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**IMO`s SULPHUR REGULATION TO BE
ENFORCEABLE FROM THE YEAR 2020 AND ITS
IMPACT ON THE SHIPBUILDING INDUSTRY**

by

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Acknowledgments

In the bible, Jesus says, *“I do not know who fitted the board on the floor that I stand upon right now, I do not know the great people who may come and stand upon this floor but I do know that the one who made the floor and the one that sweeps it is just as great as anybody in the world who may come and stand upon it if each be doing their work with the same great love, faithfulness and capability.”*

Lead by these principles, I have prepared this study with the support of many. First and foremost, I would like to thank god, my parents Ebby and Serah, my brother Thomas for leading me through the years to mould me as I am and for this opportunity to study at this prestigious university. I would like to thank my grandparents for always reinforcing my spirits and belief. I would like to thank Mr. Majumdar and Mr. Ranka, two figures who lead me through my formative years as a maritime lawyer and instilled me with all the skills that have proved to be advantageous in pursuing this study. I would like to thank Dr. Berden for patiently guiding me on this study. I thank Renee, Felicia and Martha from the MEL office who were pivotal in guiding me through the arduous challenges of the MEL programme. I would also like to thank Mr. Clayton, Dr. Pearce and Mr. Moondra for their guidance. The list is endless and to you all, dedicate this product of a conversion of thought into character. I am blessed by your presence in my life.

Abstract

In the study at hand, the impact from the use of low sulphur bunkers on the shipbuilding industry is investigated. IMO, vide its efforts to transform the shipping industry into a more environmentally friendly industry, has set out reforms requiring the industry to make substantial changes in the way the trade is conducted. One such effort is the use of regulating the bunkers used so as to reduce the shipping industry's contribution to air pollution by limiting the permissible content of sulphur in these bunkers from 1st January 2020, when the reform suggested by IMO comes into effect. The run up till the date of enforcement, the industry can choose how to comply with this sulphur regulation as the said reform permits the use of alternative technology to achieve its goal. Weighing the options available to the industry and its respective feasibility, a majority of the industry has decided to use low sulphur bunkers to comply with the sulphur regulation.

However, since low sulphur bunkers are sold at a premium as compared to the high sulphur variants popularly used as on date, it is intuitive to foresee that use of low sulphur fuels will severely impact the operating expense of vessels. However, the ripples from such a shift is very wide and carries on through various aspects of the global supply chain. Furthermore, the envisaged change is one of many ensuing measures brought into force by the members of the IMO. Since a plethora of aspects await to be investigated by analysts, the author seeks to study the impact of the global use of low sulphur bunkers on the shipbuilding industry between named major economies.

The said study is conducted using the GSIM as an econometric tool to measure the impact of trade in the shipbuilding industry. Scenarios run by the GSIM model were formulated on the cycles of changes that have commenced from the year 2020, the ambiguities around the instant regulation that consume the stakeholders and the feasibility of the various options available to the industry to comply with the said sulphur regulation. The results of the study yield that there would be a severe reduction in trade between these countries as the increment in investment to run vessels whilst maintaining compliance of the sulphur regulation translates into a rise in NTMs for the shipbuilding industry. The output of shipbuilding nations are calculated to be affected as much as – 12%. Bilateral trades are estimated to reduce as much as 30% translating to approximately \$ 9.3 Billion. State parties adopting a “wait and see” approach could yield better benefits. Since, forward thinking economies like the EU are known to have set higher standards in emissions as they have implemented the spirit of IMO's sulphur regulation in their territorial water as early as 2010, a thorough implementation of the sulphur regulation by the EU would yield comparative trade benefits to the other State Parties.

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List of Abbreviations

ABS – American Bureau of Shipping
CEIP – Centre for Emissions Inventories and Projections
CLRTAP – Convention on Long-Range Transboundary Air Pollution
ECA – Emission Control Areas
EGCS – Exhaust Gas Cleaning System
EU – European Union
GDP – Gross Domestic Product
GSIM – Global Simulation Model
GEF – Global Environment Facility
GHG – Greenhouse gas
GloMEEP – Global Maritime Energy Efficiency Partnership
HSFO – High Sulphur Fuel Oil
IMO – International Maritime Organization
IPCC – Intergovernmental Panel on Climate Change
LSFO – Low Sulphur Fuel Oil
MARPOL – International Convention on Prevention of Pollution from Ships
MGO – Marine Gas Oil
NDC – Nationally Determined Contributions
NO_x – Nitrous/Nitrate Oxides
NTM – Non-Tariff Measures
ROW – Rest of the World
RCP – Representative Concentration Pathways
SDG – Sustainable Development Goals
SECA – Sulphur Emission Control Areas
SO_x – Sulphur Oxides
UN – United Nations
UNDP – United Nations Development Programme
UNECE – United Nations Economic Commission for Europe
UNFCCC – United Nations Framework Convention for Climate Change
USA – United States of America
USD – United States Dollars

Chapter 1 – Introduction

Martin Stopford beautifully records that to thoroughly understand the drivers of change and trading economics, the evolving frameworks of trade and its symbiotic relationship needs to be studied. To do so it is imperative to abide by the distinction that maritime economists work with quantities of cargo traded whereas trade economists work with the value of the cargo traded (Stopford, M., 2007). Gereffi, et al. 2005, theorised that the shipping industry is a complex algorithm comprised of various parties establishing their value chains. Building on this, Bloor, et al. 2013, stated that the industry evidences a 'polycentric governance structure' wherein a ship owned by a company is managed by another company and equipped/manned by another thereby creating a multi-layered structure. Accordingly, the governance of the shipping industry follows a similar structure; Government, International agencies and Non-State actors collaborate in a multi-layered structure (Bloor, 2014). Accordingly, effective management and governance of the shipping industry involves these multiple parties either in a top-down or bottom-up manner (*supra*). Either way, waves of changes to the shipping industry can be seen to display an interpretive flexibility wherein the proposed changes creates a favourable environment and an objectionable environment (Bijker, 1995). Intuitively, the same can be observed with a number of reforms with the debate being divided between the proponents and the opponents of changes for the shipping industry (Latour, 1988). In light of the dual nature of reforms, the events around and leading up to the reforms are crucial to ascertain the parameters of the study at hand.

1.1. Literature review

Since IMO has officiated, in 2018, that the most drastic phase of the sulphur regulations would come into effect from 1st January 2020, the advisors, consultants and experts have been scrambling to decipher the impact of this regulation on the shipping and oil industry. Accordingly, a plethora of literature has been published since highlighting the uncertainties ahead whilst suggesting plausible options for compliance and safeguards under the proposed and imminent regime for the shipping industry and the oil industry. ABS, vide its advisory, provides an overview on the current practice, the details around different types of fuels used by ships and a detailed list of practical challenges (approximately 20 challenges) in the wake of the 2020 sulphur cap along with possible solutions for shipowners and operators (ABS, 2018). Similarly, IG P&I clubs have funded a large number of independent studies to advise their clients on how to comply with the sulphur regulation and what to expect in the days ahead.

The highlights across these literature on the global shift to low sulphur bunkers are common; uncertainty of enforcement of by State Parties, supply of compliant fuels or ECGS systems. It is undisputed that the impact of the sulphur regulation is not restricted to the shipping and the oil industry but the ripples of the same would be felt across the board wherever shipping plays even the most insignificant of roles and in this regard, lies the scope for research questions such as the one at hand. The research question at hand finds its relevance as it is one of the many industry that is expected to be severely impacted by the imminent sulphur regulation; more so in the wake of a recovering order book. However, the limitation in the literature available as on date is that they merely highlight the issues that could be faced by stakeholders in

the shipping industry. Although the industry was anticipating the enforcement of the sulphur regulation to be delayed till the year 2025, the recent confirmation on the enforcement of sulphur regulation from the year 2020 would set off a plethora of analysis on the impacts of the global shift to low sulphur bunkers and to do the same, reliance can be made on the earlier measure to control the emissions from bunkers. However, environmental efforts have a history of being met with strong obstruction when the results of its execution are too costly for industries but the envisaged change is undisputedly one of great importance and urgency and must be enforced. Thus, within these parameters, the research question poses great relevance for its time and hopes to highlight further points for research towards a run up to 1st January 2020 so that the transition into a sulphur free regime doesn't come at the cost of international trade discounting the transitional impact. Goldman Sachs, has made a sweeping statement in an update published in June 2018, that the sulphur regulation would impact the end consumers by approximately \$240 billion (Goldman Sachs, 2018).

Bloor, *et. al*, 2014, notes highlights that the the guiding and working principle of reforms are based on a principle of precaution which, by its very nature, would be defeated if the garb of uncertainty is used to defer the enforcement of the proposed reforms. In the run up to 1st January 2020, PPR5 was held in January 2018 after which MEPC 72 will be scheduled during Spring 2018 followed by MEPC 73 during Autumn 2018 and thereafter, PPR 6 in January 2019 and finally MEPC 74 in Spring 2019; all to facilitate a smooth transition into a sulphur-free shipping. Hopefully these events would shine light on uncertainties posed by the industry to facilitate a smooth transition into a sulphur-free shipping.

Till date, any rise in bunker costs over a long term has resulted in the innovation of more fuel-efficient vessels thereby limiting rise in the capital costs and voyage costs associated with the ship as result of which the question for analysts have always been whether the burden of increased capital costs outweighed the bunker savings (Drewry Shipping Consultants. Ltd., 1984). However, the imminent Sulphur regulation wouldn't seem to trigger another search for energy efficient ships but will turn the industry at its heels.

1.2. Research Objectives and Research Question

The idea for this research stems from the confusion and scrambling that has consumed the shipping industry as a result of the IMO regulating the use of bunkers by ships to reduce or eliminate the emission of pollutants such as SO_x, NO_x and particulate matter. The IMO has mandated that from 1st January 2020, no ship shall use bunkers that contain more that 0.5% of sulphur. This comes as a drastic measure that stirred the confusion and scrambling since the shipping industry was being fuelled by bunkers with a sulphur content of 3.5% m/m; which is an 85% reduction. Consecutively, ambiguity on supply and demand of compliant fuels, feasibility of alternative compliance methods cause the industry to expend great amount in an environment when the shipping industry is, colloquially, recovering. That said, the shipping industry has endured a lot of changes by bearing the brunt of economic and political changes, most of which are unknown to the common man. However, in this first bout of changes to the shipping industry, the cascading effects on international trade is unbeknownst but worthy of investigating. As part of a series of changes that await the shipping industry, the effects on trade is not anticipated to be small and short-lived. in this regard, an analysis on the prospective changes could aid in

establishing counteractive measures, incentives or policies so buffer the impact of these changes to the shipping industry. As such the research question is as below followed by sub-research questions:

Main Research Question: What is the economic and trade impact of the global shift to low sulphur fuels on the shipbuilding sector?

Sub Research Question 1: What are the commitments to the global environment by the shipping industry and their developments?

Sub Research Question 2: What are the imminent reforms facing the shipping industry and the methods of compliance?

Sub Research Question 3: What is the methodological approach used in this study and are there any assumptions applied?

1.3. Thesis Structure

The study at hand comprises of 6 chapters. Chapter 2 elucidates the global commitment towards our environment and charts out how, why and where efforts arise from and where they are intended to lead to. Upon highlighting the global framework established or sought to be established for our environment, reference is drawn to the shipping industry to indicate the impact shipping has made on the environment to build context on the efforts needed/in place to counter the same.

Accordingly, Chapter 3 emphasises on the measures instituted by regulatory agencies against air pollution by ships and the practices of the industry. Thereafter, the imminent regulation on emission of sulphur from ships is explained in detail along with the options the industry can execute to be compliance of the said regulation. However, it is imperative to understand the gravity of these reforms and the same is expressed by explaining the current context of the shipping industry and drawing a parallel to the bigger picture of cleaner shipping envisaged by global leaders and inter-governmental organizations.

Having explained the ambit of the reform and its context, Chapter 4 elucidates the methodological approach employed to ascertain the research question. Since different methodological approaches merits their respective assumptions, the same are listed subsequent to the theoretical framework behind each methodological approach.

In Chapter 5, the results from our methodological approach are reproduced and explained as a tacit conclusion and solution to the research question which is, thereafter, summarised in Chapter 6 along with points for further research and limitations in the instant study to ensure a correct interpretation of the result produced herein.

Chapter 2 – Emissions and Shipping

In this chapter, regulations and measures to transform the shipping industry as we know it into a cleaner and more environmentally friendly facilitator of international trade are highlighted by charting the various instruments and measures that were pivotal in forming the framework around emissions by the shipping industry.

2.1. *UN Sustainable Development Goals*

The United Nations, convened on an apparent dawn of the millennium on the dates of 4th to 6th September 2000 at the United Nations Headquarters in New York, USA to reaffirm their association to the organization, synchronisation of their goals and rekindle the fire to mould a sustainable environment for the future generations of this planet. This meeting of world leaders was condensed into a resolution by the General Assembly of the United Nations numbered as A/55/L/2 dated 18th September 2000 which is magnanimously titled as “*United Nations Millennium Declaration*”.

Vide this resolution, the United Nations, as a medium of speech of a unanimous global agreement, lays down values, principles and goals for the 21st Century as an oath to ensure its fulfilment. The said declaration makes a specific mention of certain values such as the need to protect the environment and joint cooperation that is noteworthy and forms the foundation of endeavours that are under the scope of this study and the reproduced below as follows (UN, 2000):

“Respect for Nature: *Prudence must be shown in the management of all livings species and natural resources, in accordance with the precepts of sustainable development. Only in this way can the immeasurable riches provided to us by the nature be preserved and passed on to our descendants. The current unsustainable patterns of production and consumption must be changed in the interest of our future welfare and that of our descendants.”*

“Shared responsibility: *Responsibility for managing worldwide economic and social development, as well as threats to international peace and security, must be shared among the nations of the world and should be exercised multilaterally. As the most universal and most representative organization in the world, the United Nations must play the central role.”*

Intuitively, a joint reading of the above principles would render an unequivocal understanding that nations ought to participate in a collaborative manner to combat the threats harming the sustenance of our environment by building a sustainable balance between need and greed. However, it is often the case that much thought is given into framing, drafting and explaining such concepts that often doesn't need any explanation but no further action is taken in realizing the contents of a paper that will be stacked in shelves as was the case regarding in 1992 with *The Rio Declaration on Environment and Development* (UN, 1992) wherein the following (select portions of the declaration are reproduced below) was agreed but not acted upon:

“Principle 7: *States shall co-operate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the*

responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.”

“Principle 12: States should co-operate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing transboundary or global environmental problems should, as far as possible, be based on an international consensus.”

“Principle 16: National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.”

Albeit the fundamentals and concepts sought to be enforced are important, an inaction to realize the same could've been in the minds of the leaders convened at the summit that they enumerated goals to realize the principles they laid down and the same is reproduced below (UN, 2000):

“We resolve therefore to adopt in all our environmental actions a new ethic of conservation and stewardship and, as first steps, we resolve:

- To make every effort to ensure the entry into force of the Kyoto Protocol, preferably by the tenth anniversary of the United Nations Conference on Environment and Development in 2002, and to embark on the required reduction in emissions of greenhouse gases.*
- To intensify our collective efforts for the management, conservation and sustainable development of all types of forests.*
- To press for the full implementation of the Convention on Biological Diversity and the Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa.*
 - To stop the unsustainable exploitation of water resources by developing water management strategies at the regional, national and local levels, which promote both equitable access and adequate supplies.*
- To intensify cooperation to reduce the number and effects of natural and manmade disasters.*
- To ensure free access to information on the human genome sequence.*

The order of the enumerated goals is noteworthy as it seems to follow, on a plain reading, a pattern of reasonable achievement, being the first goal of reducing the emission of greenhouse gasses ought to be achieved first.

However, ever since the Millennium Declaration of 2000 has been enacted, the global economy and scenario has evolved rapidly; some for the better while others for the worse. Whilst goals such as gender equality, hunger, diseases etc have become more difficult to overcome (UN, 2014), poverty and economic standards of developing and

transitioning economies have become better over time. Such development can be easily and summarily gauged by graphing the GDP of the global economy over the years and classified into three: the developed economies, transitioning economies and developing economies (UN, 2014).

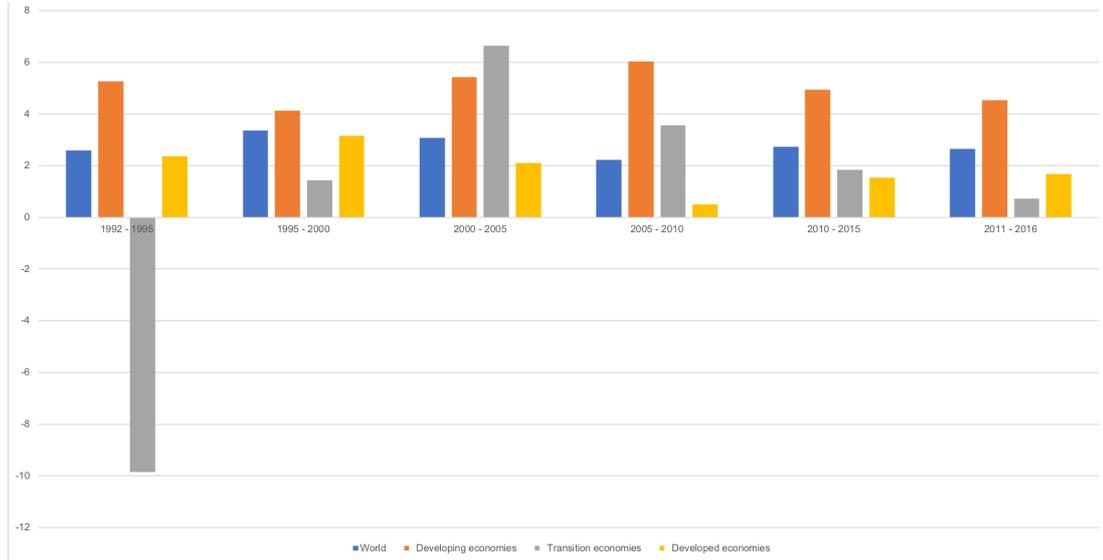


Figure 1: Graphical representation of GDP (in %) basis clustering of years
Source: UNCTADStat.org

A detailed view of Figure 1 is as below:

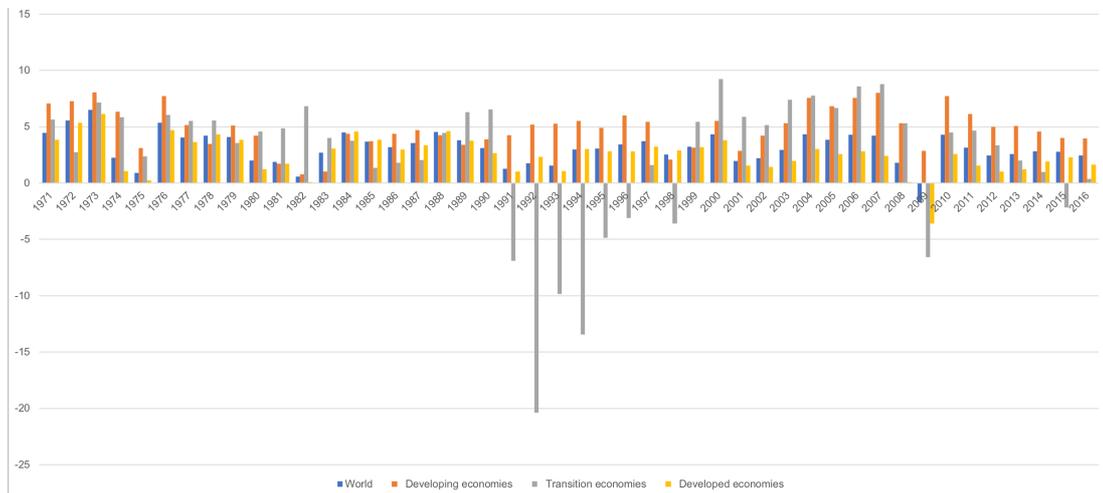


Figure 2: Graphical representation of GDP (in %) from 1971 till 2015
Source: UNCTADStat.org

GDP and global trade have a phenomenon of one hand feeding the other and therefore, it is complete to note how global trade has increased over the years as below.

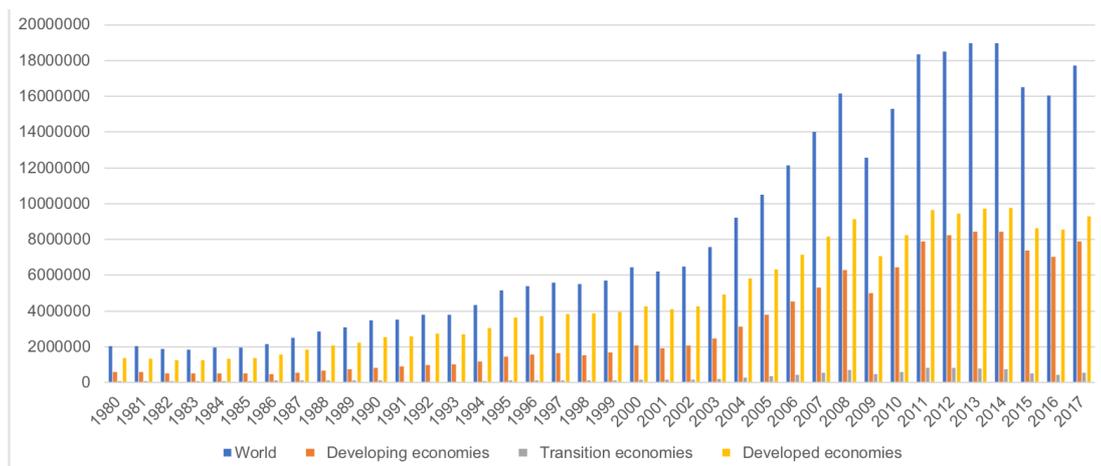


Figure 3: Graphical representation of global trade till 2017 (in USD)
Source: UNStat, 2018

Rampantly growing trade, as above, worsened the achievement of targets set earlier coupled with grave inaction necessitated the world leaders to revisit the drawing board to chalk out a revised strategy and revisiting sustainable goals. Accordingly, an Open Working Group of the General Assembly of the United Nations was formed for the purposes of preparing a “post-2015” agenda in light of Principle 7 of the Rio Declaration of 1992 (UN, 1992) as reproduced above. In order to strengthen the steps to be undertaken, Principle 7 of the Rio Declaration of 1992 (*supra*) was enshrined as a concept of Common but Differentiated Responsibilities (CBR) that later on forms the basis of the post-2015 agenda and thereafter, the SDGs (UN India, 2015).

Thereafter, much was discussed and negotiated which culminated in the adoption of Resolution A/70/L.1 by the General Assembly of the United Nations on 25th October 2015 which enumerates the 2030 agenda for Sustainable Development (UN, 2015) through 17 sustainable development goals and 169 targets.

Some excerpts of the said resolution is extracted and reproduced as below with adequate caution to avoid interpreted out-of-context (UN, 2015):

“...the interlinkages and integrated nature of the Sustainable Development Goals are of crucial importance in ensuring that the purpose of the new Agenda is realized.”

“We are determined to address decisively the threat posed by climate change and environment degradation. The global nature of climate change calls for the widest possible international cooperation aimed at accelerating the reduction of global greenhouse gas emissions and addressing adaptation to the adverse impacts of climate change. We note with grave concern the significant gap between the aggregate effect of parties` mitigation pledges in terms of global annual emissions of greenhouse gasses by 2020 and aggregate emission pathways consistent with having a likely chance of holding the increase in global average temperature below 2 degrees Celsius, or 1.5 Celsius above pre-industrial levels.”

“Seventy years ago, an earlier generation of world leaders came together to create the United Nations. From the ashes of war and division they fashioned this Organisation and the values of peace, dialogue and international cooperation which

underpin it. The supreme embodiment of those values is the Charter of the United Nations. Today we are also taking a decision of great historic significance. We resolve to build a better future for all people, including the millions who have been denied the change to lead decent, dignified and rewarding lives and to achieve their full human potential. **We can be the first generation to succeed in ending poverty; just as we may be the last to have a chance of saving the planet. The world will be a better place in 2030 if we succeed in our objectives.**”

In the same vein, there are various acknowledgements of reality; that each sovereign battles its respective priorities and hurdles in achieving the SDGs enumerated by UN, that data remains unavailable and other challenges which is strongly urged to overcome for the sake of “our common home” (UN, 2015). The 17 SDGs are as follows:

Goal 1. End poverty in all its forms everywhere.

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

Goal 3. Ensure healthy lives and promote well-being for all at all ages.

Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

Goal 5. Achieve gender equality and empower all women and girls.

Goal 6. Ensure availability and sustainable management of water and sanitation for all.

Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all.

Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

Goal 10. Reduce inequality within and among countries.

Goal 11. Make cities and human settlements inclusive, safe, resilient and Sustainable.

Goal 12. Ensure sustainable consumption and production patterns.

Goal 13. Take urgent action to combat climate change and its impacts

Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.

Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.

Since Goal 13 of the SDGs is under the scope of this study, the contents of the said Goal as enumerated by the United Nations is enumerated below. At this juncture it is noteworthy to point out that the United Nations Framework Convention on Climate Change is considered to be the primary authority to negotiate on climate change between countries however, a brief overview on the SDGs is essential to highlight the intention of all participating sovereigns to combat climate change/environmental pollution. Furthermore, for the sake of the study, the phrases climate change and environmental pollution would be used interchangeably in light of the scope of the study. Goal 13 of UN SDGs is as follows (UN, 2015):

*“Goal 13. Take urgent action to combat climate change and its impacts**

13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries

13.2 Integrate climate change measures into national policies, strategies and planning

13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning

13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly \$100 billion annually by 2020 from all sources to address the needs of Developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible

13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities”

2.2. UNFCCC and related measures

Having paved way for the United Nations Framework Convention on Climate Change, it is essential to study the same for the scope of the research question at hand. The United Nations Framework Convention on Climate Change, 1992, although a unique and vital instrument, is a culmination of various earlier efforts to combat climate change and/or curb atmospheric pollution such as:

- a. General Assembly Resolution 43/53 (UN, 1988),
- b. General Assembly Resolution 44/207 (UN, 1988),

- c. General Assembly Resolution 44/228 (UN, 1989),
- d. General Assembly Resolution 44/206 (UN, 1989),
- e. General Assembly Resolution 44/172 (UN, 1989),
- f. General Assembly Resolution 45/212 (UN, 1990),
- g. General Assembly Resolution 46/169 (UN, 1991)
- h. Rio Declaration of 1992 (UN, 1992),
- i. The Vienna Convention for the Protection of the Ozone Layer, 1985 (UN, 1985)
- j. The Montreal Protocol on Substances that Deplete the Ozone Layer, 1987 (UN, 1987)

Echoing the sentimentalities of sustainable development, the United Nations Framework Convention on Climate Change is framed for the sole purpose of maintaining the levels in the atmosphere to avoid atmospheric degradation so as to permit the environment to naturally recover from externalities caused by human interference and for the same to be done in a time-period manner (UN, 1992).

Building under the aegis of the United Nations Framework Convention on Climate Change is the Paris Agreement on Climate Change that was brought into force on 4 November 2016 which is aimed at restricting the increasing warming of the globe to under 2 degrees Celsius and thereafter to 1.5 degrees Celsius by requiring all State parties ratifying the Paris Agreement to endeavor towards the goals as set out in the said agreement through nationally determined contributions (NDCs) (UNFCCC, 2015). In addition to the above, the remainder of the agreement embodies an agreement to foster the atmosphere by adopting long term strategies lowering the emission of greenhouse gases (*supra*). The aforementioned NDCs forms the core in latter of the agreement as it encompasses the proposal and goals by each country in attaining the mandates of the Paris Agreement per Article 4, paragraph 2 (UNFCCC, 2015)

A combination of NDCs will aid in ascertaining if the mandates of the Paris Agreement can be realized and strategize accordingly. Despite political standoff during negotiations, it is noteworthy that the Paris Agreement has adopted a policy of equity wherein it is inherently provided for developing countries to take a longer duration to achieve the mandates of the said agreement. These NDCs are to be submitted every 5 years with the next round of submission due in 2020.

A striking observation is that, like most conventions, the signatory state party is incumbent to enact upon the contents of the Paris Agreement and ought to realize or partially realize (limited to its sovereignty) their goals. Although this is the basis of international law, this allows a certain leeway for the intended goals to be sought at a later stage in time as opposed to when it was intended to be fulfilled. Therefore, the crux of such international instruments boils down to the urgency of the situation at hand sought to be tackled so as to ensure a pan-global appreciation and fulfillment. In this regard, it is noteworthy to briefly glance upon the the levels of greenhouse gases in the atmosphere so as to gauge the expediency required in tackling this situation. Surely, the effects of greenhouse gases on climate change need not be delved upon.

The Graphical representation of CO₂ emissions are projected on the basis of historical data and 4 scenarios around the policies regarding emissions of greenhouse gases. Under RCP 2.6, it is estimated that emissions would peak prior to 2020 (van

Vuuren, D. *et. al.*, 2007) and thereafter decline whereas in juxtaposition, under RCP 8.5 (Riahi, K. and Nakicenovic, N., 2007), CO₂ emissions would uncontrollably increase continuously. The median scenarios are RCP 4.5 (Clark. L, *et. al.*, 2007) and RCP 6 (Fujino. J, *et. al.*, 2006) which are estimated to be intermediate stabilization scenarios, surely the preferred reality being RCP 4.5.

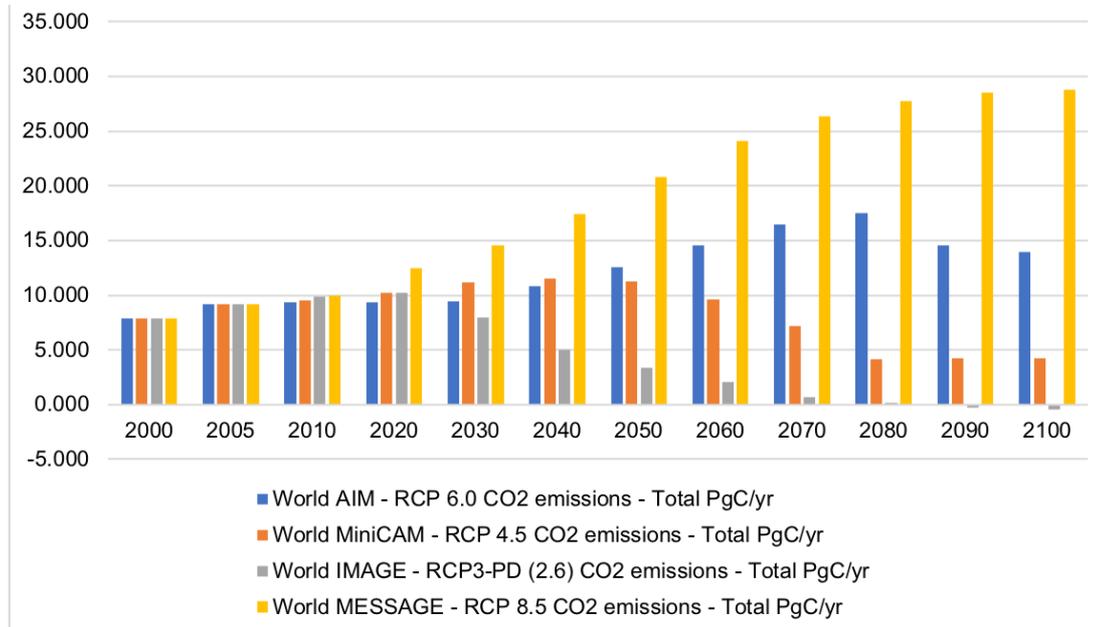


Figure 4: Graphical representation of projected CO₂ emissions based on 4 scenarios
Source: RCP Database (2018)

Despite the scientific significance of these estimations, it is beneficial to relate to change caused by these emissions. Therefore, to bring perspective, it is estimated that should RCP 2.6 be the case, the area between the tropic of Cancer and the tropic of Capricorn equatorial region would face about 1-10 days with temperatures above 35 degrees Celsius whereas if RCP 8.5 is the case then the area between the tropic of Cancer and the tropic of Capricorn would face over 180 days with temperatures about 35 degrees Celsius resulting in severe drought and/or flooding (World Bank, 2018). Data collected in time along with these RCPs would aid in determining the necessary measures so as to achieve the permissible limits of CO₂ emissions.

Having laid down a brief overview of the international measures towards combatting climate change and its urgency, it is time to piece these efforts with international shipping. In the same vein, it is only just to look upon the IMO to understand how the abovementioned international measures are being translated and enforced upon the international shipping industry. Since the underlying elements of the various efforts by intergovernmental organizations such as the UNFCCC, IMO and the likes are the same, many efforts in the past and in the present are relatable to each other and to the 17 SDGs laid down by the UN. For instance, the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (IMO, 1978) establishes the standard for training and certification of seafarers along with watchkeeping for these seafarers embodies Goal 4 of the SDG being Quality Education. Similarly, further correlation of IMO instrument and UN SDGs are enumerated as below (IMO, 2018):

1. The World Maritime University and the IMO Maritime Law Institute seeks to fulfill Goal 4 – Quality Education.
2. GloMEEP; a joint project of the GEF, UNDP and IMO, seeks to fulfill Goal 7- Affordable and Clean Energy.
3. IMO's Integrated Technical Cooperation Programme seeks to fulfill Goal 10 – Reduced Inequalities.
4. One of the pillars of IMO being the International Convention for the Prevention of Pollution from Ships, 1973 seeks to fulfill Goal 12 – Responsible Consumption and Production.
5. Through the same International Convention for the Prevention of Pollution from Ships, 1973 and other raft of measures, the IMO seeks to also fulfill Goal 13 – Climate Change.
6. Similarly, the IMO, through the Ballast Water Convention and other noteworthy instruments, seeks to fulfill Goal 14 – Life under water.

As commendable the synergy from the union of such intergovernmental instruments are, the research question at hand necessitates refinement of the scope of the study. Accordingly, the measures by the IMO in regards to climate change shall be delved into to draw the measure the ambit and draw its boundaries whilst highlighting limitations for future consideration.

The term “greenhouse gases” is an all-encompassing term that consists of any emission into the atmosphere that attributes towards climate change (Kijewska. A, *et. al.* 2016). In this regard, there is a natural process of climate change stemming from a natural emission of “greenhouse gases” like CO₂, methane etc into the atmosphere and then there is the much debated, accelerated climate change induced by excessive emission of “greenhouse gases” caused by man-made activities. One would argue that progress as we have achieved now, although subjective to each sovereign, could not have been achieved if not for the development of industries and technology and its proportionate cost to the environment but as is the case with any depleting resources, it ought to be carefully managed so as to ensure its sustenance. With the advancements and developments of today, we have created for ourselves, it is time to use that to modify our ways from barbaric methods and the time for that is now; which is effectively the premise of sustainable development.

However, synonymous to the vastness of the atmosphere are the variety of issues to be tackled to clean up the atmospheric environment and controlling the emissions into the same and it is stressed that atmospheric pollutants comprise of an an equally large threat as much as climate change does although there isn't a directly attributable SDG in its name. These pollutants are responsible for premature deaths, respiratory diseases, acid rains, imbalance of pH level of the soil and loss of agricultural yield amongst a plethora of negative effects (Corbett *et. al.* 2007).

In this context lies the significance of an international instrument, to the likes of the Paris Agreement, called the UNECE Convention on Long Range Transboundary Air Pollution, 1979 which was entered into force in 1983 where State Parties have agreed to “*protect man and his environment against air pollution and shall endeavor to limit and, as far as possible, gradually reduce and prevent air pollution including long range transboundary air pollution which is when air pollution emanates from a State party but causes its polluting effects within another State party*” (UNECE, 1979). This

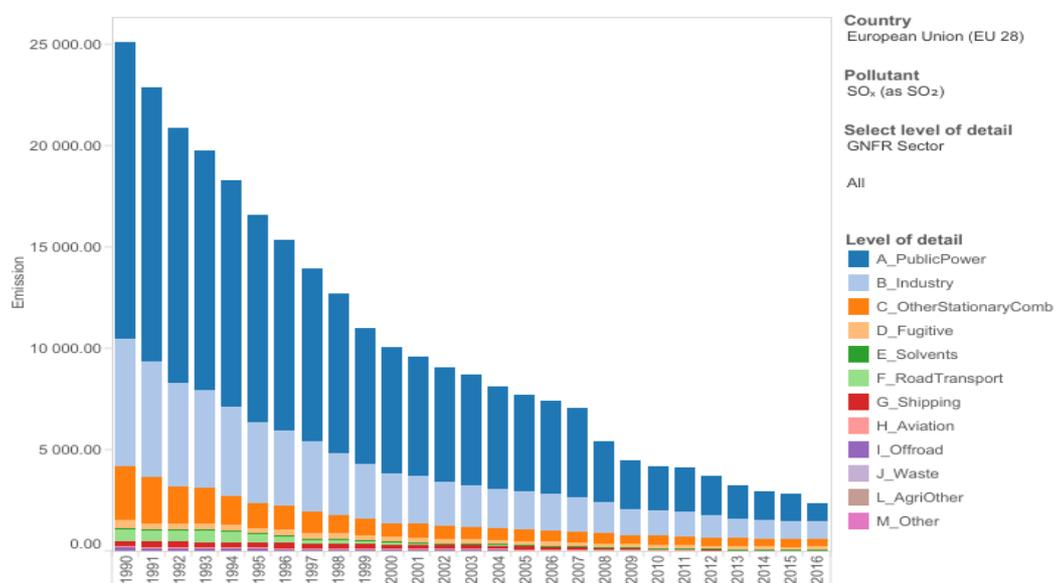
collective action was formed and enforced to monitor and share information on pollutants of the atmosphere, in particular, Sulphur compounds (*supra*).

The said convention was notably adapted time to time so as to achieve its goal of reducing air pollutants via numerous protocols namely the Protocol to the CLRTAP of 1985 signed in Helsinki, the Protocol to the CLRTAP of 1991 signed in Geneva, the Protocol to the CLRTAP of 1991 signed in Geneva and so on till the Amendment to the CLRTAP of 2012 signed in Geneva but what is most noteworthy is the Protocol to the CLRTAP of 1979 signed in Geneva for the sole purpose of including Nitrous compounds into the scope of the CLRTAP (UNTC, 2018).

2.3. Emissions by the shipping industry

That said, it is noteworthy the signatories to the CLRTAP are predominantly European nations, Russian Federation and USA (a total of 51 nations) to the exclusion of Asia, Australia and Latin America (UNTC, 2018). The said convention does not make a distinction on emission per industry or sources, however, the regulatory organization called the CEIP, formed under the convention to monitor data shared by sovereigns, does classify it per industry. Since data on emission inventories from the EU (EU28) is thoroughly available till 2016 for Sulphur and nitrous compounds, a graphical representation of the data from CEIP is reproduced below to highlight the decrease in the emission of these compounds through collective efforts (CEIP, 2018).

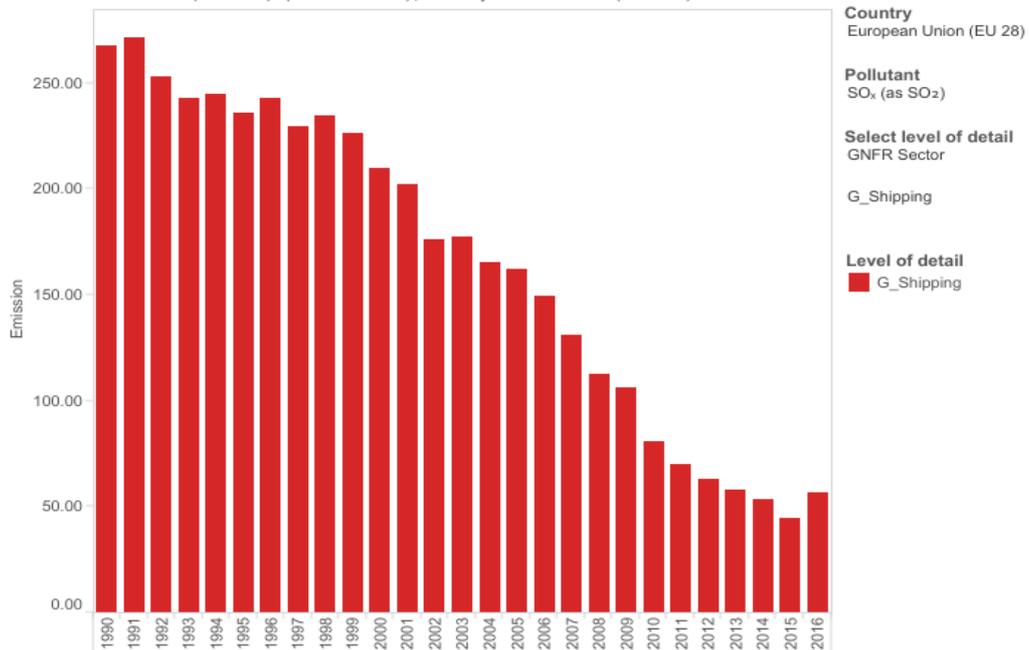
The CLRTAP regulates the emission of SO_x and NO_x and in this regard, the contribution and progress by the shipping industry is graphically represented below. For each compound, the cumulative emission from all industries are shown followed by the shipping industry's emission of SO_x and NO_x.



The data presented in this data viewer uses the GNFR14 and NFR14 nomenclature and is the officially reported data submitted up to 25 June 2018.

Figure 5: Graphical representation of SO_x emissions in EU28
Source: CEIP (2018)

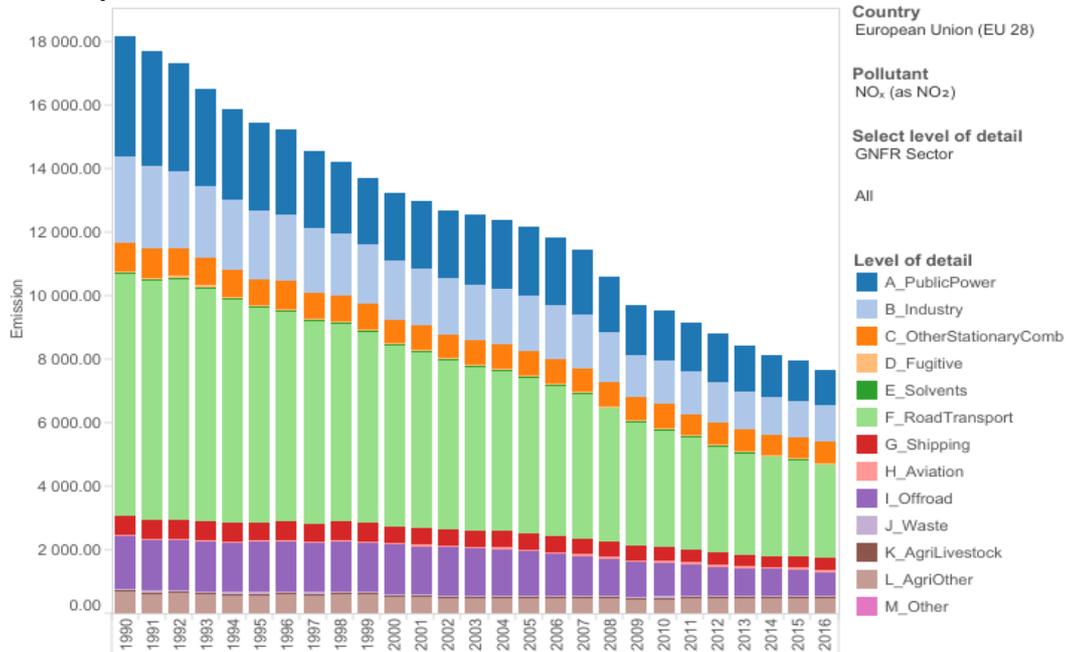
The contribution by the shipping industry towards Figure 5 as above is represented below.



The data presented in this data viewer uses the GNFR14 and NFR14 nomenclature and is the officially reported data submitted up to 25 June 2018.

Figure 6: Graphical representation of SOx emissions in EU28 by shipping
Source: CEIP (2018)

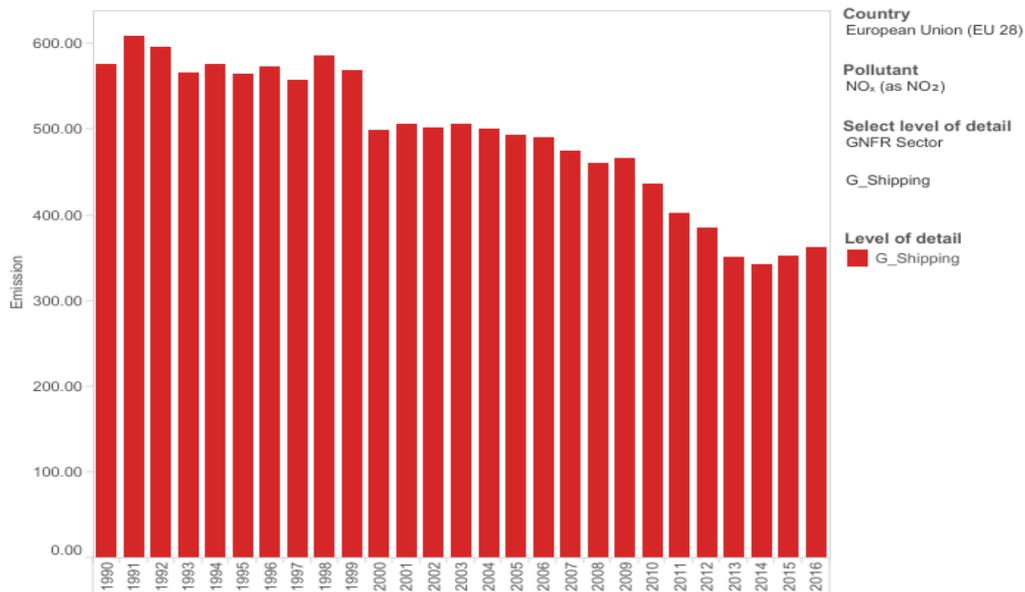
Similarly, the emission of NOx from all industries is below.



The data presented in this data viewer uses the GNFR14 and NFR14 nomenclature and is the officially reported data submitted up to 25 June 2018.

Figure 7: Graphical representation of NOx emissions in EU28
Source: CEIP (2018)

The emission of NOx by the shipping industry in Figure 7, as above, is shown as below.



The data presented in this data viewer uses the GNFR14 and NFR14 nomenclature and is the officially reported data submitted up to 25 June 2018.

Figure 8: Graphical representation of NOx emissions in EU28 in shipping
Source: CEIP (2018)

As much as the success of these collective efforts can be perceived from the above images, CEIP has calculated that there is a 40-80% reduction in the emission of pollutants (CEIP, 2017) and also due to the establishment of Sulphur Emission Control Areas in the EU since 2004 as shall be elucidated further on.

At this juncture of success, it is crucial to highlight that the CLRTAP mandates and governs only 51 nations out of 195 after acknowledging the fact that pollutants in the air have a long ranging effect. Therefore, the results or success achieved is diminished in the global context since the bulk of air polluting/developing or transitioning countries (going on the assumption that developing or transitioning countries cannot do without such polluting measures for industrialization and progress) such as parts of Asia, Africa and Latin America are excluded from the mandate of the said Convention.

With the aforesaid limitation, if one can say so, it is imperative to understand the ambit of efforts that need to be undertaken for a sustainable atmosphere. In this regard, the Representative Combination Pathways (RCPs) would be significant to draw light on the projected changes in these compounds as such RCP estimations forms the basis for calculations on climate change for the IPCC conferences (RCP Database, 2018). Similar to the projections for CO2 emission (as above), the projections for SOx and NOx are also done on the basis of 4 scenarios as graphically represented below. Being projections, it is scientifically dutybound to account for plausible outcomes and accordingly carry out experiments. Therefore, scenarios cannot be ruled out merely on account of it being too extreme as it could be a possibility and since these RCPs form building blocks for more complex calculations on climate change and other atmospheric studies (*supra*). That said, RCP 4.5 and RCP 6.0 are considered to be

median-projections, colloquially speaking, whereas RCP 2.6 and RCP 8.5 are considered to be comparatively extreme projections; all of them plausible. Therefore, these figures and their visual representations ought to be only considered to ascertain the strength of measures that's need to be executed so as to achieve a restriction on the pollution into the atmosphere and also as a measure to modify such measure from time to time.

In this regard, the projected emission of SOx and NOx is pictographically represented in the same manner as in above; first the projected emission of the compound from all industries followed by the emission of the said compound by the shipping industry. Caution to the reader that as opposed to the historical emission in Figures 5 to 8 are based on data from the EU as part of CLRTAP, the projections below are a global projection of emission of SOx and NOx.

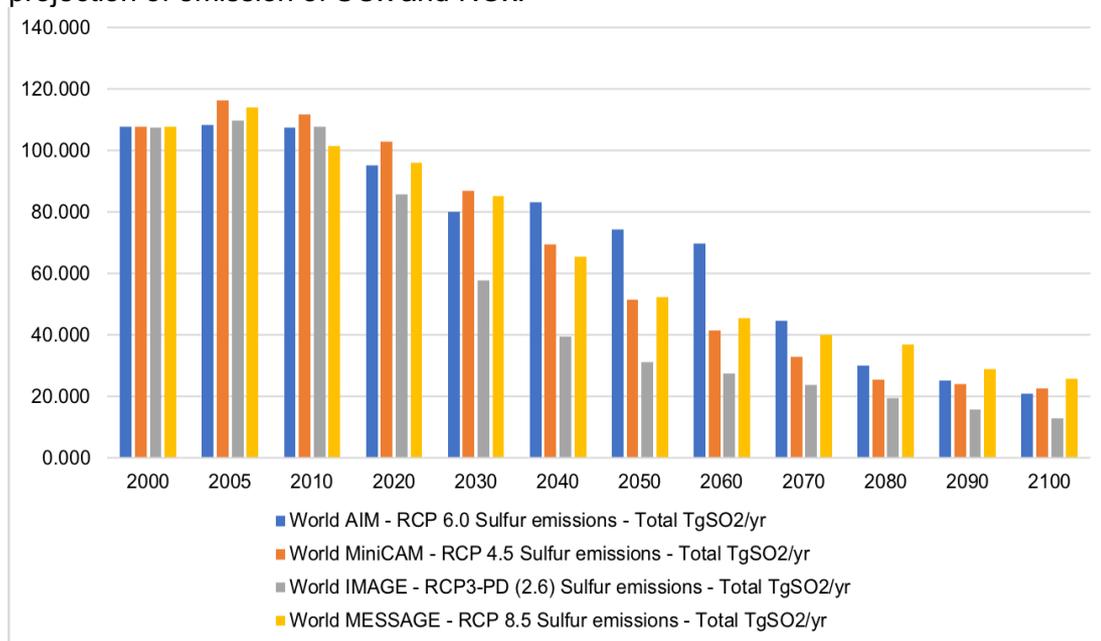
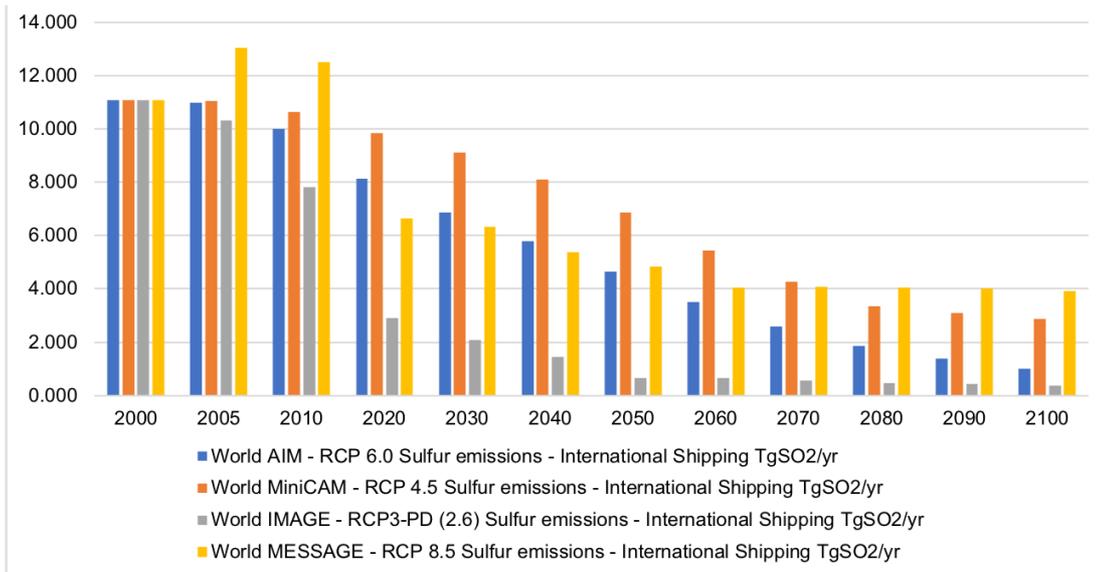


Figure 9: Graphical representation of projected Global SOx emissions based on 4 scenarios

Source: RCP Database (2018)

Projected emission of SOx by international shipping from the projection as in Figure 9 is as below.



*Figure 10: Graphical representation of projected SOx emissions from International Shipping based on 4 scenarios
Source: RCP Database (2018)*

Upon analyzing the numbers and graphs for Global SOx emissions (Figure 9) and SOx emissions (Figure 10) from International shipping; it is seen that SOx emissions from international shipping contribute between 4-11% over the predicted periods till 2100 depending upon the scenarios. To elucidate further, under RCP 6.0 SOx emissions from international shipping is seen to account for 7.28% of the Global SOx emissions, under RCP 4.5 SOx emissions from international shipping is seen to account for 11.61% of the Global SOx emissions, under RCP 2.6 SOx emissions from international shipping is seen to account for 4.3% of the Global SOx emissions and under RCP 8.5 SOx emissions from international shipping is seen to account for 10.42% of the Global SOx emissions. It may puzzle you that RCP 4.5, being a median based projection, seems to indicated the highest ratio for SOx emissions from international shipping to Global SOx emissions. This is inherent of the nature of the curve RCP 4.5 forms as opposed to RCP 8.5 from Figure 10 (for International Shipping) as it follows a more delayed fall over the projected time instead of a sharp fall between 2010 and 2020.

Similarly, the projections of NOx from all industries and projections of NOx from international shipping is represented as below.

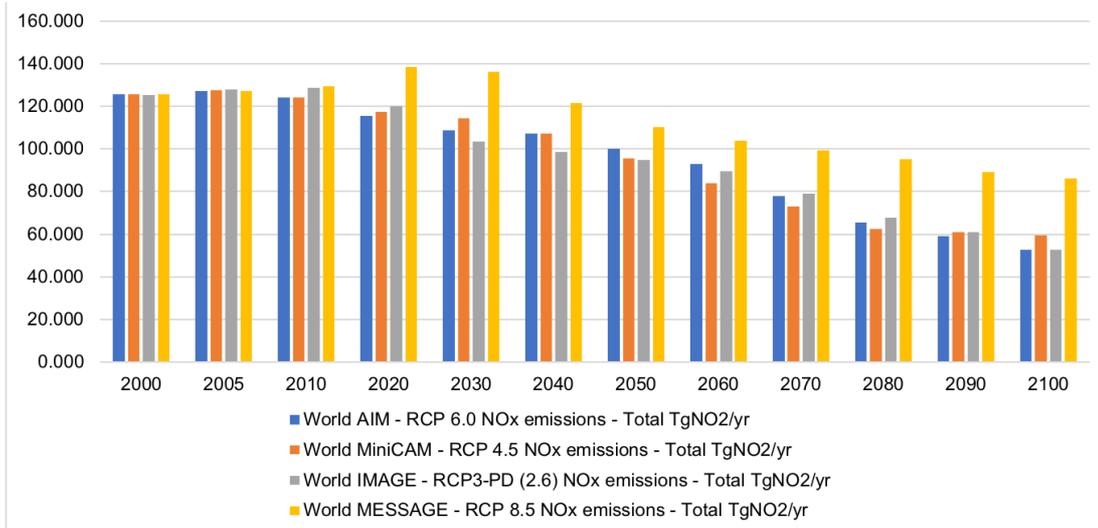


Figure 11: Graphical representation of projected Global NOx emissions based on 4 scenarios
Source: RCP Database (2018)

The projected emission of NOx from international shipping is as below.

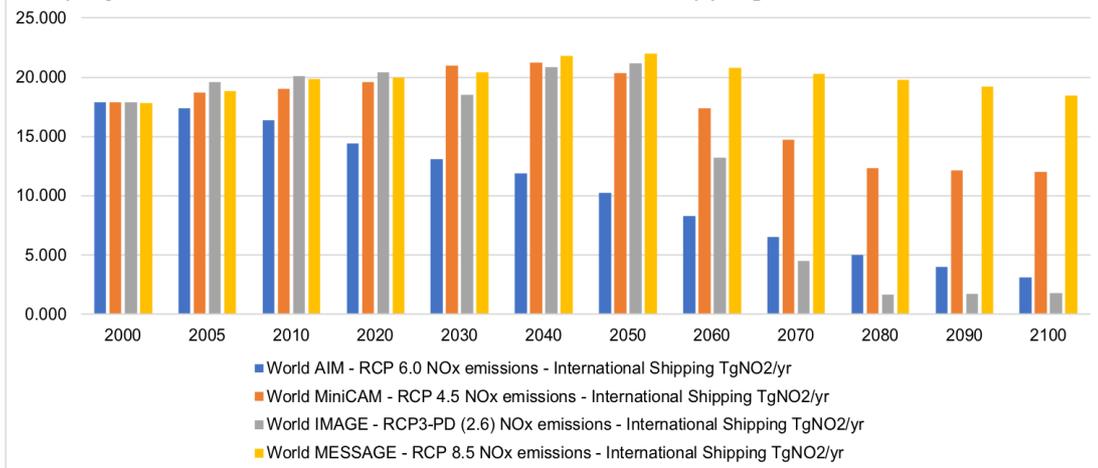


Figure 12: Graphical representation of projected NOx emissions from International Shipping based on 4 scenarios
Source: RCP Database (2018)

Similarly, upon analyzing the numbers and graphs for Global NOx emissions (Figure 11) and NOx emissions (Figure 12) from International shipping; it is seen that NOx emissions from international shipping contribute between 10-18% over the predicted periods till 2100 depending upon the scenarios. To elucidate further, under RCP 6.0 NOx emissions from international shipping is seen to account for 10.39% of the Global NOx emissions, under RCP 4.5 NOx emissions from international shipping is seen to account for 18.4% of the Global NOx emissions, under RCP 2.6 NOx emissions from international shipping is seen to account for 12.7% of the Global NOx emissions and under RCP 8.5 NOx emissions from international shipping is seen to account for 17.9% of the Global NOx emissions. As was in the case of projected SOx emissions,

is it interesting to note the the average contribution of NOx emissions from International Shipping is close under RCP 4.5 and RCP 8.5. it can be seen from Figure 12 (for International shipping) that both seems to be a wave peaking at different times thereby accounting for the slight difference in their ratios. RCP 8.5 seem to be rising till 2050 and then slowly falling whereas, RCP 4.5 rises till 2040 and then starts falling till 2080.

Chapter 3 - Restriction on emission of Sulphur Compounds

In this chapter, the measures instituted by the IMO to restrict or limit the emission of air pollutants are explained. Furthermore, the various options members of the industry may execute to comply with imminent regulations/reforms are explained along with their respective limitations. Furthermore, it is essential to understand the present status of the shipping industry so draw perspective on the impact the imminent reforms would have on the shipping industry.

3.1. Measures by the IMO

Shipping is considered to be least polluting in terms of the cargo carried in comparison to other modes of transport (UNCTAD, 2017). However, comfort in such relative figures does not absolve the emission shipping is responsible for in absolute terms. With an average contribution of 4 to 11% of SO_x emissions and 10-18% of NO_x emissions from international shipping, the IMO saw this agglomerating impediment to life, health and economy and started to/took appropriate measures. This was so as the industry predominantly used High Sulphur Fuel Oils which, to bring perspective, are the bottom of the barrel from the distillation of crude oil so much that the only grade beneath this is tar used for asphalt.

The most notable and all-encompassing of such measures is the MARPOL convention along with its Annexures. MARPOL Annexure VI seeks to deal with air pollution from shipping, particularly, the emission of pollutants into the atmosphere through the exhaust of the ships. Annexure VI specifically provides for regulations to prohibit/reduce emissions of Sulphur compounds such as SO_x, Nitrous compounds such as NO_x and particles and/or substances that deplete the ozone layer. In order to do so, the said annex mandates minimum standards for incineration on board ships and permissible limits of SO_x (Regulation 14) and NO_x (Regulation 13) in fuels used by the ships. However, Annex VI evolved to be a pivotal instrument after numerous amendments and protocols over time.

MARPOL Annex VI, having been adopted in 1997, entered into force on 19th May 2005 shortly thereafter was sought to be revised to incorporate technological advancements that occurred over time while the annex was dormant (IMO, 2018). Accordingly, Annex VI was out back into the workshop for changes and was brought back to be adopted in its new avatar in October 2008 that encompasses pollution by SO_x, NO_x etc. and was brought into force on 1st July 2010. (*supra*). Henceforth, shipping was conducted by tiptoeing around boundaries dictating pollution and emission limits as shall be elaborated further on.

The key takeaways from MARPOL Annex VI as enforced on 1st July 2010 are the following (IMO, 2010):

1. Creating of SECA which are designated areas requiring a low emission of SO_x. Regulation 13 of Annex VI names the Baltic Sea as a SECA (on account of being designated as an ECA per Annex I of MARPOL) with a proviso to include more from time to time as long as the criteria mentioned in Appendix III of the said annex is fulfilled. – Regulation 14.
2. The maximum permissible content of Sulphur in any fuel used by ships anywhere outside the ECAs are 4.5% m/m till 1st January 2012. Thereafter, it

would be reduced to 3.5% m/m till 1st January 2020 after which, it would be reduced again to 0.50% m/m. – Regulation 14.

3. The imminent enforcement of the standard for 2020 and onwards would be subject to a review on the availability of suitable fuel that ought to be completed by 2018 failing which the last phase would be enforced from 2025 onwards. – Regulation 14.
4. The maximum content of Sulphur used by ships in ECAs are 1.5% m/m till 1st July 2010. Thereafter, the limit would be reduced to 1% m/m till 1st January 2015 and reduced again till 0.1% m/m from 1st January 2015. – Regulation 14.
5. The Annex also makes a *proviso* that any attachments or modifications or other measures may be adopted so far as the goals of the said annex per the standards laid therein are fulfilled to the satisfaction of the State party. - Regulation 4.
6. The NOx technical code brought into force alongwith Annex VI provides for regulating and certifying marine diesel engines. Tier I standards mandate that marine diesel engines installed on or after 1st January 2000 would have to restrict their NOx emission to 17.0g/kWh. Thereafter, Tier II standards mandate that marine diesel engines installed on a ship on or after 1st January 2011 are to restrict their NOx emissions to 14.4g/kWh from 17.0g/kWh which would be followed by more restrictive Tier III standards for engines installed on or after 1st January 2016. – Regulation 13.
7. Ships equipped with rechargeable systems working on substances categorized as ODS shall maintain a record book or a log book which ought to contain specific details as mentioned per the annex. – Regulation 12.

The imminent or last phase of IMO regulations was officially announced to be effective from 2020 by way of MEPC 70 (IMO, 2016) by way of the following:

“HAVING CONSIDERED, at its seventieth session, based on the aforementioned assessment of fuel oil availability, whether it is possible for ships to comply with the implementation date in regulation 14.1.3 of MARPOL Annex VI,

DECIDES that the fuel oil standard in regulation 14.1.3 of MARPOL Annex VI shall become effective on 1 January 2020;”

3.2. ECAs and standards of compliance

Although capitulated into 7 points, MARPOL Annex VI brings about a wide and head turning array of changes into shipping on the basis of the pollutants it targets to reduce/eliminate. Accordingly, tackling the restriction of emission of each pollutant under the ambit of MARPOL Annex VI merits an independent study, if not more, to analyze its impact on the shipping industry. For the sake of the research question at hand, the restriction on the emission of SOx is solely under focus and scope. Furthermore, it is crucial to understand that whilst Annex VI of the MARPOL regulates the standards for Sulphur content in fuels used by ships inside and outside SECAs on one hand, it also provides for alternative measures to be adopted by ships as long as the goal of restricting the emission of Sulphur are met to the satisfaction of State Parties. However, what those standards are should one chose to adopt alternative measure to comply with the Annex VI is something the said annex is silent on. Since such alternative measure of restricting Sulphur emissions are to be done to the satisfaction of the State Party whose flag the ship is flying, the IMO encourage the

State Party to refer to its “2015 Guidelines For Exhaust Gas Cleaning Systems” (IMO, 2015). Therefore, it is assumed that the standards for Sulphur content in fuels used by ships would be considered as a numeric representation of permissible Sulphur emissions by ships and shall be used interchangeably. Surely, industry experts on emissions have codified and clarified the lacuna as highlighted above but the assumption is made for the sake of brevity and scope of the research question at hand.

As on date, the SECAs are as follows:

1. Baltic Sea
2. North Sea
3. North American coasts
4. United States Caribbean Sea

Annex I to MARPOL regulates the emission of oil and related products into the sea and has designated numerous places as “*special areas*”, vide Regulation 1.11 for the purposes of the said Annex (IMO, 2004) from which Annex VI selectively chooses the Baltic Sea to be also categorized as a SECA (IMO, 2010). Similarly, Annex V to the MARPOL regulates the disposal of garbage into the seas provides for the North Sea which also has been categorized as a SECA by Annex VI (IMO, 2010). Thereafter, after the entry into force of Annex VI on 1st July 2010, the North American Area was categorized as a SECA on 1st August 2012 vide an amendment to the said Annex (IMO, 2010) and subsequently, the United States Caribbean Sea area was last categorized as a SECA on 1st January 2014 vide another amendment to the said Annex (IMO, 2011).

Seeing as two out of the four SECAs are within the dominion of the European Parliament, the European Parliament sought to impose the most restrictive practice regarding emission of SO_x per MARPOL for SECAs upon all inland waterway vessels and ships at berth in EU Ports, i.e. Sulphur emissions shall not exceed 0.1% m/m from 1st January 2015, to be effective from as early as 1st January 2010 for all inland waterway vessels and ships at berth; as early as July 2005 (European Parliament, 2005). As one can see, this change was brought about even prior to amended Annex VI that was brought into force on 1st July 2010. Once the amended and now enforced Annex VI was brought into force, the European Parliament gave that the effect of national law vide its directive in 2012 whilst reinforcing its directive of 2005 (European Parliament, 2012). The European Parliament, by way of their directives, made an additional requirement of minimum standards for when vessels are at berth as compared to the Annex VI of MARPOL.

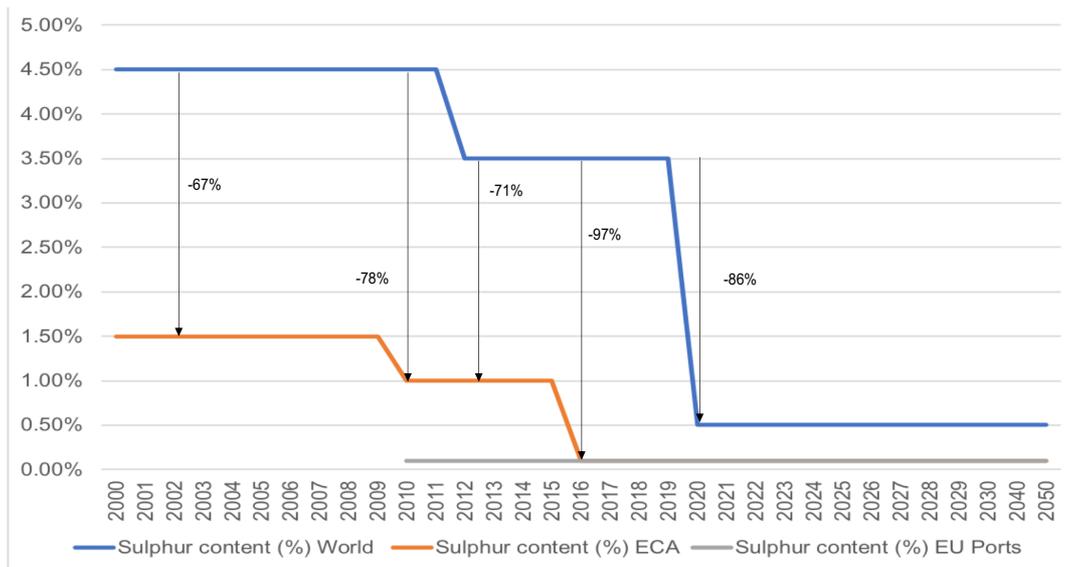


Figure 13: Graphical representation of the reduction of sulphur content in marine fuels
 Source: IMO, 2016 and Seatrade Maritime News(2016)

However, nations have principally acceded to such regulations by enforcing national legislations in line with the standards laid down by MARPOL Annex VI even though these parts of the sea/ocean are not strictly categorized as a SECA. For instance, China has mandated, since September 2015, that all vessels at berth or arriving into its ports are to run on fuels with a Sulphur content not exceeding 0/5% m/m (NRDC, 2014). This regulatory measure was brought into force as a part of the “*Ship and Port Pollution Prevention Special Action Plan (2015-2020)*”, an initiative to reduce the emission of SO_x and NO_x from shipping within Chinese territories (*supra*). The regulation as it stands today evolved from being applicable to 11 major ports in China which was extended to all Chinese port with effect from 1st January 2018. However, the regulation as it stands is for vessels to use fuels containing less than 0.5% m/m sulphur whilst at berth only. In order to facilitate this switch over, vessel ought to switch to the low sulphur fuel prior to one hour before arriving at berth and must continue on such a fuel till one hour prior to departure. This regulation would change with effect from 1st September 2019 extending itself to the entire ECA as demarcated per sovereign rights. Although Chinese regulation has codified the limitation on the emission of SO_x in terms of low sulphur fuels, it has clarified that other abatement measures would suffice as long as the standards for SO_x emission are satisfied (GARD, 2016). This is clarified in juxtaposition to other regulations as above and in other countries as would be dealt below who merely state the standards for emission of SO_x emission; a fine distinction between methods to achieve the end.

Similarly, Hong Kong has also legislated measures restricting the emission of SO_x vide a regulation dated 13th March 2015 (Government of Hong Kong, 2015) wherein vessels at berth or at anchorage ought to use fuels with Sulphur content not exceeding 0.5% m/m (UK PandI, 2015).

Despite the fact that certain parts of the globe exercised the spirit of the imminent Sulphur regulation in their own manner supplemented by IMO’s regulation over

SECAs, the shipping industry is of the strong opinion that the envisaged change “*will not be like flipping a switch*”, in the words of Mr. Unni Einemo, an IMO representative (Seatrade Maritime, 2018).

3.3. Compliance with 2020 Sulphur regulation

With these regulations in place, ships have been switching between fuels or alternative measure to comply with the same as a run up to the last phase of which is expected to come into effect in 2020, which has also already been implemented in major shipping hubs even though it is in a small proportion. Although this proportion does play a crucial role in the establishing as assumption that would be essential for the study, it does not shirk merit from the fact that options to ensure compliance of SOx emission are available.

Now begs the question; how does a shipping entity comply with these regulations on SOx emissions? Vessels can comply with these regulations by using any of the following measures (IMO, 2018):

1. low sulphur compliant fuel oil or gas as a fuel which was recognised by International Code for Ships using gases and other low flashpoint fuels which was adopted in 2015;
2. ECGS once such arrangements are approved by the Administration of the flag of the ship;
3. LNG propulsion;
4. Alternative fuels such as LPG, ethanol, methanol etc.

Implementation of the sulphur cap is incumbent on the State Parties of developing a system for reporting who shall advice the PPR Sub-committee on the progress who in turn shall report to MEPC. A survey conducted as a run up to the Future Fuels Seminar by Lloyd`s List Maritime Intelligence on the preferred options to be exercised by ships to comply with the imminent sulphur regulation shows a response rate of 38%; with 45% of the respondents opting to use low sulphur fuels, 20% of the respondents opting to use ECGS along with HFO and 16% of the respondents opting to switch to LNG propulsion at Appendix A.

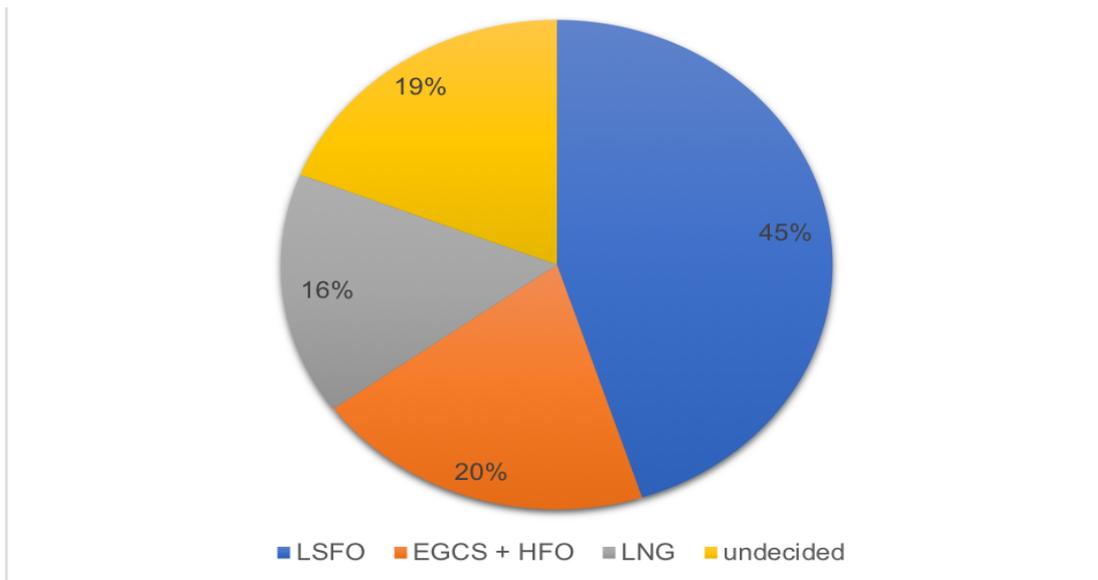


Figure 14: Pie chart showing the survey results on preferred options to comply with the sulphur regulation.

Source: Lloyds List Maritime Intelligence, 2018.

These numbers were also confirmed by a survey conducted by ExxonMobil (ExxonMobil, 2018).

The preference to use low sulphur fuels stems mainly on account of the investment required in the other method of compliance such as ECGS and LNG propulsion. Use of low sulphur fuels and scrubber systems are highly contested considering the nature of investment and urgency to comply with the impending regulation. Therefore, the use of LNG is discounted.

Even though low sulphur bunkers would be sold at a premium as compared to the high sulphur variant sold as on date, use of the same does not require any structural or engineering modification to the ship. ECGS, however, requires substantial modifications to the vessel that would require it to be dry docked so that the ECGS can be retro fitted. Retrofitting vessel with ECGS is estimated to cost approximately \$1.5 Million per ship subjective to the size of the ship with an installation cost of approximately \$600,000 along with unquantified dry docking costs and economic loss arising out of the dry dock as elucidated in Appendix B. Further details on scrubber systems are, at the moment, kept under confidentiality considering the market advantage sought to be enriched from the business of retrofitting/fitting ships with scrubbers. Furthermore, the ability to retro fit ships with ECGS is severely handicapped due to the number of dry docks available to do the needful. To this extent, the orderbooks show that 352 vessels have been ECGS installed with 100 ships pending completion of installation followed by 366 ships having confirmed dates for installation of ECGS from 2020. A cumulative of 818 ships are anticipated to have ECGS by 2023 as elucidated in Appendix C.

Considering the immediacy for compliance, the potential of grave loss of laying up ships and restriction by available dry docks, the choice of using low sulphur bunkers seems rather obvious. Therefore, to study the impact of this regulation, it is assumed

that ships would employ the use of low sulphur fuels as data on the same is comparatively available as a benchmark. The yearly average sulphur content in residual fuel oils, as of 2016, was 2.58% whereas the average sulphur content in distillate fuel, as of 2016, was 0.08% (IMO, 2018). therefore, it is considered that ships would be employing distillate fuels such as MGO to comply with the imminent regulation. In the same vein, the transition to 0.5% sulphur cap will have a greater impact on shipping that the transition to 0.1% sulphur cap in ECAs back in 2015 (Shell, 2017).

Over the years, till date, the price differential between MGO and HFO is \$ 190.75 per MT per the author`s own calculations. However, since the scope of the study is aimed at the impacts of the use of low sulphur fuels like MGO, it is thorough to understand how the increased costs of operating ships would impact the shipping industry.

In the same vein, it is intuitive in every study on the impact of a regulation that the enforcement of the regulation is thorough without any spills of leaks. In this regard, the imminent sulphur regulation, as on date, is silent on measures to ensure compliance by the industry although enforcement of regulations is solely under the ambit of each sovereign. Therefore, and with due caution not to divert from the research question at hand, it is essential that the following nations thoroughly enforce the sulphur regulation for the sake a bold step towards environmentally cleaner shipping:

Serial No.	Flag of the Ship	Percentage of Total tonnage	Ratification to Annex VI
1	Panama	18.44	Yes
2	Liberia	11.78	Yes
3	Marshall Islands	11.63	Yes
4	Hong Kong	9.31	Yes
5	Singapore	6.67	Yes
6	Malta	5.33	Yes
7	Bahamas	4.29	Yes
8	China	4.21	Yes
9	Greece	4.01	Yes
10	United Kingdom	2.20	Yes
11	Japan	1.85	Yes
12	Cyprus	1.81	Yes
13	Norway	1.18	Yes
14	Indonesia	1.08	Yes

*Table 1: List of countries per the percentage of global tonnage
Source: UNCTAD 2017 and IMO 2018*

The above list represents a cumulative 83.52% of the total fleet which suffices to indicate the level of compliance required for the goal of the Sulphur regulation to be met.

3.4. Uncertainty of adequate supply of low sulphur fuel

When IMO confirmed that the last phase of its regulation would come into effect as on 1st January 2020, it was premised on a study it had undertaken as provided for in

Regulation 14.10 of Annex VI to MARPOL. This study was published in 2016 by CE Delft, confirming that there would be adequate availability of compliant fuels, states that can produce 24% in excess of projected demand per the assumptions used in the base demand case of their study and can produce 2% in excess of projected demand per the assumption in the high demand case of their study (CE Delft, 2016).

However, Availability of fuel is still highly debated despite the report of the IMO of 2016 has affirmed thereby confirming the entry of the last phase of standards due from 1st January 2020. There is considerable evidence highlighting the non-availability of compliant fuels as shall be analysed hereinbelow. Out of 85 reported instances of non-availability of compliant fuel by flag states; the portions attributable to HFO, MDO and MGO are as below.

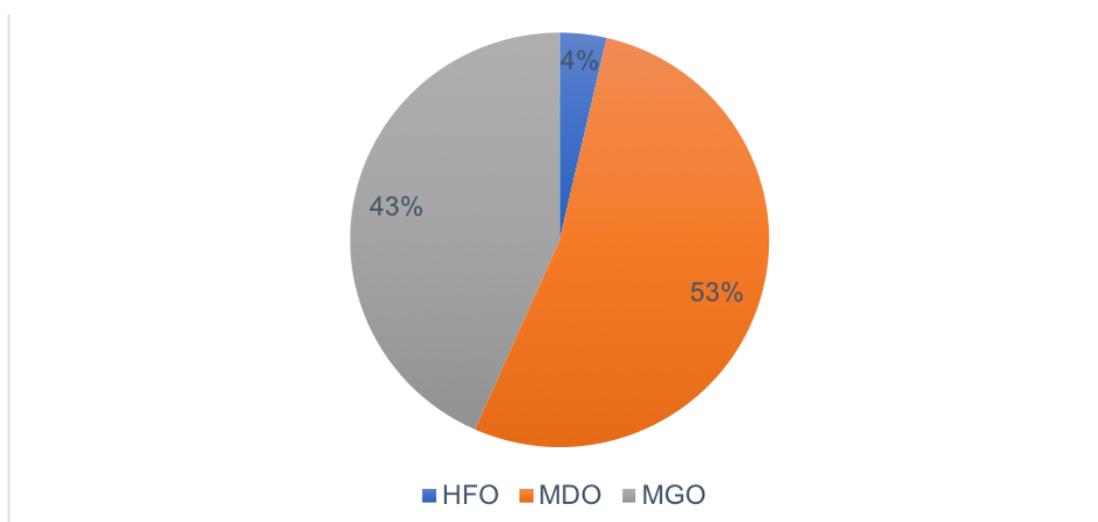


Figure 15: Pie chart of cases of non-availability of compliant fuel as reported to IMO
Source: GISIS, 2018.

One thing is for certain that bridging the lack of supply will not happen overnight as it would require very high investment from producers and building infrastructure to bridge the supply demand gap will take approximately 5 years (ExxonMobil, 2018). BIMCO, in 2016, published that the demand for low sulphur fuels would not be met at dawn of the new sulphur cap regulation (BIMCO, 2016). Furthermore, compliant fuel oil would have to be transported between regions should circumstance follow the assumptions used in the high demand case of their study. Intuitively, such a situation would increase the cost of fuels (CE Delft, 2016). Fuel providers, such as ExxonMobil, have stated that the production of compliant fuels is forecasted to be concentrated around Singapore and the ARA region thereby adding to the costs of these fuels merely on account of inter-regional transportation (ExxonMobil, 2018).

In the same vein, an informal survey conducted by American Bureau of Shipping, showed that 53% of their respondents are undecided as to how to comply with the imminent sulphur regulations (ABS, 2018). The liberty granted by Annex VI for ships to file a Compliant Fuel Non-Availability Report (FONAR) could also pose to be an instrument of misuse restricting the ends of the regulation to be met (as shown in Figure 30). That said, Sampson, B., et al. 2013, states that operators follow a culture of compliance that stems from an assumption premised on the fear that their non-

compliance would be detected and accordingly penalized resulting in hefty fines or even sanction and resonating further till the loss of insurance covers.

Since the adjudication of FONAR is considered on a case to case basis and under the pretext that nations would be anticipating an increased number of FONAR from 1st January 2020, it is reasonable that a country`s stance on granting leeway to an instance of non-availability of compliant fuel for a ship would not be lenient. Therefore, the industry would even switch between various methods of compliance with the Sulphur regulation simply to avoid penalties which would come at the cost of hefty investment and stretched credit lines.

3.5. ***Balance of supply and demand and rising freight***

The health of the shipping industry is quantified in terms of the freight rate prevalent which, in turn, stems from the interplay of the supply and demand for ships and is continuously adjusted per the supply and demand of ships in the market. It is the freight rate that, regulates the market passively by inciting the need to increase supply when freight rates increase indicating an increased demand. As the supply of ships increase, responding to the increased freight rate, the risk of oversupply continuously increases till it reached a point when supply outweighs the demand, setting back the freight rate and the cycle is bound to repeat shortly (Stopford, M., 2007). The dance of supply, demand and freight rates is synonymous to the case of whether Schrodinger`s cat is dead or alive.

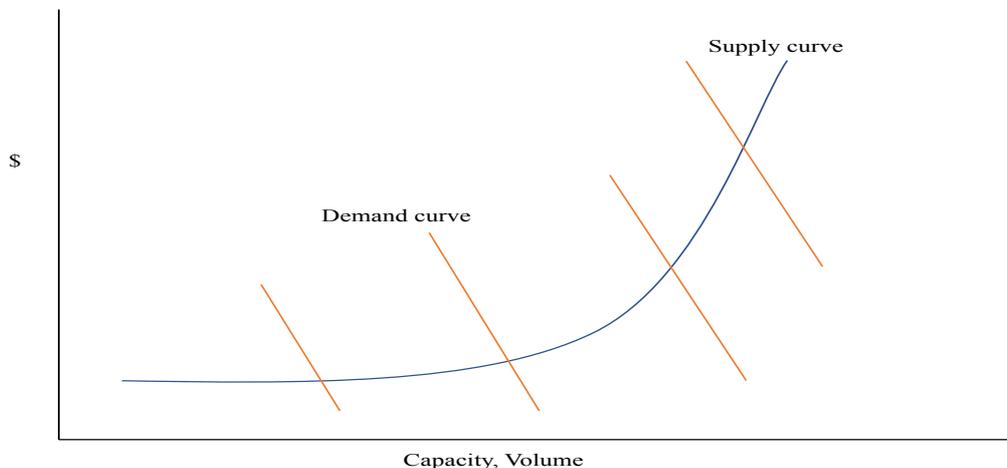


Figure 16: Graphical representation of the freight market
Source: Stopford, M., 2007

Overall, the demand and supply of ships is facing a grim situation as is pictographically represented below by plotting the tonne-mile for different cargoes to draw a conclusion on the year to year growth, if any.

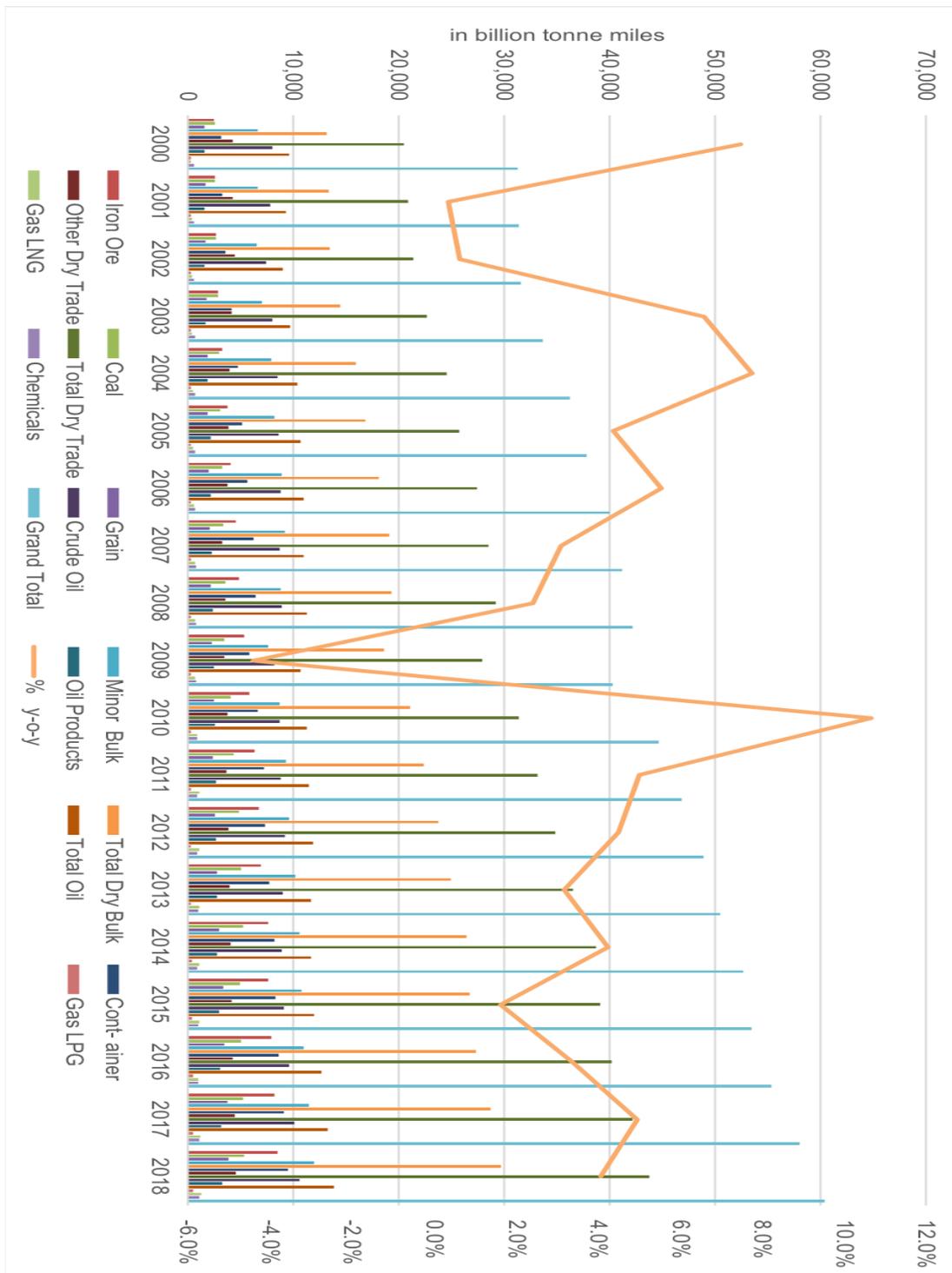


Figure 17: Graphical representation of the world seaborne trade
 Source: Clarksons Research Database, 2018

With the year on year growth currently indicating a little short of 4% after another phase of reduction, as can be observed the Figure 16, it is intuitive that the earnings of shipping companies are also bleak. To highlight this the weighted average earnings of shipping companies can be studied.

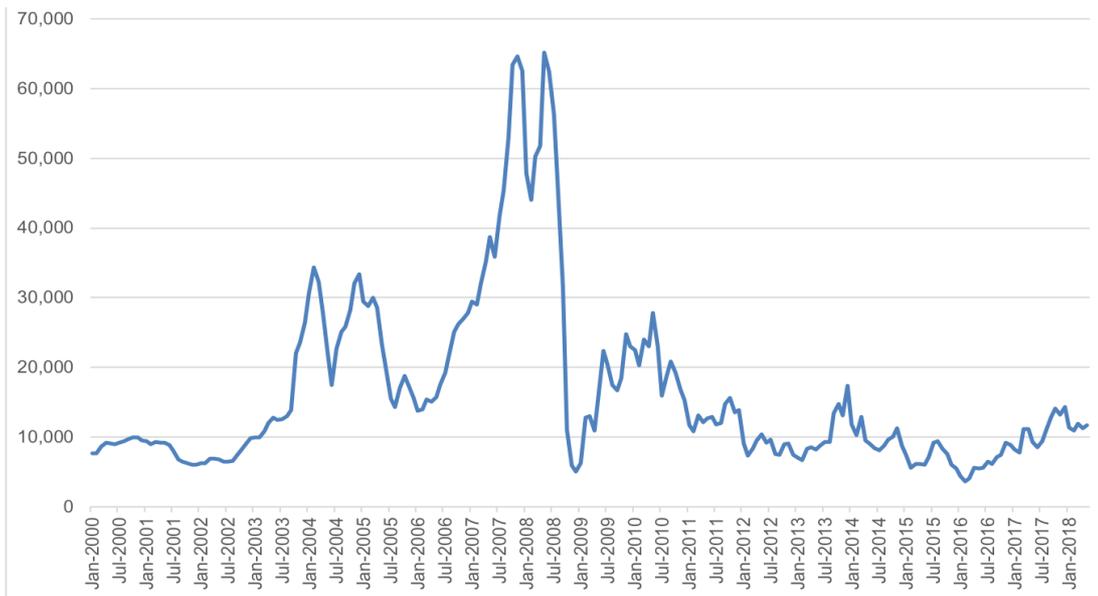


Figure 18: Graphical representation of the weighted average earnings
Source: Clarkson Research Database, 2018

The above figure indicates the bleak nature of earnings by the shipping industry that cascades into their ability to save for future investments or even sustenance. However, the imbalance in the shipping industry that lead to low freight seems to have been corrected or is in close proximity. In this regard, Moore Stephens' confidence survey indicates the concerns and confidence of the shipping industry within its different categories. The said survey is a monthly survey being done amongst shipowners, charterers, managers, brokers and advisors since August 2008 till date in which the respondents are inquired of their opinion on the industry in terms of demand trends, competition, tonnage supply, regulation, finance costs, operating costs, fuel costs etc. The latest published results of the confidence survey are depicted below:

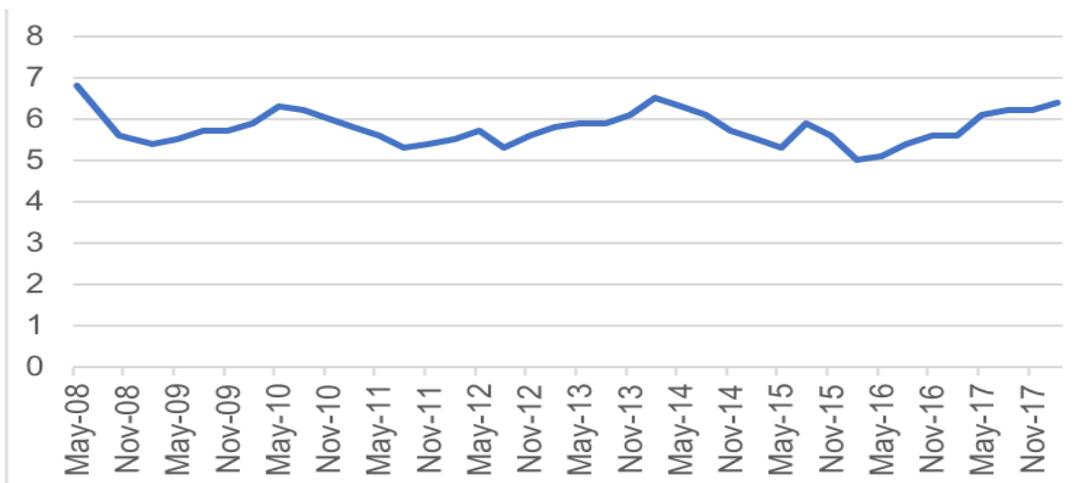


Figure 19: Graphical representation of the results from the Confidence Survey
Source: Moore Stephens UK, 2018

The results indicate that the players in shipping industry are confident in its progress but looking into the specifics, it highlights the balance in demand and supply of ships that could be a driver for better freights and it highlights the caution towards higher operating costs in light of the regulatory changes and ambiguities therein.

Through the results of the survey, the situation of the industry on the balance between supply and demand as perceived by its participants are shown below:

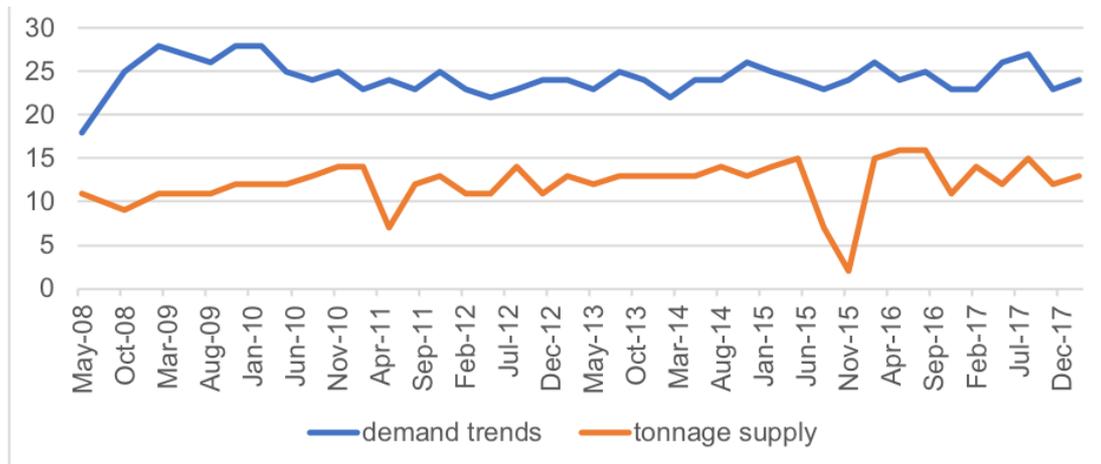


Figure 20: Graphical representation of the results from the Confidence Survey – Demand trend v Tonnage.
Source: Moore Stephens UK, 2018

It can be observed from the figure above that after years of imbalance of supply and demand of ships, the stakeholders of the industry opine that a balance seems to have been achieved that would, resultantly, ensure better freights for their ships. Similarly, the apprehension of increased operating costs *vis-à-vis* the confidence in regulatory changes for the shipping industry are shown below.

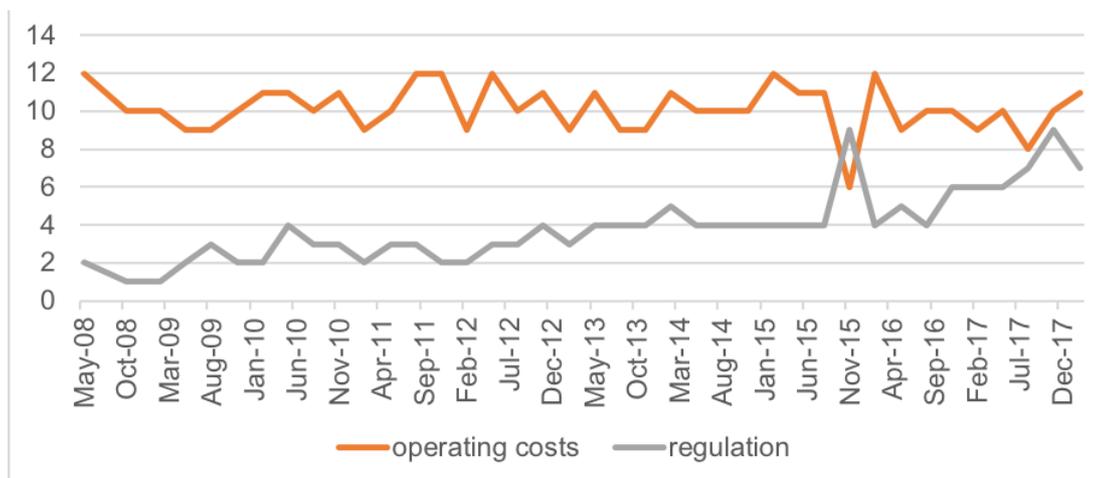


Figure 21: Graphical representation of the results from the Confidence Survey - Operating Costs v Regulation
Source: Moore Stephens UK, 2018

From the said results, the apprehension of the industry towards the reforms through regulations is very evident as they strongly believe that operating costs will greatly increase in the process of clearing the modalities of the reforms re-shaping the industry. That said, the results do not singularly indicate the the industry`s reservation to specific reforms envisaged by the law makers but represents the disdain the impact arising from the ambiguity and non-uniformity it brings along in this transition phase.

As a result of the above, it could be intuitively perceived that order for newbuild would not be very strong and for that matter could even be severely impacted in light of the changes awaiting the industry. Surely it is understandable to be wary of investing billions of dollars into newbuilds amidst this lack of earning potential and uncertainty on the extent to which the existing fleet would have to be modified to meet the legal standards.

3.5. Ship building industry

The ship building industry has been wrung by volatility the past ten years; with only 993 vessels being ordered in 2017 across the different type of vessels used (Clarksons, 2018). This indicates that the building industry has faced a 35% lower demand than a ten year average (*supra*). Clarksons, *et. al*, 2018, reports that the number of newbuilt delivered in the year 2017 was practically unchanged from the earlier years at approximately 1503 units but in the same breath warns that these figure are anticipated to plummet in the years 2018 and 2019. A cumulative effect of regular number of newbuild deliveries and the reducing orderbook over the year has driven the shipbuilding industry down by a minimum of 4% year on year (*supra*).

That said, all is not grim within the shipbuilding industry. As a result of efforts to reduce costs incurred in operating ships, the prices of newbuilt ship, despite the quantity, has increased in 2017 as compared to the 2016 (Clarksons, 2018). The Clarksons Newbuild price index reflects the same and a snapshot of the said index is reproduced as below.

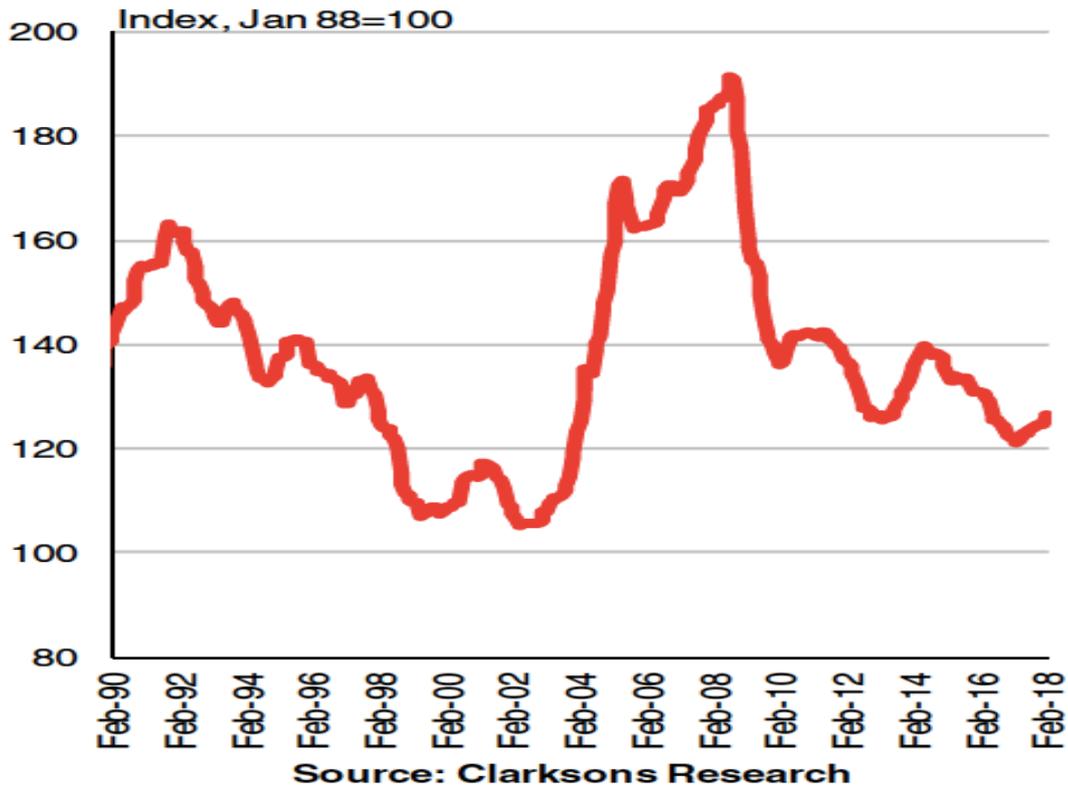


Figure 22: Clarksons Newbuild Price Index from February 1990 to February 2018
 Source: Clarksons Research Database, 2018.

To understand the reduction indicated above, it is noteworthy to delve into the key players influencing the shipbuilding industry. In comparison to the earlier years, ship yards in China received only orders for 486 units totalling to 91.1m dwt as compared to an average of 146 dwt (Clarksons, 2018) which lead to the closure of numerous yards. Similarly, ship yards in the Republic of Korea orders were reduced to 281 units totalling to 31.5m dwt indicating a 14% year on year reduction (*supra*) whereas ship yards in Japan received orders for 367 units totalling to 20.5m dwt indicating a reduction of 19% year on year. This extended downturn for the shipbuilding industry is indicative in the delivery schedule of vessels as reproduced below.

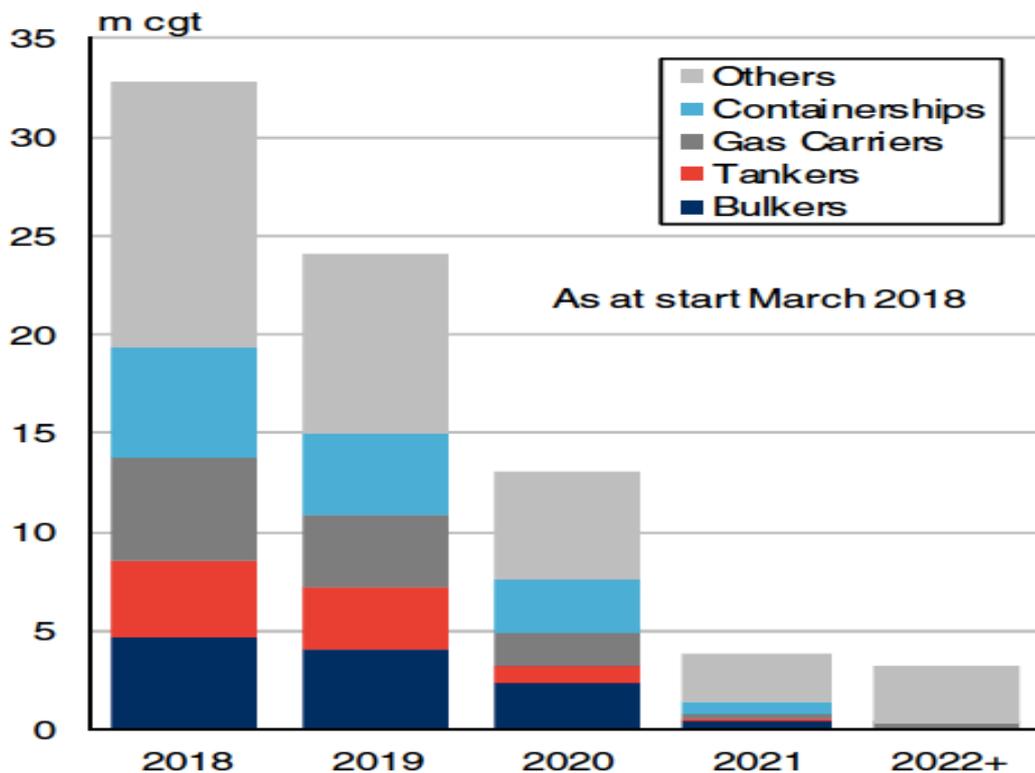


Figure 23: Delivery schedule of newbuilds from Clarksons outlook
 Source: Clarksons Research Database, 2018.

From the above figure, it can be noted that orders for special vessels are rather steady but shipyards opine that their industry continues to face significant, even crippling pressure that pose a long road for recovery.

3.6. Phases of changes awaiting the shipping industry

As part of the reforms re-shaping the shipping industry, ships are also mandated to be compliant per the *International Convention For The Control And Management Of Ships' Ballast Water And Sediments, 2004* brought into force in light of the damage to the local ecology and human health due to the transfer of aquatic fauna and flora around the world through ballasting operations of the vessels. Per the said conventions, all ships ought to be compliant by installing a ballast water management system by 8th September 2024; which requires a substantial investment of \$80,000 to \$1.5 Million, installation cost of \$100,000 to \$1 Million and operating costs of \$75,000 to \$120,000 (Care for our Oceans, 2016).

UNFCCC has excluded its applicability over shipping and civil aviation under the premise that the stakeholders and regulators of these industries will act in parallel to the works of the UNFCCC to achieve the same goals of the UNFCCC per the Paris Agreement. It was, presumably, on this basis that a representation was made in 2016 by BIMCO, ICS, Intercargo, Intertanko and WSC to the IMO to establish a regime for the reduction of GHG based on "fair share contribution" (IMO, 2016). The UN Secretary-General echoed the need for measures in the shipping industry to reduce GHG emissions at MEPC 70 saying, "I call upon nations to adopt an ambitious

strategy at the IMO that would support the modernization of the shipping sector in a manner consistent with the ambitions of the Paris Agreement” (IMO, 2018).

In the latest study by the IMO on the emission of GHG by shipping, the results indicate that out of 33,273 Million metric tonnes of GHG produced, 2.8% or 1,036 million metric tonnes of GHG is attributable to the shipping while 2.4% or 866 Million metric tonnes of GHG is attributable to International Shipping (IMO, 2014). These numbers highlighting the contribution of shipping to the warming of the planet bears great importance in the context of the predicted GHG concentration per the RCP database under four scenarios as elucidated below:

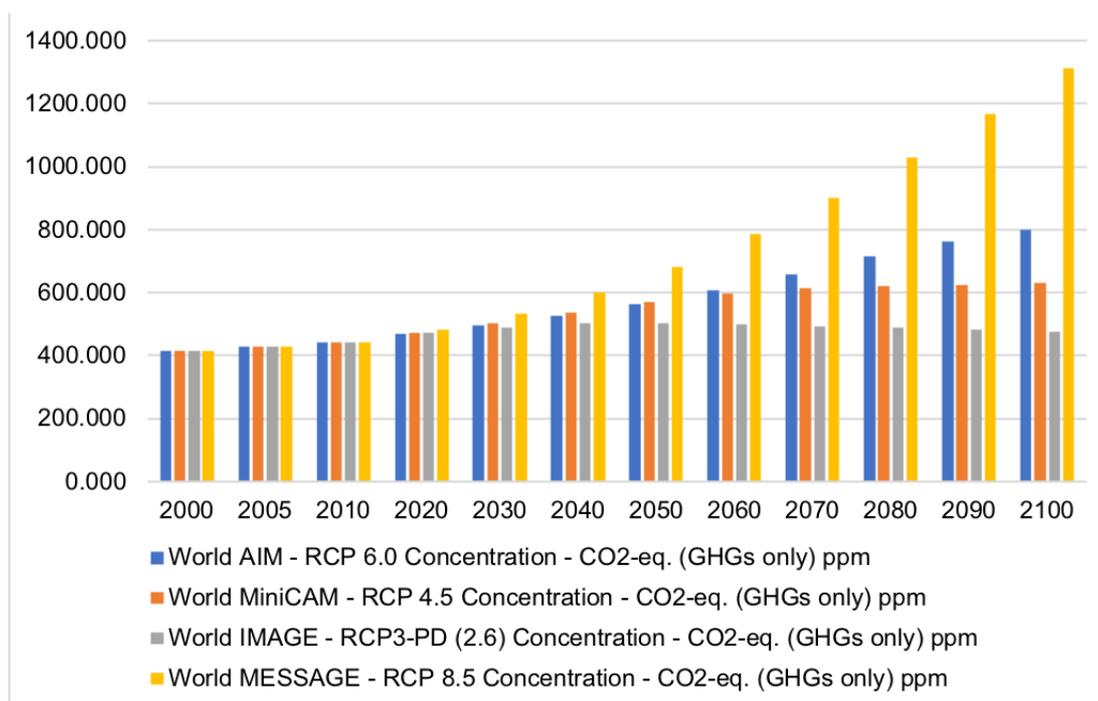


Figure 24 : Graphical representation of projected global GHG concentration based on 4 scenarios
Source: RCP Database (2018)

Accordingly, IMO adopted its initial vision to curb GHG emissions as follows (IMO, 2018):

1. The EEDI would be reviewed in 2023.
2. Reduce CO2 emissions by 40% by 2030 and thereafter 70% by 2050 keeping the base figure as the CO2 emissions of 2008, i.e. 32,204 Million metric tonnes per IMO’s GHG study of 2014.
3. Reduce emissions of GHG by 50% by 2050 keeping the base figure as the GHG emissions of 2008, i.e. 35,677 Million metric tonnes per IMO’s GHG study of 2014.

In consonance with IMO’s vision to reduce the emission of GHG and that of UN SDG Goal 13 and the Paris Agreement, the IMO, categorized efforts to be structured as short-term measures (2018-2023), medium-term measure (2023-2030) and long-term

measures (2030 and beyond) and enumerated a number of measures with its respective dates of enforcements.

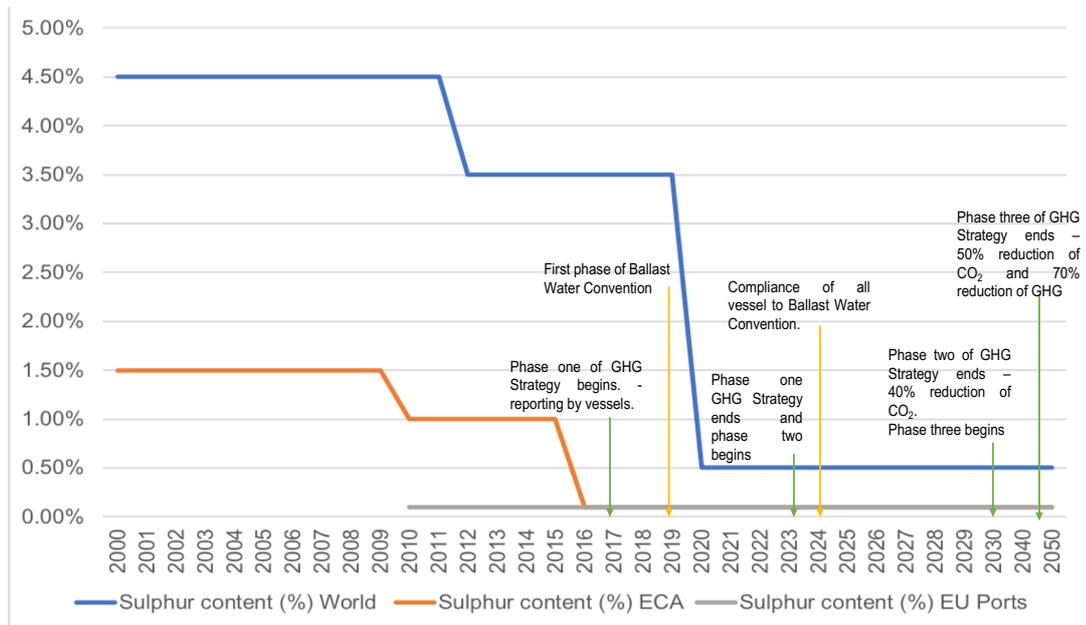


Figure 25 : Graphical representation of timeline for reforms in shipping
Source: IMO (2018)

Lane, *et. al* 1986, whilst writing about British crew working in the 20th Century was one of the first to propound that the shipping industry is characterized by a cyclical nature of events and the aforementioned are a vague outline of the cyclical changes envisaged for the shipping industry towards a cleaner and environmentally friendly shipping. In the context of the UNSDGs, Paris Agreement and other international and inter-governmental efforts towards cleaning up the planet, the shipping is facing the first cycle of changes on an environmental note the success of which is paramount!

Chapter 4 – Methodological Approach

In this chapter, the reasons for opting a methodological approach towards ascertaining the research question and the theoretical framework behind the same are explained followed by the assumptions used in the estimation of scenarios modelled.

In ascertaining the impact of a trade policy, analysts have broadly two options; based on general equilibrium or based on partial equilibrium. An analysis based on general equilibrium would model for impact between all sectors by accounting for any and all linkages between the sectors in the model. Accordingly, an analysis based on partial equilibrium delves into only one sector and, as a corollary, discounts all other sectors; like the GSIM model. The GSIM model is a partial equilibrium based model by Francois, J. and Hall, K. (2003) that aids in ascertaining the impact of trade policies within an industry. It provides rapid and insightful analysis into changes in an industry specific trade policy.

The research question at hand is purely regarding one sector and the impact of a policy in the said sector is sought to be studied and therefore, using a GSIM model to ascertain the research question at hand would certainly hold its water.

4.1. GSIM Model

The GSIM model used for *ex ante* analysis of impact of policy changes is a partial-equilibrium based model. The GSIM model works on the assumption that the global market is discounted and bilateral relationships exist between the countries that are fed into the model (UNCTAD, 2015). This model was propounded by Francois, J. and Hall, K. in 2003 by developing on pre-existing models (*supra*). The framework of the GSIM model is on the basis of mathematical equations as summarized as below from the literature published by UNCTAD and Jammes, O., *et al.* 2005.

Imports of a product can be intuitively broken down as a function of the price of the product and the total consumption of that product. Therefore imports of product g from country c by country b can be written as:

$$M_{g,c,b} = f(P_{g,c,b}; P_{g,b,\neq c}; Y_{g,b}) \quad \dots \text{Equation (1)}$$

Where;

$P_{g,c,b}$ is the price of product g in the importing country b from exporting country c;

$P_{g,b,\neq c}$ is the price of product g in the importing country b imported from other countries; and

$Y_{g,b}$ is the total consumption of product g in importing country b

Therefore, it can be deduced that, if there is any imposition of tariff or duties (t), the same would be included in the price of product in the importing country b which leads to:

$$P_{g,c,b} = (1+t_{g,c,b}) P_{g,c}^* \quad \dots \text{Equation (2)}$$

Where;

$t_{g,c,b}$ is the rate of tariff imposed on the product g between countries c and b;
and
 $P_{g,c}^*$ is the price of the product g in country c.

Similarly, exports of the product g can be said to be a function of the price of product g.

$$X_{g,c} = f(P_{g,c}^*) \quad \dots \text{Equation (3)}$$

To determine the price demand elasticity and supply elasticity for which the respective functions would have to be differentiated. Accordingly, price demand elasticity is calculated by differentiating the function for import of product g (Equation (2)) whilst using Slutsky's decomposition of partial demand and benefitting from Hicksian demand's property of zero homogeneity (UNCTAD 2015) as below:

$$\varepsilon_{g,c,b} = \theta_{g,c,b}(\varepsilon_{g,b} + \sigma_g) \quad \dots \text{Equation (4)}$$

$$\varepsilon_{g,b,\neq c} = \theta_{g,b,\neq c} * \varepsilon_{g,b} - (1 - \theta_{g,b,\neq c})\sigma_{g,b} \quad \dots \text{Equation (5)}$$

Where;

$\varepsilon_{g,b,\neq c}$ is the price demand elasticity of product g in country b imported from other countries than country c.

Similarly, the supply function is differentiated to obtain the supply elasticity as below:

$$e_{g,c} = (H_{g,c}^{\sim} / P_{g,c}^{\sim}) > 0 \quad \dots \text{Equation (6)}$$

Using equations 4, 5 and 6; and by moving the variables around we get:

$$TR_{g,c,b} = t_{g,c,b} M_{g,c,b} P_{g,c,b}^* (t_{g,c,b}^{\sim} + P_{g,c,b}^* (1 + \varepsilon_{g,c,b})) \quad \dots \text{Equation (7)}$$

Where;

$t_{g,c,b}^{\sim}$ is the percentage change in the tariff of product g, and
 $P_{g,c,b}^*^{\sim}$ is the percentage change in the price of product g

Thereafter, using Equation (7), the producer and consumer surplus can be estimated and represent as the change in the respective surplus as follows:

$$\Delta PS_{g,c} = P_{g,c}^* X_{g,c} P_{g,c}^*^{\sim} \{1 + (e_{g,c} P_{g,c}^*^{\sim}) / 2\} \quad \dots \text{Equation (8)}$$

$$\Delta CS_{g,b} = \sum_c M_{g,c,b} P_{g,c,b}^* T_{g,c,b} \{0.5 \varepsilon_{g,b} (P_{g,b}^{\sim})^2 \text{sign}(P_{g,b}^{\sim} - P_{g,b})\} \quad \dots \text{Equation (9)}$$

Although the above framework is essential to understand the model, it is also imperative to note that, being a tool for *ex ante* studies, the model allows of estimation of scenarios an analyst assumes on the basis of facts and circumstances per their discretion. Accordingly, the facts and circumstances that are believed to mould the assumptions of scenarios considered are elucidated in the following sections.

Premised on the value of trade conducted, the use of this tool require trade data from countries to analyse the impact on an industry and since the research question at hand is focussed on the shipbuilding industry, the trade data between EU (28 nations),

USA, China, Japan and South Korea. Further to the said nations, a collection of nations excluded from the GSIM model are collectively modelled under Rest of World or ROW. The data for ROW is an arithmetic subtraction of trade value date of the countries under consideration from the global trade value.

4.2. Estimation of scenarios

Tariffs are a protectionist measure employed by sovereigns to reduce the demand on imports by imposing duties and charges for the said imports. Tariffs are usually guised to be reduced by sovereigns so as to be more trade inclusive but are often coupled with complex structures involving quotas (Love, P., *et al.* 2009). Imposition of tariffs and tactical reduction of these tariffs are synonymous to the satirical petition Frederic Bastiat submitted to the parliament seeking to ban the sun to empower the sorts of candle and lamp makers by stirring a demand.

Baldwin, *et al.* 1970, terms NTMs as any measure used by a sovereign to reduce “*potential real-world income*” from the trade of goods and service. Literature clarifies that an understanding of NTMs includes restrictions on import and export of goods and services and are broadly categorized into five categories with an unaccountable yet inherent vagueness in classifying measures into these categories being (Bora, B., *et al.*, 2002):

- i. Measures to control the volume of imports;
- ii. Measures to control the price of imported goods;
- iii. Monitoring measures;
- iv. Production and export measures; and
- v. Technical Barriers to trade

However, the arbitrariness in classifying NTMs into the above categories indicates that the basis of enforcing such measures stems from a wide range of reasons such as controlling the Balance of Payment or other socio-economic goal or even targeted interests per industries (Bora, B., *et al.*, 2002) but it is imperative to consider the practical dimensions of theoretical simulations when using NTMs. Intuitively, sovereigns would not completely remove such barriers to trade however, there could be an incentive in adjusting these barriers to assist industries (Bhagwati, J., 1965). Normally, the effect of tariffs and NTMs create an additive effect on the outcome of the trade of a good however, that may not always be the case. (*supra*). Resultantly, the intention and interest to safeguard an industry causes a shock that results in the reduction of overall welfare (Corden, *et al.*, 1971). That said, in the study at hand, the effect of the Sulphur regulations is assumed to be translating through the value chain to be an incremental NTM that could affect the shipbuilding industry as unlike tariffs, the NTM are an unquantified obstruction to free trade premised under various ideologies by the imposing sovereigns (UNCTAD, 2017). Therefore, no change in tariffs will be modelled but purely change in NTMs.

Inherent in the use of an *ex ante* analysis tool, estimation of change in NTM is necessary to study its impact of the imminent reform based on the assumptions elucidated in Chapter 3. Although, the estimation of change in NTM is at the discretion of the analyst based on the unquantified assumptions above, the same could gain some credibility if literature guides a certain way. In this regard, quantification of NTMs into ad-valorem equivalents can be construed to have the same effect on increasing

the cost of trade as tariffs (UNCTAD, 2017). The works of Kee, H. L., *et al.* 2009, and Kee, H. L., *et al.* 2017 shines light on the costs associated with NTMs by quantifying them into ad-valorem equivalents to be approximately 5% for middle-income countries and 7% for high-income or low-income countries (UNCTAD, 2017). More specific to the research question at hand, Uludag, *et. al*, 2010, estimated that the cost equivalent in shifting to the use of bunkers with 0.5% Sulphur content is a 70% increase in costs. In the same vein, Elswijk, *et. al*, 2012, has stated that the average freight cost barrier is approximately 17.5%, based on literature in considering the modal splits between ports. These figures aid in estimating the incremental effect on NTM as resulting from the degree of enforcement of the Sulphur regulation.

Factors, as elucidated in Chapter 3, are essential to be considered towards estimation of scenarios to be used in the GSIM model are elaborated. The imminent sulphur regulation brings along with a certain degree uncertainty around the options available to the industry to comply with the said regulations that result in increased costs to be expended by the members of the industry in finding the suitable option or even switching between the options available. Furthermore, the imminent sulphur regulations are the first bout of a series of changes for the shipping and in considering all, the scenarios are as follows:

1. Scenario 1- Ambitious scenario: In this scenario, an absolute and complete enforcement of the Sulphur regulation is modelled resulting in an increase of costs by 12.5%.
2. Scenario 2 – Modest Scenario: In this scenario, a modest and partial enforcement of the Sulphur regulation (to the extent of 25%) is modelled resulting in an increase of costs by 3.0625%.
3. Scenario 3 – EU + US lead: In this scenario, an absolute and complete enforcement of the Sulphur regulation by the EU and the USA is modelled in the background of Scenario 2.

Djajadikerta, H. G., *et al.* 2015, highlights the importance of elasticity over the accuracy of the results produced using a GSIM model by relying upon literature detailing the GSIM model and goes further to note the difficulty in obtaining information on elasticity due to the lack of research done on the same. In light of this lacuna, the generalized values of these elasticities, calculated on the basis of the results from Kee, H. L., *et al.* 2008, providing weighted import elasticities till 2005, is used (Djajadikerta, H. G., *et al.* 2015) and as below:

Types of elasticity	Import demand elasticity	Export supply elasticity	Substitution elasticity
Values	-1.68	1.50	5

*Table 2: Elasticity data for GSIM model
Source: Djajadikerta, H. G., et al. 2015*

The above generalization finds merit per the works of the founder of this model (Francois, J., *et al.*, 2002), vide his paper in 2002 wherein constant supply elasticities were used for the illustrations.

Chapter 5 - Results and Analysis from the GSIM model

The scenarios on the impact on the shipbuilding were tested using the trade values between the entities being modelled along with the tariffs sourced from the database of the World Bank, UN Comtrade and UNStat databases. The results are collected, re-organized and analyzed in this Chapter.

5.1. Changes in output and producer revenue

The effect of an increment of NTMs would be a reduction of demand and supply across the board with differences stemming from the degree to which the NTMs have increased.

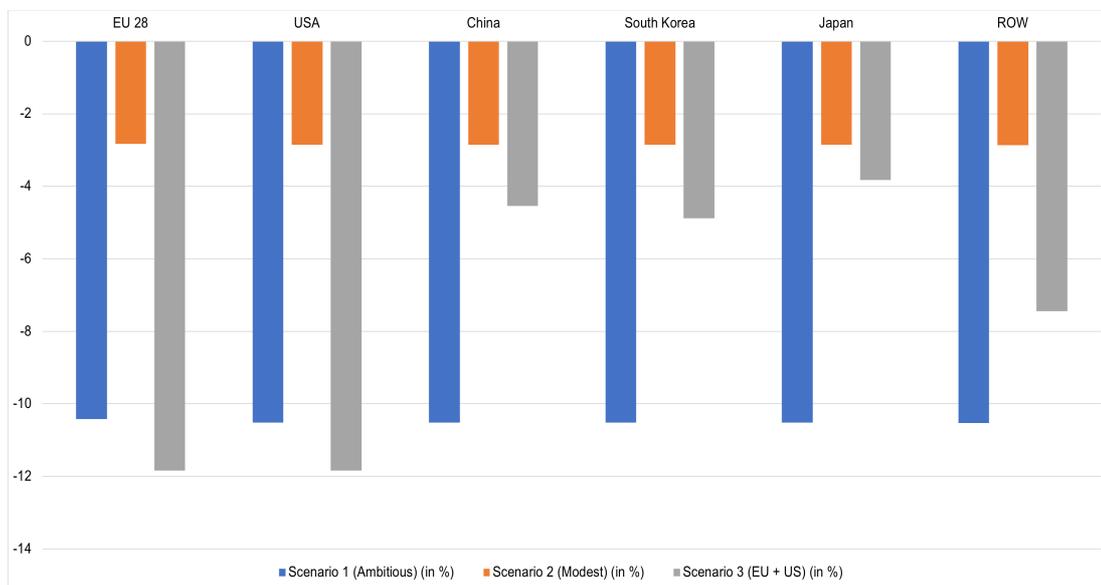


Figure 26: Graphical representation of change in output
Source: Author's own calculation

It is intuitive that a large NTM increase (as in Scenario 1) would detrimentally affect the output of regions being modelled and a small NTM increase (as in Scenario 2) would detrimentally affect output proportionally. The reduction in output under Scenarios 1 and 2 has affected all countries to the same extent. However, in the event EU and USA spearhead a rigid enforcement of the sulphur regulation (as in Scenario 3), their output would be even more severely affected with the other nations gaining from a lesser reduction of output. Japan gains the most from this whilst ROW loses the most.

In the same vein, the aforesaid reduction in output would translate to a change in producer revenues.

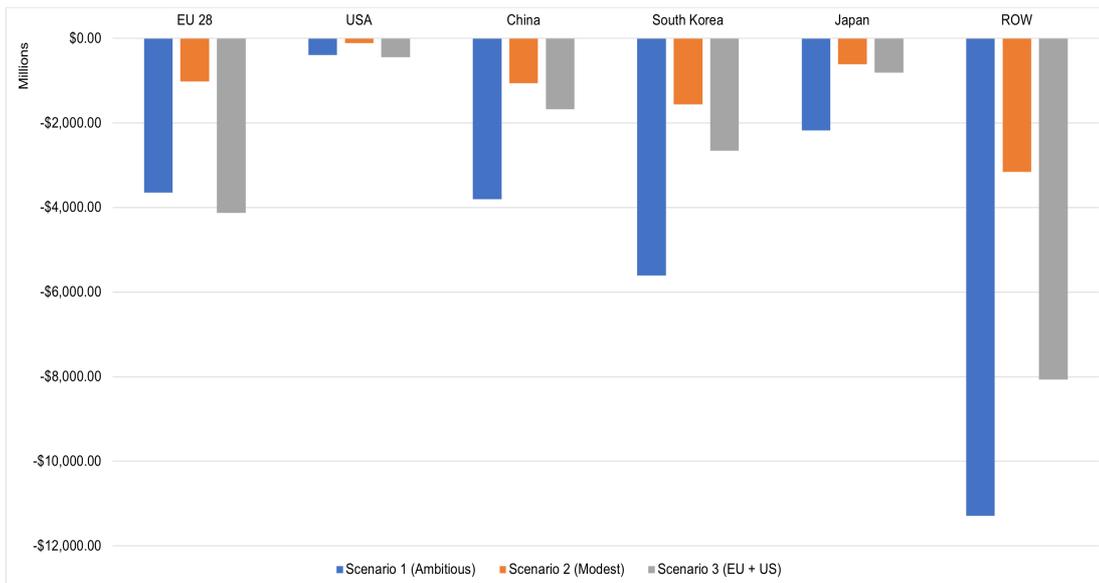


Figure 27: Graphical representation of change in producer revenues
Source: Author's own calculation

A rigid and uniform enforcement (as in Scenario 1) impact ROW the most followed by the Republic of Korea. The impact on producer revenues under Scenarios 1 and 2 seems to have proportionally affected all regions being modelled. However, the impact on the producer revenues in the event EU and USA spearhead a rigid enforcement of the sulphur regulation, gravely affects themselves even though ROW is affected the most amongst the nations being modelled.

That said, the impact on producer revenue lacks a certain perspective without the origin.

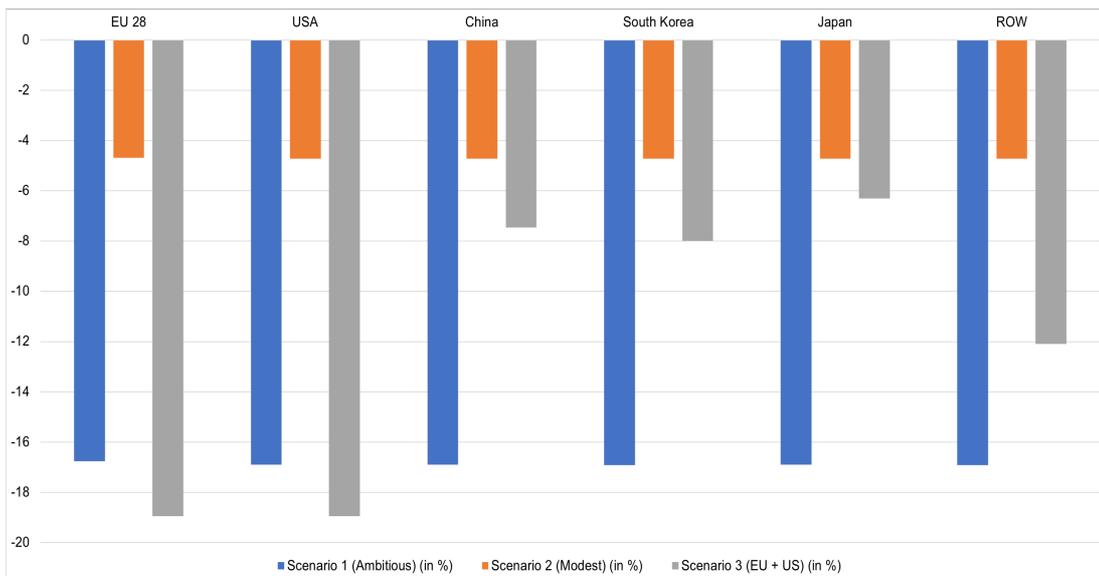


Figure 28: Graphical representation of change in percentage of producer revenue
Source: Author's own calculation

The reduction in producer revenue shown in Figure 27 is in effect a reduction of producer revenue as shown in Figure 28. What was initially perceived as a crippling loss such as the reduction of producer revenue for Republic of Korea and ROW are overshadowed by the impact on EU and USA. That said, it is striking to note that percentage change in producer revenue follows the same pattern as the reduction of output (as in Figure 26).

5.2. Changes in welfare effects

To ascertain the impact on welfare effects, elements such as the producer surplus, consumer surplus and tariff revenues ought to be studied.

5.2.1. Changes in producer surplus

It is anticipated that the effect of an increment of NTMs would result in a reduction of producer surplus across the board with differences stemming from the degree to which the NTMs have increased.

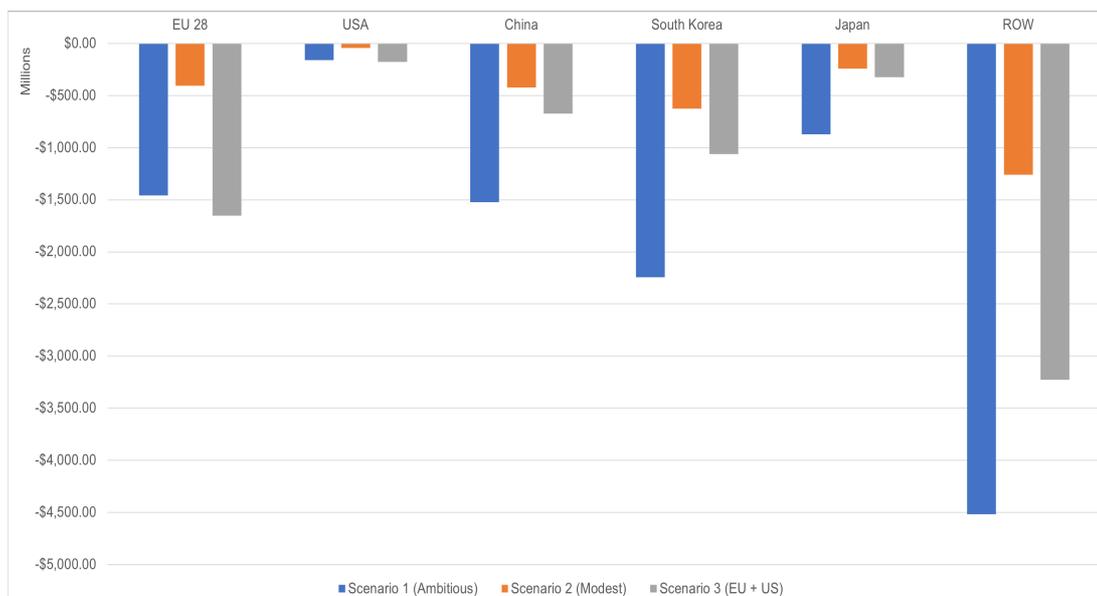


Figure 29: Graphical representation of change in producer surplus
Source: Author's own calculation

The negative impact of the three scenarios on the regions being modelled follow the degree of increment of NTMs. A uniform and rigid enforcement of the Sulphur regulation (as in Scenario 1) affect ROW the most followed by Republic of Korea and China. However, a partial enforcement of the Sulphur regulation (as in Scenario 2) benefits USA the most. That said, it seems that the EU and USA is impacted with an increased detriment to their producer surplus when they rigidly enforce the Sulphur regulations. The comparative advantage the other regions receive seems to be to the detriment of EU and the USA. However, this should not be a surprise as the producer revenue of the regions modelled are have a direct bearing on the producer surplus and for this reason Figure 29 follows the pattern of Figure 27. The correlation corroborates the veracity of the each another.

5.2.2. Changes in consumer surplus

Similar to above, it is anticipated that the effect of an increment of NTMs would be a reduction of consumer surplus across the board with differences stemming from the degree to which the NTMs have increased.

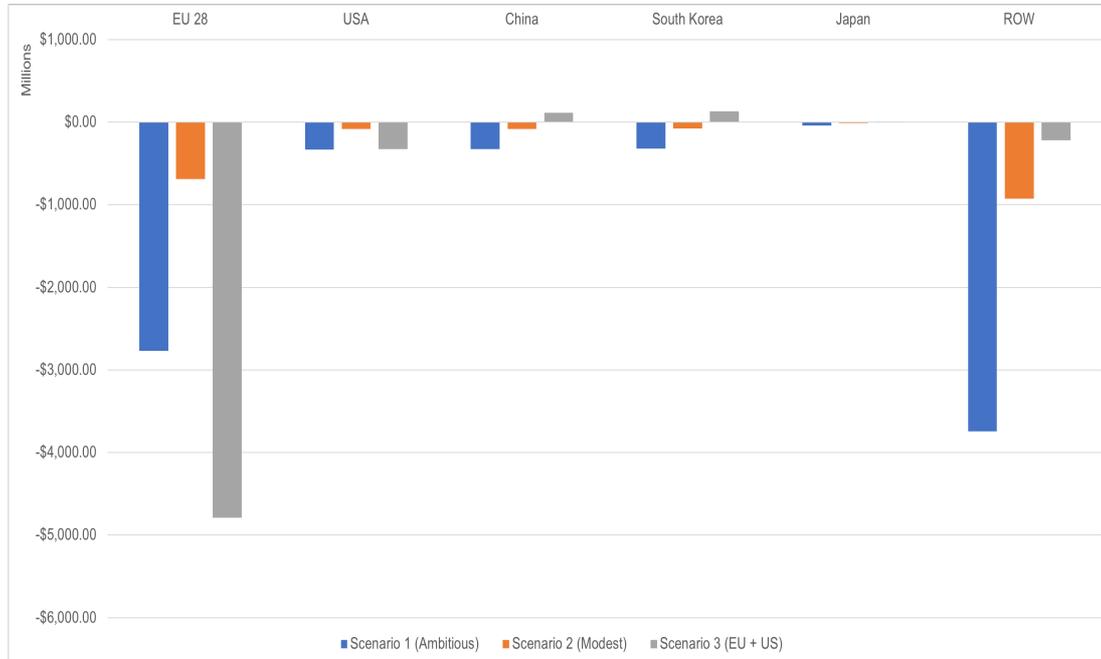
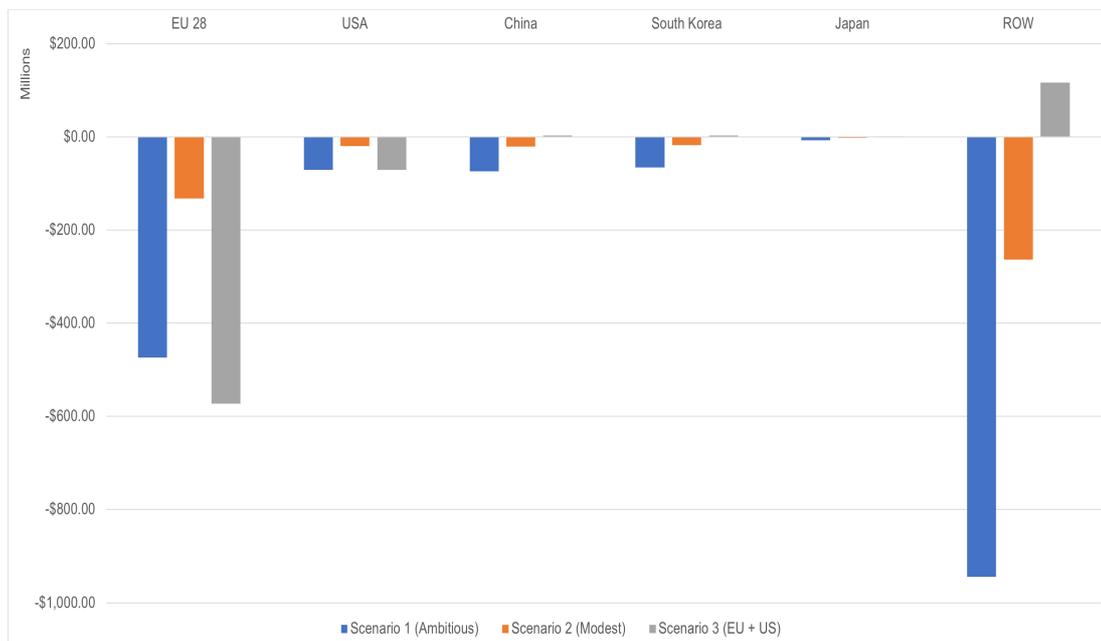


Figure 30: Graphical representation of change in consumer surplus
Source: Author's own calculation

The impact on the consumer surplus as a result of the sulphur regulation is that the impact on the EU and USA follows the impact on the producer surplus of the said regions. Spearheading a rigid enforcement of the sulphur regulation would only cause a further reduction in the consumer surplus to the EU and USA but to a great advantage for the three major shipbuilding economies, i.e. China, Republic of Korea and Japan. China, Republic of Korea and Japan gains consumer surplus in the event of Scenario 3. Japan seems to gain the most amongst the regions being modelled in all three scenarios with minimal or close to minimal impact on consumer surplus. Just as with the producer surplus of the regions being modelled, the consumer surplus of the regions are affected by the change in the consumer revenue in the regions being modelled.

5.2.3. Changes in tariff revenue

The impact on the tariff revenue is investigated and the graphical results are produced below.

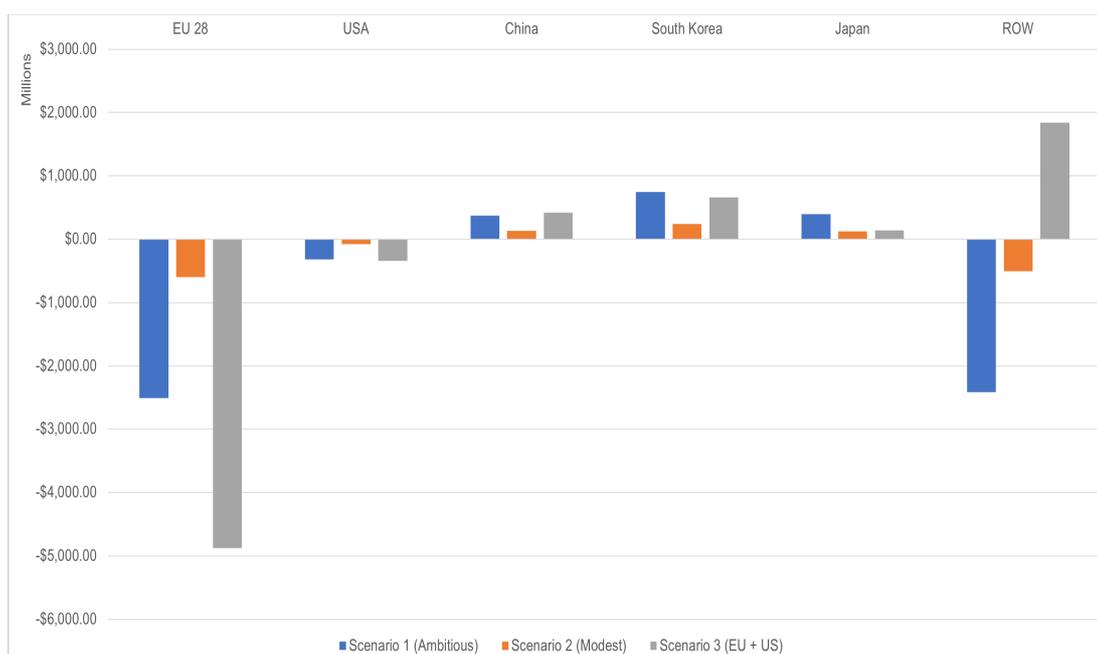


*Figure 31: Graphical representation of change in tariff revenues
Source: Author's own calculation*

At the outset, it can be observed that if EU and USA spearhead a rigid enforcement of the sulphur regulation, then they would be impacted by the most in terms of the loss of tariffs revenues earned and in the same vein, ROW would gain the most; being the only beneficiary in this regard.

5.2.4. Total Welfare effect

The Total welfare effect is a cumulative effect of the change in producer surplus, consumer surplus and change in tariff revenues. In this regard, it would be the collective effect of Figures 29, 30 and 31.



*Figure 32: Graphical representation of change in net effect
Source: Author's own calculation*

At the outset, it is vital to acknowledge that the most impact of any form of enforcement of the Sulphur regulation is going to be faced by the EU and the USA. As iterated repeatedly, spearheading a rigid enforcement of the Sulphur regulation by the EU and the USA (as in Scenario 3) would cause them more detriment than a uniform and rigid enforcement of the Sulphur regulation by all the regions being modelled. ROW gains the most from this and possibly the only instance it can benefit from the enforcement of the Sulphur regulation.

That said, the three major shipbuilding economies have a variant reaction to the scenarios modelled. China seems to gain more from the EU and USA spearheading a rigid enforcement of the Sulphur regulation, even more though in Scenarios 2 and 3 China adopts a very passive stance. However, this is not the case with the Republic of Korea and Japan. Both these sovereigns gain the most from a uniform and rigid enforcement of the Sulphur regulations.

5.3. Trade effects

The aforesaid elements, through an interplay, culminate into changes in the trade between the regions modelled resulting in new bilateral trade values between the said regions.

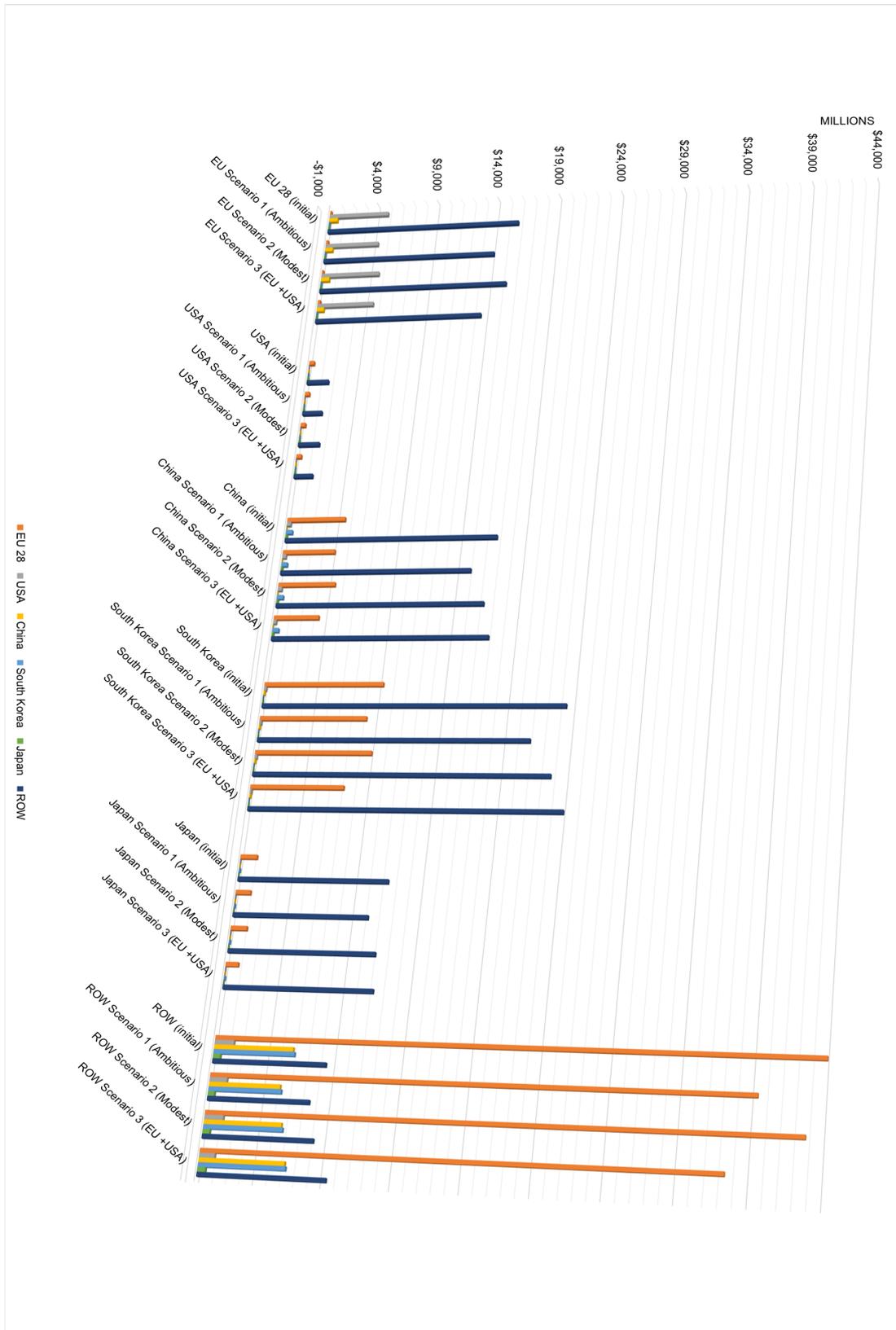


Figure 33: Graphical representation of change in trade values
 Source: Author's own calculation

The above figure depicts the changed trade values and, in itself, indicates a drastic change in bilateral trades in the shipbuilding industry but a better perspective is developed in studying the percentage of change.

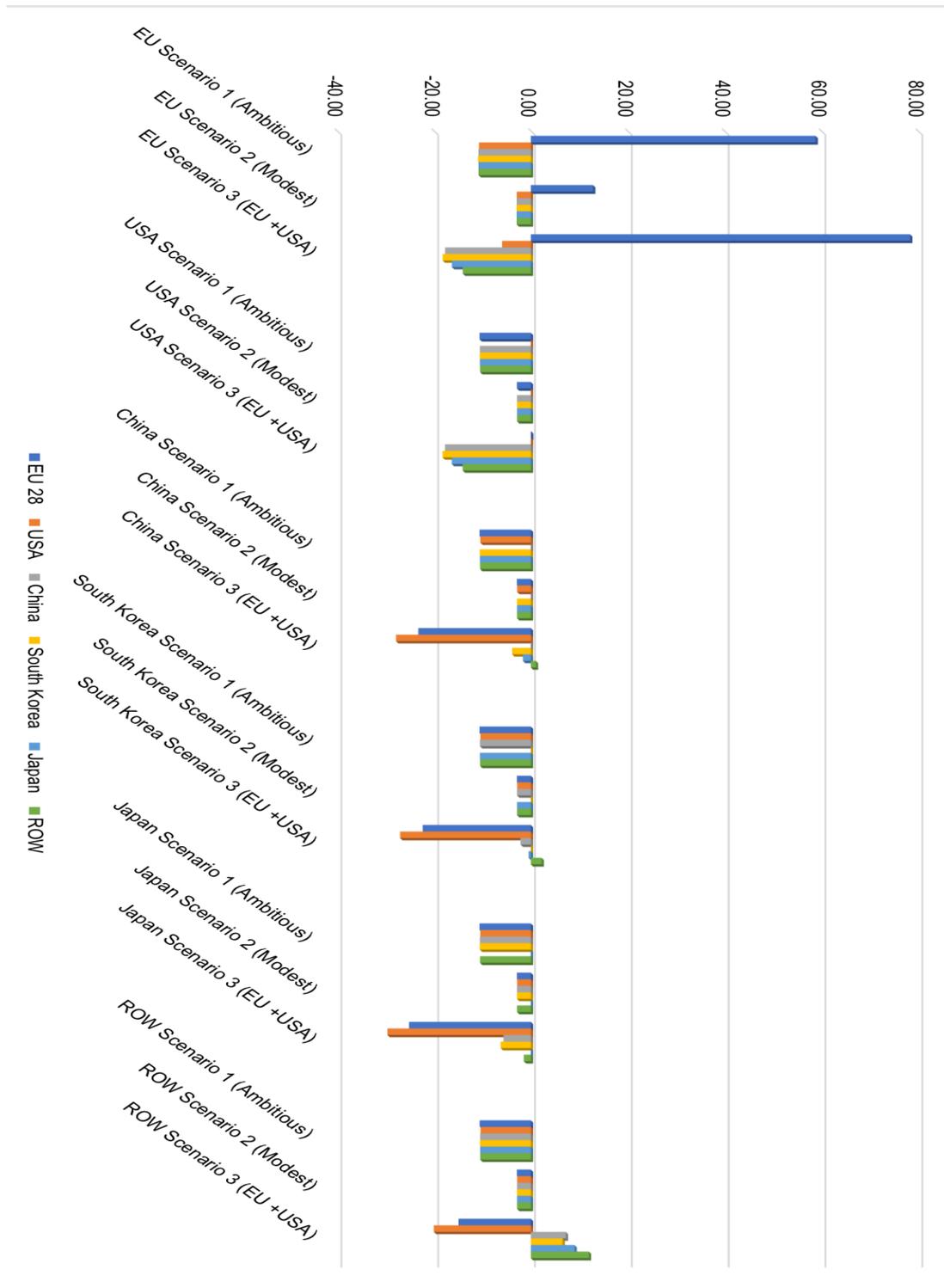


Figure 34: Graphical representation of the percentage change in trade values
Source: Author's own calculation

The comparative results shown in Figure 34 shine light on the amounts depicted in Figure 33 and highlight that change in bilateral trades between the regions modelled. The EU seems to have an increased intra-EU trade upon rigidly enforcing the Sulphur regulation; be it uniform (as in Scenario 1) or not (as in Scenario 3). In the same vein, ROW gains from an increased trade between China and Republic of Korea. Besides these positives, the effect of the Sulphur regulation across the board is detrimental to bilateral trade. However, there is merit in studying these detrimental impacts. For instance, it is poignant to note that a rigid and uniform enforcement (as in Scenario 1) detrimentally affects most of the permutation of bilateral trade to the same extent. Similar is the effect of a partial enforcement of the Sulphur regulation (as in Scenario 2).

Juxtaposed to these uniform results, the effect of EU and USA spearheading rigid enforcement of the Sulphur regulation is varied per the region being modelled. The EU only benefits from an increased intra-EU trade but lose the most amongst the regions being modelled with USA at par in terms of loss and even so, devoid of any intra-USA trade. In the same vein, the bilateral trade by EU and USA with China, Republic of Korea, Japan and ROW are also severely affected. Similarly, bilateral trade by China, Republic of Korea, Japan and ROW with EU and USA are also severely affected as a result of a rigid enforcement of the Sulphur regulation by EU and USA. However, ROW gains from bilateral trade with China, Republic of Korea, Japan. That said, the Republic of Korea is the least detrimentally affected amongst the regions being modelled under this scenario which indicates the resilience of their shipbuilding industry.

Chapter 6 - Conclusions

Research question and methodological approach

The research study at hand was intended to ascertain the impact of the imminent Sulphur regulation on an industry that has been volatile over the years and borne the brunt of various changes. In order to ascertain the impact, it is vital to study the enormity of the shock causing the impact; the Sulphur regulation and series of changes that ensue it. Although the research question is regarding the impact of the Sulphur regulation, the ensuing regulation are also considered to highlight the repetitive nature of pivotal reforms transforming the shipping industry in the years to come. Accordingly, the development of events leading up to these changes commencing with the enforcement of the Sulphur regulation is detailed to highlight the enormity to the changes ahead. Thereafter, the ambiguities and practical hurdles with the imminent Sulphur regulation are highlighted to portray the possibility of increased expenditure by stakeholders of the shipping industry towards compliance of the Sulphur regulation. These factors were accounted and modelled using a partial equilibrium model called GSIM. The said model is very useful in ascertaining the impact of a trade policy by weighing the trade values and provides prompt and insightful analysis.

Main study findings and interpretation

The results on the analysis in Chapter 5 provides interesting conclusions on the impact by the Sulphur regulation coming into force in the year 2020 on the shipbuilding industry. The impact on costs as a result of a shift to low Sulphur bunkers having been calculated to be 70% provides the foundation to estimate the incremental impact on NTMs as a result of enforcement of the sulphur regulation. To complete the said estimation, the calculated costs impact is adjusted by a freight cost barrier of 17.5% to yield the estimate of increment in NTM. According to the scenarios, the said estimate is proportioned to be input into the GSIM model.

What was initially expected to a grave and negative impact on shipbuilding economies such as China, Republic of Korea and Japan was proven to be wrong by the drastic and grave impact on the EU and USA. These economies being “forward thinking” economies have always taken pride in pioneering efforts that were soon followed by the other nations of the world. The other nations would surely benefit from a “wait and see” approach but it would be in the interest of the EU and USA to coordinate efforts towards a uniform enforcement of the Sulphur regulation, be it rigid or partial.

That said, since the EU and the USA had enforced the spirit of the Sulphur regulations over their territorial water since as early as 2010, it is unlikely that they would adopt a stance of partial enforcement of the Sulphur regulation leaving the Scenarios 1 and 2 to be the more probable ones by elimination. However, in this regard, it is often debated that prompt ratification by the member states of the IMO are often met with equally prompt enforcement of the ratified law over their respective territories by way of national laws owing to numerous reasons. This is stated as in the run up to the enforcement of the Sulphur regulation from 1st January 2020 with 1.5 years remaining, it is unlikely that the member nations such as China, Republic of Korea and Japan would enforce the Sulphur regulation rigidly, let alone partially thereby leaving Scenario 3 to be the most probable of the three. As much as it at the tip of every

reader's tongue, no member state can expressly deny enforcement of the Sulphur regulation acknowledging the detrimental impact it may have on its industries as it would be deemed to be disrespectful to the environment on a global platform (unless of course, your last name starts with a T and ends with a P). So, it is in every nation's interest to adopt a passive stance with a partial enforcement of the Sulphur regulation by taking advantage of the ambiguities therein justifying it as granting leeway to their respective shipping related industries to adopt the most feasible and viable option especially when there are more such changes to come.

Policy based recommendations

The impact of the Sulphur regulation on the shipbuilding industry stems from a shift in the policy on the use of bunkers by ships. As opposed to leaving the members of the industry to pick up the pieces of this grave impact, policy-based aid would greatly benefit the stakeholders of the shipping and shipbuilding industry as it is vital to not lose sight of the fact that only collective efforts would ensure the objective of such regulations be met; a cleaner and environmentally friendly shipping. In this regard, the enthusiastic efforts by shipping companies could be rewarded by tax rebates or efforts could be encouraged by providing subsidies. Or perhaps in line with regulations in the Republic of Korea and Singapore wherein the banking and financial sector are urged to aid the shipping industry by waiving the economic costs incurred or writing off the investments made towards efforts to comply with the Sulphur regulation to better the company's financial stance and receive a stronger credit line. At this phase wherein leader of State parties of the IMO brainstorm to enforce the regulation they ratified at the IMO, it is the most opportune time to create innovative incentives or aids for their respective shipping industries which would even pave way to be followed by other State parties to the IMO

Limitations and suggestions for further research

At this juncture, it is noteworthy to point out that the impact of the Sulphur regulation are far reaching and inter-related for these reasons, a more detailed study would find merit. Furthermore, it would be worthy to revise this study a year or two into the enforcement of the Sulphur regulation by weighing the actual state of enforcements. Despite the rollercoaster ride the imminent Sulphur regulation and the following changes pose, it is without a doubt an essential step towards cleaning the only planet we have. The debate of now or later will always plague the shipping industry just as it does for other industries but considering the recent spate of changes parts of the world has witnessed, it is the time to act now. The change would not be overnight and would take, the very reason why action needs to be taken at the earliest so as to allow a viable adjustment to it for its continued operation, which would yield benefits.

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Appendix

Appendix A – relevant portion of notes from Future Fuels Seminar 2018 indicating the results of the survey.

Future Fuels for 2020 Compliance Seminar June 2018

Unni Einemo: Survey suggests 38% of respondents think all ship owners will comply. Most common compliance option? LS fuel oil 45%, scrubbers + HFO 20%, LNG 16%. Main concern? Availability, followed by cost and infrastructure.

Edmund Hughes, Marine Environment Division, IMO:

The future is a multi-fuel mix. Industry must get its head around that. “There will not be a delay [in implementing 0.5% sulphur limit.... There is no option... Excuses are thin. January 1st 2020 deadline. Ship owners run the ships and should manage the risk. There is no chaos and confusion. Decision made in 2016, became a requirement in 2018, coming into force in 2020.

0.5% sulphur was first mooted in 2005 and 2008. Comprehensive review looked at demand for fuel oil in 2020. There’s a balance between doing it too early without all the information and doing it too late with no time to implement. Admittedly 0.5% fuel oil does not exist at the moment, it’s a blended fuel oil. If you can’t manage fuel oil, you shouldn’t be managing a ship. IMO makes rules but they are not beyond the ability of operators to manage. There is a new rule and the sector will just have to comply. When a rule is made it just has to be respected. If IMO rules are undermined, the result is regional or national legislation. IMO’s PPR subcommittee now looking at all concerns. All owners must comply or some will have a competitive advantage. Where fuel oil is not available, owners must provide evidence. This is not a ‘get out of jail free’ card. What are the safety implications to option of blended fuels?

Ban on carriage of non-compliant fuel comes into force on March 1st 2020, giving two months’ grace period. This fuel change is not new: procedures have been going on since January 2015 from 3.5% to 0.1% in ECAs. We recognise there are practical management issues. How will you manage non-availability of fuel? Crew awareness and training – the seafarers will be managing this fuel. Portable devices can now measure sulphur levels and emissions.

Increased focus on fuel availability. Ship operators will need to know where compliant fuel will be available. IBIA/IMO has issued best practice procedures to member states and fuel oil providers. Singapore won’t allow debunkering of fuel that was not sourced in Singapore. IMO urges ship owners not to focus on things that might not happen, focus on what will happen. We are moving into a multi-fuel future. If that means segregation of fuels, so be it.

Julian Clark, head of global shipping, Hill Dickinson:

Ban on carriage of non-compliant fuel March 1st 2020. Legal frameworks are playing catch-up. Concerns of cost and compliance. Who will bear the cost, risk, responsibility? Scrubbers prohibitively expensive cost that has potential for legal issues.

Appendix B – Extracts from ECGS proposal submitted to a premier shipping companies

III. PRICING

Non binding budget price for as listed below.

Description	Price (USD)
V-Heliscrub Scrubber with accessories	1,390,000
Transportation (ex China)	Included
Installation	600,000

1. Price excluding VAT or taxes
2. Price subject to final scope of supply

III. PRICING

Non binding budget price for as listed below.

Description	Price (USD)
V-Heliscrub Scrubber with accessories	1,490,000
Transportation (ex China)	Included
Installation	620,000

1. Price excluding VAT or taxes
2. Price subject to final scope of supply

Appendix C – orderbook of ECGS from Clarksons Research

Source: Clarksons Research

Data as of 25th July 2018. Extracted from World Fleet Register daily database.

Number of vessels with scrubbers fitted/scheduled to be fitted

Fleet (Fitted)	352			
Fleet (Pending Retrofits)	100			
Orderbook	366			
Total Vessels	818			

Abraham,

I'm glad the numbers were useful. The majority of planned retrofits in our database have an estimated retrofit date of start-2020; typically we do not know the exact scheduled date, but manufacturers or shipowners will often state that they are fitting the scrubbers ahead of the cap coming into force. In terms of the orderbook, the schedule for scrubber fitted vessels to be delivered stretches as late as 2023, with many of the vessels due for delivery later being cruise ships and VLOCs.