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Impact of Fit for 55 regulations on Short sea shipping (SSS) in the European Union

by

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Acknowledgment

The last year was a hectic one with continuous assessments and deadlines, with little time to spare, however, looking back, it is quite satisfying, and I am relieved to be nearing completion. I believe the MEL program has prepared me in a variety of areas, and I hope to apply what I've learned in my professional and personal life.

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Abstract

By adopting the European Carbon Law as part of the European Green Deal, the EU has set itself a goal of becoming climate neutral by 2050. In order to achieve this, greenhouse gas emissions must decline significantly in the next decade. As a first step toward reaching climate neutrality, the EU has raised its 2030 climate ambition, aiming to reduce emissions by at least 55% and thus planning to introduce the “Fit for 55”. This policy will impact the shipping sector with the introduction of ETD, ETS, and Fuel EU maritime regulations that will be applied to shipping activities within European waters. Because SSS depends on the traffic on European waterways, operating costs are expected to rise as a result.

It is crucial to evaluate how this policy will affect the SSS sector and whether the increased costs may lead to a shift in transport to other modes. Therefore, our main research question is to study the economic and transport impact on SSS. As this new policy will also apply regulations to other transport modes, we compare the different transport modes within the EU through quantitative analysis by using an econometric model. Through a literature review and calculations, we apply the expected costs for SSS, road, rail, DSS and AC in the Non-tariff section of the model using Anderson and Van Wincoop, (2004) approach to estimate the regulatory costs.

We estimate the implications of the change in costs for each mode of transportation over time using two scenarios: one in 2025 and one in 2030. In both scenarios, our results indicate a decline in trade values for all transport modes with the exception of rail. In 2025, comparing net welfare effects, SSS loses €134 million, road €4.1 billion, and DSS €11 billion in the Mediterranean, while in 2030, we see a further decline of €240 million for SSS, €9.4 billion for road and €22 billion for DSS. In both scenarios, the percentage change in producer prices for SSS remains unchanged; for the road, it decreases by 0.5% and 1%, and for DSS, it decreases by 0.4% and 0.9% in 2025 and 2030 respectively. For Consumer price, SSS sees no change, road and DSS increase to 0.4% and 0.9%. All modes of transportation are likely to see a decrease in volume, but SSS will be significantly less affected by this; its liquid bulk sector will see the most loss. Based on these results we conclude that the “Fit for 55” policy regulations have a very small percentage increase in costs for SSS when compared to road, DSS, and AC, and thus it will not create an obstacle to SSS in the near future.

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List of Abbreviations

AC	Air Cargo
DSS	Deep Sea ships
DWT	Dead Weight Tons
ECAs	Emission Control Areas
ETS	Emissions Trading Scheme
ETD	Energy Taxation Directive
EU	European Union
FUEL EU	Fuel EU Maritime regulation
GE	General equilibrium
GSIM model	Global simulation model
GHG	Greenhouse gas emissions
GT	Gross tonnage
IMO	International Maritime Organization
MoS	Motorways of the Sea
MRV	Monitoring, Reporting and Verification
NTM	Non-tariff measures
PE	Partial equilibrium
ROW	Rest of World
RORO	Roll-on-roll-off
SSS	Short Sea Shipping

Chapter 1-Introduction

1.1 Background

The European Commission proposed a package called the "Fit for 55" in July 2021, as a component of its Green Deal objectives, with the goal of making the EU carbon neutral by 2050. It is anticipated that the package presented to the Council and the European Parliament, will be ratified in 2023. “Fit for 55” means a reduction of greenhouse gas emissions (GHG) by at least 55% in 2030. This package consists of 12 elements of which 3 are relevant to the shipping industry the EU Emissions Trading Scheme (ETS), the Fuel EU (FUEL EU) Maritime regulation, and the Energy Taxation Directive (ETD) policy for Europe.

These policies have clear objectives in terms of reducing the GHG emissions and ensuring EU policies are in line with the climate goals agreed by the council and European parliament. The introduction of ETS in shipping will mean that for each ton of carbon dioxide emitted it will necessitate the purchase of allowances for ships travelling to and from European ports, the FUEL EU aims to reduce the level of GHG emitted on board of the ship from the ships energy and ETD will introduce tax to all bunker fuel sold and being used within the EU. At the same time, they will have a profound long-term impact on the EU economy in general and the shipping industry in particular, like never seen before. If “Fit for 55” is executed EU society will no longer be the same. For the long-term effect on climate change, emissions, and the economy, it is crucial to do ample research into this topic. This thesis aims to contribute to this rapidly expanding area of research. It is not possible cover all impacts of “Fit for 55” so we will focus on one element of this broad legislative package: the SSS sector.

1.2 Research Question

Based on the context of this topic, this thesis aims to cover important aspects that may have an influence on SSS based on the proposed package "Fit for 55." Hence the main research question for this thesis is **“What would be the economic and transport impact on freight costs for SSS with the implementation of Fit for 55 for EU?”**

Further, the below sub-questions are raised to address the main research question.

1. How do we define ‘economic and transport impact’?
2. What is the current situation and what are the current trends regarding freight costs for SSS prior to the implementation of the ‘Fit for 55’ for the EU?
3. What are the objectives behind the ‘Fit for 55’ regulations?
4. What are the regulatory proposals for ‘Fit for 55’ and why are they important for SSS?
5. What are the current and ‘Fit for 55’ induced types of costs and challenges to SSS, also comparing them to road and rail options? And how high are these costs?
6. What is the best model to use for this research and what data are needed?
7. Who might benefit and who might lose from the Fit for 55 regulations?

1.3 Relevance of the topic for Short Sea shipping

Short sea shipping (SSS) is the transportation of goods and people over a relatively short distance by water without having to traverse an ocean. In order to boost capacity, enhance flexibility, and achieve sustainable mobility, SSS uses ports and inland waterways to supplement conventional transportation infrastructures.

SSS when compared to road transportation is more competitive in terms of costs, but its inflexibility due to lack of last-mile connectivity and longer transit times proves to be a challenge. SSS transportation of all types is dependent on road haulage for cargo movement from origins to ports and vice versa.

SSS transports roughly 40% of all goods globally and is crucial for facilitating trade within Europe as well as with neighboring countries and countries bordering the Baltic, Black, and Mediterranean Seas. (The Blogging Crew (2021)).

In recent decades despite the significant financing being dedicated to its promotion, SSS has not increased its market share in the European Union (EU).(The European Court of Auditors (2013))

With an objective of shifting away from the use of roads in favor of other modes of transportation, the European Commission is promoting the growth of SSS. For instance, the establishment of Motorways of the Sea (MoS) and funding programs like the Marco Polo Program has encouraged the short-sea concept. In this thesis, we will analyze the impact of the “Fit for 55” policies for Europe's SSS sector.

1.4 Defining Economic and Transport Impact

In this thesis, we will investigate the economic impact of the policy by assessing its effects on producer surplus, consumer surplus, and tariff revenues, which will aid in understanding the Net welfare effects of SSS when compared with other modes of transportation in the EU. We shall also interpret the changes in trade values and finally the percentage change in producer and consumer prices. All of these will be used to measure the economic impact. Then, to understand the new capacity requirements, we can assess the transport impact by converting the new trade values to quantities. Furthermore, we will categorize these categories based on the type of cargo in order to identify the changes it brings to these specific sectors in SSS.

1.5 Research Design and Methodology

Through a literature review, we will study the current volumes transported by SSS and describe the major regions and cargo types. We will study the projected regulatory elements of the "Fit for 55" proposal and the changes it proposes to existing regulations. Following that, we list the key components that will have the greatest impact on the SSS industry. We will investigate the present operating costs for SSS, road, and rail transportation and estimate the expected increases in costs for SSS from the proposed policy. Because “Fit for 55” also impacts other modes of transport, we will need to assess the overall effect on SSS in comparison with other transport modes in the region.

We use an econometric model to identify the changes in the freight costs for SSS due to the different “Fit for 55” package elements: the Energy Taxation Directive, Emission Trading System and Fuel EU maritime regulation, which might lead to a change in transport modes used for intra-EU shipments.

The global simulation (GSIM) model which was developed by Francois and Hall (2003) is the econometric workhorse that will be used for this analysis. It is a partial equilibrium (PE) model which can be used to assess the economic and trade impacts of a policy shock (like “Fit for 55”).

The following steps will be part of the research design:

1. Gather bilateral trade data in value terms for the countries in the North Sea, Mediterranean and Baltic regions, but also for all other ports and countries in the world. Trade values are split between SSS, road, rail, Deep Sea ships (DSS,) and air cargo (AC) to ensure full coverage of all trade – a key requirement of the econometric model.
2. Identify the important ports in these regions based on trade values and volumes.
3. Find the necessary elasticities for the analysis of the different categories through a literature review.
4. Through literature review gather information on the various other costs and threats that may arise to SSS in the EU – to use as inputs for the model.
5. To calculate the impact of the ‘Fit for 55’,we need to identify the number of SSS ships in the EU and categorize them based on gross tonnage (GT). In addition, through a literature review, find out the costs per vessel based on size and category. With this we can calculate the height of non-tariff measures for all SSS regions in the model.
6. Finally, we evaluate and analyse the changes in bilateral trade with the model and identify which regions and modes of transport gain and which ones lose. This will help us shed light on how a shift in transport modes and regions could take shape, based on the “Fit for 55” proposal.
7. We will compare each of the transport modes (SSS, road, rail, Deep Sea Ships(DSS), and air cargo (AC)) in the routes of regions such as the North sea region, Mediterranean, and Baltic Sea regions. With all other regions in the world being grouped as ‘Rest of World’ (necessary to close the model).

1.6 Structure of Thesis

This research will focus on the trade routes for SSS, road, and rail in the important routes in the EU regions the North Sea, Mediterranean, and Baltic. The scope of this study will not cover the type of cargo but will look at average freight values for the various routes in SSS, road and rail transportation and then interpret the consequences that the additional costs have, stemming from the “Fit for 55” proposal.

The second chapter will discuss the current situation in the SSS, volumes transported globally and in the EU, and more specific to EU we discuss on the type of cargos and shipment by countries and regions. A brief discussion about the ships and freight rates that are prevailing in the market is included. This section also brings up the challenges faced by the SSS industry and the main reasons behind them. We will discuss through a literature review the reasons behind the proposal for ‘Fit for 55’, its objectives to support meeting EU climate change goals and the detailed regulatory elements in the proposal. We discuss the various policy measures in detail to get an overview of the overall framework of this regulation, in particular insofar it pertains to SSS. Further, we discuss three major elements that will affect the SSS industry, which is ETS, FuelEU and ETD. Detailed analysis of the various costs associated with SSS, road, rail, DSS and air transport are identified and gathered as key inputs for the econometric analysis.

The third chapter covers the econometric model, the Global Simulation (GSIM) model. In this chapter, we explain why we have chosen the GSIM model, describe how it works, specify the regions and modes of transport, the data needed (trade values, volumes, elasticities, tariffs, and non-tariff measures), and the scenarios that we will simulate. Based on the qualitative and quantitative analysis in the previous chapters, the fourth chapter will provide the results and analyze the findings. In this Chapter, we also provide a short sensitivity analysis to capture any model sensitivities and validate the robustness of the model results. Finally, we will also compare the econometric model results to understand the implications and the changes for each transport mode due to the new policy impact from “Fit for 55”. Chapter five concludes. In this Chapter, we will discuss the key aspects of this research, its shortcomings and potential for further future research.

Chapter 2-Literature Review

2.1 Current Trends in the Short Sea Shipping Industry

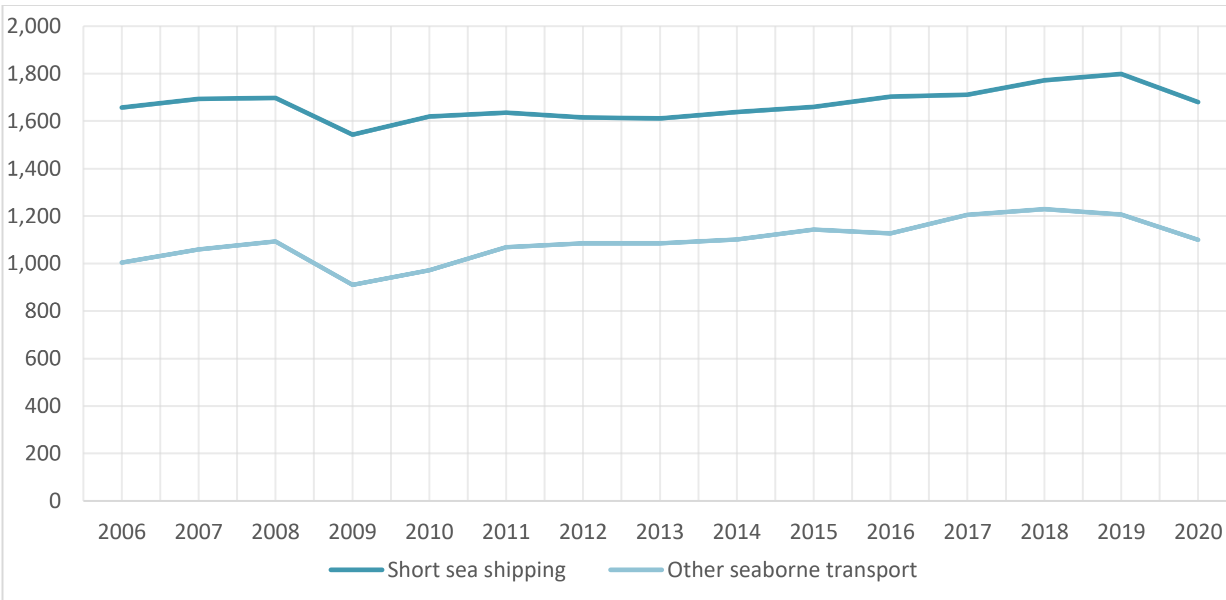
Short sea shipping (SSS) is the transportation of goods and people over a relatively short distance by water without having to traverse an ocean. In the case of the EU, we consider SSS as the movement of goods by water within EU's territorial waters. These ships are often smaller than their counterparts in the deep-sea trades, ranging in size from 400 dwt to 6,000 dwt, (Stopford, 2009, Pg 76) the vessel design and restrictions are determined by the cargo type they will accommodate. The establishment of the European market and the boom in market that followed have made it possible for marine transport to participate more actively in intra-European trade. The extensive coastline and numerous ports that define the European continent justify SSS's role to be a major transporter of goods across the EU, only behind road transportation. SSS also provides the alternative for cleaner and sustainable means of transportation when compared to other modes.

The Asian and European markets are the world's biggest short-sea markets, (Guðný Vigfúsdóttir, 2015). It is estimated that globally SSS contributes approximately 40% of the maritime trade (The Cooperative Logistics Network, 2022). Based on this we calculate to estimate it to be around 2.4 trillion Euros in trade value and 2.9 billion tons in quantity in 2020. Since SSS is very closely linked with DSS this makes it difficult to segregate the exact numbers in terms of value in the EU. Based on my own analysis of data from the Eurostat database (DS-058814) for 20 EU countries, we project an overall intra-EU trade value of 3.937 trillion euros in 2020, of which 870 billion euros represent SSS, 2.776 trillion euros for road, 116 billion euros for rail, and 66 billion euros for air mode of transport. Although not all the EU is covered by this data, it can be viewed as a representative value for the EU's major economies.

In 2020, the total gross weight of products shipped through short sea in the EU was close to 1.7 billion tonnes, a 6.6% reduction from 2019 (Eurostat (2020)). During the same period, percentage of SSS in the total maritime transport of products to and from the major EU ports increased by 0.6 percentage from the previous year.

SSS in the EU steadily recovered after the economic slump in Europe in 2009, and it reached a new high in 2019 thanks to an overall increase observed by the major EU ports. Figure 1 gives a clear depiction of the volumes handled by SSS in comparison to other sea borne modes over the years from 2006 to 2020.

Figure 1 Gross weight of seaborne freight transported in EU (million tons)



Source: Eurostat (online data code: mar_sg_am_cw)

As in the below table 1, with 287 million tonnes, or 14.4 percent of the total tonnages of the EU, Italy was the leading SSS nation in 2020 followed closely by The Netherlands with 283 million tonnes and Spain which recorded 211 million tons. In 2020, 587 million tonnes of goods were shipped between the major EU ports, with the ports in Mediterranean Sea constituting 34% of the total EU SSS tonnages. The North Sea and Baltic Sea came in second and third, accounting for 25% and 23% of the total EU SSS tonnages. For most nations, partner ports that were situated in the same sea region or sea regions accounted for the lion's share of their short sea shipping of products. There are few exceptions such as Bulgaria and Romania on the Black Sea, where 50% and 52%, respectively, of the commodities shipped originated from or were bound for ports on the Mediterranean coast. Comparatively, nations that have large ports that serve as hub ports or trans-shipment ports typically have significant share of short sea shipping with multiple ports covering several regions.

Table 1 Region wise Freight quantities in '000(2020)

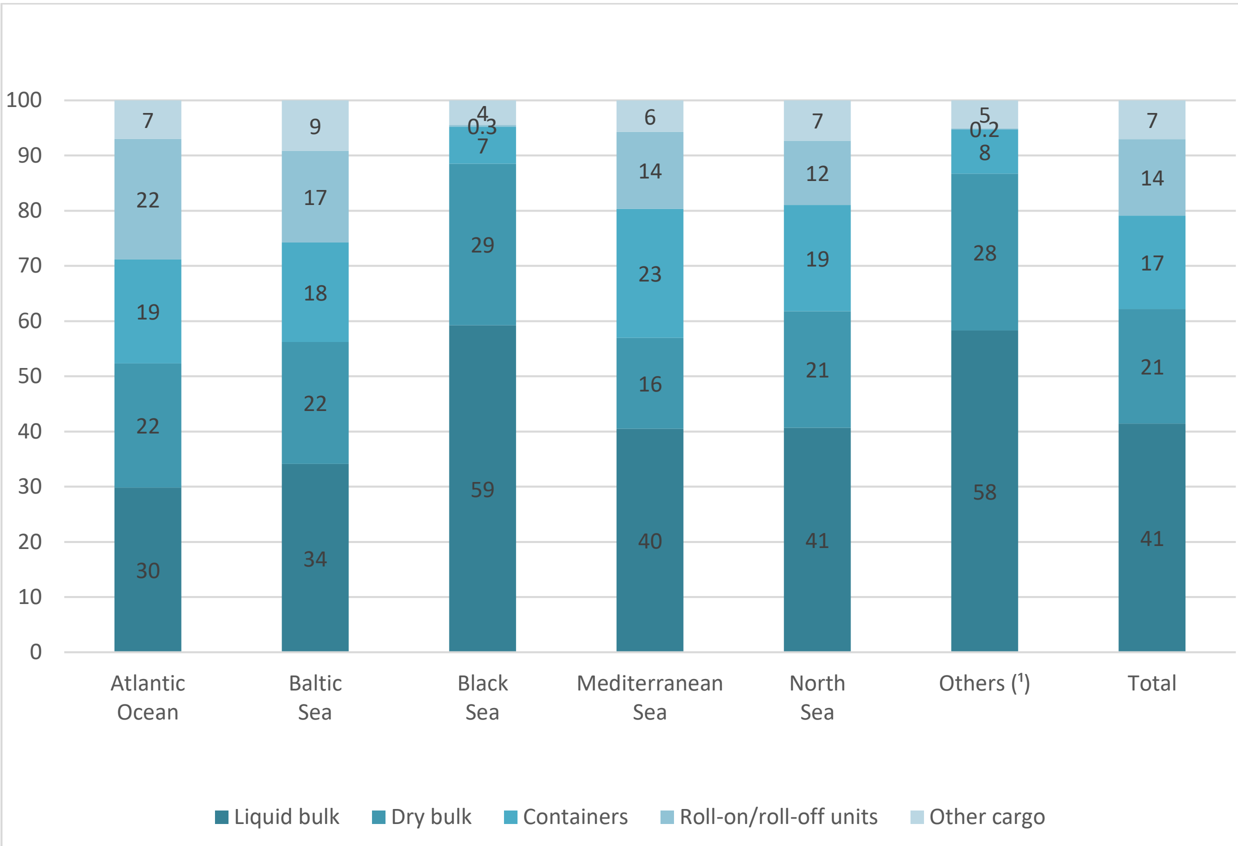
Country	Atlantic Ocean	Baltic Sea	Black Sea	Mediterranean Sea	North Sea	Others (1)	Total QTY
Belgium	24842	32327	3406	32413	41622	8570	143180
Bulgaria	929	50	8602	10718	1227	79	21605
Denmark	2409	34005	515	1900	27737	2987	69553
Germany	9803	75877	1157	13092	49611	8524	158064
Estonia	918	18049	79	786	6072	68	25972
Ireland	24069	1545	176	1193	13674	494	41151
Greece	1491	976	19310	79426	5744	624	107571
Spain	41469	13202	20104	110339	34179	2074	221367
France	43455	15789	11147	49600	29452	10427	159870
Croatia	62	268	2655	11213	180	182	14560
Italy	4656	8974	33557	225400	8455	5611	286653
Cyprus	92	38	539	3139	912	2265	6985
Latvia	2368	13591	33	3514	12423	196	32125
Lithuania	2899	18946	1454	3752	9158	64	36273
Malta	36	14	49	5220	172		5491
Netherlands	30119	74832	15478	32842	84085	45430	282786
Poland	3281	27532	898	7409	22958	2486	64564
Portugal	13247	1894	1855	13830	11682	379	42887
Romania	1679	208	12946	17955	1891	7	34686
Slovenia	41	162	847	7495	237		8782
Finland	3278	54158	566	3124	32079	159	93364
Sweden	5706	78204	61	3550	55432	7682	150635
Norway	12937	22412	1814	8584	112732	3071	161550
Montenegro	36	32	1353	20	38		1479
Turkey	10165	7771	87642	164526	33337	27885	331326

Source: Eurostat (data code: mar_sg_am_cws)

We can classify the type of cargo under six categories of goods transported by SSS, these include liquid, dry bulk, containers, roll-on-roll-off (Ro-Ro) units and other general cargo. The regions can be categorised as Baltic Sea, North Sea, Atlantic Ocean, Mediterranean Sea and Black Sea.Liquid bulk has remained the major short sea cargo within the EU in 2020, accounting for 41.4% of the total SSS goods (696 million tonnes). Dry bulk constituted 21 % (349 million tonnes), followed by containers at 17% (285 million tonnes), and RORO at 14% (233 million tonnes)

Figure 2 provides the percentage of cargo distribution region wise, and we can see that Liquid bulk is dominating with the highest percentage of cargo in all the regions especially the Black Sea and other regions, however, the volumes are way lower in comparison the quantities contributed in the major regions (Mediterranean, North sea and Baltic). We notice a similar trend for Dry bulk, and container cargoes, with Dry bulk averaging 91 million tonnes and Containers averaging 97 million tonnes in the major regions.

Figure 2 SSS freight by type of cargo for each sea region in Percentage based on tons (2020)



Source: Eurostat (data code: mar_sg_am_ewx)

Table 2 SSS Quantity in Million Tons

2020	Liquid bulk	Dry bulk	Containers	Roll-on/Roll-off units	Other cargo
Atlantic Ocean	62.0	46.7	39.2	45.4	14.5
Baltic Sea	133.1	86.2	70.3	64.7	35.8
Black Sea	80.2	39.6	9.2	0.4	6.1
Mediterranean Sea	237.8	96.6	137.5	81.9	33.5
North Sea	174.8	90.6	82.8	50.0	31.3
Others (¹)	57.3	27.9	7.9	0.2	5.0
Total	696	349	285	233	118

Source: Eurostat (data code: mar_sg_am_ewx)

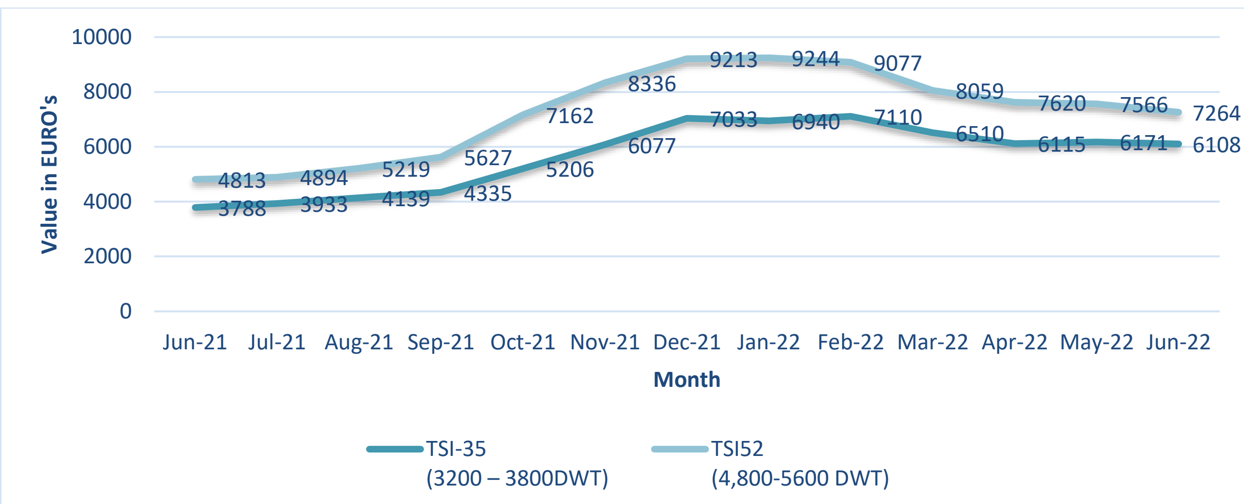
Vessels

About 4800 ships make up the European short sea fleet. Over 1100 of them are tankers, and about 2600 are bulk carriers. There are fewer containerships and Ro-Ro carriers (about 17% and 6% respectively of the total fleet). The European fleet's advancing age is a significant issue. Bulk carriers are the vessels in the fleet with the highest average age (18 years) (Papadimitriou et al., 2018).

Freight

For the recent trends in freight, we can infer from the Toepfer's short sea index in figure 3, which uses the time charter equivalent earnings of two of the most commonly used vessel specifications i.e. the TSI-35 (3200 – 3800DWT) and TSI-52 (4,800-5600 DWT), to measure market trends in the European Shortsea Market. Based on this report we can see that in the last one year the rates have climbed from EUR 3,788 in June 21 to a high of EUR 7,110 in February 2022 for the vessels with deadweight between 3200 – 3800 and similarly in the same period from EUR 4,813 in June to EUR 9,244 in Jan for 4,800-5600 DWT.

Figure 3 Own illustration from Toefer Short Sea Index (Toepfer's Transport)



Source: Toepfer Transport Index 2022

Challenges faced by the Short sea Industry

SSS in Europe is currently experiencing vessel shortages (Dalli, 2021), and the addition of new capacity is going to take at least two to three years, however this will also depend on the investment decisions based on the market.

The majority of ships operating in the area are owned by small businesses and family businesses. SSS firms' access to financing and bank funding is generally more constrained than those of larger global ports that handle transcontinental sea traffic and are characterized by substantial penetration of large-scale global shipping and port infrastructure capital. Lenders and borrowers face similar challenges, given that the timing the investment is crucial because of 1. high market volatility, 2. lengthy payback periods, 3. uncertainty caused by new legislations and technical advancements. Investments in capacity have decreased since the global financial crisis of 2008 and further the COVID-19 situation hasn't helped.

There is growing demand to move away from fossil fuels. However, due to a rising share of renewable energy in the consumed energy mix, this shift will take place gradually. This could take next 20–30 years, a greater percentage of renewable energy needs to be produced to satisfy the world's increasing energy needs

Several financial institutions, including lenders, financial guarantors, lessors, and export credit agencies jointly adopted a set of voluntary guidelines known as the Poseidon Principles that apply to ship financing transactions to meet the IMO decarbonization targets. Time will tell if these principles are sufficient to free up the supply of credit available to shipowners in a market where marine finance has already been hard to come by for many years.

The IMO has not only determined the emission criteria that apply to new ships but also brings recommendations for older ships to satisfy these targets by slowing steaming. However, setting a speed limit for ships might reduce the amount of transport capacity that is available, raising freight prices and possibly encouraging the construction of more ships to make up for the demand requirements and thereby increase fuel consumption. In around 3-4 years, European shipyards anticipate an enormous increase in demand. A sudden surge in demand for new builds and retrofits is anticipated to lead to bottlenecks due to the restricted capacity at pan-European shipyards. Shipowners need to be aware of this and time their investment appropriately. Hopefully, by then, we might see a few innovations that might be commercialized on a global scale. (Leaper, Russel (2019)).

2.2 The reason for ‘Fit for 55’

Background

Today we are at a crucial juncture where the world needs to act together and respond to the climate and biodiversity crisis we are facing. From the EU’s perspective, it is required to fulfill its commitments under the Paris agreement keeping in mind the health, prosperity, and well-being of all. The EU has been the first to initiate this process with the ambition of becoming the first continent to be carbon neutral by 2050, with this goal the EU plans to reduce its net emissions by at least 55% in 2030 compared with the base year 1990. The EU's 27 member states collectively account for over 3.5 billion tons of carbon dioxide ($CO2$) equivalent in 2019, ranking fourth after China, the US, and India in terms of global greenhouse gas emissions. (Evans and Gabbatiss, 2021). Although several nations have committed to their climate ambition through long-term net-zero targets, only a few have specified how their objectives will be achieved. The EU has been planning this for some years, prior to the Paris agreement in 2015, the bloc was preparing to cut emissions levels to at least 40% below 1990 levels targeting 2030 and by 2050 it was to be 80% lower. The European climate law made these targets legally binding to validate the aims of the European Green deal. Hence, the Fit for 55 Package is being proposed with the aim to deliver the EU’s 2030 climate target and achieve climate neutrality by 2050.

With the ‘Fit for 55 packages’, The EU is planning to update its existing regulations relating to the environment, energy, and transportation, and to bring them in line with its 2030 and 2050 goals. This also features a few new initiatives. The package was first discussed with the council working parties who are responsible for the policies, further, it is now being discussed at the level of the EU member states and eventually it will need an agreement among the 27 member states. The EU ministers will have to come to an agreement, after which the president of this council will engage in negotiations with the European Parliament and find a common ground to formally adopt these proposals in the legislative acts.

Fit for 55 objectives and proposals

Fit for 55 was proposed with the purpose of ensuring that EU policies are in accordance with the climate targets that were agreed by the council and the European Parliament, moreover, the package aims to modify and update EU legislation and also introduce new initiatives.

The proposals' goal is to provide a framework that is both reasonable and logical for achieving the EU climate objectives. This means providing a fair and equitable transition and at the same time being able to sustain a strong EU industry by maintaining and strengthening Innovation and competitiveness. As a whole, the package reinforces eight current pieces of law and introduces five new ones, covering a variety of policy areas and economic sectors, including climate, energy and fuels, transportation, buildings, land use, and forestry.

Impact assessment studies were used to support the ideas and consider how the package as a whole can be interconnected. Therefore, the proposal ensures a carefully planned mix involving Pricing, Targets, Rules and Support measures.

Emission Trading scheme (ETS)

This is a market-based mechanism that charges the user for carbon emissions per ton. The proposal includes changes to the existing Emission trading system, to achieve a 61% reduction in the overall emissions by 2030 compared with 2005. To do this the Commission proposes the inclusion of the maritime transport sector for ETS, and also gradually remove free allowance to the aviation sector and those covered by the carbon border adjustment mechanism. Further, in order to assist member states in effectively achieving their national targets under the effort-sharing legislation, the Commission suggests developing a new self-standing emissions trading system for buildings and road transportation.

Emissions reduction targets

Mandatory greenhouse gas emission targets for member states have been set for those sectors outside the purview of the EU emissions trading scheme or the regulation on land use, land use change and forestry. It also increases the emission reduction target from 29% to 40% (2005).

Land use and forestry (LULUCF)

With an objective to strengthen the contribution for land use, land-use change and forestry (LULUCF) sector and to make it aligned with the EU’s climate ambition, the proposal brings in binding objectives on all EU member states to achieve net reductions of greenhouse gases of at least 310 million tons of CO_2 equivalent by 2030.

Renewable Energy

The proposal requires a revision to the existing directive by increasing the target of the renewable energy mix to at least 32% and to at least 40% by 2030. Additionally, it suggests the addition or improvement of sector-specific sub-targets and initiatives across all sectors, with a special emphasis on those where the integration of renewable energy has progressed more slowly to date, such as the transportation, building, and industrial sectors.

Energy Efficiency

It proposes to increase the current target to 36% for primary consumption and 39% for Primary consumption. Furthermore, the package proposes a number of steps to quicken member states' efforts to improve their energy efficiency, including higher yearly energy savings responsibilities, new regulations to cut down on the energy use of public buildings, and targeted protections for vulnerable customers.

Fuel Infrastructure

Proposal for changing the legislation with the goal of speeding up the installation of infrastructure for refueling or charging alternative fuel vehicles as well as providing an alternate source of electricity for stationary airplanes and ships in ports.

CO2 emission levels for Vehicles

The proposal includes higher reduction objectives for the entire EU for 2030 and establishes a new target of 100% by 2035. In actuality, this means that starting in 2035, the EU will no longer allow the sale of automobiles or vans with internal combustion engines.

Energy taxation

The package aims to support clean technology by eliminating out-of-date exemptions and reduced rates that are obsolete, as they now support the use of fossil fuels. The revised Energy Taxation Directive is being proposed to match the taxation of energy products while keeping in mind the EU energy and climate objectives.

Carbon Border Adjustment Mechanism (CBAM)

CBAM is focused to prevent any offsets that may occur outside the EU borders by way of relocation of production facilities to Non-EU countries to bypass the strict emission control measures within the EU.

Aviation Fuels

The ReFuelEU Aviation initiative intends to lessen the aviation industry's environmental impact and make it possible for it to assist the EU in achieving its climate goals. With the use of advanced biofuels or electro fuels to reduce the emission levels.

Maritime Fuels

The objective of FuelEU Maritime is to reduce the Greenhouse gas levels for the energy used on board of the vessel by 75% in 2050 by way of substituting it with renewable and low carbon fuels.

Social climate fund

This will support the Member States to get special financing from a new Social Climate Fund to assist their households, micro-enterprises, and transport users by paying for investments in modern heating and cooling systems, energy-efficient lighting, and greener transportation.

2.3 Relevance of 'Fit for55' for the Short Sea Shipping industry

The most significant of the 12 elements for the Short Sea Ships are 1. The FuelEU Maritime regulation 2. Revised EU emission trading system 3. Revised Energy taxation Directive. We shall elaborate on each of these elements below to explain the key aspects of these proposals that will affect Short Sea Ships in Europe.

Fuel EU Maritime

To advance sustainable fuels and technologies with zero emissions this proposal limits the amount of GHG emissions on board a ship while it is operating within the European Economic Area. Short sea ships will therefore be regularly monitored to increase the GHG intensity of the fuels they use over time, and further targets must be satisfied in various years. This will need improvement by 2% in January 2025, 6% (2030),13% (2035),26 % (2040),59% (2045) and 75% (2050). All this will be applicable for ships that weigh 5000 GT and above. The amount of CO_2, N_2O, and CH_4 emissions per MJ of energy consumed is known as the GHG intensity. This is calculated in grams of CO_2 equivalent from well to wake. In addition to the emissions from burning fuel on board the ship, the emissions from the manufacturing, distribution, and transportation of fuels will also be included in the well to wake emissions. The energy intensity of GHGs used by the ship must be reported annually by the shipping company. There is also a mechanism by through which the high achieving operators can exchange their compliance points with the ones who underachieved on the targets, by way of buying and selling credits between shipping companies.

Revised EU emission trading system

Under the revised proposal shipping companies will have to purchase ETS allowances per ton of Co2 emissions during their operation within the EU, including the time at ports and berths. Though this is only applicable to the ships 5000GT and above, this will have a considerable impact for those Short Sea Ships that will be operating only within the European seas. The targets that have been set are for 20% emissions in 2023, 45% for 2024,70% in 2025 and 100% from 2026. It will be the responsibility of the company to submit the right amount of allowances by April month of the following year, if not there will be a fine of Euro 100 per ton of CO_2 not reported. Further EU ports can deny entry for ships which have failed to report allowances for more than 2 years. The shipping company or the owner or time/spot charterers who might be taking commercial decisions will be held responsible under the polluter pays principle.

Revised Energy taxation Directive

This proposal will apply to all vessels using heavy oil for voyages in the EU and will come into force in 2023. This will lead to a minimum tax for heavy fuel oil starting from 0.9 EUR per gigajoule, which could translate to a cost of 45USD per ton of Heavy fuel oil. (Sørås, G. and Asprou, N. (2021)). On the other hand, the minimum tax for other industries using similar fuel is taxed way higher at 10.7 EUR per gigajoule, the vast difference in shipping could be attributed to the fact that it might lead ships to look for bunkering options outside the EU. Other fuel types, such as LPG and LNG, will be subject to a transitional tax rate beginning in 2023 at 0.6 EUR/Gj. While the lowest would be 0.15EUR/Gj for fuels with electricity, renewable hydrogen energy and other sustainable biofuels.

2.4 Various costs in Short Sea shipping

Taking into consideration the costs related to short sea shipping, The European Conference of Ministers of Transport, 2001, state that the average stevedoring and port charges combined is to be estimated to cover around 50% of the SSS costs. But the significant issue with the involvement of ports is that the charges are unclear and expensive. A different study by Donnelly and Mazieres 1999 ((Papadimitriou et al., 2018) indicates that port dues represent over 70% of the transportation costs for SSS. Based on several studies involving different authors Andersson and Ivehammar 2016 Tzannatos 2014 and Stopford 1997 cost distribution for SSS can be categorized into categories comprising of 1. Depending on ship size and age 2. Travel distance, Speed, and fuel costs 3. Capital, crew, repairs, maintenance, administration, and insurance costs 4. Other costs such as Port related, discharge,loading operation and demurrage expenses. Further research by Grifoll, Martínez de Osés and Castells (2018), studying SSS in the open sea with certain routes between Italian and Spanish ports, with exception to costs to do with port, demurrage, other claims, this study finds that the Capital costs account for 55%, Repairs, maintenance, administrative and insurance costs to be 2%, Crew costs 18% and fuel costs to be 25%. So about 80% of the costs are to do with Fuel and capital expenses.

Due to the global nature and various complexities to do with the seas, it becomes difficult to have efficient system of regulations in comparison to other modes such as Rail and Road transport. The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI, has been the primary regulatory instrument for regulating air pollution from ships,which began enforcing tougher Sulphur limits in Emission Control Areas (ECAs) in January 2015. The Kyoto protocol exempted shipping from emissions due to the difficulties in allocating them country wise. Co2 emissions are determined by the fuel consumption, SO2 emissions depend on fuel type, and NOx emissions are based on the marine engine type. NOx has been a major concern and regulations are expected to become stricter in the near future.

The fact that SSS operators do not have official representation within the IMO most often this puts them in an unfavorable situation. The primary issue is that while some regulations are appropriate for ocean-going trades, they may undermine the competitiveness of SSS and favor land transport since they fail to consider key aspects of SSS. For instance, the Sox limits in the ECA's under

Marpol Annex VI are one of the regulations that SSS ship owner feel don't provide a level playing field. Deep-sea ships have the option to switch to Intermediate Fuel Oil (IFO), which is less expensive, as soon as they leave an ECA, while some short-sea ships are compelled to trade virtually solely within the ECAs of north Europe, which results in a substantially higher fuel cost. This has led to some shipowners using longer routes in an attempt to reduce the amount of their time spent in ECA, which basically contradicts the aim to reduce emissions.

The universal implementation of the Ballast Water Management (BWM) which aims to prevent the spread of invasive species has posed challenges to short sea ship owners. For operators in SSS who run a business with thin profit margins, the cost of this technology combined with the time taken for installation, will take the ship out of the market for many days and thus prove to be expensive.

Cost Estimations

Since there are no recent studies that report costs associated to short sea shipping, we will examine a 2020 study from the Cost Figures for Freight Transport report, (van der Meulen et al., 2020) which offers the absolute and relative costs for various transport modes including ships in the Netherlands. The base year for the data in this study is 2018. Even though the emphasis is on Dutch transportation, it nevertheless provides a useful indicator of the costs for SSS. The marine sector uses a wide range of vessel sizes, from small to large vessels. Cost estimates in this research are only based on transport for hire and reward, or freight transportation of commodities by specialized operators on behalf of third parties. Own-account transport, which is a support service provided by manufacturing and retail businesses, has been left out of the analysis.

<u>Maritime Transport</u>

Dry bulk, liquid bulk, and containers are the three categories of cargo for seagoing ships; this study considers 3000 vessels with a DWT of 79000–830000. Despite the bigger size of deep-sea vessels compared to short sea vessels, some costs will remain the same because of the similarity in how they operate. Fixed costs cover depreciation, insurance, interest, and maintenance and repairs costs. Depreciation is based on the 20-year lifetime and depreciation period for the assets. Approximately 10% of the original purchase price remains for a fully depreciated vessel. Interest costs are estimated with an average rate of 2.5%. Variable costs are categorized as 1. Maintenance and repairs, 2. Stores supplies and spares and 3. Bunkering. Maintenance and repair costs are considered at 13% for Bulk carriers, 14% for Containers and 15% for tankers. With regards to Bunkering costs in the shipping industry, average bulk carrier uses about 54 tons of fuel per day, about 53 tons for tankers and 50 tons for container carriers. With an average fuel price of Euro 330 per ton in 2018, the navigation time is assumed to be 312 days for bulk carriers, 263 days for containers, and 324 days for tankers in order to calculate fuel consumption. Stores and spares represent 13% for bulk, 12% for containers and 11% for tankers. Staff costs here is the overall expense incurred by a business to have labor provided by salaried employee. Gross salary, social (security) fees, pension contributions, and supplemental payments for all employees make up staff costs. Here, the mode-specific charges are the same as the port dues, and for this report, the calculations consider the port dues at the Rotterdam port. Finally taking into account the general operating costs which relates to administration, overhead, and communications related costs, these costs represent 17% for bulk carriers,15% for containers, and 14% for tankers. Calculations based on these costs are represented in the table 3.

Table 3 Own illustration based on Cost figures for Maritime transport, figures for 2018

Costs per Km (in Euros)				
	Bulker	Tanker	Carrier	Average
Fixed costs	18.79	25.4	18.38	20.86
Variable costs	44.53	39.66	30.45	38.21
Staff costs	6.85	9.15	7.51	7.84
Mode-specific costs	3.44	2.92	9.03	5.13
General operating costs	2.48	2.46	2.25	2.40
Total costs per km	76.09	79.59	67.62	74.43

Source : van der Meulen et al., 2020

Rail Transport

The trains in this study are categorized as Charter, Shuttle, and Wagon load trains centered on the Dutch rail network. 2800 tons has been used as the average tonnage based on the commodities and trains capacity. Fixed costs for trains include costs for lease of locomotives, wagons, and auxiliary assets. Since the rail transport assets are leased rather than purchased or rented, there will be no requirements for maintenance and repairs as the leasing company takes care of this cost. Variable costs only constitute the energy costs and is taken as the price for electricity as major rail traffic between The Netherlands and Germany use electric locomotives. Staff costs include wages, social charges, and wage taxes for train drivers and not for others. Track access charges and shunting costs are a part of Mode specific costs. Finally, the General operating costs that constitute 15% of the transport costs include Administration, Overhead and Communication related costs.

Table 4 Own illustration based on Cost Figures for Rail Transport, Figures for 2018

Costs per Km in Euros	Dry bulk	Liquid bulk	Break bulk	Container	Average
Fixed costs	6.83	6.01	9.91	5.29	7.01
Variable costs	2.95	2.95	9.06	2.95	4.4775
Staff costs	1.41	1.41	3.36	1.41	1.8975
Mode-specific costs	3.77	3.56	9.04	3.66	5.0075
General operating costs	2.24	2.09	4.71	2	2.76
Total costs per km	17.2	16.02	36.08	15.31	21.1525

Source : van der Meulen et al., 2020

Road Transport

Road transport refers to the movement of freight between warehouses, retail establishments, terminals, hubs, and other locations. Vehicles in this study are categorized as trucks, truck + trailer, tractor + trailer and LZV (Longer and heavier truck configuration). In table 5, the Fixed costs include, Depreciation of asset, Vehicle excise duty, Eurovignet (Road user charge), Interest on capital assets, Insurance costs, cost of auxiliary hauled assets and Miscellaneous costs. Variable costs cover fuel, tires, depreciation of capital assets and Maintenance and repairs. In the Netherlands, a liter of automotive diesel cost on average €1,18 in 2018 and the excise tax on diesel was €0,48981 per liter in 2018, €0,48592 in 2017, and €0,48447 in 2016 (van der Meulen et al., 2020). Staff costs include, Wages and social charges, Accommodation expenses, and other miscellaneous costs which is to do with small expenses for drivers.

Various costs such as Cargo insurance, inspections, certifications, permits, costs from damage or theft fall under the Mode specific costs segment. The last category of costs are the General operating costs, which include wages and social charges for no driver staff, administrative, IT, Communication, Real estate, and other miscellaneous costs.

Table 5 Own illustration based on Cost Figures for Road Transport, Figures for 2018

Costs per Km in Euros	Trucks	Trucks +Trailers	Tractor-trailer	LZVs	Overall
	Dry/Break bulk	Dry/Break bulk	Liquid/break/Container	Liquid/break/Container	Average
Fixed costs	0.13	0.25	0.17	0.23	0.19
Variable costs	0.66	0.71	0.61	0.68	0.66
Staff costs	1.05	1.06	0.73	0.77	0.90
Mode-specific costs	0.01	0.02	0.01	0.01	0.01
General operating costs	0.30	0.33	0.22	0.21	0.26
Total costs per km	2.13	2.35	1.74	1.90	2.03

Source: van der Meulen et al., 2020

Table 6 compares the average costs for all ship, rail, and truck categories from the study. We can notice that the truck per km costs when compared to ships is 36 times lower and rail is 3.5 times lower, this is because the below costs do not explain the higher quantities transported by ships in comparison to the other modes. We can estimate the average quantities carried for each mode from (den Boer, Otten, and van Essen, 2011), here the authors compare the standard weights for containers in TEU's transported by all of these modes. By taking an average with an assumption of 1 TEU = 25 Mt, we can determine that in general, transportation by a truck carries around 51.20 Mt, Rail 1,708 Mt and a 0-999 TEU vessel would carry 12,500 Mt. In conclusion the costs for shipping are way lower than the other modes.

Table 6 Own illustration based on Cost Figures for Freight Transport, Figures for 2018

Overall Avg. costs (in Euro)	Ships	Rail	Truck
Fixed costs	20.86	7.01	0.19
Variable costs	38.21	4.48	0.66
Staff costs	7.84	1.90	0.90
Mode-specific costs	5.13	5.01	0.01
General operating costs	2.40	2.76	0.26
Total costs per km	74.43	21.15	2.03

Source : van der Meulen et al., 2020

2.5 Expected Fit for 55 Costs for short sea

We will examine the report prepared by CE Delft "Costs of 'Fit for 55' for Dutch shipping & ports (van den Berg et al., 2022) in order to determine the costs that Fit for 55 could have on the maritime industry. Although this analysis focuses on Dutch ships and ports, it nonetheless serves as a helpful benchmark for anticipated expenses across the EU. We will only look into the costs that are associated with the following:

1. ETS (Emission trading scheme) - applicable to 5000GT and above,
2. FuelEU Maritime (applicable to 5000GT and above) and
3. ETD (Energy tax directive)

Data used is from the MRV (Monitoring, Reporting and Verification) database with the average fuel consumption and average Co2 as a base emission divided by ship type for the years 2018-2020.MRV data provides information on the CO2 emissions and fuel consumption by vessels sailing between EU, from EU and to Non-EU ports, and the ones staying in EU ports. This study calculates the typical amount of biofuel that must be blended in for each vessel type and size class in order to comply with FuelEU Maritime regulations. It is assumed that biodiesel (i.e., FAME) or bio-LNG (more particularly, LNG (duel otto medium speed) with biomethane derived from wet manure/biowaste) will be blended. Due to the higher costs associated related to Ammonia and Hydrogen it is assumed that ship owners will not use this technology.

The below table lists the costs for various categories vessels that might appear close to Short Sea Ships.

Table 7 Own illustration, Breakdown of annual costs of Fit for 55 measures for the Dutch fleet, broken down by ship type size class for the period 2025-2029 (in'000'Euros)

Ship Type	Size	No. of ships	Blending for 2% GHG reduction (Min price)	Blending for 2% GHG reduction (Max price)	ETS 25'-29'	ETD 25'-29'	Average cost Per ship range	
Bulk carrier	10000-34999 Dwt	21	€ 359	€ 1,255	€ 4,040	€ 286	€ 223	€ 266
Chemical tanker	5000-9999 Dwt	6	€ 289	€ 1,010	€ 3,284	€ 429	€ 667	€ 787
Container	0-999 TEU	18	€ 1,883	€ 6,581	€ 21,257	€ 3,036	€ 1,454	€ 1,715
General cargo	0-4999 DWT	7	€ 21	€ 745	€ 2,323	€ 276	€ 402	€ 478
General cargo	5000-9999 DWT	77	€ 2,475	€ 8,650	€ 28,089	€ 3,125	€ 438	€ 518
Oil tanker	5000-9999 DWT	14	€ 441	€ 1,543	€ 5,011	€ 565	€ 30	€ 509
Other ship types	5000-9999 GT	4	€ 162	€ 566	€ 2,304	€ 150	€ 654	€ 755
Ro-Ro	5000-9999 DWT	2	€ 260	€ 908	€ 2,913	€ 443	€ 1,807	€ 2,131

Source: van den Berg et al., 2022

Looking at table 7, the report suggests that annual costs for Bulk carrier that are much larger vessels than short sea vessel types may only account to 223-265,000 Euros per annum, whereas it's interesting to note that container vessels 0-999 TEU, will cost way higher with 1,454,216 to 1,715,224 Euros and Ro-Ro carriers with 5000-999 DWT 1,807,420 to 2,131,490 Euros. However, the ETS and FuelEU maritime schemes are only applicable to smaller portion of the vessels in short sea, but the costs for the ETD will have the main impact. Analyzing the ETD costs from the data per vessel per annum we arrive at the results as described in Table 8.

Table 8 Own illustration, Breakdown of annual costs per ship for ETD , broken down by ship type capacity 2025-2029

Type	Capacity	Cost per Annum
Bulk carrier	10000-34999 Dwt	€ 13,631.62
Chemical tanker	5000-9999 Dwt	€ 71,511.00
Container	0-999 TEU	€ 168,664.22
General cargo	0-4999 DWT	€ 39,403.00
General cargo	5000-9999 DWT	€ 40,584.19
Oil tanker	5000-9999 DWT	€ 40,388.36
Other ship types	5000-9999 GT	€ 37,551.25
Ro-Ro	5000-9999 DWT	€ 221,262.50

Source: van den Berg et al., 2022

The costs for a general cargo vessel with less than 5000 DWT is €39,403, highest are again for the containers and Ro-Ro vessel types with chemical tankers at €71,511. Further based on the requirements for 6% emission reduction from 2030 and 100% requirements for ETS from 2026 the below costs are calculated from 2030-2034.

Table 9 Own illustration, Breakdown of annual costs of Fit for 55 measures for the Dutch fleet, broken down by ship type size class for the period 2030-2034 (in'000'Euros)

Ship Type	Size	No. of ships	Blending for 6% GHG reduction (Min price)	Blending for 6% GHG reduction (Max price)	ETS 30'-34'	ETD 30'-34'	Average cost Per ship range	
Bulk carrier	10000-34999 Dwt	21	€ 424.92	€ 3,193.46	€ 5,073.13	€ 279.29	€ 275.11	€ 406.95
Chemical tanker	5000-9999 Dwt	6	€ 342.03	€ 2,570.47	€ 4,123.52	€ 418.61	€ 814.03	€ 1,185.43
Container	0-999 TEU	18	€ 2,102.58	€ 15,801.74	€ 25,190.74	€ 2,785.52	€ 1,785.55	€ 2,394.17
General cargo	0-4999 DWT	7	€ 252.21	€ 1,895.46	€ 2,916.42	€ 269.10	€ 491.10	€ 725.85
General cargo	5000-9999 DWT	77	€ 2,928.95	€ 22,012.28	€ 35,270.19	€ 3,048.82	€ 535.69	€ 783.52

Oil tanker	5000-9999 DWT	14	€ 522.40	€ 3,926.05	€ 6,292.17	€ 551.66	€ 526.16	€ 769.28
Other ship types	5000-9999 GT	4	€ 191.67	€ 1,440.49	€ 2,893.51	€ 146.54	€ 807.93	€ 1,120.13
Ro-Ro	5000-9999 DWT	2	€ 292.56	€ 2,198.72	€ 3,481.05	€ 410.90	€ 2,209.71	€ 2,986.17

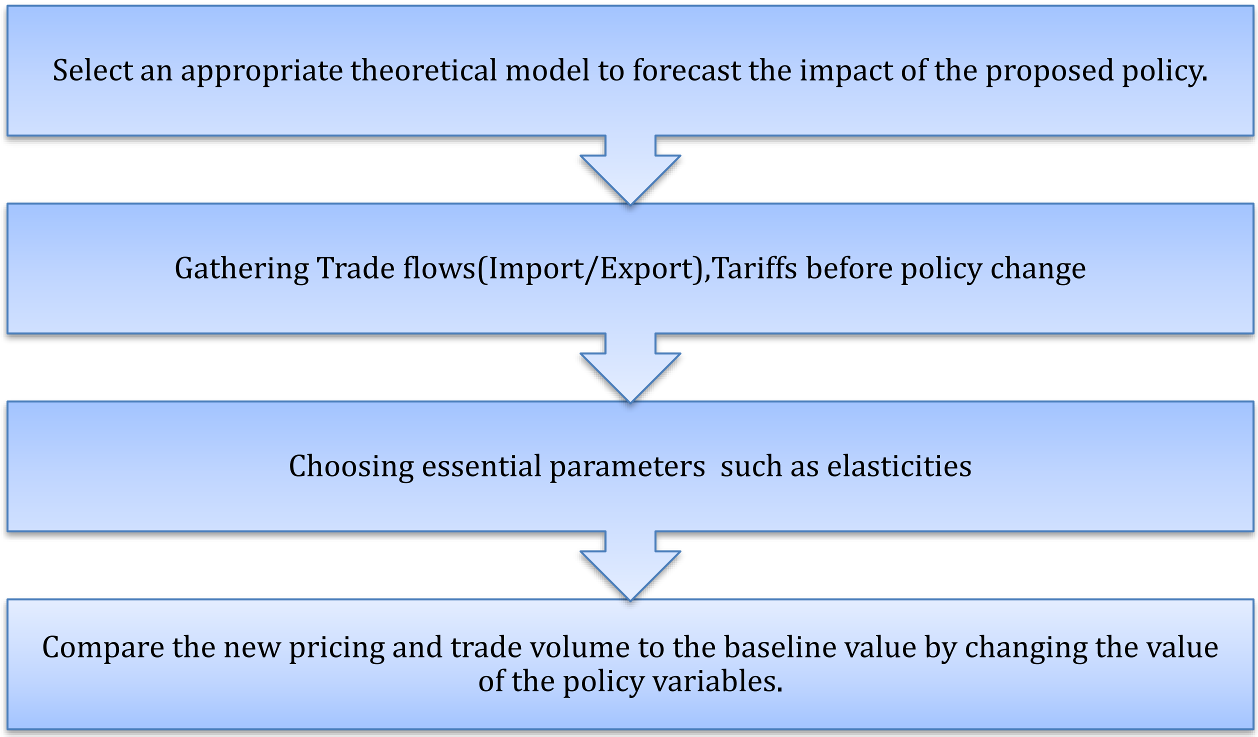
Source: van den Berg et al., 2022

Given that 1.7 billion tons were transported by SSS in 2020, we project the total value to be between 1.3 and 1.4 trillion euros. The number total fleet is estimated to be 4800, when we apply the per annum costs to the type of vessel, we notice an increase in cost of 0.17% in 2025 and 0.32% in 2030. Further details pertaining to the cost calculation is explained in the next chapter.

Chapter 3-Methodology

In Europe, SSS faces issues that are distinct from those faced by deep-sea shipping because it relies on the industries and business at a regional level, which makes its growth dependent on a fewer markets. With the "Fit for 55" policy the SSS fleet is going to be continuously monitored as they will be operating only within the EU waters, unlike DSS which has a choice of moving to different regions in the world. In addition, road, rail, and air act as alternative modes and have the potential to replace maritime transportation flows to some extent. The transportation costs can vary greatly depending on the nation, the route, the commodity, and other elements like distance and location, the size of economies, and the success of cross-border trade. According to Hummels, D. (2007), "*there are three ways to put the economic importance of transportation costs in perspective: by examining 1) transportation costs relative to the value of the goods being moved; 2) transportation costs relative to other known barriers to trade, like tariffs; and 3) the extent to which transportation costs alter relative prices*".

According to (Bacchetta et al., 2020) a typical trade policy modeling process consists of the following steps.



We could use a partial-equilibrium (PE) or a general-equilibrium (GE) model as an appropriate methodology, the PE approach is more suitable for policy changes and capturing disaggregated and short-term effects. While the GE model is better suited for considering economy-wide linkages, long-term effects, and budget constraints. The major advantages of a PE model over a GE model are that 1. The results are straightforward with a lesser number of equations used to calculate changes in demand and supply 2. Data only for the specific sector is needed such as trade flows, policy data, and elasticities.

In order to study the policy impact for SSS, we need to consider the shipment quantities for SSS, Road and Rail, to gather this kind of data is a challenging process and makes it difficult to get the exact trade figures. Given the various constraints and benefits of a PE model, it becomes an obvious choice to analyze the impact of the 'Fit for 55' policies on SSS. We will be choosing a Global simulation (GSIM) model to study this policy impact.

3.1 Global Simulation (GSIM) Model

Francois and Hall (2002) created the GSIM model to examine policy changes with an industrial emphasis that was global in scope. The model considers the interaction of multiple market access concessions across trade partners, Exporter (Producer surplus), Importer (Consumer surplus), and Tariff revenue changes. This model uses a percentage change of import demand together with export supply equations and enables the transformation of a system of extensive bilateral trade relationships into a simplified model of global supply and demand. When a shock in the form of a policy change ("Fit for 55") is introduced, this is a regulatory policy shock that can be modelled as a change in non-tariff measures. This moves global trade out of its equilibrium and the process of the world economy recalibrating towards a new equilibrium leads to a shift in supply and demand curves because of changed prices and thus to changes in production, and trade. Prices that are linked to each region will undergo changes and we can also assess the new trade values and welfare effects.

The underlying own and cross-price demand elasticities are a crucial element of this model. For the purpose of calculating elasticities, (Francois and Hall, 2002) assumed that, within each importing country *(v)*, the import demand for a certain product category *(i)* of goods from another country *(r)* is a function of industry pricing and the total expenditure on the category.

$$M_{(i,v),r} = f\left(P_{(i,v),r}, P_{(i,v),s \neq r}, y_{(i,v)}\right) \qquad \textbf{Equation 1}$$

Here *M* represents the import of good *i* into country *v* from country *r* .

$P_{(i,v),r}$ is the internal price of the good *i* from country *r* inside country *v*

$P_{(i,v),s \neq r}$ price of other varieties of goods which comes from product differentiation

$y_{(i,v)}$ total expenditure of import for good *i* in country *v*

Equation (1) is differentiated and the Slutsky decomposition of partial demand and the zero-homogeneity property of Hicksian demand is applied.

Zero homogeneity explains that the dependent variable does not change with the change in independent variables. Based on this the following equations are derived

$$N_{(i,v),(r,s)} = \theta_{(i,v),s}(E_m + E_s) \qquad \textbf{Equation 2}$$

$N_{(i,v),(r,r)} = \theta_{(i,v),r} E_m - \Sigma\theta_{(i,v),s s\neq r} E_s = \theta_{(i,v),r} E_m - (1-\theta_{(i,v),r}) E_s$ **Equation 3**

$N_{(i,v),(r,s)}$ is cross-price elasticity - It is the percentage change in demand of good i as a result of a percentage change in the price of goods from region s.

$N_{(i,v),(r,r)}$ is own price demand elasticity - The own-price demand elasticity represents the percentage change in the quantity of the demand of good *i* as a result of a percent change in the price good *i*

$\theta_{(i,v),s}$ Demand Expenditure share at internal prices

E_m Aggregate import demand elasticity

$(1-\theta_{(i,v),r})$ Expenditure share of all other goods

E_s Elasticity of Substitution

The supply and demand linkages is required for the GSIM model to function properly. To achieve this, a link is made between the global export price with the domestic price.

$P_{(i,v),r} = (1+t_{(i,v),r}) P_{i,r*} = T_{(i,v),r} P_{i,r}$ **Equation 4**

$P_{(i,v),r}$ Domestic price of the good

$T=1+t$ is the power of the tariff

$P_{i,r}$ Export price received by the exporter r on world markets

According to Francois and Hall (2002), The export supply of good i to the world market is defined as a function of the world price, denoted by P*:

$X_{i,r} = f(P_{i,r*})$ **Equation 5**

With differentiation applied to the world market (1), the exports to the world market (5) and the link between the internal and external price (4) proportional changes are noticed.

"^" represents a proportional change $\hat{x} = \frac{dx}{x}$ (Francois and Hall, 2002)

$\hat{P}_{(i,v),r} = \hat{P}_{i,r*} + \hat{T}_{(i,v),r}$ **Equation 6**

$\hat{X}_{i,r} = E_{x(i,r)} \hat{P}_{i,r*}$ **Equation 7**

$\hat{M}_{(i,v),r} = N_{(i,v),(r,r)} \hat{P}_{(i,v),r} + \Sigma_{s s\neq r} N_{(i,v),(r,s)} \hat{P}_{(i,v),s}$ **Equation 8**

To keep one function for imports in the world markets, the proportional change in internal price along with cross price elasticity and own price demand elasticity are substituted in to the equations for imports. With the proportional change equation for imports the global market clearing condition for each export type can be defined. When supply equals demand the global market is clear and the proportional change in exports has to be equal to the change in imports.

Several substitutions can be performed to simplify the formulated equations and define the equations for a workable GSIM model in terms of world prices. This is done by taking *equations*

(2) ,(3) and (6) and substituting them into *equation 8* with the addition of sum over import markets. This will result in the following equation

$$\widehat{M_{\iota,r}} = \sum_v \widehat{M_{(\mathrm{i},v),r}} = \sum_v N_{(i,v),(r,r)}\widehat{P_{(\iota,v),r}} + \sum_v \sum_{s\neq r} N_{(i,v),(r,s)}\widehat{P_{(\iota,v),s}}$$
$$= \sum_v N_{(i,v),(r,r)}\left[P_r^* + \widehat{T_{(,v),r}}\right] + \sum_v \sum_v N_{(i,v),(r,s)}\left[\widehat{P_s^*} + \widehat{T_{(,v),s}}\right]$$

Equation 9

To define the core formula for the GSIM model, Setting equation (9) equal to equation (7) results in equation (10) (Francois and Hall, 2002): $\widehat{M_{1,r}} = \widehat{X_{L,r}}$

$$\widehat{M_{1,r}} = \widehat{X_{L,r}}$$
$$= E_{X(i,r)}\widehat{P_{\iota,r}^*} = \sum_v N_{(i,v),(r,r)}\widehat{P_{(,v),r}} + \sum_v \sum_{s\neq r} N_{(i,v),(r,s)}\widehat{P_{(\iota,v),s}}$$
$$= \sum_v N_{(i,v),(r,r)}\left[P_r^* + \widehat{T_{(t,v),r}}\right] + \sum_v \sum_{s\neq r}^{v} N_{(i,v),(r,s)}\left[\widehat{P_s^*} + T_{(t,v),s}\right]$$

Equation 10

$\hat{P^*}_{i,r}$ - Internal price of goods from country r

E_X - Elasticity for export supply

The revenue under the GSIM model can be derived by solving world prices (equation (10)), equation (8) for export quantities and equation (9) with import quantities. By combining this the partial equilibrium measure for changes in consumer and producer surplus and welfare effects is obtained. $\triangle PS = R_{(i,r)}^0 * \widehat{P_{(\mathrm{l},r)}^*} + 0.5R_{(i,r)}^0 * \widehat{P_{(,r)}^*} * \widehat{X_{\iota,r}}$

$$\triangle PS = R_{(i,r)}^0 * \widehat{P_{(\mathrm{l},r)}^*} + 0.5R_{(i,r)}^0 * \widehat{P_{(,r)}^*} * \widehat{X_{\iota,r}}$$
$$= \left(R_{(i,r)}^0 * \widehat{P_{(,,r)}^*}\right) * \left(1 + \frac{E_{x(i,r)*}\widehat{P_{l,r}^*}}{2}\right)$$

Equation 11

The above defines the changes in producer surplus

$R^0(i,r)$ = Export revenues (bilateral or total at world prices)

$$\Delta CS_{(i,v)} = \left(\sum_r R_{(i,v),r}^0 * T_{(i,v),r}^0\right) * \left(0.5E_{M(i,v)}\widehat{P_{(\iota,v)}^2} * sign\left(\widehat{P_{(\iota,v)}}\right) - \widehat{P_{(,v)}}\right.$$

Equation 12

With

$$\widehat{P_{(,v)}} = \sum_r \theta_{(i,v),r}\widehat{P_r^*} + \widehat{T_{(1,v),r}}$$

Based on the equation the GSIM model can show the trade creation that results from the tariff reduction and trade diversion which is because of the changes to tariffs and NTM's.

$$TC_{(i,v),r} = M_{(i,v),r} * \left(N_{(i,v),r,rr)}\widehat{T_{(1,v),r}}\right.$$

Equation 13

Trade Creation

$$TD_{(i,v),r} = M_{(i,v),r} * \sum_{s\neq r} N_{(i,v),(r,s)}\widehat{T_{(\iota,v),s}}$$

Equation 14

Trade Diversion

Table 10 Indexes and Variables Notation

Indexes	
r,s	exporting regions
v,w	importing regions
i	industry designation
Variables	
M	imports (quantity)
X	exports (quantity)
Em,(i,v)	aggregate import demand elasticity Defined for aggregate imports $M(i,v)$ and composite price $P(i,v)$ $= \frac{\partial M_{(i,v)}}{\partial P_{(i,v)}} \cdot \frac{P_{(i,v)}}{M_{(i,v)}}$
Ex,(i,r)	elasticity of export supply $= \frac{\partial X_{(i,r)}}{\partial P_{(i,t)} *} \frac{P_{(i,r)*}}{X_{(i,r)}}$
Es	elasticity of substitution
N(i,v),(r,r)	own price demand elasticity
N(i,v),(r,s)	cross-price elasticity
T(i,v),r	The power of the tariff, T=(1+t)
θ*(i,v),r*	demand expenditure share (at internal prices) $\theta_{(i,v),r} = M_{(i,v),r} T_{(i,v),r} / \sum_{s} M_{(i,v),s} T_{(i,v),s}$
φ*(i,v),r*	export quantity shares $\phi_{(i,v),} = M_{(i,v)r} / \sum_{\underline{w}} M_{(i,v),r}$

Source: Francois and Hall, 2002

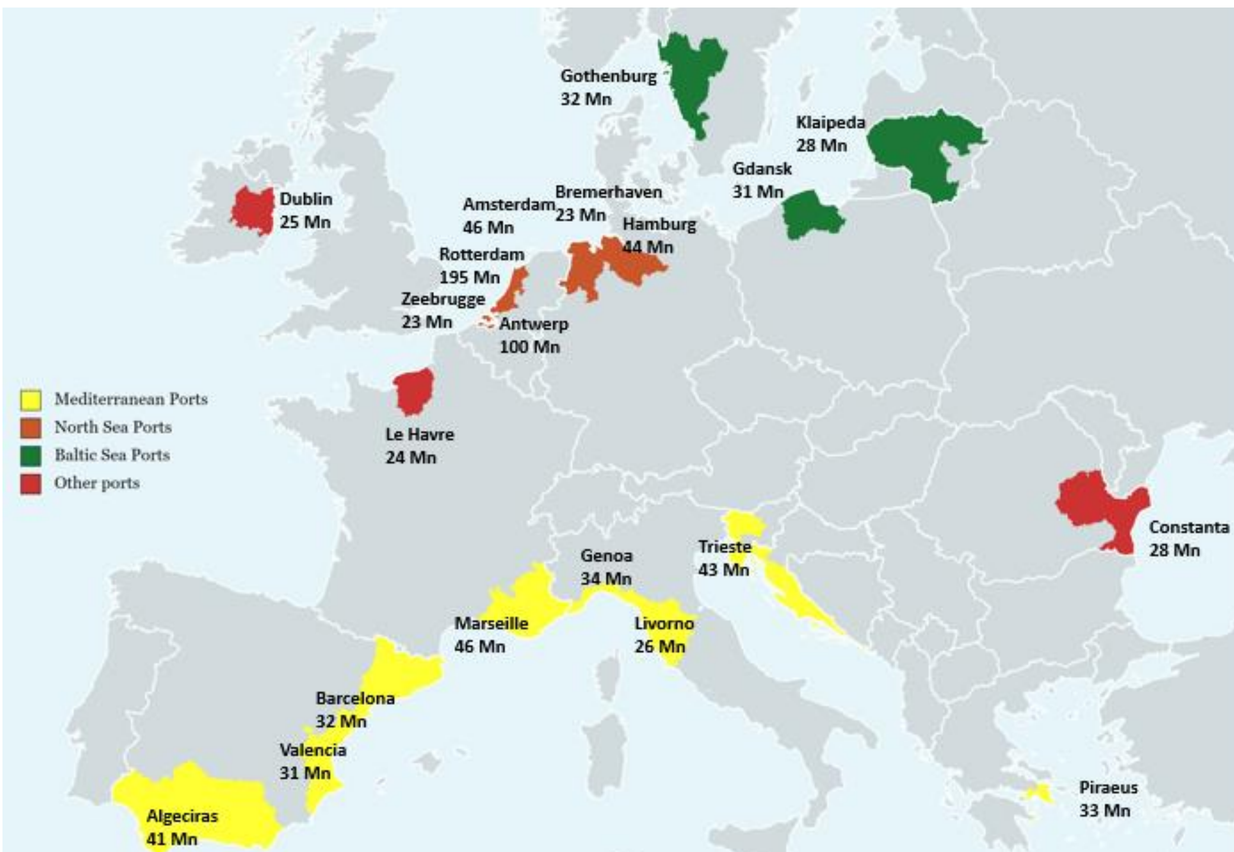
3.2 Country selection & Data Collection

The 'Fit for 55' policy is only applicable in European regions, and to study its impact on SSS, we must also compare other modes such as road, rail, deep sea, and air cargo. For this, we use Eurostat and UN Comtrade sources as the main sources of data, Eurostat provides data on transportation volumes within Europe for SSS, Rail and Road modes, while UN Comtrade is used to gather data on Deep Sea and Air cargo Trade values.

3.2.1 Country Selection

The research question focuses on the impact of the Fit for 55 packages for the SSS in Europe. Since the European region is quite extensive, we want to narrow down on the important SSS ports based on the volumes handled in 2020. As describe in figure 4, we find that 20 of the busiest ports in SSS account for about 52% of the goods transported, and out of this twenty, 17 of them belong to the Mediterranean, North Sea, and Baltic regions. The total volume of SSS transport in Europe in 2020 is 1.68 billion (Eurostat), with the Mediterranean, North Sea, and Baltic regions accounting for 1.09 billion (around 65%). Thus, for the GSIM model, we will use data on transport volumes and values for the countries located in these three regions.

Figure 4 Top 20 SSS ports in terms of volume in 2020



Source: Own illustration from Eurostat database

The above figure 4 illustrates the major SSS ports in the EU based on volumes handled, We identified the below regions and countries to have about 65% of the trade volumes for SSS and thus use the major countries in this region for this research.

Table 11 Country choice for regions -SSS, Road, Rail, DSS and AC

Mediterranean	North sea	Baltic Sea
Greece	Belgium	Estonia
Spain	Germany	Latvia
France	Netherlands	Lithuania
Italy		Poland
		Finland
		Sweden

Rest of the World (ROW) for SSS includes all other countries in the world (from Japan and China to Brazil and remaining EU countries) with all SSS trade to close the model.

We use the same European regions and countries for Road, Rail, Deep Sea and Aviation transportation as it will compare the transportation volumes between these modes and allow for substitution between them if 'Fit for 55' impacts modes of transport asymmetrically.

3.2.2 Data Collection

The data for this thesis is obtained from UN COMTRADE and EUROSTAT. The reason is that EUROSTAT data for intra-EU trade is more reliable to compare the trade within EU, especially for SSS, Road, and Rail transport modes, however it, is not suitable for data with rest of the world, therefore we used UN COMTRADE data for Rest of the world trade and also for Deep Sea shipping and Air cargo as these modes have a more international impact. We compared the datasets of UN COMTRADE and EUROSTAT for Intra EU imports/Exports and EU to World Imports/Exports and found that on average the data confluency is between 95-96%.

Table 12 Comparing Trade values with Eurostat and UN Comtrade data for 2020

Data Sets	Intra EU Imports (In million USD)	Intra EU Exports (In million USD)	World EU Imports (In million USD)	World EU Exports (In million USD)
EUROSTAT	3,188,784	3,260,998	5149862	5,468,464
UNCOMTRADE	3,312,075	3,469,472	5546023	5,546,023
Confluence %	96%	94.0%	93%	99%

Source: Own compilation from Eurostat and UN Comtrade

<u>SSS Data</u>

For the transport volumes, we used the data from Eurostat for 2020. SSS data was available based on the transport volumes handled by country or region. Unfortunately, there is no data available from other origin port/ country to the destination port or country. So, we used the data of the volumes handled by each country with regions along with the data available for the inward and outward quantities for these countries. The inward and outward were converted to percentages and the same was applied to the total volume's country-wise to regions to know the quantity movements inwards/outwards to various ports/country/regions. The data was segregated further to capture the relevant countries with the regions to arrive at the final matrix of origin to a destination within the three regions (Mediterranean Sea, North Sea, and Baltic sea).

The data from goods transported to/from main ports, by sea region of partner ports was taken from [mar_sg_am_cws] (Eurostat data code) and the data country level goods transported to/from main ports, by direction was obtained from [mar_sg_am_cwd] (Eurostat data code).

Table 13 Compilation of SSS data from Eurostat data in thousand tons

Imports in 000' tones	Region wise qty multiplied by the percentage of inwards for each country			
Mediterranean	Ports	Mediterranean	North Sea	Baltic
	Greece	41,083.92	2,971.14	504.85
	Spain	61,161.21	18,945.51	7,317.90
	France[1]	16,219.77	9,631.14	5,163.19
	Italy	135,738.68	5,091.71	5,404.25
North Sea	Belgium	18,724.58	24,044.51	18,674.90
	Germany	7,939.35	30,085.47	46,013.90
	Netherlands	22,512.97	57,639.70	51,296.84
Baltic Sea	Estonia	345.54	2,669.40	7,934.78
	Latvia	822.16	2,906.58	3,179.86
	Lithuania	1,671.04	4,078.72	8,438.03
	Poland	4,488.43	13,908.12	16,679.08
	Finland	1,548.91	15,905.05	26,852.01
	Sweden	1,918.75	29,960.57	42,268.67

Source: Eurostat Data 2020

To gather the data for ROW-to-ROW values we used the UN Comtrade values by considering 40% of maritime trade as short sea shipping. (The Cooperative Logistics Network, 2022; The Blogging Crew, 2021).

[1] France quantities were split to only show port in the Mediterranean

Road Data

Data was collected by freight volumes from origin to destination country, the same countries for the three regions were used. We used the data from country-to-country flows in intra-EU road freight transport, 2020 Eurostat data.

Rail Data

Similar to Road we were able to get the origin to destination country freight volumes for the Rail transport. We used data from Eurostat Railway transport - national and international railway goods transport by loading/unloading 2020 NUTS 2 region (data code: tran_r_rago). SSS, road and rail quantities from Eurostat are available in the Appendix section Table 32

Deep Sea Shipping

According to (Verschuur, Koks and Hall, 2022) 50 % of the global trade in terms of value is maritime related. We used the 2020 Trade values from UN Comtrade in USD at 50% and converted to Euros using (Exchange Rates UK, 2021) USD to EUR Average exchange rate in 2020: 0.877 EUR.

Air Cargo

According to (Shepherd, 2016), "*In 2015, airlines transported 52.2 million metric tons of goods valued at USD 5.6 trillion. Air cargo is key in supporting the current global trading system, with an estimated 35% of value of global trade carried by air, even though it covers less than 1% by volume".* We used the 2020 Trade values in USD at 35% collected from UN Comtrade and followed the same conversion procedure to Euros as done for DSS.

Monetizing transport volumes

Since the GSIM model requires input in values and not volumes, we have to find a way to monetize the volumes for SSS, Road, and Rail Transportation. To make the data consistent we used the data available at Eurostat by using the total EU Intra imports, Intra exports and EU exports and imports with the world. The total volume of goods traded in the EU was divided with the total value to arrive at an average price.

Table 14 Price per ton calculation with Intra EU imports and exports values and quantities in 2020

	Intra EU Imports	Intra EU Exports
Values in Euro	€ 2,792,280,364,490	€ 2,855,514,985,862
Total Qty in kg	1,616,897,775,835	1,596,366,457,080
Price per ton	€ 1,726	€ 1,788

Source: Eurostat data 2020

While the above table 14 provides a general idea of the price per ton, the transport mode is not made explicit. We used data from the Eurostat database (DS-058814), which does not include all intra EU trade values and volumes but has broken out the transport modes, to get closer to a more accurate estimate as in table15.

Table 15 Intra EU 20 countries trade values and quantities

Mode	In Million tons	In Million Euros	Per Mt Price
Sea	291	€ 247,757	**€ 850.29**
Road	1,084	€ 2,776,390	**€ 2,559.90**
Rail	120	€ 116,415	**€ 962.98**

Source: Eurostat data code DS-058814

Furthermore, for volumes to ROW we used data as in the table below i.e., Transport costs for importing goods by transport mode, world, LDCs, and LLDCs, 2016, percentage of FOB value from the (UNCTAD, 2021) report to convert the average CFR price to FOB. The percentages for various modes of transportation are shown in the table below. We used 9.40% to reduce the average price and arrive at the FOB value as indicated in the below table.

Table 16 Percentage of freight cost per transport mode

Transport Mode	Percentage of value applied
Sea	5.60%
Road	7.70%
Rail	2.30%
For all modes	9.40%

Source: UNCTAD,2021

A similar method was carried out to attain Extra-EU trade values. This price is then multiplied by the total volumes for each of the modes to arrive at the trade values in EurosWith the FOB values, we then calculated the respective percentage of each of the modes and calculated the CFR per Mt price as mentioned in tables 17 and 18. Final values after conversion are shown in table 33 in the Appendix section

Table 17 Price per ton calculation from World to EU imports and Exports in Value and Quantities in 2020

	World EU Imports	World EU Exports
Values in Euro	€ 4,509,512,171,133	€ 4,788,497,495,136
Total Qty in kg	3140040656184	2316178595361
Price per ton	€ 1,436	€ 2,067

Source: Eurostat 2020

Table 18 Calculation of Freight Per ton rate

World Freight calculation	
Extra Eu Avg. price	€ 1,751.77
Reduce transport at 9.4%	€ 164.67
Final price FOB	€ 1,587.11
SSS CFR Price	€ 1,675.98
Road CFR Price	€ 1,709.31
Rail CFR price	€ 1,623.61

Source: Eurostat and UNCTAD 2021

3.3 Scenarios

To achieve the EU's goals of climate neutrality by 2050, the EU has set a target of cutting at least 55% emissions by 2030. The targets and the costs for emissions change with the time period. For this reason, we are going to apply two scenarios, one based on the costs in 2025 and the other in 2030 to determine the impact on the various transport modes. In 2025 and 2030 the initial and final tariffs will remain the same, But NTM's will vary based on the calculations for each mode, for SSS the cost will increase by 0.17% in 2025 and 0.32% in 2030 for voyages within the EU region, for the exports and imports to ROW the cost will increase by 0.09% in 2025 and 0.15% in 2030 considering 50% of the voyage time will be in the EU. ROW to ROW NTM costs will remain unchanged as there is no impact. For road there will be a 4% (2025) and 9% (2030) increase in costs in the final NTM and 2% (2025) and 4.5% (2030) increase for the movement to ROW and EU and ROW to ROW will remain the same for Initial and Final NTM's. In Rail we already applied the costs for emissions in the initial NTMs, so this remains the same for 2025 and 2030. DSS costs for the final NTM is an addition of 3.78% (2025) and 4.03% (2030), similarly for voyages from and to EU countries the costs increase is 1.89% (2025) and 3.92% (2030), with ROW to ROW unchanged. With Air cargo we have 9.40% as the final NTM costs for both scenarios, with trade with EU and ROW considered as 4.7% and ROW to ROW being the same.

For SSS, the main focus will be the costs and targets pertaining to ETS,ETD and FUEL EU maritime, for Road considered ETS, Rail is the least pollutant and will not have much of an impact, Deep sea shipping will include the same costs as for the SSS, with the parameters based on the Vessel Dwt and considering 50% rule in cases with the rest of the world ports, Finally, air cargo will consider the costs for ETS till 2030. The reason for creating two scenarios is to gauge the impact in stages in the next years to come and check the policy impact in the short run.

3.4 Tariffs and NTM's

3.4.1 Tariffs

Tariffs are gathered from the WITS world bank database and chosen as TRAINS (MFN) weighted average values. Tariffs are only imposed on trade between EU countries and ROW, as well as ROW to EU and ROW to ROW. For all intra-EU trade there are no tariffs. Table 34 in Appendix has details of the tariffs inputted in the model.

3.4.2 Non-Tariff measures

According to Anderson and Van Wincoop, 2004 trade costs are defined as the costs incurred to deliver the good to the end consumer. This cost excludes the marginal cost of producing the good and includes freight and time costs as transportation costs, there are also costs associated with Policy barriers, contract enforcement, information, currency, language, and local distribution costs. Anderson and Van Wincoop, 2004 estimate these costs to be 170% with 74% as international trade costs and 55% as local distribution costs.

The international trade costs comprise 21% which is transport costs and 44% is a combination of inferred costs and direct observation, lastly, the retail and distribution costs are considered to be 55%. We arrive at a total cost of 170% ((1.21 x 1.44 x 1.55)-1).

<u>Short Sea Shipping</u>

Using the costs as in the paper by Anderson and Van Wincoop, 2004 excluding currency and security barriers which will not be relevant for trade within the EU, we arrived at an Initial NTM of 138.19% and final NTM for 2025 as 138.28% and final NTM for 2030 as 138.36%, this is because of an increase of 0.17% in 2025 and 0.32% in 2030 which is included in the other costs section. Costs were applied based on the type, Gross tonnage, and number of SSS vessels in the EU. Costs calculated based on estimations from the report by van den Berg et al., 2022 were applied. The main cost heads were ETS, ETD, and FuelEU, we also had to classify the vessel GT (5000GT) based on restrictions for ETS and FuelEU to arrive at the final calculation. Due to the lack of information on the short sea vessel fleet and their Gross tonnage, we estimated the number of SSS vessel as 4800 (Papadimitriou et al., 2018) and segregated them based on the vessel type as Tankers, Bulk carriers, containers, and RORO vessels. Next, we categorized them based on information from (BMTI, 2017) which has the DWT range for a group of SSS vessels in the EU, with this information we used the percentage of each category in terms of DWT and applied this to vessel type and numbers available at Papadimitriou et al., 2018. The below table 19 indicates the calculation results and type of vessel that have been categorized.

Table 19 Calculation for classifying the DWT and type of vessel for SSS

	Conversion to DWT BMTI data as estimate of the percentage					
	5-5.9K (5500 DWT)	6-6.9K (6500DWT)	7-7.9K (7500DWT)	8-8.9K (8500DWT)	9-9.9K (9500DWT)	Total
Tankers	318	271	220	190	101	**1100**
Bulk carriers	751	642	520	449	238	**2600**
Containers	231	197	160	138	73	**800**
RORO carriers	87	74	60	52	28	**300**
BMTI %	29%	25%	20%	17%	9%	4800

Source: Own analysis from BMTI,2017 and Papadimitriou et al., 2018

For e.g., 29% of the tankers from the below table 20 were taken as 318 vessels under 5500 DWT, it was similarly carried out for the other vessel types. Total number of vessels and their DWT listed in table 20.

Table 20 Based on own calculation number of vessels by DWT for SSS

Vessels Nos.	Deadweight (DWT)	Percentage
775	5-5.9K	29%
662	6-6.9K	25%
537	7-7.9K	20%
463	8-8.9K	17%
246	9-9.9K	9%

Source: Own analysis from BMTI,2017 and Papadimitriou et al., 2018

Further to convert them from Dead weight tonnes to Gross tonnage we used (Stopford, 1997) for the conversion values from DWT to GT . For instance, a 5500 DWT vessel was multiplied by 1.75 for the tanker to arrive at 3143 GT. The same calculation method was applied with a conversion rate of 1.7 for bulk,0.96 for containers, and 1.07 for Ro-Ro vessels, this corresponds to vessel categories of 5500Dwt, 6500Dwt, 7500Dwt, 8500Dwt, and 9500Dwt. Basis this we could estimate the costs for vessels above and below 5000GT. The Overall NTM costs categories for the initial NTM's were estimated as in the below table.

Table 21 NTM cost categories for SSS

Transport Costs	**21.00%**
Freight	12%
Time value of goods transit	9%
Other costs	27.00%
Policy Barrier + NTB's	8.00%
Language barrier	7.00%
Currency barrier	0.00%
Information costs barrier	6.00%
Security barrier	0.00%
Others	6.00%
Wholesale and distribution costs	55%

Source: Own compilation based on Anderson and Wincoop,2004

As illustrated in table 21 for using them in the econometric model, the Initial NTM costs was calculated as (1.21 x 1.27 x 1.55) – 1 = 138.19%. Similarly, with the costs applied for 2025 and 2030 we arrived at 138.28% and 138.36% respectively. For ROW calculations we arrived at 170.07% this steep increase in due to the addition of currency and security barriers, which remained the same for final NTM's for ROW to ROW. The next is the calculation for NTM's for SSS to ROW and vice versa, the Initial was 170.07% and the final NTM's was 170.15% in 2025 and 170.20% in 2030. Since these voyages included only some part of the EU route, we considered the ETS, ETD and FuelEU to be an average 50% of the costs calculated for SSS within the EU.

<u>Road</u>

Information from (European Commission, 2007) report indicates a 25% cost increase in the toll for heavy lorries because of additional air and noise pollution costs. This cost is considered to be an existing part of the Initial NTM's. The total initial NTM for Road cargo transport is calculated to be 138.19%. While the NTM's for ROW was calculated as 170.07%. For the initial NTM same parameters were applied which is similar to SSS. For the final NTM 2025 the below table indicates the share of NTM costs for Intra EU road.

Table 22 NTM cost categories for Road in 2025 and 2030

NTM 2025	140.21%
Transport Costs	21.00%
Other costs	28.08%
Wholesale and distribution costs	55%
NTM 2030	**142.84%**
Transport Costs	21.00%
Other costs	29.48%
Wholesale and distribution costs	55%

Source: Own compilation based on Anderson and Wincoop,2004

Based on the above table 22 the final in 2025 and 2030 were 140.21% and 142.84% respectively. The costs increase was due to ETS with a 11% Co2 reduction in 2025 costing about 4% and 30% Co2 costing an additional 5% in 2030(Schroten et al., 2021). In 2030 the impact is assumed lower under the assumption of major shift towards electrical and other sustainable energy options. While Road EU to ROW were assumed to be impacted by half the costs and were calculated to be 171.72% in 2025 and 173.83% in 2030.

<u>Rail</u>

The rail industry is already paying 500 million Euros per year (Geerts, 2021) and being compliant with the polluter pays principal with 0.4% of the transport-related CO2 emissions. (Community of European Railway and Infrastructure Companies (CER), 2021). The calculation remained the same for the initial and final NTMs as in the table 23. The costs of 500 million is about 0.057% of the total trade value for Rail. The initial and final NTM's for the Intra EU rail remained at 138.23% as indicated in the table below. The ROW-to-ROW costs were calculated to be 170.07% after adding currency and security barriers. Rail EU to ROW/ROW to EU was calculated to include the costs as in Intra EU trade with addition of currency and security barriers at 170.13%.

Table 23 NTM cost categories for Rail in 2025 and 2030

NTM Initial and Final for Intra EU	138.23%
Transport Costs	21.00%
Other costs	27.02%
Wholesale and distribution costs	55%

Source: Own compilation based on Anderson and Wincoop,2004

Deep-sea

We calculated the DSS costs using the van den Berg et al., 2022 report. The number of vessels arriving in Europe was derived from UNCTAD data from country maritime profiles. We determined the number of ships and their dead weight tons from this data. The average cost per vessel was applied to consider only partial costs for the ETS, ETD and FUELEU. This cost was applied to the total number of vessels to calculate final costs, which was 3.78% in 2025, and increased by a further 4.18% in 2030. The initial NTM within EU is 138% and after the shock, it increases to 140.2% in 2025 and 142.3% in 2030. ROW to EU and vice versa is initially 170% and increases to 172% in 2025 and 173% in 2030, it is calculated at 50% of the intra EU costs considering that only one part of the voyage will be in EU waters. The 50% is because the policy applies emission costs only for 50% of the emissions for sea going vessels to and from EU to countries outside the EU. ROW to ROW remains unchanged at 170% for the initial and final scenarios.

Air cargo

According to (Schlumberger, 2009) "*The demand for air freight is limited by cost, typically priced 4–5 times that of road transport and 12–16 times that of sea transport. Air freight rates generally range from $1.50–$4.50 per kilogram, while the value of air cargo typically exceeds $4.00 per kilogram".*

The air passenger and cargo industries rely on one another; when the amount of cargo required for a freighter service is insufficient, it is transported in the belly of a passenger aircraft. In order to calculate a reliable cost structure, we used the report prepared by CE delft (de Vries, van den Toorn and Grebe, 2021 which considers the 'Fit for 55' impact on the Air passenger traffic in Netherlands. Here the costs arising due to ETS is considered to increase the ticket price by 9.4% in 2030. We use the same costs for 2025 and 2030 to check the impact in comparison to the other modes. Based on the calculations we arrive at an Intra-EU initial NTM of 138.19% increasing to 142.95% in 2025 and 2030. EU to ROW and ROW to EY has an initial NTM of 170.07% like the other modes and increases to 173.95% in 2025 and 2030, these costs are calculated assuming 50% the route is outside the EU. ROW to ROW remains at 170% for both scenarios. Tables 35,36 and 37 in the Appendix section provides an overview of the tariffs used in the model.

3.5 Elasticities

Trade policy analyses rely on import demand and export supply elasticities. To study the impact of a policy, we must know the change in trade volumes, which requires both import demand and export supply elasticities. According to (Kee, Nicita and Olarreaga, 2004) *"To provide estimates of overall protection including both tariff and non-tariff barriers one would need first to transform non-tariff barriers into ad-valorem equivalents, for which import elasticities are necessary"* Export elasticities show the exporter's tenacity in the face of an unanticipated drop in their position. The price elasticity for imports serves as a summary of the competitiveness between domestic and international manufacturers in response to changes in demand.

For this Econometric model, we require three different types of elasticities 1. Composite demand elasticity 2. Export supply elasticity and 3. Elasticity of substitution. The demand elasticity values vary from minus to zero, the closer the values are towards minus infinity it means the demand is elastic, on the contrary the closer these values are towards zero it means the demand is inelastic. Typically, the demand elasticity would range between -10 to 0 (Khemani and Shapiro, 1993). Concept of Elasticity of substitution is to classify if a product is a substitute or complement, the value will be positive and ranges from zero to any positive value. At zero it means there are no close substitutes, according to Khemani and Shapiro, 1993 a number higher than 2 could indicate the close substitutability of those products. In a study by (Merkel et al., 2021) which compares various studies on Own-price and cross-price elasticities of maritime freight transport demand, we find the average demand elasticity to range from -0.11 to -2.0. In another study by (Tokarick, 2010) which groups countries by income level, indicate demand elasticities for low-income countries to be -1.17, lower middle -1.11, upper middle income -1.20 high income -1.28, and high-income OECD which includes most of the European countries to be -1.14. Similarly for the Export supply elasticities we find the range for the same group to be 0.59 to 1.28. For substitution elasticities a study by (ZOFÍO Jose et al., 2020) suggests that the range for the EU countries is between 10.1 to 4.6. In the same research it states that for trade policy evaluations the Substitution elasticity is assumed to be between 4 and 5.

Since we are studying the impact of policy for various transport modes, our focus for the elasticities will be for all products because the trade values represent the same. Francois and H Keith Hall, 2009 the developers of GSIM model had taken Import demand elasticity as -1.25, Export supply elasticity as 1.5 and substitution elasticity to be 5, for all countries and products. For the purpose of this study, we will be using Substitution elasticity of 5, Import demand elasticity of -1.40 and Export supply elasticity as 2. We will do a sensitivity analysis in the next chapter to assess the impact of the individual variable of substitution elasticity on the results formulated by the model.

Chapter 4-Results and Analysis

To evaluate the economic and transportation effects of the "Fit for 55 Policy" on SSS, we run our econometric model with two scenarios as explained in Chapter 3: once for the scenario that simulates the goal of 2025 and one for 2030. The model then allows us to look at net welfare effects, including changes in consumer and producer surplus, changes in trade flows, and changes in prices for both consumers and producers. Since we included trade values for different modes of transportation in the model, the analysis in this part will give a solid indication of the impact of the added costs to trade, which reflects the increased costs to the transportation sector and ultimately consumers.

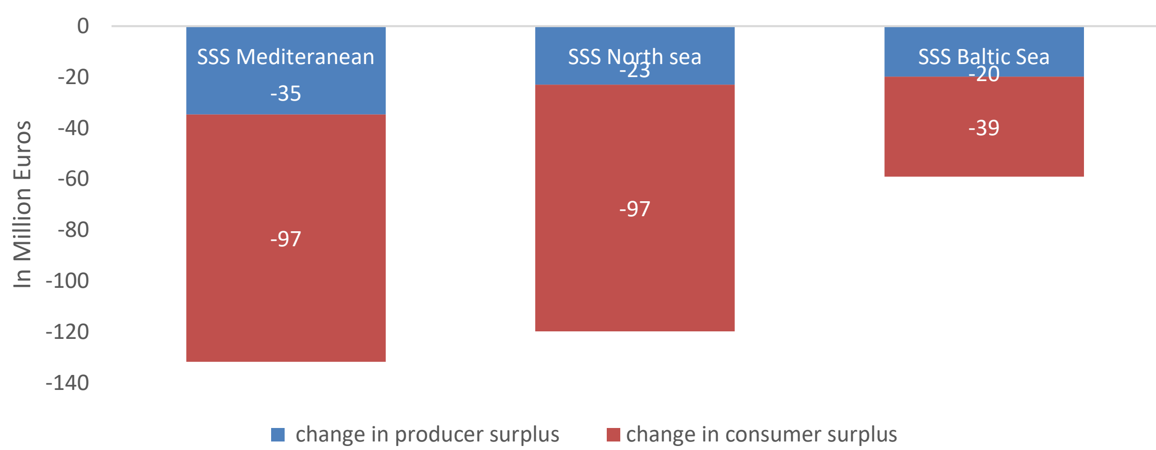
4.1 Scenario 2025

In the 2025 scenario, the cost increase we calculated for SSS to be about 0.2%, Road 4.0%, DSS 3.8%, AC 9.4%, and for Rail there was no increase as the costs are considered to be in effect in their existing state. While we notice the cost increase for SSS to be the lowest among the others, we must note that this is because of exceptions to the ‘Fit for 55” policies to do with ETS and FuelEU, where the costs are only applied to vessels with Gross tonnage greater than 5000 tonnes.

4.1.1 Welfare effects

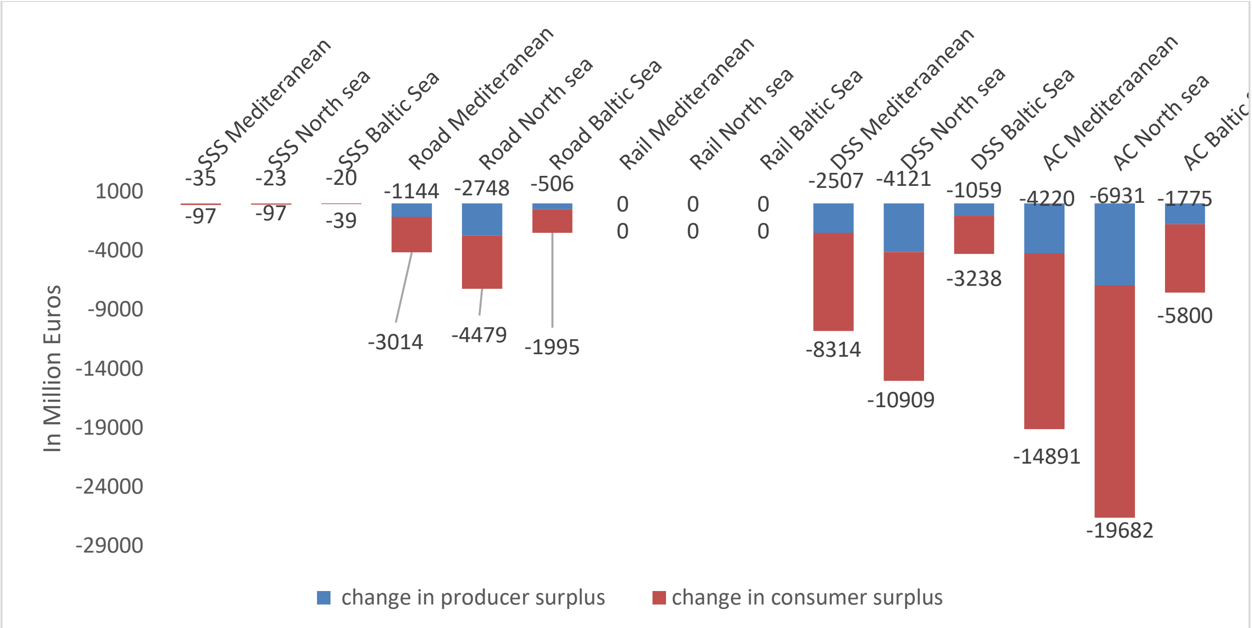
Based on the results from GSIM we analyse the effect of the producer surplus, consumer surplus, and tariff revenue changes on all the transport modes. Since the GSIM provides results based on the trade values, the increase or decrease in producer and consumer surplus is based on demand, supply, price, and trade tariffs in global trade. Producer surplus indicates the gains or losses to the suppliers or exporters and likewise, the consumer surplus gives an insight on the gains or losses to end customers or receivers. In figure 5 we can see that SSS has a negative change in value for producer surplus in the Mediterranean Sea, the North Sea, and Baltic Sea regions. Among the three, the Baltic region is better off with a negative change of 20 million Euros while the North sea has 23 million and the Mediterranean 35 million. This is because the Baltic Sea region exports with a trade value of 236 billion Euros which is lower to the Mediterranean and North Sea regions which export 428 and 281 billion respectively. Thus, the increase in costs has a lesser effect on producer surplus for the Baltic region. Moving to the consumer surplus we see a similar trend with Baltic Sea region reducing by 39 million and the Mediterranean and North Sea have similar values of 96.98 and 96.78 million respectively. The overall imports which are 433 billion in the Mediterranean, 438 billion in North Sea and 191 billion in Baltic Sea region reflect the negative change in consumer surplus. The elasticities in the model for demand, supply and substitution calculate the share of consumer and producer surplus based on the impact from NTM's used for the 'Fit for 55' policy impact.

Figure 5 Change in Producer and Consumer surplus for SSS (in Million Euros)



Source: Own illustration from GSIM results

Figure 6 Change in Producer and Consumer surplus, global effect comparison (in Million Euros)



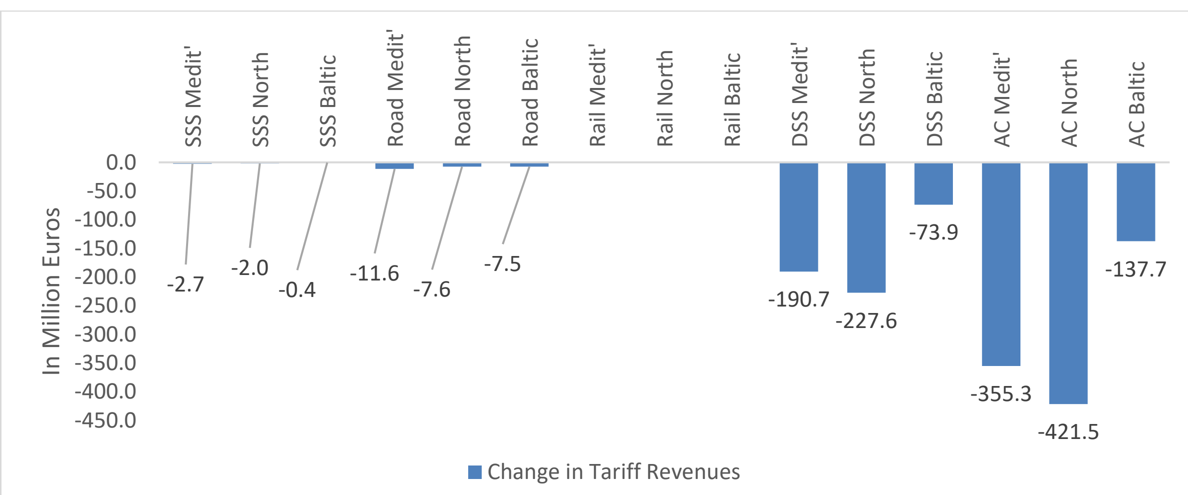
Source: Own illustration from GSIM results

When comparing road to SSS we see a huge impact on the road, with producer surplus decreasing by 2.75 billion euros in the North Sea region, 1.14 billion in the Mediterranean and 0.50 billion in the Baltic. This is because the trade values for road are about 50% more than SSS and secondly the costs that impact road are at 4% while SSS is only 0.17%, so that clearly indicates the increased impact to road. The North Sea region has the maximum movement of road trade in comparison to the other two regions and this rightly reflects this very large change in consumer surplus of 4.4 billion. While there is no change in rail value as there are changes in costs from the new policy change.

Figure 6 compares the SSS and road modes with Deep Sea shipping (DSS) and Air cargo (AC). We notice a huge spike in the change for producer and consumer surplus for AC, which is followed by DSS, road, and SSS. Although Air cargo contributes to a very small percentage of the volumes transported, the value of the cargo transported is way higher and that is the cause for a huge change in these numbers. In addition, AC is estimated to suffer a 9.4% from the ‘Fit for 55’ policy increase in costs which is way apart from the other modes compared. It is interesting to note that DSS sees a larger change although the increased costs from the policy impact is slightly lower than road. The decremental change we see is due to the huge volumes transported by deep sea at a reasonable value. When we compare road and DSS we can see the North Sea region to have this major change, mainly because of the important ports and access to the hinterland in this region and the volumes traded are quite high. For all of these transport modes we see the change to be in negative at a higher rate for the consumer surplus than the producer surplus.

Revenues based on tariffs from trade are also impacted due to the increasing cost for trade. In Figure 7 we can see the comparison of all transport on the tariff revenues. We notice the policy impact to produce negative results for the tariffs too, we see that all transport modes and regions except rail are negatively impacted. For SSS we see a similar trend with maximum affect in the Mediterranean regions which has a reduction of 2.7 million followed by North Sea at 2 million and Baltic Sea having the least impact of 0.4 million. In comparison to SSS, Road Mediterranean is reporting more than 4 times the losses for the same regions. The North and Baltic Sea for Road are almost similar with reduction in 7.6 million and 7.5 million respectively, however, the effect on road Mediterranean is the highest with a reduction of 11.6million. The revenue loss for DSS and AC are way higher which is due to the larger share of trade values. DSS sees the highest impact in the North Sea region with a reduction of 227.6 million followed by the Mediterranean region with 190.7 million and the Baltic which has the least impact of 73.9 million. Similar trends are seen in Air Cargo where the North Sea reports a reduction of 421.5 million, Mediterranean 355.3 million and the Baltic Sea 137.7 million. The overall impact on SSS in comparison to the other modes is almost insignificant.

Figure 7 Tariff revenues (in Million Euros)

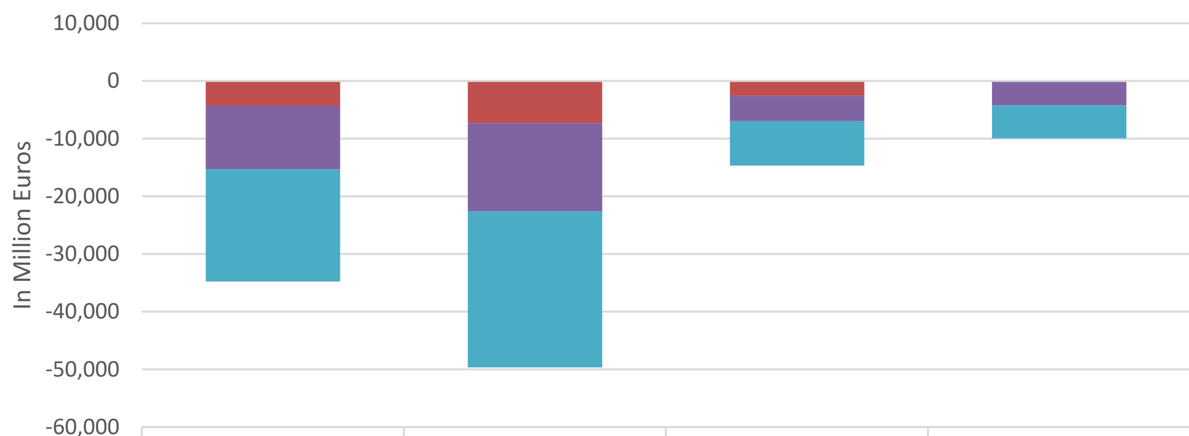


Source: Own illustration from GSIM results

Net Welfare effects

The overall welfare effect is a combination of producer surplus, consumer surplus, and tariff revenues. We will compare the net welfare effects for the various modes followed by the regions wise effects to get an overall understanding of these results.

Figure 8 Net welfare effects- 2025 (in million Euros)



	Mediterranean Sea	North sea	Baltic Sea	ROW
AC	-19,466	-27,034	-7,712	-5,720
DSS	-11,012	-15,258	-4,370	-4,201
Rail	0	0	0	0
Road	-4,170	-7,235	-2,509	35
SSS	-134	-122	-60	13

Source: Own illustration from GSIM results

From figure 8 we see a similar trend to be continuing in the overall net welfare effect, this is consistent with the increase in costs having an impact of reduced values for producer and consumer surplus. While the change for SSS is in millions there is greater impact to the other modes such as the road, DSS and AC for which see a change in billions. From the overall change in values, we see the highest for AC with a reduction of 27 billion Euros in the Nort sea region followed by 19 billion and 7 billion in the Mediterranean and Baltic Sea regions respectively. DSS in comparison to SSS is facing a greater impact due to the fact that almost all vessels are above 5000 GT, and this creates a higher cost for this sector. We notice the least impacted is the Baltic Sea region with a reduction in value of 4.3 billion and the North Sea and Mediterranean having a closer comparison of 15 billion and 11 billion euros. Further with road, the change in values is much lower in comparison to DSS and AC, but nevertheless it is a big change with a drop in 2.5 billion in the Baltic region,7.2 billion in North Sea and 4.1 billion in the Mediterranean Sea. Considering Road and SSS are competing in the domestic flows in the EU, we find that the lower results of SSS with reduction of 60 million in Baltic,124 million in North Sea and 134 million in Mediterranean Sea are clear indicators that the policy impact is evident but evaluating this based on the lower shipment values and policy related costs for SSS display a much lower impact in comparison to Road.

When we compare the overall effect to all transport modes region wise as in figure 8, we notice the biggest negative change is to the North Sea region, which seems rational given the major ports in Europe, Rotterdam, Antwerp, and Hamburg are located here. The model estimates a negative change of 49 billion Euros for the North Sea region followed closely by the Mediterranean with 34 billion and Baltic Sea region with 14 billion. We also see a negative impact to the ROW trade values with a drop by 9 billion which is way lower than the costs for the European regions. However, the increased costs in EU also requires the transport modes using European waterways and roads to pay for the emission and thus it leads to a reduction in welfare for the rest of the world.

4.1.2 Change in Trade values

In table 13 we can see the trade values lost in billion euros for each of the modes operating in the three regions. The below values are the difference between the initial inputted values in GSIM for trade in 2020 and the final trade values calculated as results by the model. As per our calculation we see impact to be in billions and some case trillions. When comparing all transport modes, the decrease in value for SSS appears low, while these number gives a true picture of change in trade values, we notice that even though the costs for rail are not going up, there is an overall effect that reduces the trade through rail transport which has no impact, however it remains the lowest amongst other modes. For SSS within EU in the Mediterranean we notice a drop in 8.5 billion of trade, which is the highest followed by trade with North sea losing 4.3 billion and exports from Baltic to North sea at 4 billion. However, there is a gain when it comes to ROW as we see an increase in trade values by 16.3 billion. For road the biggest losers in trade flow are within North sea ports / countries amounting to 672 billion, followed by north sea to Mediterranean 352.3 billion and within Mediterranean a loss of 243.7 billion. As in SSS we see a similar trend with ROW road value, which increase by 179 billion. The increase in costs is leading to the diversion of trade to ROW countries.

Table 24 Trade values changes in the various regions and Transport modes in Billion Euros

Modes	Mediterranean	North Sea	Baltic Sea	ROW
SSS Mediterranean	(8.5)	(2.2)	(0.4)	(6.1)
SSS North Sea	(1.2)	(4.3)	(2.5)	(3.3)
SSS Baltic Sea	(0.6)	(4.0)	(3.8)	(1.1)
SSS ROW	(12.2)	(12.1)	(2.6)	16.3
	Mediterranean	**North Sea**	**Baltic Sea**	**ROW**
Road Mediterranean	(243.7)	(181.7)	(82.2)	(43.6)
Road North Sea	(353.2)	(672.8)	(236.4)	(56.2)
Road Baltic Sea	(28.4)	(109.8)	(61.3)	(47.8)
Road ROW	(86.6)	(96.2)	(91.1)	179.1
	Mediterranean	**North Sea**	**Baltic Sea**	**ROW**
Rail Mediterranean	(0.0)	(0.0)	(0.0)	(0.0)
Rail North Sea	0.0	(0.0)	(0.0)	(0.0)
Rail Baltic Sea	-	(0.0)	0.0	0.0
Rail ROW	(0.0)	0.0	0.0	0.0
	Mediterranean	**North Sea**	**Baltic Sea**	**ROW**
DSS Mediterranean	(192.0)	(224.9)	(46.1)	(831.8)
DSS North Sea	(343.9)	(311.3)	(127.8)	(1,342.9)
DSS Baltic Sea	(48.3)	(115.5)	(53.7)	(326.4)
DSS ROW	(1,339.4)	(1,877.4)	(521.6)	2,120.1
	Mediterranean	**North Sea**	**Baltic Sea**	**ROW**
AC Mediterranean	(258.6)	(299.4)	(62.0)	(1,587.7)
AC North Sea	(464.1)	(415.2)	(172.4)	(2,569.9)
AC Baltic Sea	(65.6)	(155.2)	(73.0)	(630.2)
AC ROW	(2,581.7)	(3,595.2)	(1,005.3)	4,399.7

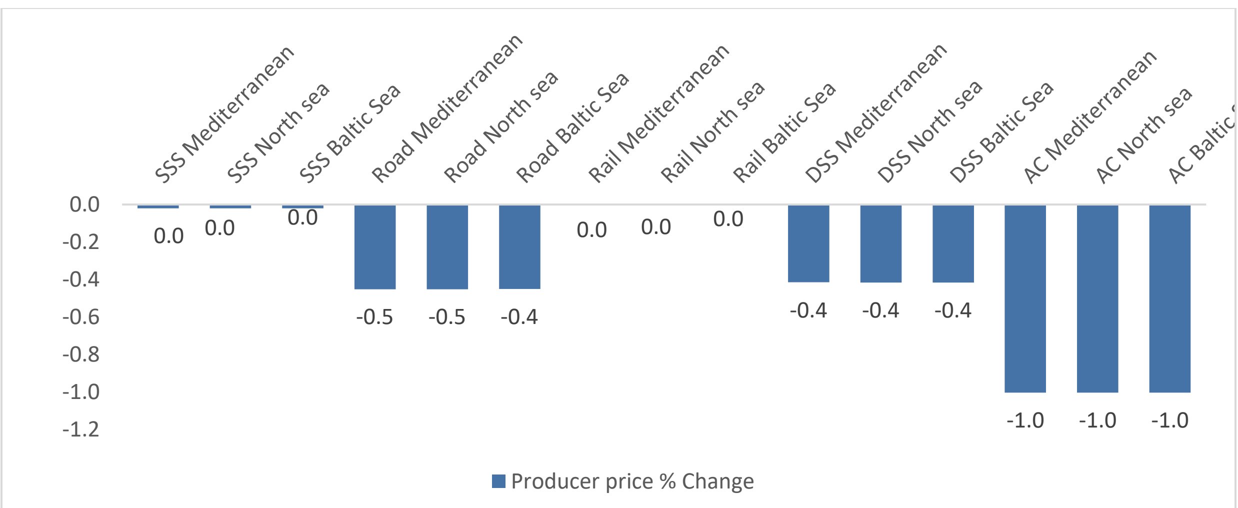
Source: Own illustration from GSIM results

For DSS the major losers are North Sea to Mediterranean at 344 billion and Within North Sea ports 311 billion. Here we also see a major impact in trade from ROW to the three regions which indicate a decline of 1.3 trillion for Mediterranean,1.8 trillion for North Sea and 0.5 trillion for Baltic Sea. This impact is due to the fact that the export from ROW countries will have to pay for the EU policy change and that's why we see an increase in exports by 2 trillion to the rest of the world. We find that air cargo follows the same trend as DSS with the major losses in the routes North Sea to Mediterranean (464 billion) and within North Sea region (415 billion). Here too there is a similar effect with huge reduction in exports from ROW and the exports to ROW increasing by 4.4 trillion.

<u>4.1.3 Change in overall prices</u>

With the changes in trade values and analysis of Producer and consumer surplus and net welfare effects, now we look at the percentage change in price to the consumer due this policy impact. In this section, we shall discuss on the changes to producer and consumer prices and what it means for each of these parties. Producers here could be supplier's and manufacturers of products and consumers are the end consumers or receiver of the product. Both these parties will be affected due to these policy changes and the results indicate what impact it will have on their expenses or gains.

Figure 9 Change in Producer prices in percentage



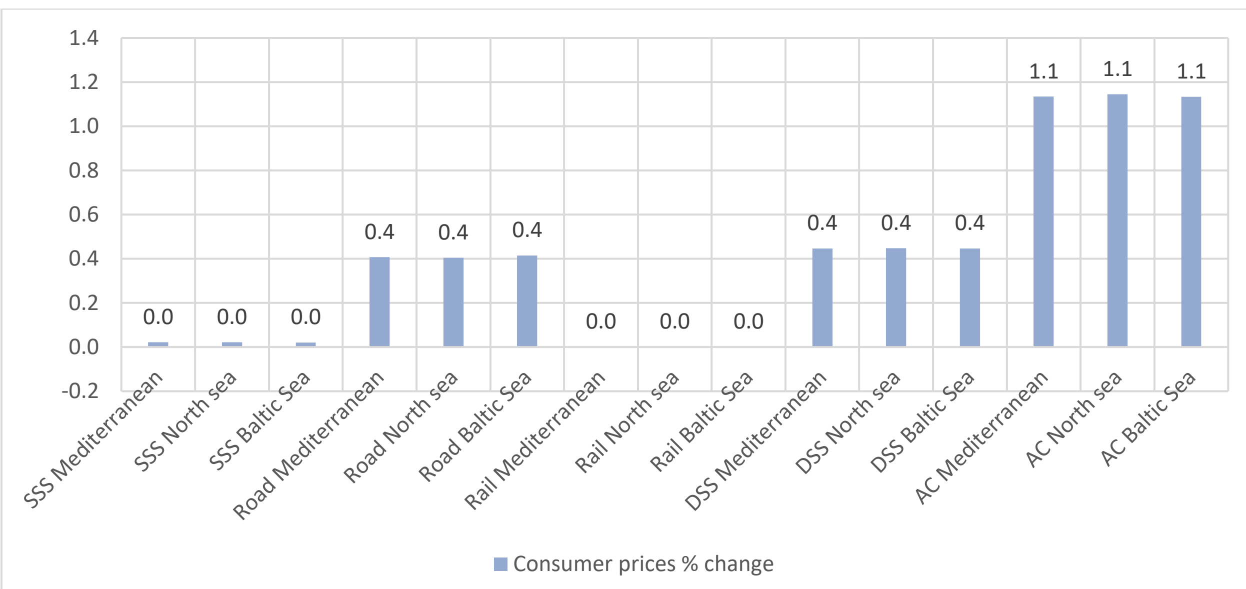
Source: Own illustration from GSIM results

From the results from the model in figure 9 and 10, we see that trade through each of these transport modes are impacted differently. We applied a cost of 0.17% as consequence of the policy impact on SSS, and the overall change in consumer prices show an increase of 0.0% for all regions using SSS transportation and a reduction in producer price by 0.0% in the same regions. This explains that the producer and consumer have almost no impact.

On the other hand, when we analyze road, we see an increase of 0.4% for the consumer prices and a reduction in producer prices up to 0.5%, between the regions traded. From this we can understand the reason for a massive reduction in trade values for road in comparison to the initial trade discussed in the previous section 4.1.3. This also means the producers suffer slightly more than the consumers, which could lead to the producers trying to cut down trade with lower margins as they might also see a reduction in consumer demand due to price rise. Rail has zero impact; this is mainly because there aren't additional costs from the 'Fit for 55" policy.

DSS display a rise in consumer price by 0.4 % and reduction to producer prices between 0.4% and is in a way very similar to Road. The overall picture in price increase for the same products indicates a similar reduction in producer and increase in consumer prices for both Road and DSS which are the modes responsible for the major trade in these regions. This in fact might help SSS to become more efficient for trade, which is what the results indicate. Finally, we look at the Air cargo which has the highest price changes, the producer prices are down by 1% and the consumer prices increase by 1.1%. AC relates to high value cargo and the price rise may need to be relatively compared with the value of the commodity. This kind of price change in AC encourages diversion of transport through SSS, Road, Rail and DSS.

Figure 10 Change in Consumer prices in percentage



Source: Own illustration from GSIM results

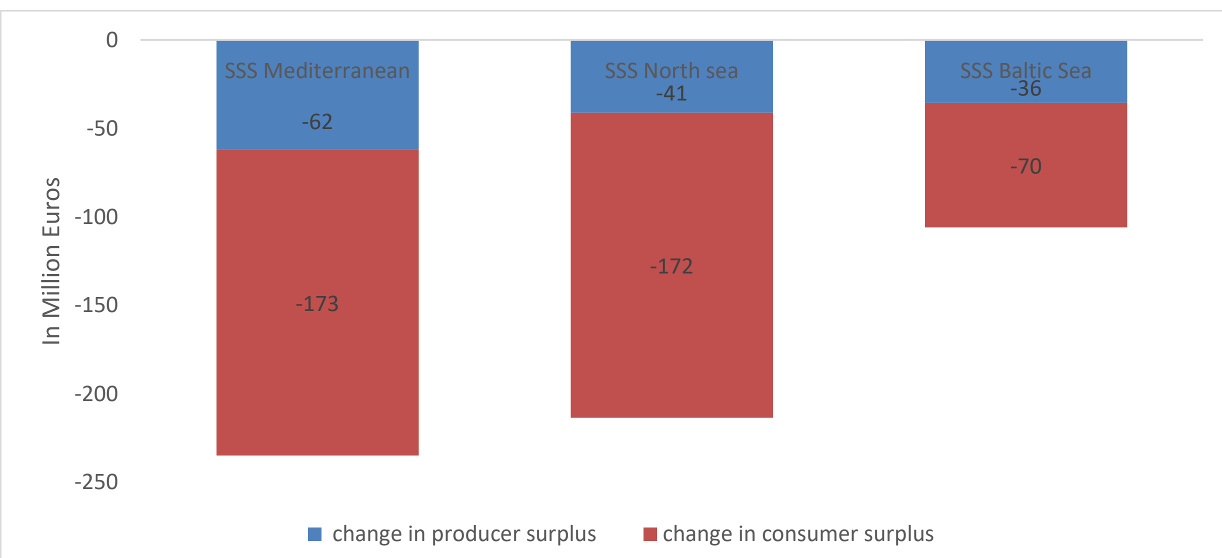
4.2 Scenario 2030

In this section, we will analyse the results from the econometric model for the scenario 2030, with a focus on producer surplus, consumer surplus, Net welfare effects, change in trade value and percentage change in consumer and producer prices. The cost increase we calculated for SSS is about 0.32%, Road 9%, DSS 7.8, AC remains the same as in 2025 at 9.4%, and the same for Rail, no increase as the costs are considered to be in effect in its existing state.

4.2.1 Welfare effects

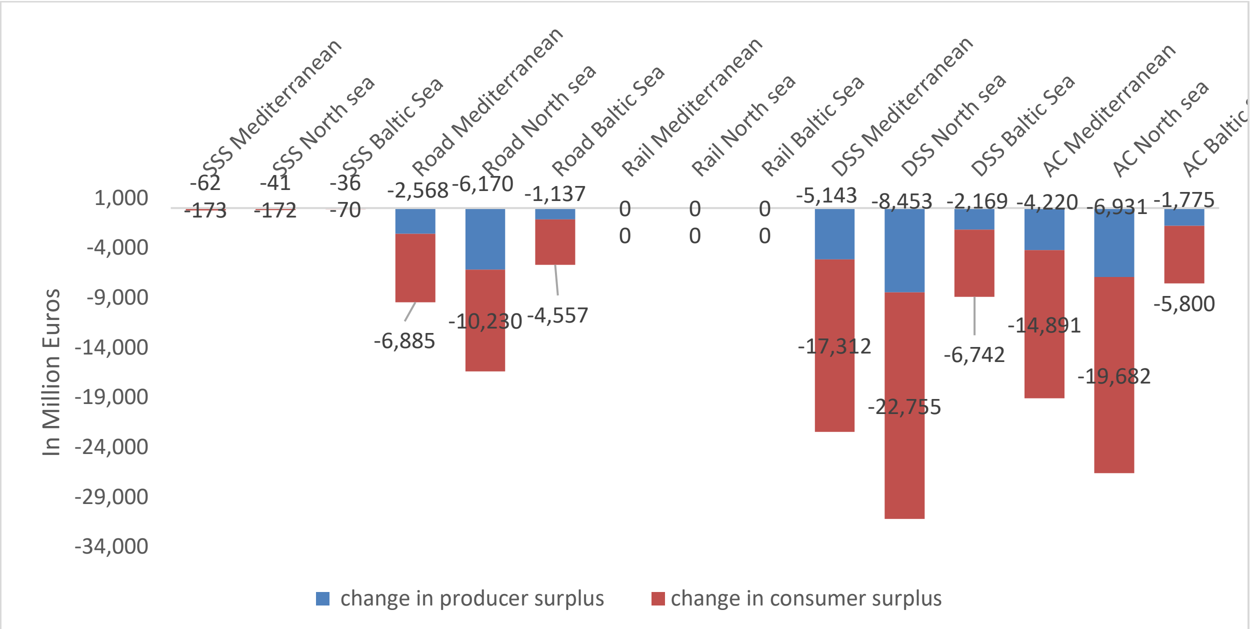
As mentioned in the earlier section, the results from the econometric model will help us to analyse the consumer surplus, producer surplus and tariff revenues for the various modes of transportation. In figure 11 for SSS we notice the highest impact has been to the Mediterranean Sea with a loss in consumer surplus at 173 million and producer surplus down by 62 million. For the North Sea region, the gap in impact between the consumer and producer surplus is the largest, strangely producer surplus is reduced only by 41 million while consumer surplus has a loss of 172 million. This means the consumer must sacrifice a lot more for the trade to materialize. While the Baltic region is the least affected with a producer surplus down by 36 million and a consumer surplus at 70 million.

Figure 11 Change in Producer and Consumer surplus for SSS (in Million Euros)



Source: Own illustration from GSIM results

Figure 12 Change in Producer and Consumer surplus, global effect comparison (in Million Euros)

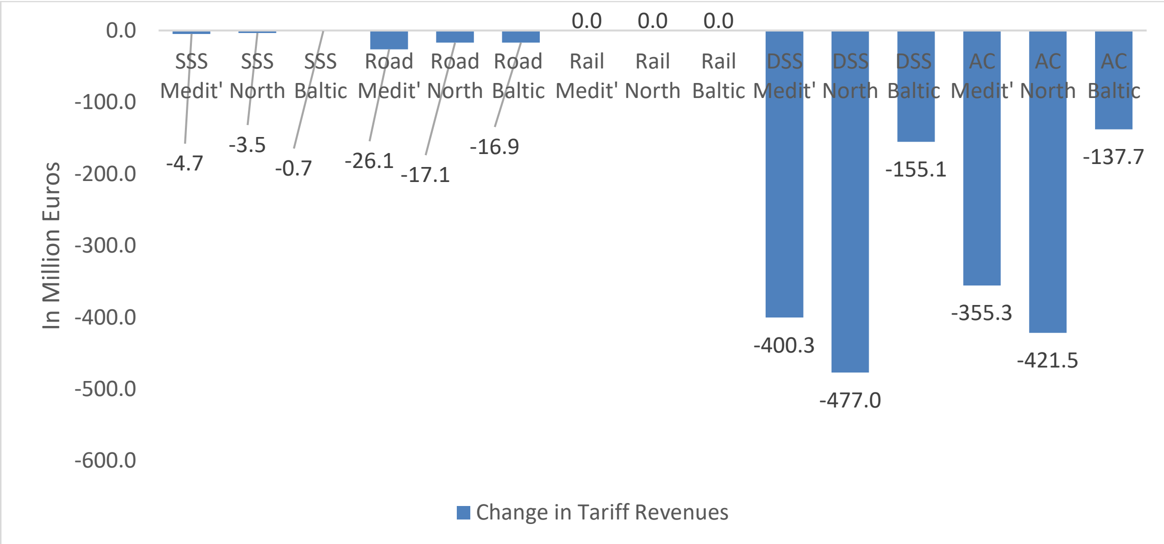


Source: Own illustration from GSIM results

Figure 12 provides an overall overview of the producer and consumer surplus values with all transportation modes. The road North Sea region is worst effected with a decrease in consumer surplus by 10 billion and producer surplus of 6 billion. This is followed by the Road Mediterranean region which sees a decrease of consumer surplus of 6.8 billion and producer surplus of 2.5 billion. The reason for such increase is because of the large trade values in these regions along with a cost increase of 9%. However when we compare with DSS we see much higher values with its largest reduction in the North sea where consumer surplus is down by 22.7 billion and a producer surplus of 8.5 billion. Further with Air cargo the reduction in producer and consumer surplus are lower than DSS. This result trends are like 2025 scenario with the highest losers in DSS and AC sectors. But looking at SSS, the effect still seems negligible in comparison to others.

In figure 13 we see the impact on the tariff revenues, SSS has a slight decrease with 4.7 million in the Mediterranean,3.5 million in North Sea and 0.7 million in Baltic. While the Road follows a similar trend with the Mediterranean facing biggest drop by 26.1 million followed by North Sea 17.1 million and 16.9 million in Baltic. DSS and Air cargo have almost similar but with a slightly higher decrease in DSS. Both have the highest loss in the North Sea region with 477 million to DSS and 421.5 million to AC.

Figure 13 Tariff revenues (in Million Euros)

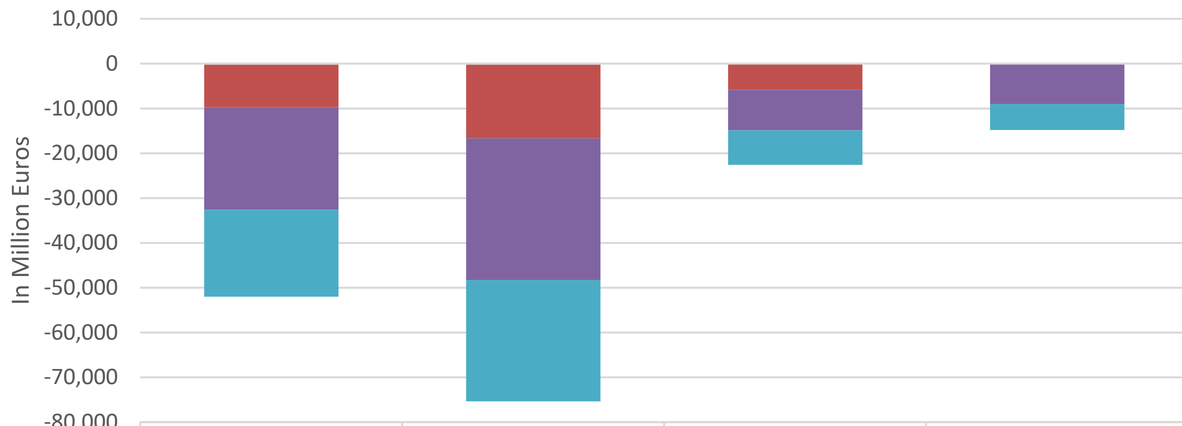


Source: Own illustration from GSIM results

<u>Net welfare effects</u>

Overall welfare effects are presented in figure 14, SSS has a very small negative effect in comparison to other modes, except rail which has no impact. The highest loss is in the Mediterranean with 240 million. Further the trade with SSS and ROW sees an increase in welfare by 24 million. The impact on DSS is the largest followed by AC and road. Nevertheless, for Road the ROW countries see an increase of 71 million. When we compare region wise effect, North sea suffers the greatest loss with a reduction in welfare by 75 billion, followed by Mediterranean with 52 billion and Baltic 22 billion. Rest of the world sees a decline of 14 billion.

Figure 14 Net welfare effects- 2030 (in million Euros)



	Mediterranean Sea	North sea	Baltic Sea	ROW
AC	-19,466	-27,034	-7,712	-5,720
DSS	-22,855	-31,686	-9,067	-9,060
Rail	0	0	0	0
Road	-9,478	-16,417	-5,710	71
SSS	-240	-217	-107	24

Source: Own illustration from GSIM results

4.2.2 Change in Trade values

In Table 25 we see in the EU, SSS faces major decrease in trade within the Mediterranean 15.8 billion followed by North Sea region 8 billion and exports from Baltic to North Sea 7.4 billion. When we compare ROW, exports to the Mediterranean drop by 21 billion and North Sea 20.8 billion, these being the largest decrease. On the other hand, exports from Mediterranean to Baltic is the least affected with 0.7 billion. However, trade between ROW and ROW has an increase of almost 28 billion. We can clearly see the higher cost for SSS in the EU leading to the diversion of trade to ROW. For Road the biggest loser in trade is the North Sea region with a reduction of 1.5 trillion followed by North Sea to Mediterranean 795 billion and trade within Mediterranean decreasing by 548 billion. However, we see the only winners in this to be ROW to ROW, this is because for road transport near the borders of the EU there isn't much of an impact from the 'Fit for 55' policy.

Table 25 Trade values changes in the various regions and Transport modes in Billion Euros

Modes	Mediterranean	North Sea	Baltic Sea	ROW
SSS Mediterranean	(15.8)	(4.2)	(0.7)	(10.1)
SSS North Sea	(2.2)	(8.0)	(4.6)	(5.4)
SSS Baltic Sea	(1.1)	(7.4)	(6.9)	(1.8)
SSS ROW	(21.1)	(20.8)	(4.4)	27.9
	Mediterranean	**North Sea**	**Baltic Sea**	**ROW**
Road Mediterranean	(548.6)	(408.9)	(185.1)	(98.4)
Road North Sea	(795.2)	(1,514.8)	(532.4)	(126.8)
Road Baltic Sea	(63.9)	(247.1)	(138.0)	(107.9)
Road ROW	(194.3)	(215.8)	(204.3)	402.2
	Mediterranean	**North Sea**	**Baltic Sea**	**ROW**
Rail Mediterranean	(0.0)	(0.0)	(0.0)	(0.0)
Rail North Sea	0.0	(0.0)	(0.0)	(0.0)
Rail Baltic Sea	-	(0.0)	0.0	0.0
Rail ROW	(0.0)	0.0	0.0	0.0
	Mediterranean	**North Sea**	**Baltic Sea**	**ROW**
DSS Mediterranean	(371.8)	(434.6)	(89.2)	(1,774.4)
DSS North Sea	(666.3)	(601.8)	(247.6)	(2,867.1)
DSS Baltic Sea	(93.7)	(223.6)	(104.3)	(698.8)
DSS ROW	(2,816.7)	(3,941.5)	(1,096.9)	4,480.0
	Mediterranean	**North Sea**	**Baltic Sea**	**ROW**
AC Mediterranean	(258.6)	(299.4)	(62.0)	(1,587.7)
AC North Sea	(464.1)	(415.2)	(172.4)	(2,569.9)
AC Baltic Sea	(65.6)	(155.2)	(73.0)	(630.2)
AC ROW	(2,581.7)	(3,595.2)	(1,005.3)	4,399.7

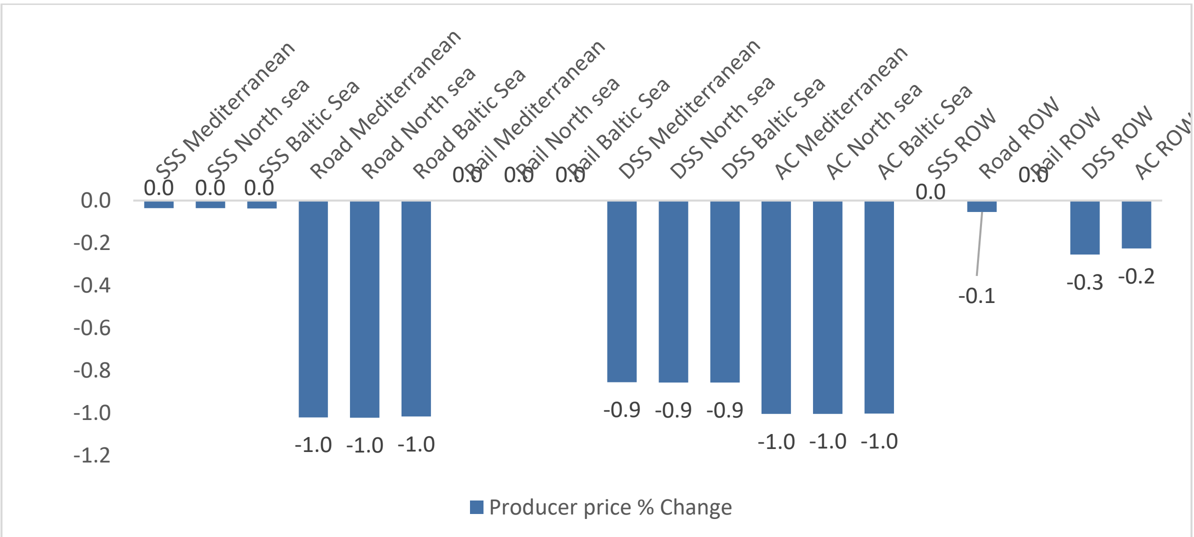
Source: Own illustration from GSIM results

For Rail there is very small impact which is insignificant when compared to the others. DSS and AC have a similar impact with decreasing trade with all regions except for ROW to ROW, which in both cases increase by approx. 4.4 billion. The increase in cost is diverting trade to other regions which are less expensive. In EU DSS and AC faces a major decrease in trade for exports from North Sea to Mediterranean which is 666 billion for DSS and 464 billion for AC.

4.2.3 Change in overall prices

In figure 15 & 16 we can observe the change in producer and consumer prices in percentages. In SSS the change in Producer prices reduces by 0% and consumer prices increase by 0%. This indicates that both exporters and importers see no change in costs

Figure 15 Change in Producer prices in percentage



Source: Own illustration from GSIM results

For Road we observe the highest price change for producers compared to all other modes. The producer will have to discount their price by about 1 % and the consumers or importers for road cargo will pay 0.9 % more in Mediterranean and North Sea and Baltic. Unlike SSS, for road the producer ends up paying a higher price.

The producer price for DSS falls by 0.9 % and the consumer price increases by 0.9 % change. DSS changes imply a that the importers and exporters will have to equally share the burden of cost increase. AC also looks very similar to DSS with Producer prices dropped by 1% and consumer price increases around 1.1 %.

For SSS and rail ROW prices remain unchanged for producers and consumers which is a good sign for SSS in the EU, it means the policy change doesn't reduce the business for SSS at a global level. ROW for DSS and AC percentage changes are quite close, with DSS producer prices falling by 0.3% and increase in consumer price by 0%, this indicates a bigger chunk of revenues lost by producers and AC with consumer price increase of just 0% and producer price loss of 0.2% shows the additional costs to be borne by producer while exporting to ROW.

Figure 16 Change in Consumer prices in percentage

Source: Own illustration from GSIM results

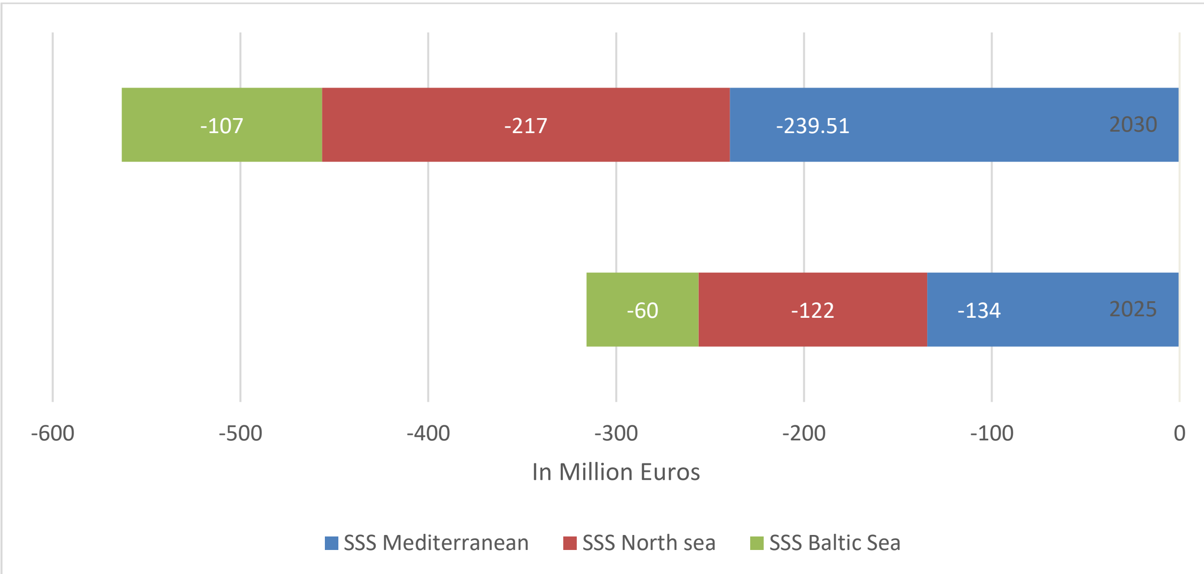
4.3 Scenario comparison 2025 & 2030

In this section we will compare and analyze the results for the scenarios in 2025 and 2030. To compare the trade and economic impact we will look at the overall welfare effects, which includes producer surplus, consumer surplus and Tariff revenue, further we also analyze the change in trade values and percentage change in price for producers and consumers for the two scenarios. Since this thesis is focused on the impacts to the SSS sector we will first compare the net welfare effect to SSS in 2025 and 2030.

In figure 17, we see a comparison in the welfare effects for SSS in 2025 and 2030 scenarios. With the increasing costs we notice a decrease in welfare in both circumstances. The overall loss in 2030 is 563 million euros and in 2025 it is 316 million euros. When comparing the different regions under SSS in 2025 and 2030, we see highest percentage decrease in welfare in Baltic at 79% change from 2025 to 2030. The other two regions see a decrease of 78%. However, the Baltic has the least reduction in terms of value with 60 million in 2025 and 107 million in 2030. The

Mediterranean is seen to be the worst affected in both scenarios with 134 million in 2025 and 239 million in 2030, this can also be attributed to the reason of higher levels of trade in this region. This is followed closely North Sea which sees a reduction of 122 million in 2025 and 217 million in 2030.

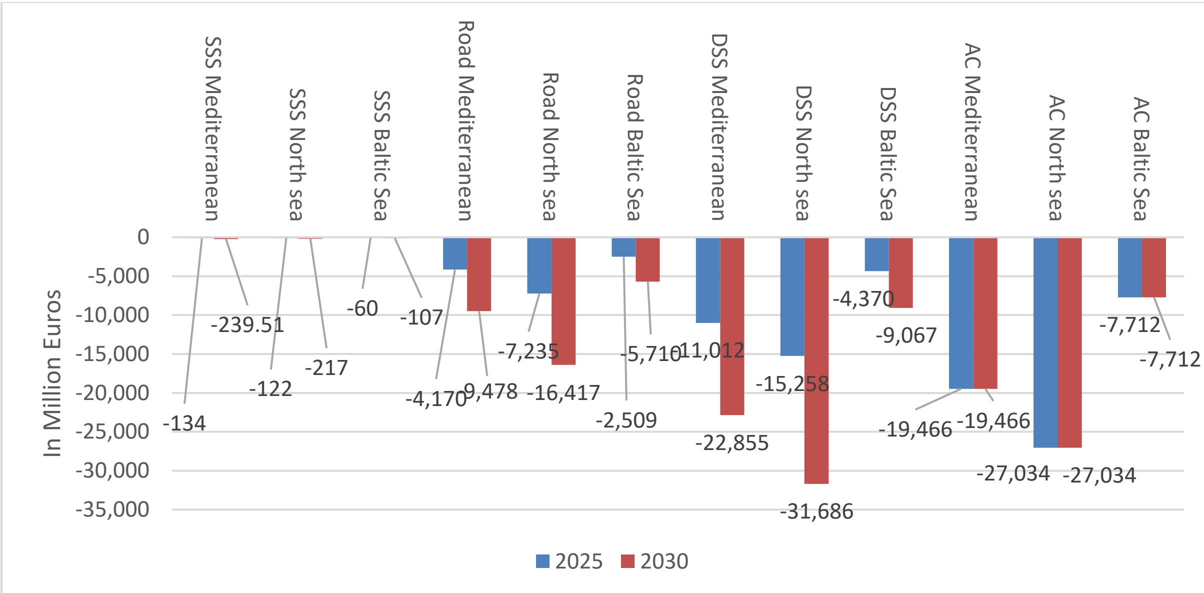
Figure 17 Net welfare effect comparison for SSS in 2025 & 2030 (In Million Euros)



Source: Own illustration from GSIM results

In the below figure 18, we see the comparison for all modes except for rail where the impact is almost zero. We see the highest welfare loss to be in DSS Mediterranean with 31 billion in 2030 and 15 billion in 2025, the decrease in welfare is about 108% in 2030 compared to 2025. We also notice that there is no change to the welfare for AC, this is because the costs inputted for these scenarios are the same. Road is faced with the highest percentage change from 2025 to 2030, with change around 127% to 128%

Figure 18 Net welfare effect comparison for all modes except rail in 2025 & 2030 (In Million Euros)



Source: Own illustration from GSIM results

In table 26 we present the amount of change for the loss in trade values from 2025 to 2030. We notice sectors such as rail and AC with no change. AC because the cost increase applied in the model is the same for both scenarios. In the EU regions for SSS we see the smallest changes in a reduction for the Baltic Sea an 81%, all other regions see a change between 83% and 85%. SSS trade with ROW has a relatively lesser change from 63 to 66 % exports to ROW and imports at 72-73%. SSS imports from ROW, we notice the change to be lesser than the trade within EU regions, this is because the increase in cost from the policy impact is 50% lower compared to the regions within the EU assuming the ship will travel only half its voyage in the waters. The road is affected by a huge reduction mainly because the costs have increased more than double from 2025, therefore we see a constant change of 125% reduction in EU regions and ROW is around 124% to 126%.

Table 26 Percentage change in Trade values from 2025 to 2030

	Mediterranean	North Sea	Baltic Sea	ROW
SSS Mediterranean	85%	85%	83%	66%
SSS North Sea	85%	85%	83%	65%
SSS Baltic Sea	83%	83%	81%	63%
SSS ROW	73%	73%	72%	72%

	Mediterranean	North Sea	Baltic Sea	ROW
Road Mediterranean	125%	125%	125%	126%
Road North Sea	125%	125%	125%	126%
Road Baltic Sea	125%	125%	125%	126%
Road ROW	124%	124%	124%	125%
	Mediterranean	North Sea	Baltic Sea	ROW
Rail Mediterranean	0%	0%	0%	0%
Rail North Sea	0%	0%	0%	0%
Rail Baltic Sea	0%	0%	0%	0%
Rail ROW	0%	0%	0%	0%
	Mediterranean	North Sea	Baltic Sea	ROW
DSS Mediterranean	94%	93%	94%	113%
DSS North Sea	94%	93%	94%	114%
DSS Baltic Sea	94%	94%	94%	114%
DSS ROW	110%	110%	110%	111%
	Mediterranean	North Sea	Baltic Sea	ROW
AC Mediterranean	0%	0%	0%	0%
AC North Sea	0%	0%	0%	0%
AC Baltic Sea	0%	0%	0%	0%
AC ROW	0%	0%	0%	0%

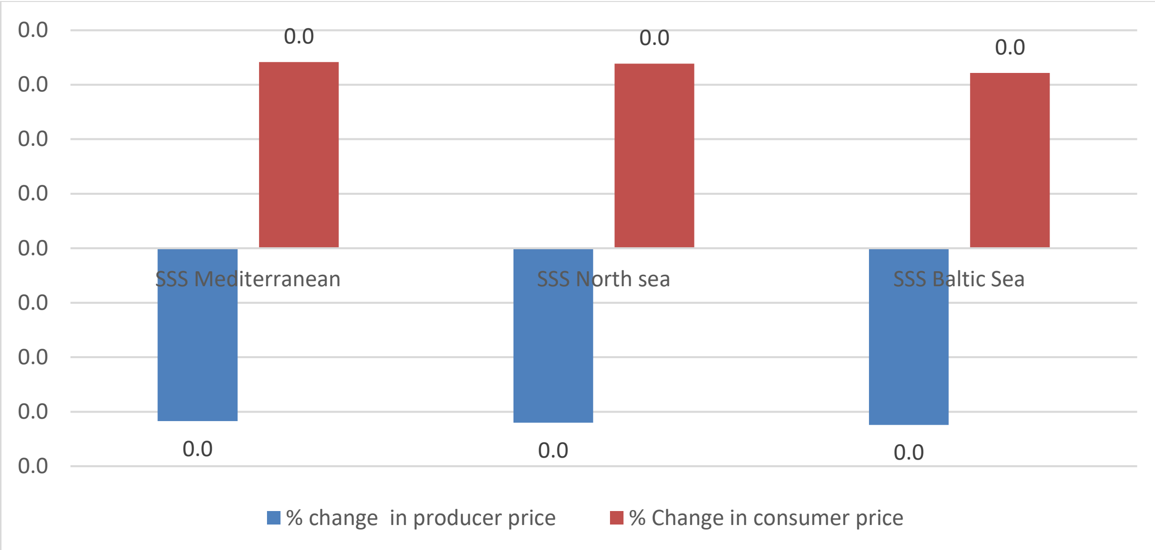
Source: Own illustration from GSIM results

DSS also has an almost 100% decrease in trade values compared to 2025. Lowest change seen in Mediterranean to North Sea and within North Sea at 93%, which is not really a big difference considering all other regions change by 94%. However surprisingly the DSS trade with ROW countries are dropping even more ranging from a change reduction of 110% to 114%.

Consumer and producer Price changes

Below figure 19 compares the percentage change of the producer and consumer prices from 2025 to 2030 for SSS, we see a uniform trend in producer prices with 0% which was exactly the same percentage in 2025 scenario. It remains similar for the consumer price as the change from 2025 to 2030 is the same proportion. We can infer from this graph that the producer and consumer price see no change over the years even though the overall costs increase.

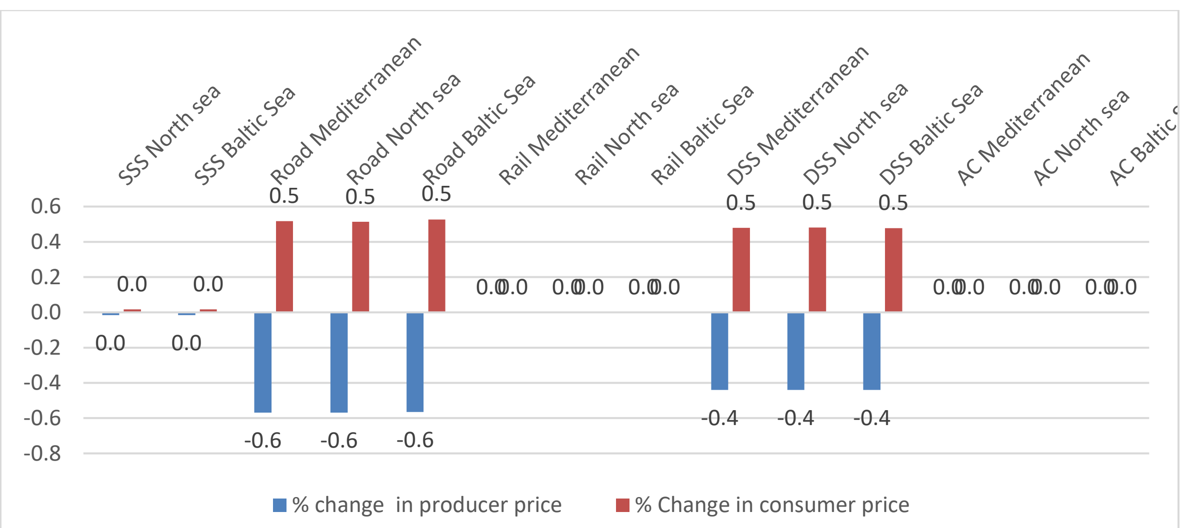
Figure 19 change in producer and consumer price for SSS from 2025 to 2030 in percentage



Source: Own illustration from GSIM results

Figure 20 depicts the producer and consumer price changes in percentage for each of the transport modes from 2025 to 2030. We see drastic changes in road which has an increase in consumer price by 0.5% compared to the levels in 2025. A similar effect is seen for the producer price change for road with a 0.6% reduction in producer price from 2025. AC and rail see no change. DSS has a similar trend as road, with an increase by 0.5% of consumer prices and a decrease of 0.4% in producer prices in 2030.

Figure 20 change in producer and consumer prices for all modes from 2025 to 2030 in percentage



Source: Own illustration from GSIM results

4.4 Transport Impact on SSS

According to Rodrigue and Notteboom, 2020, “Transportation provides market accessibility by linking producers and consumers so that transactions can take place”. In general transportation costs account for 5%-10% of the value of the product, while this is a very small percentage of costs it still becomes impossible to carry out the trade without the availability of viable transport options. Therefore, even small changes in transport costs can have a relatively large impact on trade.

In this section, we shall analyze the impact on transport volumes due to the “Fit for 55” policy. In order to convert the values to volumes, we use the same calculation we used in chapter 3 to arrive at the Trade values from Quantities shipped in the EU. The calculations are basis information from (UNCTAD, 2021) for world and Eurostat database (DS-058814) for the EU conversion as seen in table 27 and 28.

Table 27 Average Per Metric ton trade price in EU per transport mode (In Euros)

EU	Avg. price per Mt in Euros
SSS	850.29
Road	2,559.90
Rail	962.98
DSS	1,675.98
Air	56,158.76

Source: Own calculation from UNCTAD 2021 and Eurostat

Table 28 Average Per Metric ton world trade price per transport mode (In Euros)

World	Avg. price per Mt in Euros
SSS	1,675.98
Road	1,709.31
Rail	1,623.61
DSS	1,675.98
Air	56,158.76

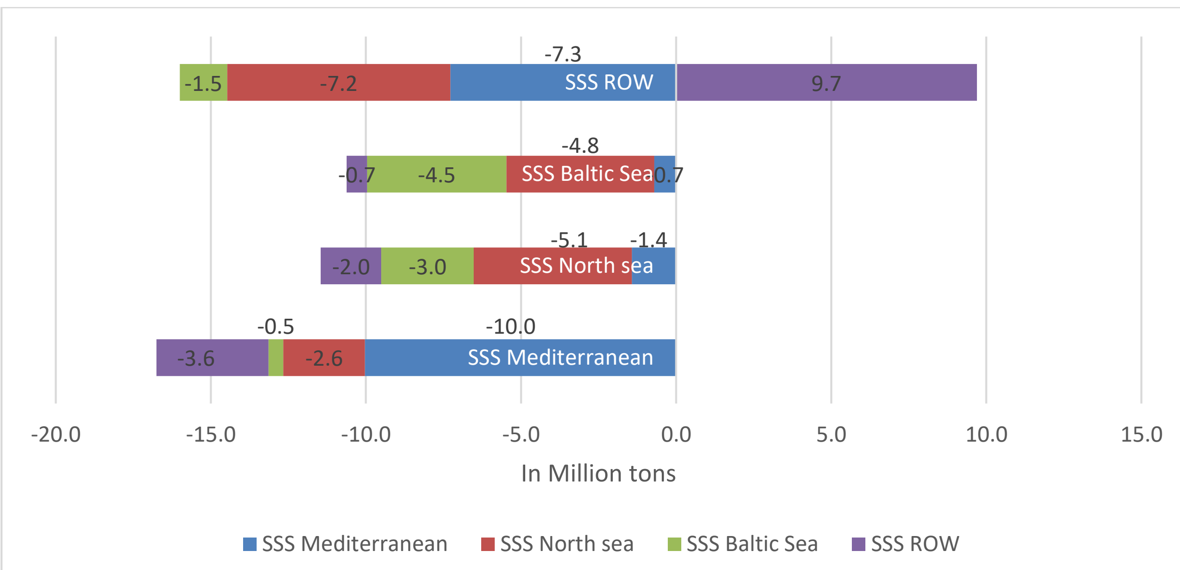
Source: Own calculation from UNCTAD 2021 and Eurostat

In this section we will compare the change to transportation volumes for Scenario 2025 followed by Scenario 2030

Scenario 2025

In the below figure 21, we see the converted quantities from values for the SSS sector. The graph depicts the movement of goods from one region to other in the form of exports and imports. We see a major drop in quantities in the Mediterranean region with a reduction in 10 million tons with in the same. This is followed by almost half the impact in North Sea and Baltic region with 5.10 million and 4.5 million tons when we compare quantities within the same regions. Within the EU we notice the North Sea region to have the highest reduction in terms of imports by 12.5 million tons. For Exports the Mediterranean region suffers a loss of 13.1 million tons. Exports from ROW to EU reduce by 16 million tons and imports by ROW from EU at 6.2 million tons. The biggest winners from this policy impact are the trade between ROW to ROW which sees an increase in quantity by 9.7 million tons.

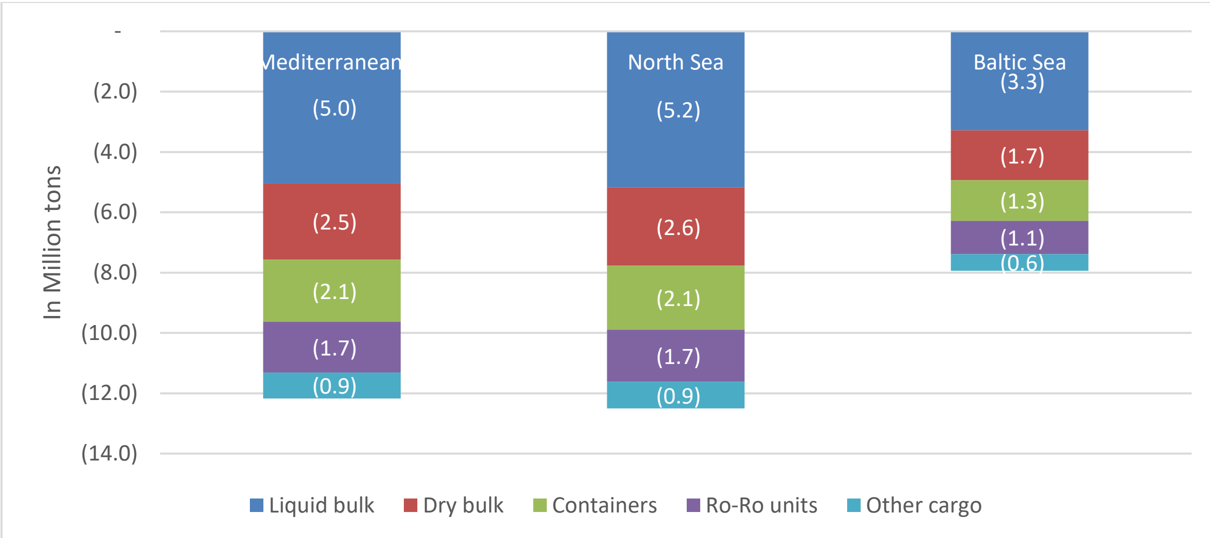
Figure 21 Change in Quantities for SSS in 2025 Scenario (In Million tons)



Source: Based on own calculation from GSIM, UNCATD and Eurostat data base

In figure 22 we categorize the reduction in quantities based on cargo type for trade within the three EU regions. The percentage allocation for each cargo type quantities was applied basis the overall break up of SSS volumes for 2020 from Eurostat database. We see the overall reduction to be 32.61 million tons. Liquid bulk has the biggest proportion and reduced by 13.5 million tons, followed by dry bulk at 6.78mn tons, containers 5.51 million tons, Ro-Ro 4.53 million tons and others at 2.28 million tons.

Figure 22 Quantity reduction by Cargo type region wise classification for SSS in 2025 (In Million tons)

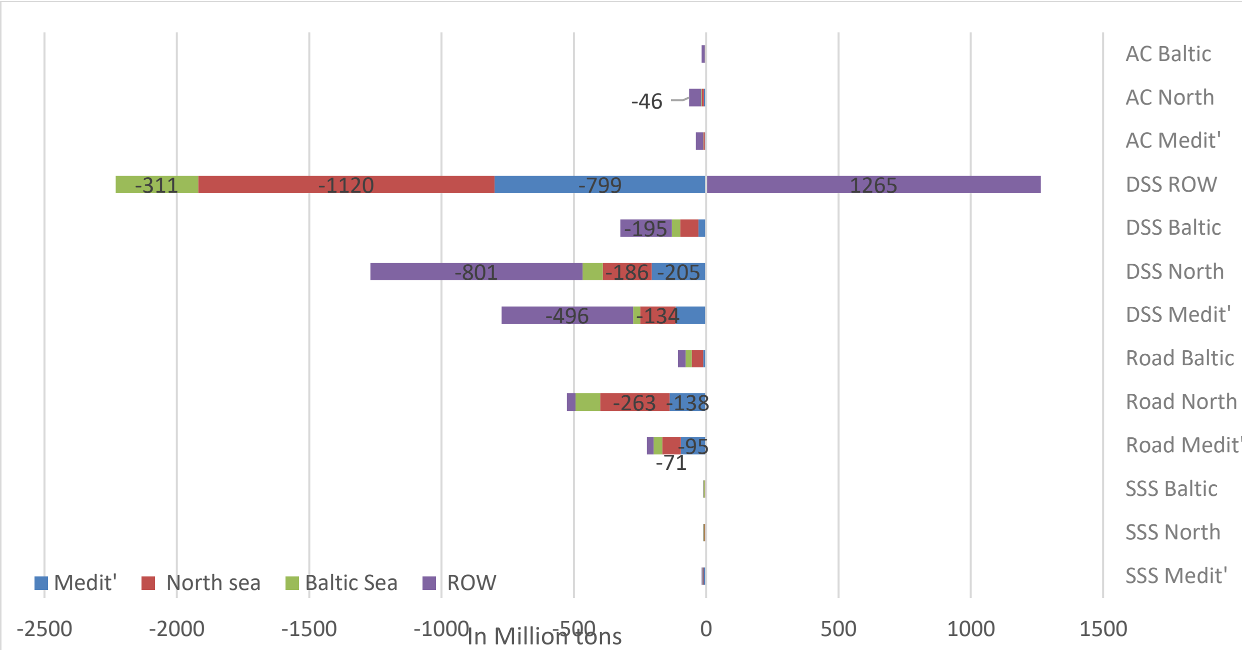


Source: Own calculation from Eurostat database: mar_sg_am_cwk and GSIM results

The above loss in quantities suggests that due to an increase in costs, there will be a direct effect on the business of the SSS ship owners and that they may have to bear some portion of the "Fit for 55" costs to keep up with the business volumes with major impact on the Liquid bulk and Dry bulk vessels.

In figure 23 we compare the overall reduction in quantities with all modes with the exception to rail which remains unchanged. For road, North Sea region suffers the highest reduction in quantities which is 263 million. In DSS we see trade with ROW having the maximum impact and the is the highest loss in quantities when compared to any other mode. Quantities from ROW to Mediterranean reducing by 799 million, North Sea 1.1 billion and Baltic 195 million. However, we see the trade quantities between ROW to ROW gaining with 1.26 billion tons. For Air cargo, the quantities reduced appear very small compares to other modes with 8 million losses between North Sea and Mediterranean highest in the EU region. The loss in value reaches 64 million with trade to ROW, but the trade between ROW-to-ROW gains with 78 million. While the quantities for AC are very small, their overall value is way higher, and this will lead to a very big impact to the Aviation industry.

Figure 23 Change in Quantities for all modes in 2025 Scenario (In Million tons)

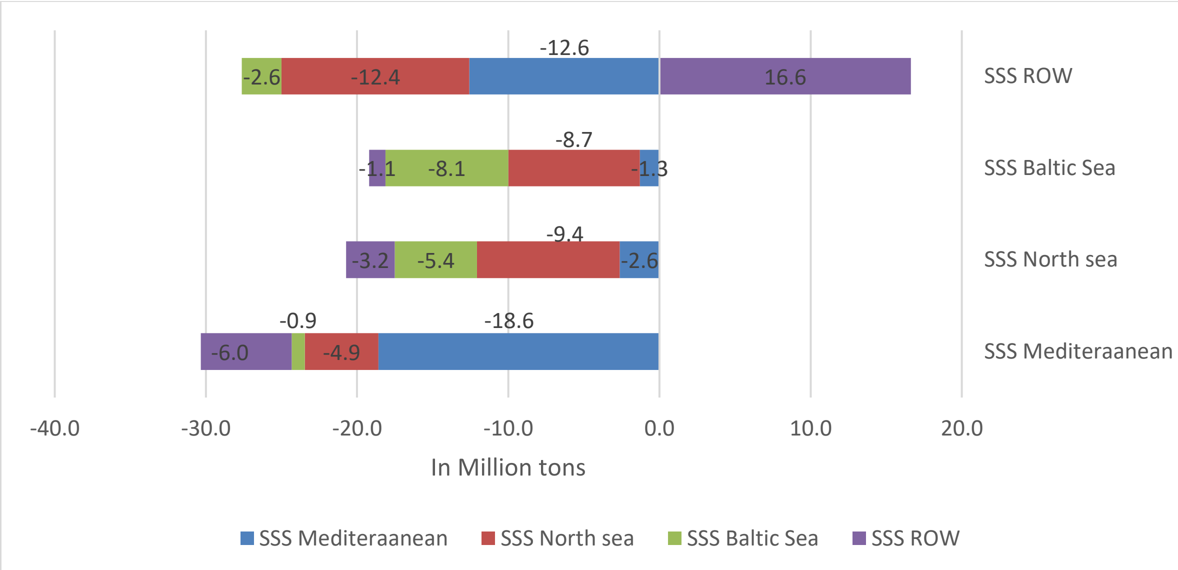


Source: Based on own calculation from GSIM,UNCATD and Eurostat data base

<u>Scenario 2030</u>

Figure 24 compares the change in quantities with the various regions where SSS operates. Within EU regions we see the biggest loss suffered by the Mediterranean region with 22.5 million tons, followed by North Sea 23 million tons and Baltic Sea with 14.4 million tons. Imports from ROW drops by 27.6 million tons, which is the biggest loss for the SSS industry. The exports to ROW drop by 10.3 million. However, the ROW-to-ROW gains in this overall effect with increase in quantities to 16.6 million tons. Compared to 2025 the cost impact is only making it worse for SSS in 2030. This will again lead to the transporter to bear some part of this cost to facilitate higher volumes of trade. Transport costs for SSS need to be attractive enough for the business to increase, this might lead to some SSS owners bearing losses in the short term. However, we also need to evaluate the overall impact of 'Fit for 55' effects on the other transport modes. The higher the impact to other transport modes, SSS will be able to cash in some opportunities from other modes and increase its volumes eventually.

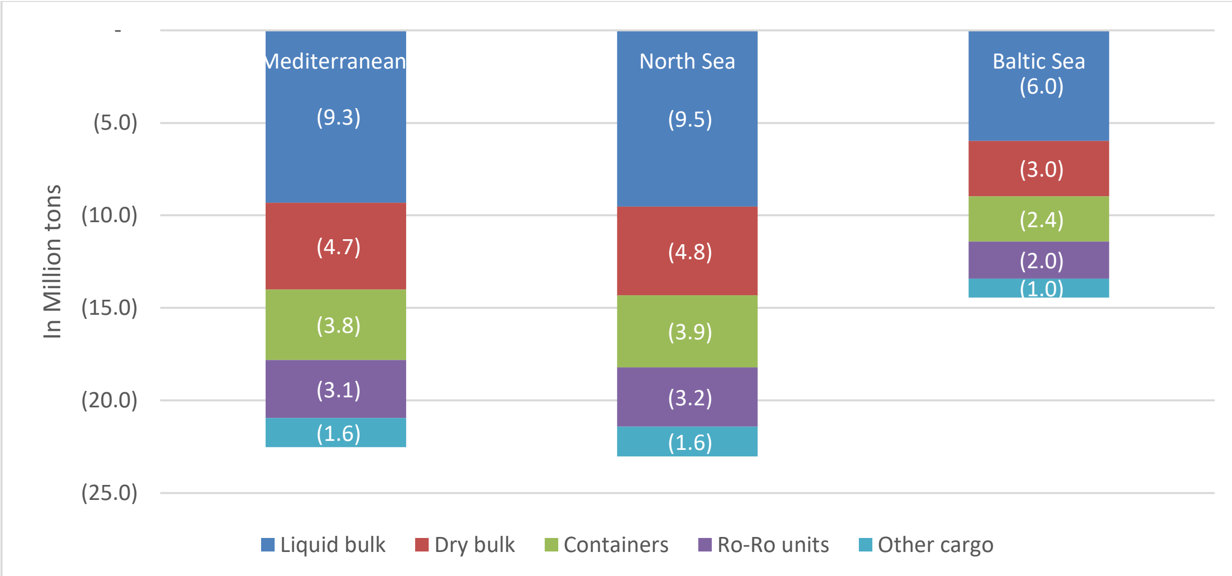
Figure 24 Change in Quantities for SSS in 2030 Scenario (In Million tons)



Source: Based on own calculation from GSIM,UNCATD and Eurostat data base

In figure 25 we split the quantities to compare the impact on different types of cargo such as Liquid bulk, Dry bulk, containers, Ro-Ro units, and other cargo types. Once again liquid bulk suffers the maximum loss, it is also because it represents the highest volume of trade for SSS. In this scenario, we see a decrease of 9.5 million tons in the North Sea region, followed by 9.3 million tons in the Mediterranean and 6 million tons in the Baltic region. This means that the owners of Liquid bulk vessels will see a huge drop in their freight rates and reduced demand in the region. The dry bulk will also be affected and may look for accommodating different cargo or look for suitable business outside the EU.

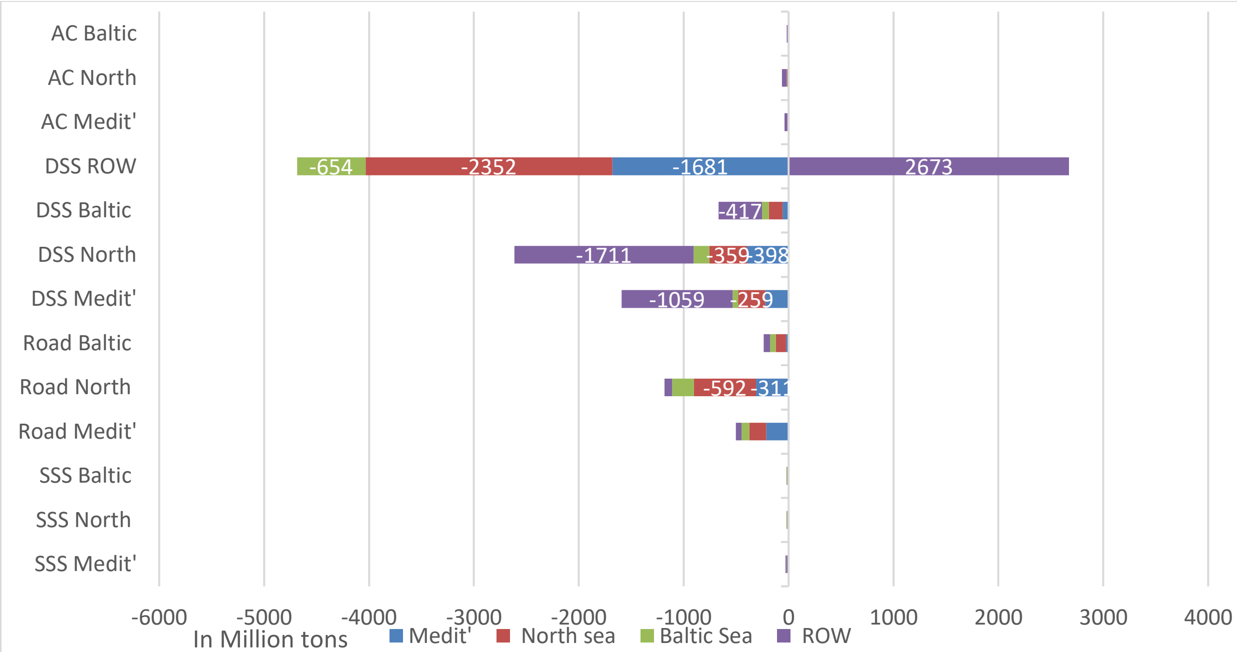
Figure 25 Quantity reduction by Cargo type region wise classification for SSS in 2030 (In Million tons)



Source: Own calculation from Eurostat database: mar_sg_am_cwk and GSIM results

Finally, we look at figure 26 to compare the reduction of volumes for all transport modes. We know that the change for rail is almost zero, hence we keep it outside this graph. Compare to other modes the impact in loss of volumes for SSS is very low. Road volumes between North Sea has a huge decline by 592 million tons followed by 311 million exports from North Sea to Mediterranean. The lowest volume loss is for exports from Baltic to Mediterranean which is 25 million tons. Imports and exports to ROW countries also see a significant loss, with the only winners being the trade between ROW and ROW which gains by 235 million tons, this is mostly because of trade diverted from the EU regions. DSS has the highest volume loss in EU regions compared to all other sectors, the exports from North Sea to Mediterranean are reduced by 398 million tons, However the negative values get higher for the trade with ROW, with the worst loss for exports from North sea to ROW at 1.7 trillion tons. Air cargo volumes look low compared to the other modes but the impact wise it is quite high comparing the high value of goods being transported.

Figure 26 Change in Quantities for all modes in 2030 Scenario (In Million tons)



Source: Based on own calculation from GSIM,UNCATD and Eurostat data base

4.5 Sensitivity analysis

To analyze the impact of independent variables in the form of elasticities on the final result formulated by the GSIM model and to check the robustness of these calculations, we run a few simulations for each of the elasticities with a tolerance of 0.5+/- to assess the changes it brings to the results. We will compare the changes with the base elasticity with a 0.5+/- change for each of them (Composite Demand elasticity, Substitution Elasticity and Export supply Elasticity).

With the results in the tables 29,30 and 31 we compare the changes in the result of Net welfare effect, percentage change in producer price and consumer price. For the Demand elasticity when we increase to -1.9, we see a very slight decrease in impact on the welfare, it suffers fewer losses, but the shift is stable, we see a similar proportion of change with an increase in losses when the elasticity is changed to -0.9. However, the impact on producer and consumer prices and very small percentage changes and hence doesn't really affect the results.

Table 29 Composite demand elasticity changes and its impact on the results

Composite Demand Elasticity	Welfare effect			% Producer Price			% Consumer Price		
0.5+/-		Base			Base			Base	
	-1.9	**-1.4**	**-0.9**	**-1.9**	**-1.4**	**-0.9**	**-1.9**	**-1.4**	**-0.9**
SSS Mediterranean	-133	-134	-136	-0.02	-0.02	-0.02	0.02	0.02	0.02
SSS North Sea	-119	-122	-125	-0.02	-0.02	-0.02	0.02	0.02	0.02
SSS Baltic Sea	-59	-60	-61	-0.02	-0.02	-0.02	0.02	0.02	0.02
Road Mediterranean	-4005	-4170	-4371	-0.49	-0.45	-0.41	0.37	0.41	0.45
Road North Sea	-7072	-7235	-7434	-0.49	-0.45	-0.41	0.37	0.40	0.45
Road Baltic Sea	-2386	-2509	-2658	-0.48	-0.45	-0.41	0.38	0.42	0.46
Rail Mediterranean	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Rail North Sea	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Rail Baltic Sea	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
DSS Mediterranean	-10751	-11012	-11336	-0.43	-0.41	-0.39	0.43	0.45	0.47
DSS North Sea	-14945	-15258	-15645	-0.43	-0.42	-0.39	0.43	0.45	0.47
DSS Baltic Sea	-4275	-4370	-4490	-0.43	-0.42	-0.39	0.43	0.45	0.47
AC Mediterranean	-19146	-19466	-19879	-1.04	-1.00	-0.95	1.09	1.13	1.19
AC North Sea	-26666	-27034	-27509	-1.04	-1.00	-0.95	1.10	1.15	1.20
AC Baltic Sea	-7597	-7712	-7862	-1.04	-1.00	-0.95	1.09	1.13	1.19
SSS ROW	22	13	1	0.00	0.00	0.00	0.00	0.00	0.00
Road ROW	169	35	-148	-0.03	-0.02	-0.02	-0.02	-0.01	0.00
Rail ROW	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
DSS ROW	-3229	-4201	-5392	-0.14	-0.12	-0.09	0.00	0.02	0.04
AC ROW	-3692	-5720	-8172	-0.27	-0.23	-0.17	-0.03	0.01	0.06

Source: Own compilation from GSIM results

With changes in substitution elasticity, we find that there is hardly any change in the welfare effect or the producer and consumer price percentage, we can say that the substitution elasticity alone doesn’t bring huge changes to the results.

Table 30 Substitution elasticity changes and its impact on the results

Substitution Elasticity	Welfare effect			% Producer Price			% Consumer Price		
0.5+/-		Base			Base			Base	
	5.5	**5**	**4.5**	**5.5**	**5**	**4.5**	**5.5**	**5**	**4.5**
SSS Mediterranean	-134	-134	-134	-0.02	-0.02	-0.02	0.02	0.02	0.02
SSS North Sea	-122	-122	-122	-0.02	-0.02	-0.02	0.02	0.02	0.02
SSS Baltic Sea	-60	-60	-60	-0.02	-0.02	-0.02	0.02	0.02	0.02
Road Mediterranean	-4171	-4170	-4168	-0.45	-0.45	-0.45	0.41	0.41	0.41
Road North Sea	-7234	-7235	-7236	-0.45	-0.45	-0.45	0.40	0.40	0.40
Road Baltic Sea	-2510	-2509	-2506	-0.45	-0.45	-0.45	0.42	0.42	0.42

Substitution Elasticity	Welfare effect			% Producer Price			% Consumer Price		
Rail Mediterranean	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Rail North Sea	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Rail Baltic Sea	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
DSS Mediterranean	-11072	-11012	-10943	-0.42	-0.41	-0.41	0.45	0.45	0.45
DSS North Sea	-15360	-15258	-15142	-0.42	-0.42	-0.41	0.45	0.45	0.45
DSS Baltic Sea	-4394	-4370	-4344	-0.42	-0.42	-0.41	0.45	0.45	0.45
AC Mediterranean	-19547	-19466	-19374	-1.02	-1.00	-0.99	1.14	1.13	1.13
AC North Sea	-27175	-27034	-26873	-1.02	-1.00	-0.99	1.15	1.15	1.14
AC Baltic Sea	-7743	-7712	-7677	-1.02	-1.00	-0.99	1.14	1.13	1.13
SSS ROW	13	13	13	0.00	0.00	0.00	0.00	0.00	0.00
Road ROW	38	35	32	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01
Rail ROW	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
DSS ROW	-4005	-4201	-4424	-0.12	-0.12	-0.13	0.02	0.02	0.02
AC ROW	-5453	-5720	-6025	-0.22	-0.23	-0.23	0.01	0.01	0.01

Source: Own compilation from GSIM results

Supply elasticity changes brings a bit more fluctuation than the demand elasticity, for instance we see an increase to 2.5 leads to a bigger loss in welfare by about 2 million and similar trend is seen when we reduce the elasticity to 1.5. However, the increase and decrease are stable and that shows the model is quite robust.

Table 31 Export supply elasticity changes and its impact on the results

Export supply Elasticity	Welfare effect			% Producer Price			% Consumer Price		
0.5+/-		**Base**			**Base**			**Base**	
	2.5	**2**	**1.5**	**2.5**	**2**	**1.5**	**2.5**	**2**	**1.5**
SSS Mediterranean	-136	-134	-132	-0.02	-0.02	-0.02	0.02	0.02	0.02
SSS North Sea	-125	-122	-118	-0.02	-0.02	-0.02	0.02	0.02	0.02
SSS Baltic Sea	-61	-60	-58	-0.02	-0.02	-0.02	0.02	0.02	0.02
Road Mediterranean	-4367	-4170	-3925	-0.41	-0.45	-0.51	0.45	0.41	0.36
Road North Sea	-7436	-7235	-6986	-0.41	-0.45	-0.51	0.45	0.40	0.35
Road Baltic Sea	-2653	-2509	-2329	-0.41	-0.45	-0.50	0.45	0.42	0.37
Rail Mediterranean	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Rail North Sea	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Rail Baltic Sea	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
DSS Mediterranean	-11222	-11012	-10737	-0.38	-0.41	-0.46	0.47	0.45	0.42
DSS North Sea	-15438	-15258	-15014	-0.38	-0.42	-0.46	0.47	0.45	0.42
DSS Baltic Sea	-4446	-4370	-4272	-0.38	-0.42	-0.46	0.47	0.45	0.42
AC Mediterranean	-19770	-19466	-19069	-0.92	-1.00	-1.11	1.18	1.13	1.07
AC North Sea	-27270	-27034	-26708	-0.92	-1.00	-1.11	1.19	1.15	1.09
AC Baltic Sea	-7819	-7712	-7571	-0.92	-1.00	-1.10	1.18	1.13	1.07

Export supply Elasticity	Welfare effect			% Producer Price			% Consumer Price		
SSS ROW	3	13	26	0.00	0.00	0.00	0.00	0.00	0.00
Road ROW	-124	35	244	-0.02	-0.02	-0.03	0.00	-0.01	-0.02
Rail ROW	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
DSS ROW	-5733	-4201	-2306	-0.11	-0.12	-0.14	0.04	0.02	-0.02
AC ROW	-8530	-5720	-2239	-0.19	-0.23	-0.27	0.06	0.01	-0.06

Source: Own compilation from GSIM results

From the above tables we can say that the change in elasticity has a very small or insignificant effect in the percentage change in price and welfare effects. Based on this we can tell that the Demand elasticity, Supply elasticity and substitution elasticity doesn't single handedly change or affect the determination of the final values in the GSIM model. On the contrary if there were huge changes in the values then it would mean that the elasticity values need to be very close in reality to determine the correct results.

Chapter 5 - Conclusion

This chapter will cover two sections 1. Key findings and Analysis, 2. Limitations and areas for further research.

Key Findings and Analysis

With the introduction of ETD, ETS, and Fuel EU initiatives as part of the "Fit for 55" Climate package, it is evident that ship owners will be impacted in a number of ways. The primary goal of this thesis is to investigate the economic and transport impact on the EU's short sea shipping sector (SSS). We chose the study regions in the EU, to be the Mediterranean Sea, North Sea, and Baltic Sea, as they were relevant in terms of SSS volumes from major ports located in these locations. We also know that it is necessary to compare the upcoming costs for the "Fit for 55" with other modes of transportation such as road, rail, deep-sea ships (DSS), and air transportation (AC) in order to determine the overall impact on SSS in comparison to the other transportation options available in the EU. To investigate this effect further, we created two scenarios, one with projected costs until 2025 and the other in 2030, to estimate the implications of cost changes over time for various transportation modes.

The Literature review explains the importance of SSS, its current volumes, and vessels in operation. Further adding the challenges faced by SSS owners, where the majority of vessels are owned by small or family businesses, as well as their financial difficulties and coping with rising costs, energy transition, and competition to their business from other modes of transportation. However, the severe climate change and biodiversity catastrophe the world is currently facing makes the significance of the EU's climate goals rather clear. Thus the ‘Fit for 55’ package is vital to update the existing regulations to comply with the EU’s climate goals in 2030 and 2050.

We used the GSIM model to analyze and answer the research question in a quantitative manner. This econometric model is a partial equilibrium model and is used to assess the impact of trade policy changes. The model considers the interaction of various market access concessions among trading partners, exporter (producer surplus), importer (consumer surplus), and variations in tariff revenue, and can be seen as a valuable tool to study the policy impact such as the “Fit for 55”. Further, the regulatory policy shock can be modeled with a change in non-tariff measures. To determine the NTM’s, we assess the existing costs for the SSS and other modes and the added cost from the new regulations. One of the important aspects of SSS is that the ETS and Fuel EU policies will only be applied to vessels above 5000 GT, which exempts about 61% of the SSS vessels (based on own calculations). However, the overall costs per annum seemed quite high, for instance in 2025 a bulk carrier vessel incurred about 266 thousand Euros, a container vessel was 1.7 million Euros, and an RO-RO vessel 2.1 million Euros. Based on these costs for various modes and with the required elasticities and tariffs for the model, we ran the GSIM model for each of the scenarios, one in 2025 and the other in 2030 to assess the impact of the changing costs during these periods

Based on the results we answer the economic impact by analyzing the net welfare effects, the percentage change in producer and consumer price and the change in trade value after the shock. For all modes except rail, we see an increase in costs and a decrease in trade values. The net welfare consists of the producer surplus, consumer surplus and revenue from tariffs.

In 2025 the results from the model suggest a decrease in net welfare effects for all modes (except rail) in the EU. For SSS the Mediterranean region has the major losses with a reduction of 134 million euros followed closely by the North Sea region at 122 million Euros, in both cases, the major losses are seen to be with the consumer surplus which alone is 97 million euros for each of these regions. However, the main competitors of SSS, which are road and DSS have much larger losses with road losing 4.1 billion in the Mediterranean and 7.2 billion euros in the North Sea. With losses of 11 billion euros in the Mediterranean and 15 billion euros in the North Sea, DSS suffers greater losses. The consumer surplus, which for the road in the North Sea alone is lowered by 4.4 billion of the 7.2 billion euros loss in net welfare, and for DSS in the North Sea, we see 10 billion of the 15 billion euros loss in Net welfare, hence similar to SSS the consumer surplus alone accounts for the largest portion of losses. For all of the modes with the exception to rail, we notice the Baltic region to be the least affected, which is at least 50% lower losses compared to the Mediterranean and the North Sea comparing the net welfare effect.

Based on the GSIM results we notice the new trade values reduction to be quite high. SSS accounts for a reduction of 27.7 billion euros in trade in the EU regions. With a major loss in trade within the Mediterranean region accounting for 8.5 billion euros. However, in comparison road reports losses of 243 billion euros and DSS 192 billion euros in the Mediterranean region. This indicates that the losses for SSS are way lower and insignificant when compared to road and DSS. Further this is clear when we compare the producer and consumer price percentage changes, we notice no change for SSS, but for road and DSS, the producer price reduces by 0.5% and 0.4%, consumer price increases by 0.4% for both. This implies that the shipper's and the receivers using SSS to transport goods will be at an advantage in comparison to road and DSS users.

When we compare the results from 2025 and 2030, we see a similar pattern prevalent. From the results, we notice an average 78% negative increase in the net welfare effect for SSS, 127% negative increase for road and 108% for DSS. In Trade values, we see a negative change in 84% for SSS, 125% for road and 94% to DSS. Further for the change in producer price we see zero impact for SSS, while road and DSS see a decline by 0.6% and 0.4% respectively. Likewise for consumer price SSS has no change while road and DSS increase by 0.5% compared to 2025.

We then analyze the transport impact by converting the trade values to volumes to get a clear understanding of the volumes impacting each mode. In 2025 for SSS the highest decline of 10 million tons is seen for trade within the Mediterranean, in comparison road sees a reduction of 95.2 million and DSS 114.6 million tons. But when we look at the total losses by region for SSS we see that the North Sea Region suffers the most with a reduction of 19.7 million tons followed by the Mediterranean at 19.5 million tons. This is because the North Sea region has a major loss in quantity in trade with the Baltic region, while the Mediterranean region is more concentrated within its region for trade. When we compare tons with the different types of cargo in SSS (2025), we find that liquid bulk suffers a loss of 13.5 million tons, followed by dry bulk with a loss of 6.8 million tons and containers with a loss of 5.5 million tons. This illustrates the potential intensity of the "Fit for 55" package on this sector. In 2030 we see a further decrease in shipment volumes as in the trend with the trade values.

From the results we notice the overall trade value and transport volumes to suffer a huge impact in terms of the numbers indicated, however, we need to keep in mind that the model being a partial equilibrium model has its own limitations and doesn't consider other factors that are not captured in the model, with this outcome, we may predict that a certain amount of trade will continue to grow or remain at the same level despite the cost increases. Nevertheless, we must appreciate the robustness of the results calculated by the model which gives a good indication of the effects on the economy.

Based on the results and analysis we conclude that the impact of “Fit for 55” based costs to SSS is insignificant compared to its effect on road and DSS. Only rail which performs better than SSS could be seen as competition, however, given the inflexibility of rail and its infrastructure requirements in comparison to SSS, it should not be a major concern to the SSS industry. While we analyze the results based on the immediate future, it must be kept in mind that the speed of energy transition and technologies available for road will play a key role in determining the success of SSS’s future. We believe that road transportation is more adaptable and capable of transitioning faster than SSS, thus lowering future emission costs. Therefore, in order to remain competitive, SSS shipowners must accelerate their transition to cleaner energy.

Limitations and areas for Further research

Even though we covered a significant part of SSS trade in this thesis, it will be interesting to also study the effect on the entire EU region, including ports in the Black Sea and North Atlantic regions. Especially in light of the current conflict between Russia and Ukraine, which could have a serious impact on SSS transport in the Black Sea region.

One of the challenges we encountered in this thesis was the SSS vessel data and information on fleet size and types; while we used relevant information from reliable sources, we believe this is an area for further research and a separate topic of study by itself.

We could use the findings of this study to further investigate the technological impacts of the energy transition on the SSS industry. Research in this area could also be conducted using market research data collected following the implementation of the 'Fit for 55' policy to assess market players and their strategies for dealing with the additional costs. This could be used to study the impact on certain commodities and the type of cargos that will have a major impact on SSS.

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Appendix

Table 32 Quantity in thousand tons for SSS, Road and Rail

	SSS Mediterranean	SSS North sea	SSS Baltic Sea	ROW
SSS Mediterranean	254204	66132	10795	87702
SSS North Sea	36640	129834	69428	48017
SSS Baltic Sea	18390	122102	105352	16259
ROW	101756	99989	20213	170843
	Road Mediterranean	**Road North Sea**	**Road Baltic Sea**	**ROW**
Road Mediterranean	104607	77239	36103	31788
Road North Sea	152198	287181	104218	41163
Road Baltic Sea	12054	46209	26626	34477
ROW	27362	30252	29081	31373
	Rail Mediterranean	**Rail North Sea**	**Rail Baltic Sea**	**ROW**
Rail Mediterranean	37,411	16,743	3	566
Rail North Sea	23,413	258,464	1,919	7,566
Rail Baltic Sea	16,562	9,068	173,383	8,271
ROW	2,516	6,978	71,955	113,636

Source: Eurostat Database

Table 33 Trade values used in GSIM model (In Million Euros)

Short sea Ship	SSS Mediterranean	SSS North Sea	SSS Baltic Sea	SSS ROW
SSS Mediterranean	216,147.9	56,232.0	9,178.8	146,987.9
SSS North Sea	31,154.4	110,396.7	59,034.6	80,475.9
SSS Baltic Sea	15,637.1	103,822.3	89,580.6	27,249.3
SSS ROW	170,541.0	167,580.3	33,877.3	2,167,501.3
Road	**Road Medit'**	**Road North Sea**	**Road Baltic Sea**	**ROW**
Road Medit'	267,783.9	197,724.5	92,420.2	54,335.6
Road North Sea	389,612.3	735,155.9	266,788.1	70,360.4
Road Baltic Sea	30,857.1	118,290.6	68,160.0	58,932.0
Road ROW	46,770.2	51,710.1	49,708.5	1,830,108.3
Rail	**Rail Mediterranean**	**Rail North Sea**	**Rail Baltic Sea**	**ROW**
Rail Mediterranean	36,025.7	16,123.0	3.2	919.4
Rail North Sea	22,546.5	248,895.8	1,847.8	12,284.5
Rail Baltic Sea	15,948.9	8,732.7	166,964.3	13,429.0
Rail ROW	4,085.3	11,330.2	116,826.2	94,044.0

Deep sea	**DSS Mediterranean**	**DSS North Sea**	**DSS Baltic Sea**	**DSS ROW**
DSS Mediterranean	193,744.3	227,575.7	46,482.4	1,108,005.3
DSS North Sea	347,645.7	315,560.4	129,161.0	1,793,019.6
DSS Baltic Sea	49,031.1	117,664.0	54,572.9	438,769.9
DSS ROW	1,218,026.8	1,711,408.3	474,263.6	3,251,251.9
Air cargo	**AC Mediterranean**	**AC North Sea**	**AC Baltic Sea**	**AC ROW**
AC Mediterranean	135,621.0	159,303.0	32,537.7	775,603.7
AC North Sea	243,352.0	220,892.3	90,412.7	1,255,113.7
AC Baltic Sea	34,321.8	82,364.8	38,201.0	307,139.0
AC ROW	852,618.7	1,197,985.8	331,984.5	3,793,127.3

Source: Own compilation from Eurostat and UN Comtrade

Table 34 Initial and Final tariff used in GSIM

s: source	SSS Medi	SSS North	SSS Baltic	Road Medi	Road North	Road Balti	Rail Medite	Rail North	Rail Baltic	DSS Medi	DSS North	DSS Baltic	AC Medite	AC North s	AC Baltic S	SSS ROW	Road ROW	Rail ROW	DSS ROW	AC ROW
SSS Mediteranean	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.053425	1	1	1	1
SSS North sea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.053633	1	1	1	1
SSS Baltic Sea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.041667	1	1	1	1
Road Mediteranean	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0543	1	1	1
Road North sea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.049433	1	1	1
Road Baltic Sea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.042217	1	1	1
Rail Mediteranean	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.052375	1	1
Rail North sea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0493	1	1
Rail Baltic Sea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.040417	1	1
DSS Mediteraanean	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.064494	1
DSS North sea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.056675	1
DSS Baltic Sea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.049402	1
AC Mediteraanean	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.064494
AC North sea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.056675
AC Baltic Sea	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.049402
SSS ROW	1.057925	1.043833	1.043	1	1	1	1	1	1	1	1	1	1	1	1	1.121053	1	1	1	1
Road ROW	1	1	1	1.035775	1.0211	1.022017	1	1	1	1	1	1	1	1	1	1	1.121053	1	1	1
Rail ROW	1	1	1	1	1	1	1.035375	1.0213	1.02315	1	1	1	1	1	1	1	1	1.121053	1	1
DSS ROW	1	1	1	1	1	1	1	1	1	1.034666	1.029508	1.0345	1	1	1	1	1	1	1.121053	1
AC ROW	1	1	1	1	1	1	1	1	1	1	1	1	1.034666	1.029508	1.0345	1	1	1	1	1.121053

Source: UN Comtrade WITS

Table 35 Initial NTM used in GSIM

Initial NTM	SSS Medi	SSS North	SSS Baltic	Road Medi	Road North	Road Balti	Rail Medite	Rail North	Rail Baltic	DSS Medi	DSS North	DSS Baltic	AC Medite	AC North s	AC Baltic S	SSS ROW	Road ROW	Rail ROW	DSS ROW	AC ROW
SSS Mediteranean	2.382	2.382	2.382	1	1	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1	1
SSS North sea	2.382	2.382	2.382	1	1	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1	1
SSS Baltic Sea	2.382	2.382	2.382	1	1	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1	1
Road Mediteranean	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1
Road North sea	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1
Road Baltic Sea	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1
Rail Mediteranean	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	1	1	2.701	1	1
Rail North sea	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	1	1	2.701	1	1
Rail Baltic Sea	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	1	1	2.701	1	1
DSS Mediteraanean	1	1	1	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	2.701	1
DSS North sea	1	1	1	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	2.701	1
DSS Baltic Sea	1	1	1	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	2.701	1
AC Mediteraanean	1	1	1	1	1	1	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	2.701
AC North sea	1	1	1	1	1	1	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	2.701
AC Baltic Sea	1	1	1	1	1	1	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	2.701
SSS ROW	2.701	2.701	2.701	1	1	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1	1
Road ROW	1	1	1	2.701	2.701	2.701	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1
Rail ROW	1	1	1	1	1	1	2.701	2.701	2.701	1	1	1	1	1	1	1	1	2.701	1	1
DSS ROW	1	1	1	1	1	1	1	1	1	2.701	2.701	2.701	1	1	1	1	1	1	2.701	1
AC ROW	1	1	1	1	1	1	1	1	1	1	1	1	2.701	2.701	2.701	1	1	1	1	2.701

Source: Own compilation

Table 36 Final NTM in Scenario 2025

Final NTM 2025	SSS Medit	SSS North	SSS Baltic	Road Medi	Road Nortl	Road Balti	Rail Medite	Rail North	Rail Baltic	DSS Medit	DSS North	DSS Baltic	AC Medite	AC North s	AC Baltic	SSS ROW	Road ROW	Rail ROW	DSS ROW	AC ROW
SSS Mediteranean	2.383	2.383	2.383	1	1	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1	1
SSS North sea	2.383	2.383	2.383	1	1	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1	1
SSS Baltic Sea	2.383	2.383	2.383	1	1	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1	1
Road Mediteranean	1	1	1	2.402	2.402	2.402	1	1	1	1	1	1	1	1	1	1	2.717	1	1	1
Road North sea	1	1	1	2.402	2.402	2.402	1	1	1	1	1	1	1	1	1	1	2.717	1	1	1
Road Baltic Sea	1	1	1	2.402	2.402	2.402	1	1	1	1	1	1	1	1	1	1	2.717	1	1	1
Rail Mediteranean	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	1	1	2.701	1	1
Rail North sea	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	1	1	2.701	1	1
Rail Baltic Sea	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	1	1	2.701	1	1
DSS Mediteraanean	1	1	1	1	1	1	1	1	1	2.402	2.402	2.402	1	1	1	1	1	1	2.716	1
DSS North sea	1	1	1	1	1	1	1	1	1	2.402	2.402	2.402	1	1	1	1	1	1	2.716	1
DSS Baltic Sea	1	1	1	1	1	1	1	1	1	2.402	2.402	2.402	1	1	1	1	1	1	2.716	1
AC Mediteraanean	1	1	1	1	1	1	1	1	1	1	1	1	2.430	2.430	2.430	1	1	1	1	2.740
AC North sea	1	1	1	1	1	1	1	1	1	1	1	1	2.430	2.430	2.430	1	1	1	1	2.740
AC Baltic Sea	1	1	1	1	1	1	1	1	1	1	1	1	2.430	2.430	2.430	1	1	1	1	2.740
SSS ROW	2.701	2.701	2.701	1	1	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1	1
Road ROW	1	1	1	2.717	2.717	2.717	1	1	1	1	1	1	1	1	1	1	2.70072	1	1	1
Rail ROW	1	1	1	1	1	1	2.701	2.701	2.701	1	1	1	1	1	1	1	1	2.701	1	1
DSS ROW	1	1	1	1	1	1	1	1	1	2.716	2.716	2.716	1	1	1	1	1	1	2.701	1
AC ROW	1	1	1	1	1	1	1	1	1	1	1	1	2.740	2.740	2.740	1	1	1	1	2.701

Source: Own compilation

Table 37 Final NTM in Scenario 2030

Final NTM 2030	SSS Medit	SSS North	SSS Baltic	Road Medi	Road Nortl	Road Balti	Rail Medite	Rail North	Rail Baltic	DSS Medit	DSS North	DSS Baltic	AC Medite	AC North s	AC Baltic	SSS ROW	Road ROW	Rail ROW	DSS ROW	AC ROW
SSS Mediteranean	2.384	2.384	2.384	1	1	1	1	1	1	1	1	1	1	1	1	2.702	1	1	1	1
SSS North sea	2.384	2.384	2.384	1	1	1	1	1	1	1	1	1	1	1	1	2.702	1	1	1	1
SSS Baltic Sea	2.384	2.384	2.384	1	1	1	1	1	1	1	1	1	1	1	1	2.702	1	1	1	1
Road Mediteranean	1	1	1	2.428	2.428	2.428	1	1	1	1	1	1	1	1	1	1	2.738	1	1	1
Road North sea	1	1	1	2.428	2.428	2.428	1	1	1	1	1	1	1	1	1	1	2.738	1	1	1
Road Baltic Sea	1	1	1	2.428	2.428	2.428	1	1	1	1	1	1	1	1	1	1	2.738	1	1	1
Rail Mediteranean	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	1	1	2.701	1	1
Rail North sea	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	1	1	2.701	1	1
Rail Baltic Sea	1	1	1	1	1	1	2.382	2.382	2.382	1	1	1	1	1	1	1	1	2.701	1	1
DSS Mediteraanean	1	1	1	1	1	1	1	1	1	2.423	2.423	2.423	1	1	1	1	1	1	2.733	1
DSS North sea	1	1	1	1	1	1	1	1	1	2.423	2.423	2.423	1	1	1	1	1	1	2.733	1
DSS Baltic Sea	1	1	1	1	1	1	1	1	1	2.423	2.423	2.423	1	1	1	1	1	1	2.733	1
AC Mediteraanean	1	1	1	1	1	1	1	1	1	1	1	1	2.430	2.430	2.430	1	1	1	1	2.740
AC North sea	1	1	1	1	1	1	1	1	1	1	1	1	2.430	2.430	2.430	1	1	1	1	2.740
AC Baltic Sea	1	1	1	1	1	1	1	1	1	1	1	1	2.430	2.430	2.430	1	1	1	1	2.740
SSS ROW	2.702	2.702	2.702	1	1	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1	1
Road ROW	1	1	1	2.738	2.738	2.738	1	1	1	1	1	1	1	1	1	1	2.701	1	1	1
Rail ROW	1	1	1	1	1	1	2.701	2.701	2.701	1	1	1	1	1	1	1	1	2.701	1	1
DSS ROW	1	1	1	1	1	1	1	1	1	2.733	2.733	2.733	1	1	1	1	1	1	2.701	1
AC ROW	1	1	1	1	1	1	1	1	1	1	1	1	2.740	2.740	2.740	1	1	1	1	2.701

Source: Own compilation