterdam	2812.98	
5	Ningbo	Le Havre	3247.98	
6	Shanghai	Hamburg	2709.95	
7	Shanghai	Bremerhaven	2667.60	
8	Shanghai	Zeebrugge	2630.26	
9	Shanghai	Rotterdam	2742.61	
10	Shanghai	Le Havre	3177.62	
11	Xiamen	Hamburg	2675.13	
12	Xiamen	Bremerhaven	2632.78	
13	**Xiamen**	**Zeebrugge**	**2595.44**	**Chain with lowest cost**
14	Xiamen	Rotterdam	2707.79	
15	Xiamen	Le Havre	3142.79	

Table 1: Total generalised chain cost for all route options with vessel size 23,964 TEU

No.	Vessel size	From Hinterland cost	From Port cost	Maritime cost	To Port cost	To Hinterland cost	Total generalised chain cost
1	4600	1085.75	102.53	896.65	388.59	390.62	2864.13
2	9115	1085.75	99.92	753.67	384.51	390.62	2714.46
3	14800	1085.75	96.55	1069.38	202.08	390.62	2844.37
4	14990	1085.75	97.31	697.52	380.22	390.62	2651.41
5	20568	1085.75	97.35	646.77	379.28	390.62	2599.76
6	23964	1085.75	99.65	637.59	381.83	390.62	2595.44

Table 2: Chain cost structure for all vessel options for Xiamen – Zeebrugge route

Chain Cost Components	Regular Fuel	Scrubber only	Change
From Hinterland cost	1085.74820	1085.74820	0
From Port cost	99.65251	99.65251	0
Maritime cost	637.59082	632.24188	-0.00839
To Port cost	381.82987	381.82987	0
To Hinterland cost	390.61684	390.61684	0
Total generalised chain cost	**2595.43824**	**2590.08931**	**-0.00206**

Table 3: Comparison of Chain Cost: With vs Without scrubber for Xiamen – Zeebrugge route

Vessel Cost Component	Regular Fuel		Scrubber only		Change
	Total cost per leg	Cost/TEU	Total cost per leg	Cost/TEU	
Running cost ship					
Manning cost ship	207612.09	8.663	207612.09	8.663	0
Store cost	8306.57	0.347	8306.57	0.347	0
Insurance cost	217422.36	9.073	217422.36	9.073	0
Repair and Maintenance cost	18890.76	0.788	18890.76	0.788	0
Management cost	28704.57	1.198	28704.57	1.198	0
Voyage cost ship					
Fuel cost ship in Port	202937.41	8.468	202937.41	8.468	0
Fuel cost ship ECA	473412.93	19.755	315770.32	13.177	-0.333
Fuel cost ship Non ECA	4454960.32	185.902	4454960.32	185.902	0
Lub oil cost ship	27717.86	1.157	27717.86	1.157	0
Cannel cost ship	2053900.37	85.708	2053900.37	85.708	0
ETS cost ship	413617.32	17.260	413617.32	17.260	0
Port cost					
Total port charges	1302973.74	54.372	1302973.74	54.372	0
Port handling cost	7403357.85	308.937	7403357.85	308.937	0
Total variable cost ship per loop	9410456.3	392.691	9252813.67	386.113	-0.017
Fixed cost ship per loop	3977508.98	165.979	3977508.98	165.979	0
Total port handling cost per loop	7403357.85	308.937	7403357.85	308.937	0
Total cost ship per loop	20791323.13	867.607	20633680.5	861.028	-0.008

Table 4: Comparison of Vessel Cost: With vs Without Scrubber

Chain Cost Components	Regular Fuel	Scrubber or LNG	Change
From Hinterland cost	1085.74820	1085.74820	0
From Port cost	99.65251	99.65251	0
Maritime cost	637.59082	1180.09232	0.850861532
To Port cost	381.82987	381.86849	0.000101135
To Hinterland cost	390.61684	390.61684	0
Total generalised chain cost	2595.43824	3137.97837	0.209036038

Table 5: Comparison of Chain Cost: With vs Without LNG Directive for Xiamen – Zeebrugge route

Vessel Cost Component	Regular Fuel		Scrubber or LNG		Change
	Total cost per leg	Cost/TEU	Total cost per leg	Cost/TEU	Total
Running cost ship	480936.36	20.069	480936.36	20.069	0
Manning cost ship	207612.09	8.663	207612.09	8.663	0
Store cost	8306.57	0.347	8306.57	0.347	0
Insurance cost	217422.36	9.073	217422.36	9.073	0
Repair and Maintenance cost	18890.76	0.788	18890.76	0.788	0
Management cost	28704.57	1.198	28704.57	1.198	0
Voyage cost ship	7626546.21	318.250	28830499.3	1203.075	2.781
Fuel cost ship in Port	202937.41	8.468	202937.41	9.062	0.070
Fuel cost ship ECA	473412.93	19.755	1728733.28	72.139	2.652
Fuel cost ship Non ECA	4454960.32	185.902	24389368.8	1017.750	4.475
Lub oil cost ship	27717.86	1.157	27717.86	1.157	0
Cannel cost ship	2053900.37	85.708	2053900.37	85.708	0
ETS cost ship	413617.32	17.260	413617.32	17.260	0
External cost at sea	.	.	.	.	.
Port cost					
Total port charges	1302973.74	54.372	1302973.74	54.372	0
Port handling cost	7403357.85	308.937	7403357.85	308.937	0
Total variable cost ship per loop	9410456.3	392.691	30614409.4	1277.517	2.253
Fixed cost ship per loop	3977508.98	165.979	3977508.98	165.979	0
Total port handling cost per loop	7403357.85	308.937	7403357.85	308.937	0
Total cost ship per loop	20791323.13	867.607	41995276.22	1752.432	1.020

Table 6: Comparison of Vessel Cost: With vs Without LNG

Chain Cost Components	Regular Fuel	No FuelEU	Change
From Hinterland cost	1085.74820	1085.74820	0.000
From Port cost	99.65251	99.65251	0.000
Maritime cost	637.59082	635.13984	-0.004
To Port cost	381.82987	380.72794	-0.003
To Hinterland cost	390.61684	390.61684	0.000
Total generalised chain cost	2595.43824	2591.88534	-0.001

Table 7: Comparison of Chain Cost: With vs Without FuelEU Directive for Xiamen – Zeebrugge route

Vessel Cost Component	Regular Fuel		No FuelEU		Change
	Total cost per leg	Cost/TEU	Total cost per leg	Cost/TEU	
Running cost ship	480936.36	20.069	480936.36	20.069	0
Manning cost ship	207612.09	8.663	207612.09	8.663	0
Store cost	8306.57	0.347	8306.57	0.347	0
Insurance cost	217422.36	9.073	217422.36	9.073	0
Repair and Maintenance cost	18890.76	0.788	18890.76	0.788	0
Management cost	28704.57	1.198	28704.57	1.198	0
Voyage cost ship	7626546.21	318.250	7212928.89	300.990	-0.054
Fuel cost ship in Port	202937.41	8.468	202937.41	8.468	0
Fuel cost ship ECA	473412.93	19.755	1728733.28	72.139	0
Fuel cost ship Non ECA	4454960.32	185.902	2438936.88	1017.750	0
Lub oil cost ship	27717.86	1.157	27717.86	1.157	0
Cannel cost ship	2053900.37	85.708	2053900.37	85.708	0
ETS cost ship	413617.32	17.260	413617.32	17.260	0
Port cost					
Total port charges	1302973.74	54.372	1302973.74	54.372	0
Port handling cost	7403357.85	308.937	7403357.85	308.937	0
Total variable cost ship per loop	9410456.3	392.691	8996838.98	392.691	2.253
Fixed cost ship per loop	3977508.98	165.979	3977508.98	165.979	0
Total port handling cost per loop	7403357.85	308.937	7403357.85	308.937	0
Total cost ship per loop	20791323.13	867.607	20377705.81	850.347	-0.020

Table 8: Comparison of Vessel Cost: With vs Without FuelEU