INTERSESSIONAL MEETING OF THE WORKING GROUP ON REDUCTION OF GHG EMISSIONS FROM SHIPS
7th session
Agenda item 2

ISWG-GHG 7/2/20
7 February 2020
ENGLISH ONLY

# FURTHER CONSIDERATION OF CONCRETE PROPOSALS TO IMPROVE THE OPERATIONAL ENERGY EFFICIENCY OF EXISTING SHIPS, WITH A VIEW TO DEVELOPING DRAFT AMENDMENTS TO CHAPTER 4 OF MARPOL ANNEX VI AND ASSOCIATED GUIDELINES, AS APPROPRIATE

## Detailed impact assessment of the mandatory operational goal-based short-term measure

**Submitted by Denmark, France and Germany**

**SUMMARY**

| | |
|---|---|
| *Executive summary:* | This document provides a detailed impact assessment of the mandatory operational goal-based short-term measure submitted by Denmark, France, and Germany in document ISWG-GHG 7/2/9. The detailed impact assessment is undertaken in accordance with the procedure for a comprehensive impact assessment as defined in MEPC.1/Circ.885. The detailed impact assessment is provided in annex to this document, and recommendations are provided in paragraph 15 of this document. |
| *Strategic direction, if applicable:* | 3 |
| *Output:* | 3.2 |
| *Action to be taken:* | Paragraph 16 |
| *Related documents:* | MEPC 75/7/2; ISWG-GHG 7/2/9, ISWG-GHG 7/6; ISWG-GHG 6/2/1, ISWG-GHG 6/2/7, ISWG-GHG 6/2/9, ISWG-GHG 6/2/10, ISWG-GHG 6/2/11; MEPC 74/7/4; ISWG-GHG 1/2/4, ISWG 1/2/14; MEPC 72/INF.12 and MEPC.1/Circ.885 |


## Introduction

1 The Marine Environment Protection Committee, at its seventy-fourth session (13 to 17 May 2019, MEPC 74), instructed the Working Group on Reduction of GHG Emissions from Ships at its sixth and seventh intersessional meetings (ISWG-GHG 6 and ISWG-GHG 7) to further consider concrete proposals to improve the operational energy efficiency of existing ships, with a view to developing draft amendments to chapter 4 of MARPOL Annex VI and associated guidelines, as appropriate.

2 MEPC 74 approved the *Procedure for assessing impacts on States of candidate measures* as set out in MEPC.1/Circ.885.

3 ISWG-GHG 6 noted "the concerns expressed by the delegation of Cook Islands, […], supported by the delegations of Vanuatu, Palau and several other delegations, that the initial impact assessments provided to this session did not adequately address whether the proposed measure was likely to result in disproportionately negative impacts on small island developing States (SIDS) and least developed countries (LDCs), and as such did not identify how those impacts could be addressed (e.g. avoided, remedied, mitigated), as appropriate" (MEPC 75/7/2, paragraph 20).

4 In the ensuing discussion, the comment was made that "a future submission by the co-sponsors of document ISWG-GHG 6/2/11 (Denmark et al.) would include a focus on impacts on Pacific SIDS" (MEPC 75/7/2, paragraph 20.3). The report of ISWG-GHG 6 also noted that "several delegations reiterated their concerns that the impact assessments submitted with the proposals to date were inadequate and that, in accordance with MEPC.1/Circ.885, a comprehensive impact assessment was required prior to the adoption of any measure" (MEPC 75/7/2, paragraph 29).

5 ISWG-GHG 6 "invited the sponsor(s) of proposed measures to continue their work on impact assessment, paying particular attention to the needs of developing countries, especially SIDS and LDCs, in accordance with the procedure approved by the Committee and to submit their assessment to next meeting" (MEPC 75/7/2, paragraph 33).

6 Paragraph 6 of MEPC.1/Circ.885 sets out that "a proponent of a measure (…) may submit a more detailed impact assessment in the first instance, taking into account the elements listed in paragraph 15".

7 Paragraph 15 of MEPC.1/Circ.885 details that "the comprehensive impact assessment should pay particular attention to the needs of developing countries, especially SIDS and LDCs and include, inter alia:

.1 a description of the assumptions and methods used in the analysis;

.2 a detailed qualitative and/or quantitative assessment of specific negative impacts on States; and

.3 an assessment of whether the measure is likely to result in disproportionately negative impacts and, if so, recommendations on how they could be addressed (e.g. avoided, remedied, mitigated), as appropriate."

8 The co-sponsors of the mandatory operational goal-based short-term measure (ISWG-GHG 7/2/9) provide in annex to this document a detailed impact assessment continuing the work in the initial impact assessments. The co-sponsors note that the detailed impact assessment fulfils the requirements of a comprehensive impact assessment.

9 The detailed impact assessment was commissioned by the Danish Maritime Authority to the Technical University of Denmark (DTU) and supported by the Danish Maritime Fund under the umbrella project "Maritime DTU, Forskningsbaseret maritim rådgivning 2019-2020". It was prepared by Harilaos N. Psaraftis, Thalis Zis (both DTU), and Ronald A. Halim from Equitable Maritime Consulting. The work of Ronald A. Halim was commissioned by the French Maritime Affairs Directorate.

10 The detailed impact assessments is made up of 65 pages. It includes chapters on: Assumptions and methods; Update of literature; List of potential negative impacts; The South American case study; The LDCs/SIDS case study; The Indian case study; and Conclusion. Recommendations are provided in this document below.

**Conclusion of the detailed impact assessment**

11 The purpose of the detailed impact assessment has been to provide insights and analysis as regards the operational goal-based measure proposed by the co-sponsors. The challenges of a detailed impact assessment were highlighted and were seen to be mainly due to many uncertain factors that are relevant and to the lack of relevant data.

12 Based on the analysis of the case studies, the detailed impact assessment concludes that negative and, by implication, disproportionately negative impacts are unlikely for South American countries and for India. For SIDS/LDSCs, the evidence at our disposal does not prove that negative impacts will occur. However, the case studies suggest that there may be a risk related to financing retrofitting of existing ships or investments in new ships, particularly since most of the external trade of SIDS falls onto shipowners of other countries serving these SIDS.

13 Potential mitigation measures can be considered in terms of capacity-building, technical assistance, R&D support and financial assistance to cater for the special circumstances of SIDS/LDCs. However, these measures are beyond the scope of the operational goal-based measure per se. They would need to be discussed and designed through other appropriate fora and instruments.

14 Additional data and analysis are necessary to shed more light on these issues. For SIDS and LDCs negatively affected, the detailed impact assessment suggests that any mitigation action should be considered outside the strict mandate of the goal-based measure as far as IMO is concerned, and maybe should also be considered in the context of other international bodies.

**Recommendations**

15 The co-sponsors recommend that:

.1 MEPC invites Member States and other intergovernmental and international organizations to support new research on maritime transport and decarbonization of shipping in SIDS and LDCs. Such research should pay special attention to the challenges identified in this detailed impact assessment, including lack of data, should be initiated as soon as possible, and should have a long-term perspective on data collection; and

.2 any short-term measure should include a review clause whereby possible new and better knowledge and data related to assessing impacts on States is included in the review of the measure, as soon as possible, with a view to amend the measure accordingly.

**Action requested of the Working Group**

16 The Group is invited to include the detailed impact assessment and the initial impact assessments in its further consideration of the operational goal-based approach and take action as appropriate.

***

# DETAILED IMPACT ASSESSMENT OF THE MANDATORY OPERATIONAL GOAL-BASED SHORT-TERM MEASURE proposed in doc. ISWG-GHG 7/2/9

**Harilaos N. Psaraftis and Thalis Zis**
**Department of Technology, Management and Economics**
**Technical University of Denmark**

**Ronald A. Halim**
**Equitable Maritime Consulting**

**February 7, 2020**

# TABLE OF CONTENTS

# ABSTRACT

The purpose of this document is to provide insights and analysis as regards the detailed impact assessment of the mandatory operational goal-based short-term measure as proposed initially in doc. MEPC 74/7/4 (Denmark, Germany and Spain) and subsequently in doc. ISWG-GHG 7/2/9 (Denmark, France and Germany). The document builds on the initial impact assessment as per doc. ISWG-GHG 6/2/1 (Denmark). As per doc. MEPC.1/Circ.885, this document attempts to identify potential negative and disproportionately negative impacts. Particular focus groups are countries in South America, in selected LDCs/SIDS, and in India.

The challenges of a detailed impact assessment ae highlighted and are seen to be mainly due to many uncertain factors that are relevant, and to the lack of relevant data. The analysis conjectures that even though negative and disproportionately negative impacts are unlikely for South American countries and for India, for LDCs/SIDS a risk for such impacts exists and that appropriate mitigation measures are warranted. The main issue that is seen to involve a risk of disproportionate negative impact was as regards the difficulty to finance retrofitting of old ships or investment in new ships, particularly since most of the external trade of SIDS falls onto shipowners of other countries serving these SIDS.

The degree of share (or responsibility) of the goal-based measure with respect to such potential negative impacts, vis-à-vis the share of other factors contributing to these impacts, cannot be precisely ascertained, even though we conjecture this share to be low. Additional data and analysis are necessary to shed more light on this issue. For LDCs and SIDS negatively affected, the study suggests that any mitigation action should be considered outside the strict mandate of the goal-based measure as far as the IMO is concerned, and maybe should also be considered in the context of other international bodies.

In terms of IMO's mandate, potential mitigation measures can be considered in terms of capacity building, technical assistance, R&D support and financial assistance to LDCs/SIDS. However, these cannot happen in the context of the goal-based measure per se, but would need to be discussed and designed through other appropriate fora and instruments.

# ABBREVIATIONS

| | |
|---|---|
| AIMS | Africa, Indian Ocean, Mediterranean and South China Sea |
| AIS | Automatic Identification System |
| AOSIS | Alliance of Small Island States |
| APEC | Asia-Pacific Economic Cooperation |
| ASEAN | Association of South East Asian Nations |
| ASOEX | Chilean Fruit Export Association |
| BAF | Bunker Adjustment Factor |
| CEPII | Centre d' Etudes Prospectives et d'Informations Internationales |
| CIF | Cost Insurance Freight |
| CII | Carbon Intensity Indicator |
| $CO_2$ | Carbon Dioxide |
| CSC | Clean Shipping Coalition |
| ECLAC | Economic Commission for Latin America and the Caribbean |
| EE | Energy Efficiency |
| EEXI | Energy Efficiency Existing Ship Index |
| ETS | Emissions Trading System |
| EU | European Union |
| FEU | Forty foot Equivalent Unit |
| FOB | Free On Board |
| GDP | Gross Domestic Product |
| GHG | Greenhouse Gas |
| GT | Gros Tons |
| HFO | Heavy Fuel Oil |
| ICS | International Chamber of Shipping |
| ICAO | International Civil Aviation Organization |
| IMO | International Maritime Organization |
| IOPCF | International Oil Pollution Compensation Fund |
| ISWG | Intersessional Working Group |
| LDC | Least Developing State |
| LSCI | Liner Shipping Connectivity Index |
| MAC | Marginal Abatement Cost |
| MBM | Market Based Measure |
| MCR | Maximum Continuous Rating |
| MDO | Marine Diesel Oil |
| MEPC | Marine Environment Protection Committee |
| MGO | Marine Gas Oil |
| NM | Nautical Mile |
| OECD | Organisation for Economic Cooperation and Development |
| PLCSI | Port Liner Shipping Connectivity Index |

| | |
|---|---|
| SEEMP | Ship Energy Efficiency Management Plan |
| SIDS | Small Island Developing State |
| SS | Slow Steaming |
| TEU | Twenty foot Equivalent Unit |
| UNCTAD | United Nations Conference on Trade And Development |
| UN DESA | United Nations Department of Economic and Social Affairs |
| UNFCCC | United Nations Framework Conference on Climate Change |
| UK | United Kingdom |
| UN | United Nations |
| USA | United States of America |
| USD | United States Dollar |
| WG | Working Group |
| WTO | World Trade Organization |

# 1. INTRODUCTION

In doc. MEPC 74/7/4, Denmark, Germany and Spain (abbreviated from now on as "Denmark et al.") proposed a mandatory operational goal-based short-term measure (abbreviated from now on as the "goal-based measure") so as to meet the 2030 carbon intensity target set by the IMO in the context of the Initial IMO Strategy. Doc. MEPC 74/7/4 included an initial impact assessment, which was updated in doc. ISWG-GHG 6/2/1 (Denmark). Further details of the goal-based measure were provided in doc. ISWG-GHG 6/2/11 (Denmark et al.), and more recently Denmark, France and Germany (abbreviated from now on as the "co-sponsors") submitted a more detailed proposal in doc. ISWG-GHG 7/2/9. As per the terms of reference specified in doc. MEPC.1/Circ.885, the aforementioned initial impact assessment identified which impacts should be assessed, taking into account, as appropriate, inter alia (1) geographic remoteness of and connectivity to main markets; (2) cargo value and type; (3) transport dependency; (4) transport costs; (5) food security; (6) disaster response; (7) cost-effectiveness; and (8) socio-economic progress and development.

The initial impact assessment identified several *positive impacts*, which included the following, among others (ISWG-GHG 6/2/1):

1. securing a level playing field and reducing emissions across the fleet by targeting the existing fleet and not just new ships;
2. possibly lower transport cost;
3. cost-effective energy efficiency gains;
4. incentivizing development and integration of better ship designs, technological innovations, and efficient operation of ships because the regulation can be met by operational and technical measures and the means for reducing emissions is open. Hence, the measure is also compatible with pursuing efforts of towards 70% reduction by 2050 as well as the third level of ambition of the Initial Strategy;
5. incentivizing the shift towards sustainable alternative fuels, since the means for reducing emissions is open. Hence, the measure is also compatible with pursuing efforts of towards 70% reduction by 2050 as well as the third level of ambition of the Initial Strategy;
6. climate action will reduce costs associated with climate change to many States and shipping

In addition, the benefits of the goal-based approach versus other short-term approaches were extensively discussed (refer to doc. ISWG-GHG 6/2/11, paragraphs 1.2.1 to 1.2.16) and need not be repeated here. In short, and according to Denmark et al, the goal-based measure offers the most effective regulation of carbon intensity reduction as it is effective in several different aspects. It is effective in time from before 2023 towards 2030 and 2050. It is effective in its direction of innovation from construction, technology, operation, future fuels and their innovative combinations. Finally, it is effective in coverage of the fleet as it targets individual ships and is based on the principle of securing a level playing field.

At the same time, the initial impact assessment (ISWG-GHG 6/2/1) also identified the following *expected negative impacts*, inter alia:

1. possibly higher costs on States that export or import large amounts of high-value goods; and
2. a few ships could be laid-up or scrapped earlier than expected at time of purchase possibly leading to extra costs for the shipowner (depending on efficiency gains and lower fuel costs).

The purpose of the present document is to provide insights and analysis as regards the detailed impact assessment of the goal-based measure. The document builds on the initial impact assessment of doc. ISWG-GHG 6/2/1. Per doc. MEPC.1/Circ.885, this document attempts to identify potential negative and disproportionately negative impacts, and, in that sense, mostly focuses on such impacts.

It should be emphasized that this document's specific focus, as stated above, by no means negates or downgrades the positive impacts of the goal-based measure, as these have been identified in doc. ISWG-GHG 6/2/1. In fact, the documentation of these positive impacts would be incomplete without a more detailed consideration of any potential negative impacts, and as per doc. MEPC.1/Circ.885 this is carried out in the present document. For methodological and other reasons that are explained in Chapter 2, particular focus countries in this document are countries in South America, in selected LDCs/SIDS, and India.

Per doc. MEPC.1/Circ.885, the detailed impact assessment should pay particular attention to the needs of developing countries, especially SIDS and LDCs and include, inter alia:

1. a description of the assumptions and methods used in the analysis;
2. a detailed qualitative and/or quantitative assessment of specific negative impacts on States; and
3. an assessment of whether the measure is likely to result in disproportionately negative impacts and, if so, recommendations on how they could be addressed (e.g. avoided, remedied, mitigated), as appropriate.

The structure of the rest of this document mirrors the above list to a significant extent, with some additional explanations about the approach offered in Chapter 2. To that effect, we proceed as follows.

Chapter 2 outlines the assumptions and methods used in the analysis, including an exposition of the challenges of a detailed impact assessment. Chapter 3 performs an update of the literature on impact assessment. Chapter 4 presents a list of possible negative impacts on states, including disproportionately negative impacts. Chapters 5, 6 and 7 examine the South American, the LDCs/SIDS, and the Indian case studies respectively. Chapter 8 summarizes the document’s conclusions.

# 2. ASSUMPTIONS AND METHODS

## 2.1. Challenges of a detailed impact assessment

From a methodology perspective, performing a detailed impact assessment of *any* goal-based GHG reduction measure, including the one assessed in the present document, is not a straightforward proposition, for at least the following reasons:

A. Randomness of many of the relevant variables

Any operational carbon intensity indicator CII(x,w) associated with a goal-based measure, however defined, is a function of both x, the vector of decision variables that the ship operator has at his disposal, and w, the vector of exogenous variables that are random and outside of the ship operator's control. The indicator CII should be such that the choices in x can be readily reflected in improvements in CII(x,w), particularly if such improvements will be required on a yearly basis.

Take for instance the case in which a shipowner retrofits his vessel with energy-saving devices, or uses a low-carbon fuel. Such measures would improve the indicator CII and hopefully help the ship meet the 2030 (and possibly also the 2050) target.

For recent analyses of such technologies, fuels, and operational practices as regards reducing GHG emissions, see Bouman et al. (2017), OECD (2018), de Kat et al. (2019), and Psaraftis (2019), among others.

The ship may also apply a combination of capacity utilization and speed optimization that can further improve the indicator. The ship may also coordinate with ports of call in the context of virtual arrival/just-in-time/port call optimization, to reduce fuel costs and emissions at the same time.

At MEPC 74, the IMO adopted resolution MEPC.323(74) on invitation to Member States to encourage voluntary cooperation between the port and shipping sectors to contribute to reducing GHG emissions.

At the same time, the actual numerical value of the indicator will also depend on the weather conditions that the ship will encounter in its trades, as well as on other exogenous variables. Two identical ships, one trading in the North Atlantic and one in the Mediterranean, may exhibit different values of the indicator, due to factors outside the shipowner's control.

Table 1 (which is not necessarily complete) indicatively shows what variables belong to the x category and what variables belong to the w category. The table further distinguishes between operational and technical variables for x and between weather and other exogenous variables for w.

**Table 1: Distinction between decision variables x and exogenous variables w**

| | | |
|---|---|---|
| x | Operational variables | Technical variables |
| | Speed optimization<br>Optimized routing<br>Fleet management<br>Capacity utilization<br>Network design<br>Virtual arrival/just-in-time[1] | Buy a new ship/scrap or sell old one<br>Ship retrofit (e.g. bulbous bows, propellers, etc.)<br>Engine retrofit/derating<br>Energy saving devices (waste heat recovery, etc.)<br>Power limitation<br>Electric/hybrid propulsion<br>Alternative fuels<br>Hull condition (coatings, cleaning, etc.)<br>Digitalization |
| w | Weather variables | Other exogenous variables |
| | Waves- sea state<br>Wind<br>Currents<br>Tides<br>Ice | Cargo demand<br>Cargo value<br>Freight rates<br>Fuel prices<br>Port efficiency<br>"Political" variables (port strikes, trade embargoes, civil unrest, etc.) |

The following observations are important:

1. Variables x and w are not independent. Generally there is a dependency of decision variables such as ship speed and routing to exogenous variables like cargo demand, freight rates and fuel prices. For instance, when market is high and/or fuel prices are low, ships tend to speed up and vice versa. Also, more expensive cargoes induce higher speeds, and that is one of the reasons liner shipping involves higher speeds than tramp shipping and there are speed directional imbalances in various trades, especially in the liner sector[2]. These imbalances increase emissions, as sailing with an average common speed $v=0.5(v_1+v_2)$ in both directions would result in lower emissions versus the case that ship speeds $v_1$ and $v_2$ in the two directions are different.
2. If the focus is on operational measures, it is clear that the tools to be used are those listed in the top left corner of Table 1. By contrast, if the focus is on technical measures, one should look at the top right corner of the table.
3. For existing ships, the most obvious operational measure that can be taken so as to meet operational goal-based targets is speed reduction. How this can be done is at the discretion of whoever pays for the fuel (shipowner if ship on voyage charter and

[1] Collaboration with ports is required here. See IMO Resolution MEPC.323(74).
[2] Liner shipping involves regular scheduled services, mainly in the container and Ro-Ro sectors. Ships typically carry higher value products including manufactured products, perishable products and other general cargoes typically shipped in unitized format. In tramp shipping there are no regular scheduled services and ships carry bulk commodities such as crude oil, petroleum products, iron ore, coal, grain, and other cargoes that are shipped in bulk.

charterer if ship is on time charter). A similar situation plays out for technical measures, since EEXI (doc. ISWG-GHG-6/2/3 by Japan and Norway) or power reduction (doc. ISWG-GHG-6/2/4 by Greece) would lead to speed reduction. Here the shipowner is the relevant decision maker.

4. In case of ships on time charter, some the x operational variables are outside of the control of the shipowner, the charterer being the relevant decision maker.
5. It would be easier to comply with any operational goal-based target in periods of depressed market conditions and/or high fuel prices than the opposite. Such periods would induce slow steaming and make the realization of the 2030 carbon intensity target easier. However, and short of introducing a fuel or carbon levy, which is outside the scope of the potential short-term measures stipulated in the Initial IMO Strategy, the state of the market and the level of fuel prices are outside the ship operator's or policy makers' control.
6. Related to the previous point, the implementation of the 0.5% global sulphur cap as of 1.1.2020 is expected to lead to higher fuel prices in much of the maritime sector and, in that respect, induce lower speeds and hence lower $CO_2$ emissions, in both absolute and carbon intensity terms. An exception is for ships with scrubbers that burn HFO and which are expected to sail faster than ships burning more expensive MDO/MGO. Even though the sulphur issue is generally expected to make compliance with the goal-based measure easier, the full extent of this cannot yet be assessed, due to the inherent unpredictability of fuel prices.
7. Equally unpredictable is the uptake of alternative and low carbon fuels and other energy savings solutions such as wind propulsion, Flettner rotors, air bubbles, waste heat recovery and others, as well as how preferences of such measures will evolve or change over time.
8. As argued in doc ISWG-GHG 6/2/11, a "rebound effect" may occur when a planned carbon intensity reduction does not fully translate into practice, often because of profit maximizing incentives. For example, a technical solution can theoretically reduce carbon intensity at a given level, but in practice, the full potential would not be reached if higher profits can be gained by increasing speed thereby underutilizing the potential reduction. The goal-based measure mandates a limit on operational emissions; thus, speed and other operational characteristics have to observe the carbon intensity target in practice.
9. Trying to find a way to separate the effect caused by the x variables from that caused by the w variables and thus remove or reduce the noise in the data, it is far from clear if something like this can be done, as the emissions function, which can be a complex function due to the reasons explained earlier, is not a priori separable into a term that is only a function of x and another term that is only a function of w.
10. The stochasticity of various operational indicators due to the stochasticity of the w variables has been documented by various studies (for instance Polakis et al. (2019), Lindstad et al. (2019), Panagakos et al. (2019), and doc. ISWG-GHG 6/2/10 by China).

B. Influence of factors not related to the goal-based measure per se

A related issue is that, in addition to the impacts on states that can be attributed to the goal-based measure *per se*, impacts may also be due to other factors that are not connected to the goal-based measure, or are connected to it only indirectly. Take for instance the implementation of the global 0.5% sulphur cap, as of 1.1.2020, as per point No. 5 above. Such a measure could have very important (albeit still not well understood) ramifications on fuel prices, freight rates and speeds, and, by extension, on the exports or imports of LDCs, SIDS, or other states. It could also impact the fleets and trade flows serving these countries in an unspecified way. Another example is the recent surge in tanker freight rates as a result of exogenous factors, which could again significantly impact oil imports of LDCs, SIDS or other states. In a yet another example, a trade war could impact trade flows and commodity prices world-wide. Last but not least, the recent plan of the European Commission to include shipping within the EU Emissions Trading System (ETS) in the context of the European Green Deal (EU, 2019), if realized, could have a profound impact on fuel prices, ship speeds, freight rates as well as trade flows on a global basis. It could be difficult or impossible to dissect or isolate such impacts from the impact of the goal-based measure per se, and these other impacts could conceivably be more important than those attributed to the goal-based measure itself. This observation is important since measures proposed to mitigate any negative effects of the goal-based measure should in principle only reflect the fair share of the goal-based measure within the overall spectrum of impacts, and not assume responsibility for other factors that are disconnected from this measure.

C. Uncertainty of shipowners' response

One of the advantages of the goal-based measure is its inherent flexibility, leaving all of the pertinent choices (upper part of Table 1) to the shipowner. Such flexibility would also allow for strategies to minimize the effect of external factors (as per point B above), and in that sense the goal-based measure can also have a positive effect on the outcome of external factors. This is in contrast to other approaches, for instance EEXI, let alone prescriptive approaches (power limits or speed limits), for which only a subset of these choices is available. This flexibility maximizes the feasible solution space and hence the likelihood of the 2030 target being achieved. It also has a higher chance to help reach the 2050 target than other, more restrictive proposals. At the same time, this flexibility renders the task of impact assessment more difficult, as the possible impacts of the goal-based measure depend, among many other things, on the precise way the world's shipowners will choose to implement the measure. The potential uptake of GHG-reduction technologies is usually studied in the context of the Marginal Abatement Cost (MAC) curves, and several attempts to construct such curves are known, including DNV (2009), Eide et al (2010), and IMAREST (2011). However, a shipowner is unlikely to choose a technology that has a positive MAC and in that sense MAC curves are more useful in the context of Market Based Measures (MBMs) that can help some of these technologies achieve a negative MAC (Psaraftis and Woodall, 2019). As MBMs are outside the scope of the IMO discussion on short-term measures, and as the shipowners' choice depends on company strategy, preferences and other factors, the mix of actions to be undertaken by these owners in response to the goal-based measure is inherently difficult to predict.

D. Lack of pertinent studies

As further explained in Chapter 3 (update of literature), an observation is that, strictly speaking, none of the studies on impact assessment address the impact of the specific goal-based measure on states. However, some of the studies examine the impact of *speed reduction* on states. These studies can be (indirectly but clearly) useful in our analysis, as one of the possible responses to meet the goal-based measure is speed reduction. Other studies examine the impact *of a carbon levy* on states. Again, to the extent that this can be translated into an assessment of the impact of *freight rates* on states, these can be useful in our analysis (see also Chapter 3).

E. Lack of data

There is no question that much data is available in the maritime sector from various sources, covering for instance fleet statistics, shipping schedules and connectivity, ship movements via AIS data (Automatic Identification Systems), trade statistics, and other data. However, for the purposes of this assignment, and even though relevant specific data was solicited from selected LDCs/SIDS and from selected developing countries after MEPC.1/Circ.885 was circulated, not much was available by the time this submission was being finalized. This is true particularly as regards transport costs and freight rates and in particular for LDCs/SIDS it was stated that reliable data collection for the specific purpose would be a long term undertaking, impossible to be carried out under the existing time schedule. However, and even though the above lack of relevant or reliable data made our analysis more difficult and to some extent rendered its conclusions qualitative and subject to review once additional information or other data becomes available, we believe that still something can be said, as further explained in Section 2.2 below.

## 2.2. Outline of approach

The difficulties listed above perhaps were less relevant for the initial impact assessment, as reported in doc. ISWG-GHG 6/2/1, as the terms of reference of that assessment did not require a very detailed analysis. However, these same difficulties are very valid as regards the detailed impact assessment. Even if there were a model that could map the entire process from assembling all of the required inputs to ultimately determining the impacts on states, the lack of data as well as the factors outlined above would make such a model not particularly useful. To our knowledge, such a model does not currently exist, nor do we think that models developed for other purposes (for instance, to estimate global GHG emissions or project scenarios for future uptake of emissions reduction technologies or alternative fuels) would be much useful here. Developing such a model is feasible whenever the data for it becomes available. The model itself will depend, to a large extent, on the kind of data that becomes available. It was impossible to develop such a model within the timeline of the present assignment.

Yet, in spite of the above obstacles, and short of abandoning this task altogether for the reasons stated earlier, we believe that some analysis is possible, and one that can identify some important parameters and help obtain some insights. To that effect, we believe that the analysis reported in the rest of this document satisfies the terms of reference of MEPC.1/Circ.885 as regards the detailed impact assessment.

Our methodological approach consists of the following steps:

STEP 1: Update of the literature- see Chapter 3.
STEP 2: Define list of potential negative impacts- see Chapter 4.
STEP 3: Focus on some specific case studies- see Chapters 5, 6 and 7.
STEP 4: On the basis of the previous steps, draw some conclusions- see Chapter 8.

Regarding STEP 3, it was decided to focus on specific case studies. The specific case studies selected are in three groups:

- South America and specifically Argentina, Brazil, Chile and Peru- see Chapter 5.
- Selected LDCs/SIDS- see Chapter 6.
- India- see Chapter 7.

The reason these case studies were selected is threefold: (a) the above countries have been very active in the IMO discussion on GHGs, (b) the co-sponsors of the goal-based measure pay particular attention to the impact assessment as regards developing countries, including LDCs and SIDS, and (c) in view of the lack of data as described above, we believe that a study of these countries can provide an adequate focus of the main issues at stake and can be considered as sufficiently representative of the analysis of relevant problems (understanding of course that exceptions may occur elsewhere).

# 3. UPDATE OF LITERATURE

Even though there are many references in other parts of this document, this chapter focuses on literature on impact assessment. Doc. ISWG-GHG-6/2/1 has already identified some related literature. In the context of our analysis, we have reviewed some additional documents that we think are relevant. None of these documents pertains to the goal-based measure per se. However, to the extent they examine potential impacts of measures or other factors that can lead to a freight rate increase or to other impacts, these documents can be useful.

The exposition below is non-encyclopedic. We divide it in three sections, one on general literature, one on the role of connectivity as a determinant of freight rates, which will be seen to be important for impact assessment, and one on miscellaneous other literature.

## 3.1 General literature

UNFCCC (2005) highlighted the SIDS' participation in the UNFCCC as well as some of the ongoing needs and concerns that they have expressed in the course of the UNFCCC process.  SIDS are among the most vulnerable to climate change impacts, which will become critical if no appropriate action is taken. Many islands are threatened by rising sea levels. Another growing concern is the increasing number and severity of extreme weather events—with all they entail in terms of loss of life and damage to property and infrastructure that can easily cripple small economies. SIDS are among the Parties least responsible for climate change and are dependent on others to ensure that significant action is taken in support of the UNFCCC.

Briguglio et al. (2010) constructed a vulnerability index for small states taking into consideration among others the population count, GDP per capita, and parameters such as dependencies on strategic imports, narrowness of range of exports, remoteness and insularity. They also examine the resilience of the economies of small states to recover from the effects of adverse shocks.

Scobie (2013) examined the effects of global climate change regulation (not only on maritime transport) on Caribbean SIDS and argues that frequently this can have an unwanted effect on their economic competitiveness. The author notes that emissions reduction schemes for aviation and maritime transport can increase international transportation costs and constitute exports from remote SIDS less competitive globally. The author raises the issue of environmental justice where SIDS should not bear equal burdens of paying for carbon, but stresses the need for the quantification of the economic impact of relevant regulation. The author also notes that the lack of data that would allow such analyses is a limiting factor on the SIDS' ability to debate on the effects of such measures.

UNCTAD (2014) discussed the key issues at the interface between maritime transport, sustainability and resilience in SIDS. The study identified gaps and needs facing the maritime transport sector in SIDS and highlighted potential response measures with a view to more sustainable and resilient maritime transport systems.

On the issue of environmental justice, Adelman (2016) examined the damage and losses that several SIDS face as a consequence of climate change. The author proposed a compensation mechanism for affected SIDS from market based mechanisms that would be in line with the CBDR principle, and would be compelling with all principles of climate justice.

Shi (2016) considered the effects of potential market-based measures to reduce GHG emissions from international shipping, and notes that while potential exemptions for SIDS and LDCs would seem appropriate; this runs the risk of certain ship operators to opt to include such states in their routes, in order to get emission exemptions.

Krammer and Smith (2017) provided an analysis of impacts on New Zealand, including the territory of Tokelau, of potential IMO targets and measures to control greenhouse gas (GHG) emissions from international shipping. Among other findings, if a carbon price of 25 USD per ton of $CO_2$ is introduced (e.g. through the means of an MBM) in international shipping, the study finds that New Zealand's real income drops by approximately 16USD per person. These price changes materialize into a drop of 0.076 USD billion in GDP or a drop of 0.038% in GDP respectively and on a once only basis if the carbon price remains constant over time. On Tokelau the study found that it is very likely that Tokelau is more prone to price shifts in international transport. The study argued that if Tokelau is included in the IMO GHG reduction policies, its economic impacts from MBMs in international shipping are likely to be above world average.

NZIER (2018) assessed the economic and environmental impact of international maritime measures on New Zealand. A model of the New Zealand economy is used to estimate the potential economic impacts of higher fuel prices and a shift to more slow/super-slow steaming that will be associated with New Zealand acceding to MARPOL VI. Neither scenario is found to result in significant economic costs, with GDP impacts between USD2 million and USD33 million in the higher fuel price scenario; and between USD4 and USD10 million for slow or super-slow steaming. The commodities affected by slow or super-slow steaming are chilled exports to the EU, which account for just 2.6% of total merchandise exports.

ICS (2018) outlined the broad spectrum of measures toward meeting the IMO targets. Among other things, the document indicated a strong opposition to the concept of IMO establishing a mandatory system of operational efficiency indexing for application to individual ships. According to ICS, this is because of the potential inaccuracies of such a metric and the significant danger of market distortion. The document also highlights the opposition of ICS to including shipping into the EU ETS.

Parry et al. (2018) discussed the possibility of a carbon tax as a key element of GHG mitigation policy for international maritime transport. The paper discusses the case for the tax over alternative mitigation instruments, options for the practical design issues, and then presents estimates of the impacts of carbon taxation and other instruments from an analytical model of the maritime sector.

Halim et al (2019) reviewed research on the economic impacts of GHG mitigation measures on states, using model-based analysis. Specifically, the paper identified four areas of economic impacts and their relationships, compiled the latest findings on the estimated magnitudes of these impacts, and presented relevant modeling approaches along with best practices for selecting and applying these approaches in impact assessments. Several related references were cited. No model was run to investigate impacts, but results of related literature were assessed. A conclusion from this review was that introducing carbon prices in the range of 10 to 50 USD/ton of $CO_2$ might increase maritime transport costs by 0.4% to 16%. However, this would only marginally increase the import prices of goods (by less than 1%, according to the study). For transport choices, the increased cost of maritime transport induced by GHG mitigation measures might only slightly reduce the share of maritime transport, by 0.16% globally. Furthermore, a global carbon tax applied to all transport modes might stimulate a shift toward maritime transport from all other modes. The impacts of a carbon price in the range of 10 to 90 USD/ton of CO2 on national economies were found to be modest.

Of course, the goal-based measure under study is not equivalent to a carbon levy. In that sense, the above study is probably more relevant in relation to an analysis of Market Based Measures (MBMs). However, to the extent that the goal-based measure might result in an equivalent increase in freight rates, the results of the above paper and of the associated literature could very well be relevant.

Last but not least, APEC (2019) investigated the impacts of slow steaming to distant economies, with a focus on the Asia Pacific region. The objective of the study was to explain the various parameters that need to be considered when evaluating slow steaming and what the environmental and economic impacts are across a varied vessel types, fleet, distance, and cargo. Depending on the commodity, the study found slow steaming to have a different impact. For nonperishable products, the study found the delay due to slow steaming to be minimal. For perishable products, such as fresh cherries, the study found the impact due to the delay caused by slow steaming to be considerable and that it may result in a shift to air freight.

Again, what is termed in the above study as “slow steaming” is not equivalent to the goal-based measure, which is not analyzed in the study. Therefore the findings of that study do not directly translate to results that pertain to the goal-based measure case. However, to the extent that the goal-based measure might result in speed reductions equivalent to those examined in APEC (2019), the results of the above study could very well be relevant. We shall have the opportunity to revisit this issue in Chapter 5.

## 3.2 Literature on connectivity

According to UNCTAD, the access of countries to world markets depends largely on their transport connectivity, especially as regards regular shipping services for the import and export of manufactured goods. UNCTAD's Liner Shipping Connectivity Index (LSCI) aims at capturing a country's level of integration into global liner shipping networks.

LSCI takes into account the following six factors:

(a)The number of scheduled ship calls per week in the country;
(b) Deployed annual capacity in TEU: total deployed capacity offered at the country;
(c) The number of regular liner shipping services from and to the country;
(d) The number of liner shipping companies that provide services from and to the country;
(e) The average size in TEU (Twenty-Foot-equivalent Units) of the ships deployed by the scheduled service with the largest average vessel size;
(f) The number of other countries that are connected to the country through direct liner shipping services (a direct service is defined as a regular service between two countries for which the transport of a container does not require transshipment).

It should be noted that this index is relevant only for the liner shipping market, since the carriage of unitized cargoes may involve a number of transshipments and since monopolistic/oligopolistic situations may conceivably occur in the sector. There is no equivalent index in the tramp shipping market, in which bulk shipments typically follow direct routes and in which freight rate formation is typically competitive, with little room for monopolistic/oligopolistic scenarios.

In the initial impact assessment of doc. ISWG-GHG 6/2/1, it was argued that less connected states are not likely to be disproportionately impacted. In this report, and in the context of the examination of potential negative impacts, including disproportionately negative impacts, we will carry out some further investigation of this issue.

According to Wilmsmeier and Hoffmann (2008), see Fig. 1 below, a high connectivity index implies a reduced risk of monopolistic/oligopolistic schemes and hence it implies reduced freight rates, vis-à-vis situations of a low connectivity index, which imply the opposite. Their estimates suggest that one transshipment has the equivalent impact on freight rates as an increase in distance between two countries of 2612 km.

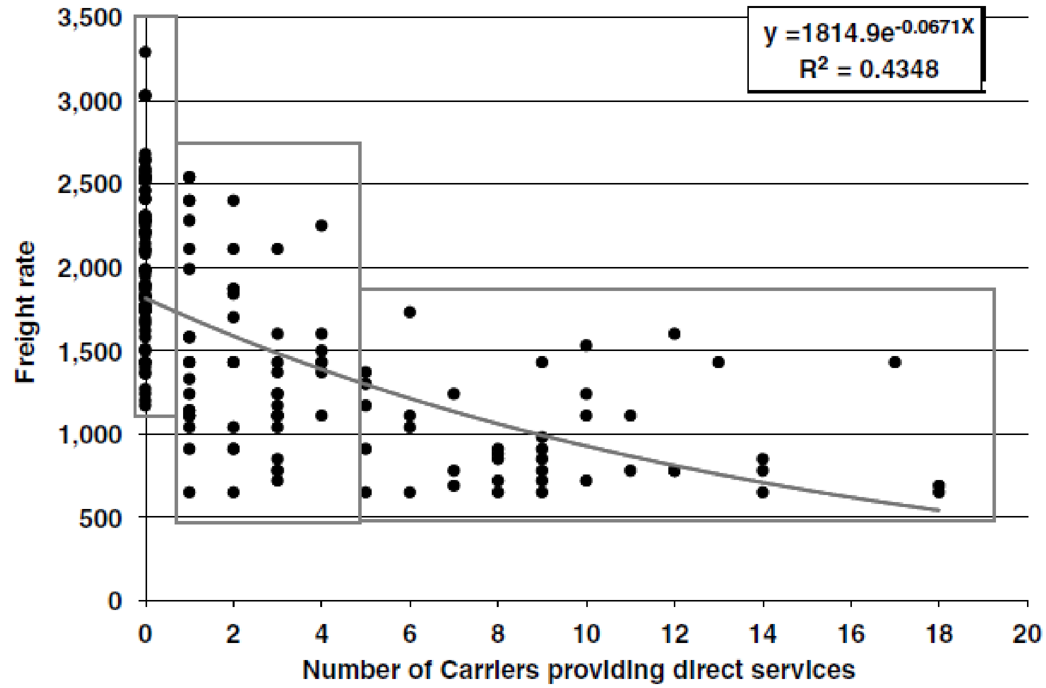
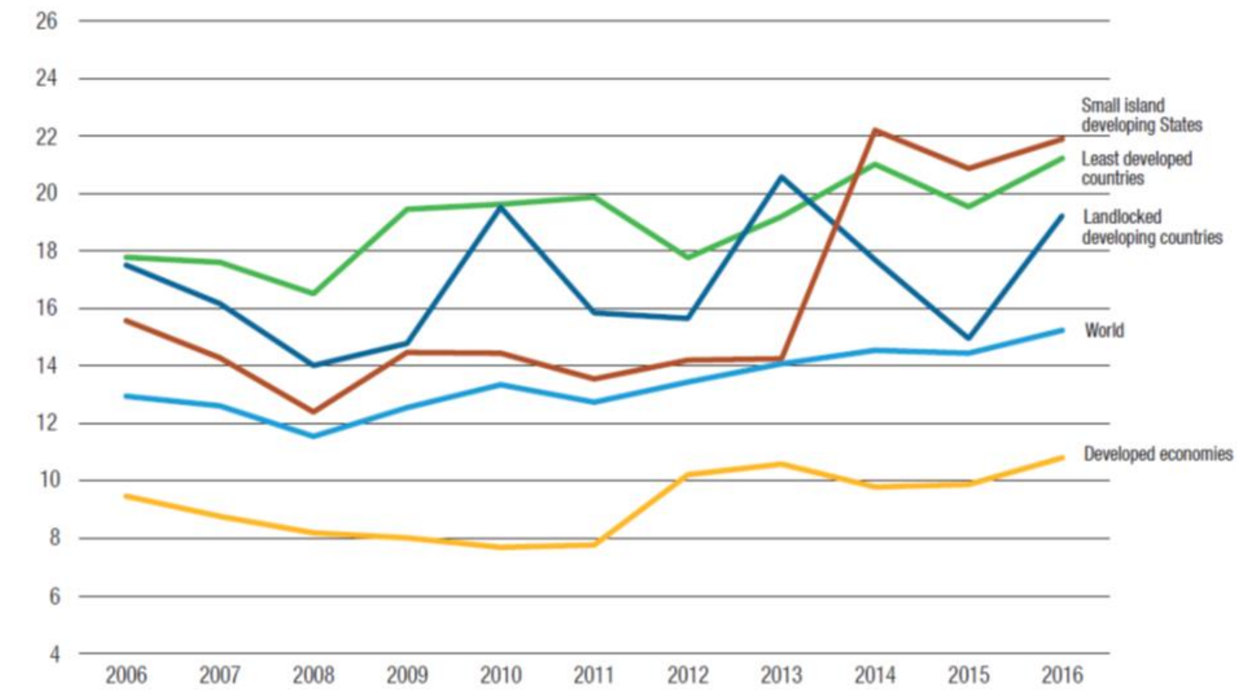



**Fig. 1: Relationship between number of carriers providing direct service and freight rates. Source: Wilmsmeier and Hoffmann (2008).**

The above study was conducted for Caribbean LDCs/SIDS but there are valid reasons to believe that the same or worse is the case for Pacific or other LDCs/SIDS. In fact, according to Fugazza et al. (2017), for the 14 Pacific developing member countries of the Asian Development Bank for the time period 2011–2013, a direct shipping connection more than doubles trade in goods imports. Using a gravity model approach based on a dataset on maritime connections for a sample of 178 countries collected over the 2006–2012 period found that the absence of a direct connection was associated with a drop in exports value varying between 42 and 55%. Similar conclusions pertain for South Africa (Hoffmann et al. 2019).

The world's highest connectivity index is held by China. It will be seen in Chapter 5 that South American developing countries exhibit intermediate and generally rising connectivity indices, whereas Chapter 6 will show that the LCSs/SIDS under study exhibit very low connectivity indices.

To complement this argument, we also show Fig. 2 from UNCTAD (2017), which shows freight cost as a percentage of value of imports for various world regions.




*Source:* UNCTAD secretariat calculations.
*Note:* All modes of transport; the least developed countries grouping includes 48 countries for all periods up to 2016.

**Fig. 2: Transport and insurance costs as a percentage of value of imports. Source: UNCTAD (2017).**

It can be seen that LDCs/SIDS have the highest transport costs as a percentage of the value of their imports, in comparison with the world average, let alone vis-à-vis developing economies.

Yet another related figure is Fig. 3, which shows (on a logarithmic scale) the LSCI for members of the Association of South Eastern Asian Countries (ASEAN). It can be seen that some countries in South-East Asia have extremely low connectivity indices as compared to other countries in the area (for instance Singapore and Malaysia).

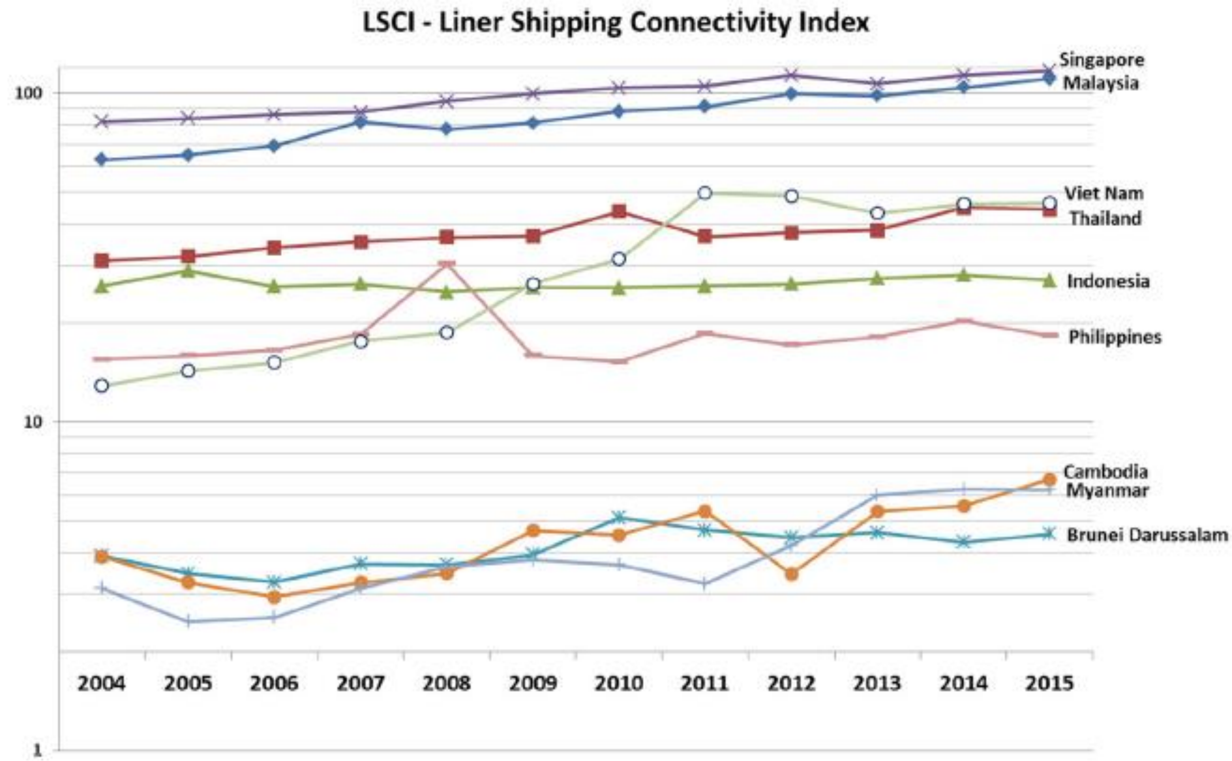



**Fig. 3: LSCI for ASEAN countries. Source: Lun and Hoffmann (2016).**

Note that Singapore, even though a SIDS, is one of the best connected countries in the world, with a LSCI comparable to China's.

It should also be realized that connectivity is not the only determinant of freight rates. In general the latter depend on the interaction between supply of and demand for shipping services, which in turn depend on a multitude of factors, including (but not limited to) fuel prices, fleet composition, competition in the shipping markets (or lack thereof), port infrastructure, commodity-specific supply and demand, and others. However, as seen above the impact of connectivity can be quite significant for specific scenarios in the liner market.  Moreover, the above considerations show the inherent disadvantages of some countries as regards the formation of liner freight rates. A relevant issue of course is to what extent the goal-based measure may make the situation worse. We shall have the opportunity to further examine this issue in later parts of this report.

## 3.3 Miscellaneous other literature

The sample references below are only indirectly related to impact assessment, but we mention them nonetheless.

Mills et al. (2014) examined issues associated with the spoilage and shelf-life of lamb when transported to distant markets. These issues are highly relevant for the trades of perishable products.

Chatzinikolaou and Ventikos (2016) examined maritime emissions from a lifecycle perspective, by factoring in emissions that are due to shipbuilding and ship recycling. Such an analysis is important in case the world fleet is expanded because ships may have to reduce speed.

Imbs and Mejean (2017) carried out an investigation of elasticities in selected countries. Import and export elasticities are very important as any increase in freight rates would translate into a combination of decrease in the prices of the products exported and/or an increase of the prices of imported products.

Psaraftis and Kontovas (2010) developed a methodology to estimate modal shifts due to speed reduction in deep-sea routes and investigate, among other things, possible shifts to the railway mode in the Far East to Europe corridor as a result of speed reduction in the maritime mode. A binomial logit model was used.

Zis and Psaraftis (2017, 2018) performed a similar analysis in short-sea routes. The methodology takes is based on the generalized cost concept which takes into account time and costs including value of time and inventory costs. Modal shifts would also result because of higher freight rates.

# 4. LIST OF POTENTIAL NEGATIVE IMPACTS

As already argued in docs MEPC 74/7/4 and ISWG-GHG 6/2/1, the adoption of the goal-based measure would entail significant *positive* impacts on states. At the same time, and as per doc. MEPC.1/Circ.885, the detailed impact assessment is tasked to investigate possible *negative* impacts of the proposed measure, including *disproportionally negative* impacts. On this, the following can be said.

In the context of the initial impact assessment, doc. ISWG-GHG 6/2/1 assessed the following eight impacts: (1) geographic remoteness of and connectivity to main markets; (2) cargo value and type; (3) transport dependency; (4) transport costs; (5) food security; (6) disaster response; (7) cost-effectiveness; and (8) socio-economic progress and development. There have been no commenting documents to doc. ISWG-GHG 6/2/1, and we believe that these eight impacts were sufficiently addressed in that document and that no additional considerations for these impacts are deemed necessary here. However, in the context of the detailed assessment, and as per doc. MEPC.1/Circ.885, one would need to go deeper and perform a finer grain investigation of potential negative impacts. This is so because each of the eight impacts as identified above depends on a multitude of factors, many of which are inter-related, and in order to examine the ultimate dependency of each of the above eight impacts to the goal-based measure, one would need to look at the picture in more detail.

In that context, this chapter builds upon the analysis of the eight impacts of doc. ISWG-GHG 6/2/1, and carries out this more detailed analysis of the relevant impacts which could potentially be negative due to the introduction of the goal based measure. The case studies examined in Chapters 5, 6 and 7 will use this analysis for the specific geographical contexts examined there.

Looking at Table 1, *at the operational level* a possible outcome of the goal-based measure is an increase of sailing time, to the extent that the measure would induce speed reduction to meet the goal-based carbon intensity target. *At the technical level*, retrofitting existing ships or investing in new ships could entail costs whose financing may be difficult. In both cases, negative impacts on states may be experienced.

The following list includes some of these possible negative impacts. These include, inter alia:

I. Undesirable degradation in the quality of the cargo: This is particularly true for perishable agricultural or other cargoes, which may lose quality if in transit for more than a certain duration, even if frozen.

II. Increased cargo in-transit inventory costs: More sailing days will imply increased in-transit inventory costs for the shipper, which are proportional to (a) the value of the cargo and (b) the increase in sailing time. These costs could translate into lower FOB prices[3] for exports and/or higher CIF prices[4] for imports, depending on import/export elasticities.

III. Cargo shifts to faster modes of transport: Slower maritime speeds may encourage some cargoes to shift to other, faster modes of transport, including road, rail or air. This may increase overall GHG emissions. Specialized reefer ships that can sail faster than conventional containerships may cause another potential shift. Modal shifts would also result because of higher freight rates (see also IV below).

IV. Higher freight rates: This may be a potential *short-term* consequence of speed reduction, or of the development of monopolistic/oligopolistic situations. Freight rates are functions of shipping supply and demand and any contraction of the ship supply curve could result in higher freight rates, which could be unfavorable for the shippers. It should be realized of course that such monopolistic/oligopolistic situations may already exist prior to the implementation of the goal-based measure. If so, an examination to what extent the goal-based measure is expected to make the situation worse is warranted.

V. Decrease of product FOB prices and/or increase of product CIF prices: Any potential increase in freight rates would translate into a combination of decrease in the FOB prices of the products exported and/or an increase of the CIF prices of these products. The extent of these price changes would depend on the export/import elasticities of the product.

VI. Loss of market share to competitors who are closer to target markets: As a result of the potential price changes highlighted above, a potential drop in market share of the product in question may take place.

VII. Change of stock levels: There may be an impact of slower speeds on stock levels, as this would also depend on other factors, such as for instance service frequency and other attributes. In general, if speed goes down, required stock levels are expected to increase.

VIII. Higher lifecycle GHG emissions: Even though in the short term freight rates may increase, in the long term, and after idle fleet is absorbed, more ships will be needed to sustain trade throughput in the face of a reduced speed regime. Building these additional ships would produce additional GHG emissions due to shipbuilding and recycling (lifecycle GHG emissions).

[3] The FOB price is the price of a product at its origin.
[4] The CIF price is the price of a product at its destination.

IX. Difficulty to finance retrofitting of old ships or investment in new ships: This includes all of the technical measures displayed in the top right corner of Table 1. Countries whose trade depends on ageing fleets may have a problem going down that path.

How are the nine (I to IX) finer grain impacts as identified above connected with the eight impacts as those were assessed in doc. ISWG-GHG 6/2/1? It is clear that many linkages exist. Below is a mapping showing the main linkages.

(1) geographic remoteness of and connectivity to main markets: I, II, III, IV, VI, VII

2) cargo value and type: I, II, III, IV, VI, VII

(3) transport dependency: III, IV, VI, VII

(4) transport costs: I, II, III, IV, VI, VII, IX

(5) food security: I, IV, V, VII, IX

(6) disaster response: VII, IX

(7) cost-effectiveness: II, III, IV, V, VI, VIII

(8) socio-economic progress and development: IV, V, VI, IX

This means that any of the eight impacts that were assessed in doc. ISWG-GHG 6/2/1 is connected to several of the nine finer grain impacts to be assessed here, and any analysis of the latter would provide additional insights on the former.

For the reasons outlined in Section 2.1, performing a complete quantitative evaluation of all impacts in the above list (I to IX) is impossible, let alone within the time frame of this assignment. However, by focusing on the specific case studies as outlined earlier, it will be seen that we were able to obtain some insights, some of them quantitative and some qualitative. These will be included in the chapters of the respective case studies (Chapters 5, 6 and 7).

In assessing each of the impacts of the above list, two dimensions will be deemed important: (a) probability and (b) consequence. For instance, an impact may conceivably be very unlikely but may have a very important negative consequence, or vice versa. In that sense, both the above dimensions are important.

# 5. THE SOUTH AMERICAN CASE STUDY

## 5.1. Introduction

A number of documents comment on the possible impact of GHG emissions reduction measures on developing countries in South America. These countries include (alphabetically) Argentina, Brazil, Chile and Peru. To our knowledge, none of these documents examines the impact of the goal-based measure. However, some documents examine the possible impact of *speed reduction* on these countries. To the extent that speed reduction will be one of the operational measures that the ship operator will choose to implement the goal-based measure, the corresponding documents are worthy of note and relevant for our analysis.

Before we look at these documents, some information on these countries LSCI is relevant. The following four figures provide some insights. Indices have been normalized so that China has an index of 100 in 2006.

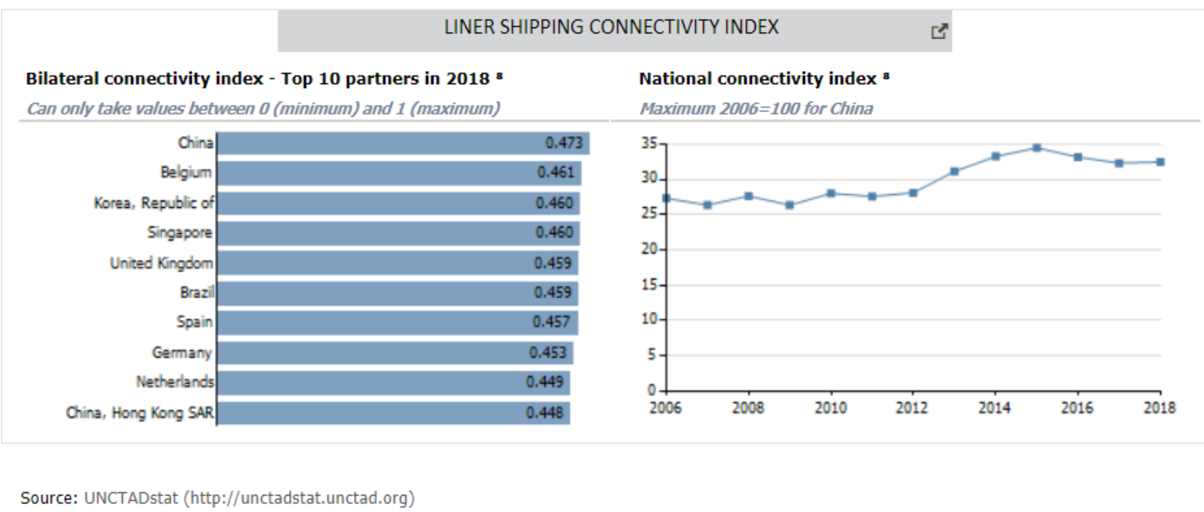
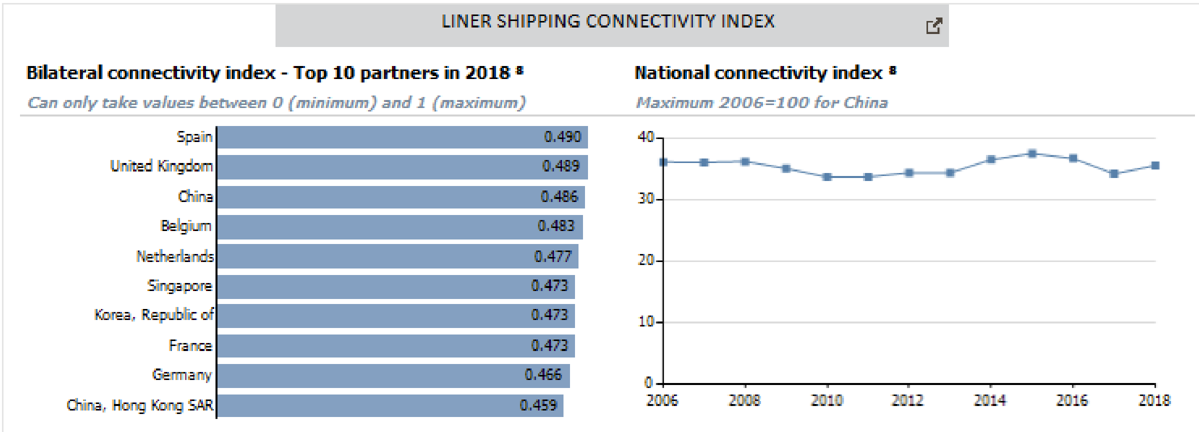


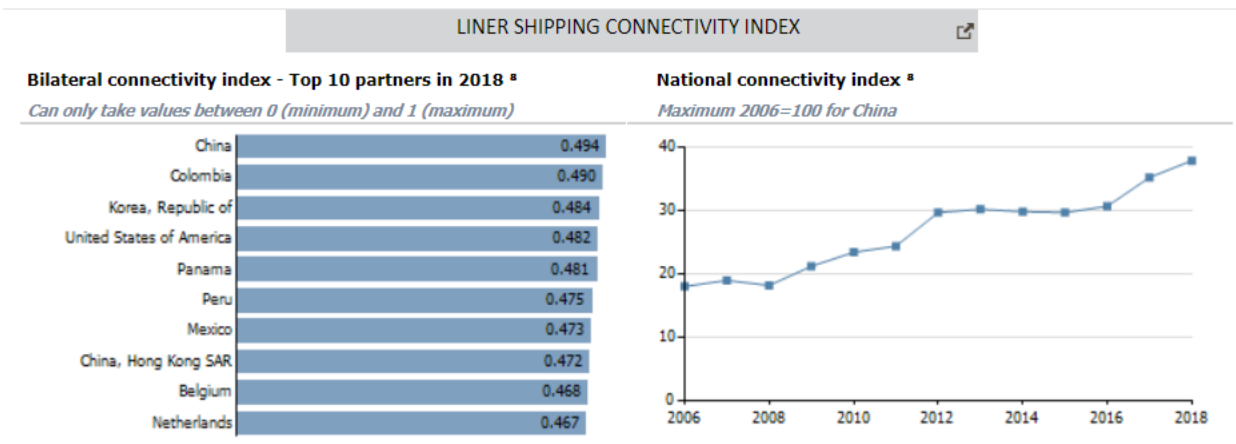

**Fig. 4: Argentina's connectivity index. Source: UNCTADSTAT**[5]

[5] https://unctadstat.unctad.org/




Source: UNCTADstat (http://unctadstat.unctad.org)

**Fig. 5: Brazil's connectivity index. Source: UNCTADSTAT**




Source: UNCTADstat (http://unctadstat.unctad.org)

**Fig. 6: Chile's connectivity index. Source: UNCTADSTAT**

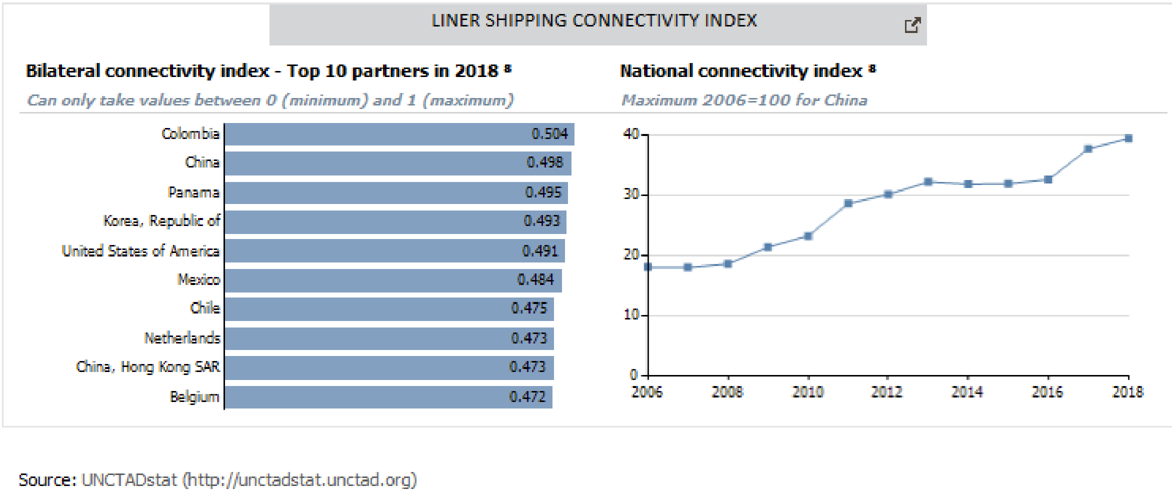



**Fig 7: Peru's connectivity index. Source: UNCTADSTAT**

In all cases we observe a steady or rising connectivity index in the range of 25% to 40% of China's 2006 connectivity index, which is the global maximum. Although the numbers are well below China's, they show surely a sign of steady or rising competition in the liner sector in these trades. In view of shipping overcapacity in the sector, this also means that the establishment of monopolies or oligopolies that would stifle competition and increase freight rates is unlikely. Actually, quite the opposite is to be expected.

With these introductory remarks, we next comment on some specific cases.

## 5.2. Chile and Peru

We start by Chile and Peru. Document ISWG-GHG 3/2/10, entitled "Analysis of the impact on States and the implications of speed reduction" and submitted by Chile and Peru to the 3rd Intersessional WG on GHGs, the one that immediately preceded MEPC 72, was the trigger that explicitly introduced the term "speed optimization" into the debate on the IMO Initial Strategy (or re-introduced it, as it was already implicitly there because of SEEMP). In the document, Chile and Peru expressed serious concerns on the possible negative repercussions that speed reduction might have on their exports of agricultural products, and specifically cherries from Chile and avocado and blueberries from Peru. The export of these products to markets such as Asia and Europe takes place in narrow time intervals during the year, for instance from October to February for Chilean cherries, with a peak in December (see Fig. 8).

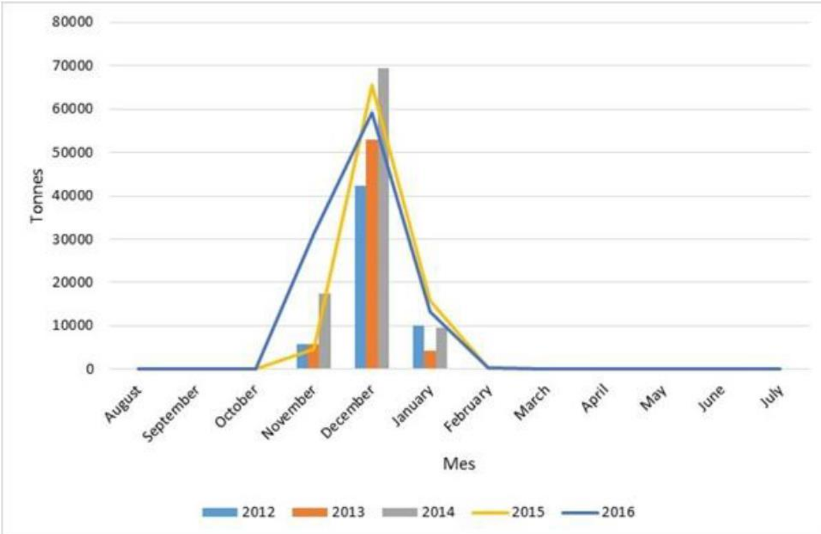



**Fig. 8: Chilean cherry exports. Source: ISWG-GHG 3/2/10**

These countries argued that if transit times from South America to China go over 40 days (which corresponds to an average speed of 15 knots), then damage to these products is likely to occur. Instead, they calculate that if a speed of 20 knots is used, transit time will be 33 days, which is, according to them, within the allowable limits. Even though there is no mention of the term “speed optimization” in the document, in the ensuing discussion at the 3rd intersessional WG meeting, Chile and Peru suggested to replace the term “speed reduction” by “speed optimization”, and at the end both terms were included in the text of Initial IMO Strategy, within the set of candidate short-term measures.

From the above document one can also see that shipping is not the only export mode for Chilean cherries. Road and air are also relevant, with road being around 2% of exports and air being around 14%. Presumably the only alternative mode to Asia is air transport, and one would envision a scenario in which some of the cargo is shifted to the air mode if ship speed is lowered considerably. We shall come back to this point in Section 5.5 below.

The above submission clearly stated the case for Chile and Peru, even though, and for these services, evidence as presented below suggests that the speed of 20 knots mentioned in the document is unlikely to occur under current or medium-term market conditions.

DTU project ShipCLEAN[6] analyzed a Yang-Ming/Cosco transpacific service that includes these two countries (see Fig. 9 below). Observed were an average eastbound speed of 17.5 knots and an average westbound speed as low as 12.5 knots (see also

[6] https://www.chalmers.se/en/projects/Pages/ShipCLEAN---Energy-efficient-marine-transport-through_1.aspx

Vilas (2018) and Psaraftis (2019)). Both speeds indicate significant slow steaming, especially in the direction from South America to Asia.


**Fig. 9: Transpacific service. Source: Project ShipCLEAN and Psaraftis (2019)**

The above scenario refers to spring 2018. The situation in the fall of 2018 was not significantly better. A Maersk Line service from Valparaiso, Chile to Yangshan, China for mid-December 2018 (the peak of the cherry export season) would sail the 12,000 nm of distance in 35 days, meaning an average speed of 14.3 knots, still rather slow.

In 2019 there were certain services that sailed at higher speeds. For example, Maersk offers a service from San Antonio (Chile's largest port) to Yangshan (Shanghai, China) with a transit time of 28 days. This would require an average sailing speed of 15.2 knots, which is faster than the same time in 2018.

That speeds are already slow from South America to Asia (and surely also elsewhere) is obviously due to market conditions that have to do with the chronic overcapacity in liner trades worldwide and with other factors that are trade-specific. The speed directional imbalance has surely to do with the imbalances in the values of goods and/or load factors in the two directions, both of which are speculated to be significant. Whatever it is, and without any GHG reduction measure being imposed, the speed situation is already one that Chile and Peru characterize as undesirable, raising the question how worse the situation might get by the "speed reduction" that these two countries state that should be avoided. Slow steaming, *not so much as a measure but as an outcome*, is already there. It should be noted that for one of the ships of the ShipCLEAN scenario (a 10,114 TEU vessel whose design speed is about 25 knots), a 12.5 knot speed means sailing at 10% of the ship's MCR, which can achieve significant fuel and GHG emissions savings. The situation for all other ships in this service is pretty similar, since to maintain regularity of service all ships in a specific liner shipping route sail at the same speed (and even though speeds may vary for each leg of the route).

A later document which attempted to explicitly address the concerns of Chile and Peru was document ISWG-GHG 4/2/8 entitled “The regulation of ship operational speed: an immediate GHG reduction measure to deliver the IMO 2030 target”, and submitted by the Clean Shipping Coalition (CSC) to the 4th Intersessional WG on GHGs. In that document, CSC argued for the speed limit option, branding it as a measure that can have an immediate impact on reducing GHG emissions, and as a “bridge” measure until more permanent measures are taken.

The way CSC addressed Chile and Peru’s concerns was by stating that containerships would be allowed to *not* slow down during the export period, so long as they do so in the remainder of the year, on a maximum average per year speed basis. For instance, a large containership in the China to South America trade which went 17.5 knots eastbound and 12.5 knots westbound (as per ShipCLEAN scenario presented earlier) would have to slow down only on the eastbound leg, but could, if deemed appropriate, speed up on the westbound leg, up to 15.17 knots (the computed maximum average speed for the top tier containership size), except for the “cherry export” periods in which the ship could exceed that speed limit altogether so long as the yearly speed average is at most 15.17 knots. How that yearly average would be computed however is unclear, average with respect to time, distance, or other. In the example above, the arithmetic average of 17.5 knots and 12.5 knots is 15 knots, below the 15.17 knots stipulated maximum. If so, then the benefits in terms of GHG emissions reduction would be questionable, since the fuel consumed in a 17.5/12.5 knot scenario would be higher than those in a 15/15 knot scenario (and so would be the GHG emissions).

Of course, the goal-based measure under consideration, being less restrictive than the CSC prescriptive measure, would provide ship operators with more flexibility on how the targets of the measure would be met.

A possible question might be what is the impact of speed reduction on the in-transit inventory cost of cargoes exported from South America to Asia. Depending on export elasticities, such cost could conceivably increase CIF prices and/or reduce FOB prices, thus hurting export competitiveness. According to Imbs and Mejean (2017), Chile is a country with a low export elasticity, among a set of 28 developing and developed countries.

However, a crude calculation for Chilean cherries finds that such cost is negligible as compared to the value of the cargo. In fact, assuming a 14,000 USD/ton CIF price for Chilean cherries[7] and a 3% interest rate, a reduction of sailing speed from 13 to 10 knots

[7] https://www.freshplaza.com/article/9136791/chilean-cherries-popular-in-china-because-of-excellent-price-quality-ratio/

across the 12,000 nautical miles from Chile to China would increase the sailing time by 11.5 days and would amount to an extra inventory cost of 13.3 USD/ton, or less than 0.1% of the value of the cargo. In the extreme (but in our opinion unrealistic) case speed is reduced from 20 to 10 knots, this would increase the sailing time by 25 days and would amount to an extra inventory cost of 28.8 US/ton, or some 0.2% of the value of the cargo.

A more pertinent question is the potential degradation of the cargo itself if sailing times are high. Mills et al (2014) documented such potential degradation for lamb products, and a similar concern is for agricultural products. APEC (2019), which refers to 2017 data, documented (among other impacts) the case of serious negative economic impacts for Chilean cherry exports in case of significant slow steaming. However the goal-based measure was not examined in that study and the slow steaming scenarios which were examined and which might lead to such negative impacts are plausible to be caused by an across-the-board speed limit regime and not from the goal-based measure which (as already stated) would allow much more flexibility to the ship operator to adjust ship speed profile along the course of the year. In addition, the chartering of dedicated reefer vessels should be considered as an alternative in the unlikely scenario of non-compliance vis-à-vis the goal-based measure, and in fact the so-called Cherry Express service by Hapag Lloyd has been launched to address this issue. Section 5.5 has more details on this issue.

## 5.3. Argentina

As regards Argentina, in the liner sector the country's connectivity index has been steady over recent years and on the average comparable to those Chile or Peru (see Figs 4, 6 and 7 above). So we conjecture[8] that the same trends and results that were mentioned above for Chile and Peru hold for Argentina as well. Another study that can shed light into Argentina was a study by CE Delft (2017).

The above study examined the impact of speed reduction in South America and generally argued for speed limits. In addition, the study analyzed two cases of exports from Argentina to Europe, sailing across the Atlantic. Even with very conservative assumptions about the impacts, the study claimed that the economic impacts of slow steaming are modest: export values would be reduced by a few tenth of a percent at most, and the overall economic impact would be well below a tenth of a percent for the whole of South America.

Regarding impacts, the study was actually restricted to the examination of the trade of just two products, oilcake and chilled beef, both from Buenos Aires to Rotterdam. In the

[8] *To conjecture* (verb) is to form an opinion or hypothesis in the face of incomplete information. Such an opinion or hypothesis is called *a conjecture* (noun).

first case they considered a bulk carrier already slow steaming at 12.2 knots, and in the second a containership whose speed was assumed to be equal to an average speed of 16.3 knots. Using these two examples the study estimated the costs due to increased sailing time and reached the conclusion that impacts of speed limits on trade are minimal.

Again, the above study did not analyze the goal-based measure, however the goal-based measure does not prescribe specific speeds and this means that the flexibility to meet the carbon intensity targets would be higher than for a prescriptive measure. Based on the above, the baselines that would be established may very well render ships on these trades as compliant with the goal-based measure anyway. In that sense, scenarios such as the above, which entail significant slow steaming, will make ships deployed on these trades likely to meet the carbon intensity targets to 2030, plus whatever intermediate targets are stipulated in the context of implementing the goal-based measure.

## 5.4. Brazil

As regards Brazil, in the liner sector the country's connectivity index has been steady over recent years and on the average higher than those of Argentina, Chile or Peru (see Figs 4 to 7 above). So we conjecture that the same trends and results that were mentioned above for Chile, Peru and Argentina, also hold for Brazil. This hypothesis is confirmed by Lucena (2018), who analyzed the impact of the 2050 IMO targets on the competitiveness of Brazilian exports *in the tramp market*. Iron ore is by far Brazil's main export. The study found, among other things that for Brazilian iron ore exported to China $CO_2$ emissions per exported ton are 3 times higher than those of its main competitor (Australia), and that similar disadvantages pertain to other main export markets, such as Japan and Germany. However, if the comparison is made on a carbon intensity basis, which takes also into account distance, it is seen that Brazil actually performs very well vis a vis its trade competitors, as shown in Fig. 10.

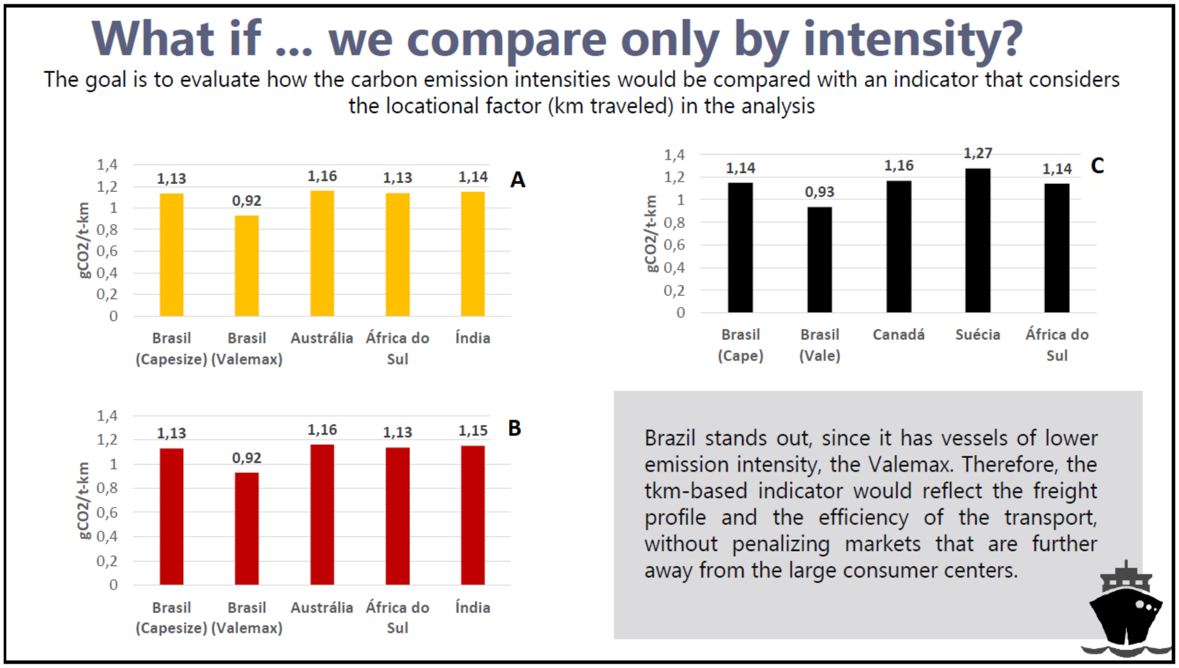



**Fig. 10: Carbon intensity of Brazilian iron ore exports (A: China; B: Japan; C: Germany). Adapted from Lucena (2018).**

The study also calculated significant potential reductions in carbon intensity if slow steaming (SS) and energy efficiency (EE) measures are taken, as shown in Fig. 11. Again Brazil seems to be well positioned vis-à-vis its trade competitors.

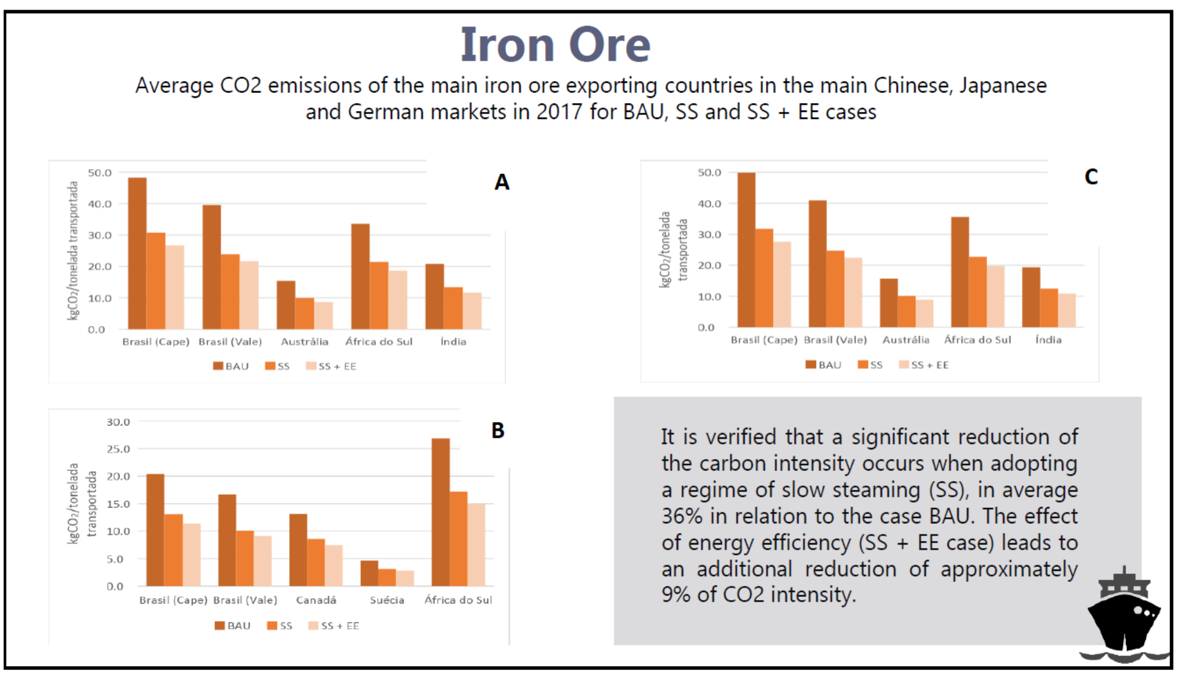



**Fig. 11: Reductions in carbon intensity due to slow steaming and energy efficiency measures (A: China; B: Japan; C: Germany). Adapted from Lucena (2018).**

The study reached similar conclusions as regards exports of Brazilian crude oil and also analyzed the prospects of Brazilian soybean production to be used for biofuels to meet the 2050 IMO targets.

## 5.5. Modal shift analysis

In this section we return to Chile and focus on cherries as this is one of the most important export products of Chile that has seen a steady growth in recent years. According to ASOEX (the Chilean Fruit Export Association), the main season for cherries is between mid-October and late February (depending on the variety), with the peak season being December. Fig. 12 shows the growth in cherry exports over recent years and the main export destinations for the product.

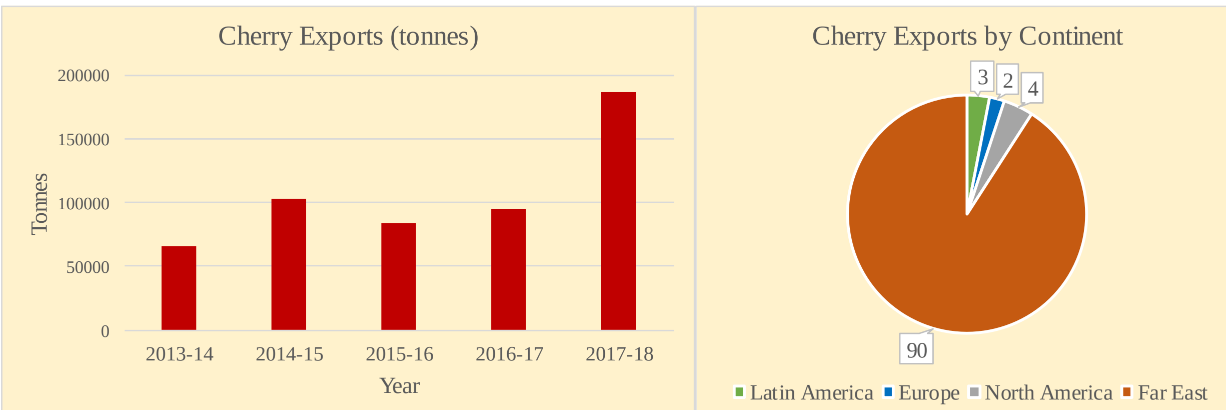



**Fig. 12: Cherry exports by year and destination. Data source: ASOEX**

This significant growth in the export markets is projected to continue in the coming years. For 2019/20 ASOEX released a projection for 209,000 tonnes of cherries (41.8 million boxes of 5kg per box). In this section we are presenting a what-if analysis to see potential negative impacts of decarbonization measures, taking the example of cherry exports as our case study.

Through document ISWG-GHG 3/2/10 Chile raised its concerns that a potential speed reduction (as a short term measure under discussion then) “could generate a distortion or a barrier to trade, because the exporter may not be able to arrive at its destination with its products in optimum condition and this would have repercussions on the competitiveness of the State”.

To achieve the effects of a goal-based measure, it is possible that certain ship operators will choose to reduce their sailing speeds as a potential response. Cherry producers have voiced concerns on the impacts of a longer transit time in their shipments. A potential reduction in speed could in our opinion have two effects. The first obvious effect is that it would make maritime shipping less attractive and thus could potentially lead to certain shipments being moved from water to air, with the obvious negative environmental consequences. The second effect which would be more important has to do with the very small season for demand for cherries in the Far East. As shown earlier, the peak production of cherries in Chile is between October and February, with the majority of the volumes in December. Following that period, other producers would be competitive in the markets of China.

A numerical example may provide insights on the potential modal shifts. We consider shipments from Chile to China with two available transportation options; waterborne and airborne. It is possible to estimate shifts caused by a distortion in the market (for example a change in the total freight cost, or travel time) by using modal split models for the transportation of cargoes. These models are effectively trying to capture the decision making process of a shipper when two or more alternatives are available. For our case study we consider an extension of a binary modal split model based on the work of Zis and Psaraftis (2017, 2018). To use these models the first step is the identification of all transport options, and gathering information on the market share of each option. We consider the generalized cost of transporting cherries from Chile to China. According to Chile, approximately 84% of exports to China are seaborne with the remainder being transported via airplane. The cost of transporting cherries via airfreight is estimated to be 4.5 times higher than maritime. Given the current state of the market, one refrigerated FEU would cost around USD5600 for transportation from Chile (San Antonio) to Yangshan. We consider a total transit time of 30 days (based on the existing service from Maersk that requires 28 days) versus a total transit time of 50 hours using air. The ensuing analysis considers lowering the sailing speed from 15.2 to 14 and 12.5 knots. The resulting modal shifts are summarized in Table 2, which also shows total chain $CO_2$ which is seen to increase as cargo shifts to the air mode.

**Table 2: Potential modal shifts**

| Scenario | Maritime | | | | Air | | | | Total Chain |
|---|---|---|---|---|---|---|---|---|---|
| | Market Share (%) | Days | Cost per FEU | $CO_2$ per ton | Market Share (%) | Days | Cost per ton | $CO_2$ per ton | $CO_2$ (tons) |
| Baseline Sailing Speed 15.2 knots | 84 | 28.2 | 5500 | 0.022 | 16 | 2.1 | 833 | 12 | 405197 |
| New Sailing speed 14 knots | 83.5 | 30.6 | 5500 | 0.019 | 16.5 | | | | 416552 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| New Sailing speed 12.5 knots | 82.8 | 34.4 | 5500 | 0.017 | 17.2 | | | | 434393 |

Impacts from reducing the season

From the previous section it can be seen that any modal shifts due to the lower sailing speed would almost negligible. Perhaps a more important concern from a significantly lower sailing speed is the fact that a slower sailing speed would reduce the "consumption" period of the product in China. Currently the first batches of cherries arrive in mid-October using air transport options, and the first ships are scheduled to arrive by mid-December after leaving Chilean ports in mid-November. In a worst case scenario with sailing speeds dropping to 12.5 knots (minimum acceptable speed) the total transit time of the first and last shipment would increase by 6 days respectively. Assuming that the consumption pattern of the import markets is unchanged throughout the season (there is actually a peak during holiday seasons and the Chinese new year), we could consider a worst case scenario of reducing the total transport demand by 12 days in the total period of 120 days, that would lead in a reduction of 10%, that could be replaced by air transportation.

In 2018/19 the total volume of cherries increased and smaller shipments were sent on more vessels, something that was hailed from importers due to the reduction in risk. We expect that if the season is actually reduced due to lower sailing speeds, one possible reaction would be to increase the shipment size.

Other concerns/limitations

The previous section showed that according to theory significant modal shifts should not be expected as a consequence of a small reduction in sailing speed. In addition, recent years have seen the emergence of dedicated faster shipping services for cherries (the so-called Cherry Express services from Hapaq Lloyd) that offer transit times of only 22 days from Chile to Hong Kong, and 27 days to Shanghai[9]. This fact shows that there is significant demand for this product to generate additional services offering competitive advantages in terms of total transit time. We therefore believe that if due to the goal-based measure certain shipping routes would reduce sailing speeds, the existing capacity and the great demand for such products may result in a differentiation of services. This would mitigate any potential loss of market share to potential trade competitors. Finally, as the goal-based measure considers the annual emissions reductions, it would be possible to maintain existing sailing speeds during this season,

[9] https://www.hapag-lloyd.com/zh/news-insights/news/2019/10/chile---asia---an1-cherry-express-service.html

and reduce speeds at other periods where less perishable products are being transported.

However, in reality there are additional factors that could distort this market. For example, recent unrest in Chile and riots in Santiago led to some ports temporarily halting their activities[10], and delays were experienced in shipments of cherries to the US[11]. In 2018 the first maritime shipment to China was sent on November 22 for a 35-day journey[12]. We can therefore observe that the market would have increased the season for exporting cherries, and at the same time offer faster services. Air transport of cherries is more expensive but has a larger season due to the smaller transit times. According to online sources the first shipment via air for 2019 (141 boxes) arrived on October 18[13].

Another important issue concerns the impacts of the global sulphur cap that will affect the sea transportation costs. According to current BAF surcharges, an increase in fuel price by USD100/ton could translate in an increase of USD64/TEU. Estimating the impacts of the global cap is beyond the scope of this document and certainly cannot be ascribed to the goal-based measure, but it can be easily understood that freight rates for cherries could increase by up to 7% using a simplified conservative estimate as a result.

## 5.6. Potential negative impacts

In terms of the potential negative impacts identified in Chapter 4, and on the basis of the exposition of the previous sections, Table 3 attempts to synthesize the above results into our assessment of the potential negative impacts on South American states as a result of the goal-based measure, on the following (probability, consequence) scale:

0: very low or 0
1: low
2: moderate
3: high
4: very high

It should be noted that the numbers in Table 3 by necessity entail a degree of subjectivity, and they reflect the best possible mapping of the authors' opinion based on all available information as outlined in the previous sections of this chapter.

**Table 3: Potential negative impacts on South American states**

| Potential negative impact | Probability | Consequence |
|---|---|---|
| Undesirable degradation in the quality of the cargo | 1 | 2 |

[10] https://www.freshplaza.com/article/9162949/unrest-in-chile-affects-cherry-export-to-china/
[11] https://www.freshplaza.com/article/9167451/we-ve-experienced-delays-in-cherry-shipments-due-to-protests-in-chile/
[12] http://www.xinhuanet.com/english/2018-11/23/c_137626431.htm
[13] https://www.freshplaza.com/article/9154946/the-first-batch-of-chilean-cherries-arrives-in-shanghai/

| | | |
|---|---|---|
| Increased cargo in-transit inventory costs | 0 | 0 |
| Cargo shifts to faster modes of transport | 0 | 1 |
| Higher freight rates | 1 | 1 |
| Decrease of product FOB prices and/or increase of product CIF prices | 1 | 1 |
| Loss of market share to competitors who are closer to target markets | 0 | 1 |
| Change of stock levels | 1 | 1 |
| Higher lifecycle GHG emissions | 1 | 1 |
| Difficulty to finance retrofitting of old ships or investment in new ships | 1 | 1 |

In our view, a disproportionately negative impact would have to score at least 3 in both probability and consequence. In that sense, Table 3 shows no disproportionately negative impacts due to the goal-based measure.

It should be clarified that due to the various uncertainties and other difficulties as those were identified in Section 2.2, such an assessment is by necessity qualitative and is subject to review once additional information or other data that may alleviate these uncertainties becomes available.

The bottom line from Table 3 is that on the basis of the previous analysis, any hypothesis that developing countries in South America would face negative (or disproportionately negative) impacts from the goal-based measure does not seem to be supported by evidence or other information at our disposal. Quite on the contrary, and as already argued in docs MEPC 74/7/4 and ISWG-GHG 6/2/1, the adoption of the goal-based measure would likely entail significant benefits, mainly in the form of reduction of fuel consumption and hence fuel costs and freight rates. Depending on import and export elasticities for these countries, these would translate into a reduction of prices of imports or an increase of prices of exports, or both.

As no disproportionately negative impacts are foreseen, no potential mitigation measures are considered necessary in the South American case study.

In the chapter that follows, it will be seen that the outcome of the LDCs/SIDS case study is quite different.

# 6. THE LDCs/SIDS CASE STUDY

## 6.1. Scope

There are several categorizations of states as SIDS. The largest group of SIDS is the one suggested by the United Nations Department of Economic and Social Affairs (UN DESA) which lists 52 SIDS[14]. These are further classified into three groups based on geographical criteria: Caribbean, Pacific, and Africa, Indian Ocean, Mediterranean and South China Sea (AIMS). Another important group is the intergovernmental organization Alliance of Small Island States (AOSIS) that consolidates the voices of SIDS as regards global warming. It consists of 39 UN members and 5 observers. UNCTAD uses a smaller, unofficial list of 28 SIDS on its website[15], which does not contain certain more developed economies (for example Singapore is considered a SIDS under UN DESA but is not on the UNCTAD list), and also does not contain continental states (for example Suriname is also in the UN DESA list of SIDS but is not on the UNCTAD list either). Table 4 presents a list of the SIDS under the different definitions accompanied by their most recent LSCI (as defined in Section 3.2).

**Table 4: List of SIDS and their LSCIs. Source: UNCTADSTAT.**

| Caribbean | LSCI | Pacific | LSCI | AIMS | LSCI |
|---|---|---|---|---|---|
| Anguilla | 4.39 | American Samoa | 7.47 | Bahrain | 25.71 |
| Antigua and Barbuda | 5.32 | Cook Islands | 2.68 | Cape Verde | 6.49 |
| Aruba | 9.51 | Federated States of Micronesia | 4.47 | Comoros | 6.72 |
| Bahamas | 31.36 | Fiji | 11.2 | Guinea Bissau | 4.55 |
| Barbados | 7.44 | French Polynesia | 10.79 | Maldives | 7.42 |
| Belize | 11.49 | Guam | 8.3 | Mauritius | 28.01 |
| British Virgin Islands | 5.5 | Kiribati | 2.01 | Sao Tome and Principe | 6.32 |
| Cuba | 9.61 | Marshall Islands | 4.92 | Seychelles | 9.11 |
| Dominica | 6.21 | Nauru | 2.2 | Singapore | 108.08 |
| Dominican Republic | 38.78 | New Caledonia | 11.02 | | |
| Grenada | 6.08 | Niue | NA | | |
| Guyana | 9.23 | Northern Mariana Islands | 5.12 | | |
| Haiti | 11.12 | Palau | 3.4 | | |
| Jamaica | 33.19 | Papua New Guinea | 12.63 | | |
| Montserrat | 4.39 | Samoa | 8.07 | | |

[14] https://www.un.org/esa/sustdev/sids/sidslist.htm
[15] https://unctad.org/en/pages/aldc/Small%20Island%20Developing%20States/UNCTAD%C2%B4s-unofficial-list-of-SIDS.aspx

| | | | | |
|---|---|---|---|---|
| Netherlands Antilles | NA | Solomon Islands | 10.66 | |
| Puerto Rico | NA | Timor-Lest | 2.91 | |
| St. Kitts and Nevis | 6.64 | Tonga | 7.59 | |
| St. Lucia | 6.67 | Tuvalu | 2.01 | **LEGEND** |
| St. Vincent | 6.97 | Vanuatu | 7.91 | |
| Suriname | 9.06 | | | In UNCTAD list |
| Trinidad and Tobago | 15.43 | | | Member at AOSIS |
| US Virgin Islands | NA | | | Observer at AOSIS |

Most of the SIDS listed in Table 4 are UN members, while some are actually dependencies of (or self-governing in free association with) other UN nations (mostly Australia, USA, New Zealand, UK, and France). In order to proceed with the analysis of potential impacts from the goal-based measure, a filtering process is necessary to identify representative case studies for the SIDS that might be more negatively affected. Certain SIDS from Table 4 are excluded from the analysis due to the lack of appropriate data, due to the fact that they are actually strong economies (for example Singapore, Bahrain), or due to geographical reasons (Suriname is actually a continental state, and certain other SIDS are very close to important hubs).

## 6.2. Fleet Statistics on SIDS

In order to reach the Initial IMO Strategy ambitious goals, it is inevitable that shipowners and ship operators will be affected. Under the goal-based measure, it will be up to the shipowner to choose how to reach the targets, for instance by investing in emissions reduction technologies, or by choosing to improve environmental efficiency by changing the ship operations. To better understand the impacts of the goal-based measure on SIDS, it is important to have a proper understanding of the fleet for each SIDS.

In this section we present information on the ownership of the merchant fleet for these countries, as well as the number of vessels by flag of registration for the examined SIDS.

**Table 5: SIDS fleet statistics[16]. Adapted from UNCTADSTAT.**

| Caribbean | Vessels | | Pacific | Vessels | | AIMS | Vessels | |
|---|---|---|---|---|---|---|---|---|
| | Flag | Owner | | Flag | Owner | | Flag | Owner |
| Anguilla | 2 | 9 | American Samoa | | NA | Bahrain | NA | 137 |
| Antigua and Barbuda | 780 | 3 | Cook Islands | 205 | 8 | Cape Verde | 44 | 10 |
| Aruba | 1 | NA | Federated States of Micronesia | 39 | NA | Comoros | 230 | NA |
| Bahamas | 1401 | 1058 | Fiji | 64 | 7 | Guinea Bissau | 2 | NA |
| Barbados | 132 | NA | French Polynesia | 17 | 18 | Maldives | 62 | 87 |
| Belize | 786 | 30 | Guam | 3 | NA | Mauritius | 28 | 94 |
| British Virgin Islands | 29 | 130 | Kiribati | 89 | 1 | Sao Tome and Principe | 15 | 6 |
| Cuba | 52 | 51 | Marshall Islands | 3537 | 632 | Seychelles | 25 | 268 |
| Dominica | 108 | NA | Nauru | 2 | NA | Singapore | 3433 | 2727 |
| Dominican Republic | 37 | NA | New Caledonia | 19 | 2 | | | |
| Grenada | 6 | 2 | Niue | 61 | NA | | | |
| Guyana | 56 | 37 | Northern Mariana Islands | | NA | | | |
| Haiti | 4 | 10 | Palau | 203 | NA | | | |
| Jamaica | 39 | NA | Papua New Guinea | 171 | 123 | | | |
| Montserrat | 0 | NA | Samoa | 13 | 54 | | | |
| Netherlands Antilles | 0 | NA | Solomon Islands | 23 | NA | | | |
| Puerto Rico | NA | NA | Timor-Lest | 1 | 0 | | | |
| St. Kitts and Nevis | 218 | 19 | Tonga | 36 | 1 | | | |
| St. Lucia | 0 | 2 | Tuvalu | 243 | 1 | | | |
| St. Vincent | 810 | 11 | Vanuatu | 369 | 3 | | | |
| Suriname | 10 | 9 | | | | | | |
| Trinidad and Tobago | 105 | 8 | | | | | | |
| US Virgin Islands | NA | NA | | | | | | |

[16] Data Source: Clarkson Research Services (London). The column “Flag” shows the number of vessels under the respective flag. The column "Owner” refers to “Beneficial Ownership Location”: it indicates the economy in which the company that has the main commercial responsibility for the vessel is located. The economy of beneficial ownership may be different from the country in which the vessel is registered. The vessels covered in this table include all propelled sea-going merchant vessels of 1000 gross tons (GT) and above, including offshore drill ships and Floating Production, Storage and Offloading units (FPSOs). Military vessels, yachts, waterway vessels, fishing vessels, and offshore fixed and mobile platforms and barges are excluded.

Table 5 should be interpreted with caution as flag information may not be directly relevant. For instance, the Marshall Islands is a major international registry and most of the ships under its flag are foreign owned. In the same vein, many of the ships of Table 5 are engaged in global trades and may seldom call at the respective SIDS. Also it is not clear from Table 5 how many ships are engaged in domestic vs international trade. What is mostly of interest in Table 5 is the observation that the majority of the SIDS have a very small number of vessels that are "beneficially owned". From a GHG perspective, this means that for most of these SIDS the responsibility to achieve appropriate GHG emissions reductions will fall onto shipowners from other countries serving these SIDS. An issue here is that significant dependency on foreign fleets entails the risk of trade disruption in case the owners of these fleets decide either not to serve these SIDS in the future because of commercial or other considerations, or to charge disproportionately high freight rates to serve these SIDS. Of course, such risk exists already irrespective of what short-term GHG reduction measure will be adopted. Whether such a risk will be made higher in case the goal-based measure is adopted is a hypothesis whose likelihood cannot be precisely ascertained on the basis of information currently at our disposal. It should be noted however that under the goal-based measure shipowners would have more flexibility to respond than under other short-term GHG reduction measures, therefore the benefits they would enjoy under the goal-based measure would be higher than benefits under other candidate short-term measures. To the extent these benefits entail transport cost reductions, they could directly map into benefits to SIDS. Also, prescriptive measures such as speed limits would offer no incentives for shipowners to improve energy efficiency and would thus be at a disadvantage versus the goal-based measure.

More on the freight rate subject is in Section 6.5, and more on the fleet risk can be found on Section 6.6 of this chapter.

## 6.3. Number of Ports and Port Connectivity

Some of the main concerns of SIDS are geographic remoteness, the higher shipping costs associated with the low connectivity to main markets, the need for transshipment, and the transport dependency particularly in emergencies. As stated earlier, one way to measure the liner shipping connectivity of a state to the main markets is through data provided by UNCTAD. Table 4 showed the latest LSCI for each of the SIDS in 2019, and as explained in Section 3.2, a lower score for the LSCI is an indication for higher transport costs. In the ensuing investigation we are narrowing down the scope of the analysis by looking at the number of ports and their respective connectivity scores. The port liner shipping connectivity index (PLSCI) is an annual number provided by UNCTAD for each port to reflect its position in the global liner shipping network. A higher score indicates better connectivity. Again, Indices have been normalized so that China has an index of 100 in 2006. Table 6 shows the number of existing ports for each of the SIDS, and the

PLSCI (average, minimum and maximum) as retrieved from the UNCTADSTAT database (2006-2019).

**Table 6: SIDS Port Liner Connectivity Index (PLSCI), 2006-2019. Source: UNCTADSTAT.**

| SIDS | Number of Ports | Average PLSCI | Min PLSCI | Max PLSCI |
|---|---|---|---|---|
| Anguilla | 1 | 3.02 | 1.82 | 4.05 |
| Antigua and Barbuda | 1 | 4.15 | 2.75 | 5.19 |
| Aruba | 2 | 6.74 | 3.02 | 9.02 |
| Bahamas | 6 | 8.68 | 0.71 | 30.35 |
| Barbados | 1 | 7.05 | 6.13 | 10.32 |
| Belize | 2 | 4.84 | 2.27 | 8.75 |
| British Virgin Islands | 2 | 3.41 | 1.84 | 4.52 |
| Cuba | 4 | 4.58 | 1.61 | 9.84 |
| Dominica | 1 | 3.81 | 2.77 | 6.04 |
| Dominican Republic | 7 | 8.08 | 0.61 | 33.45 |
| Grenada | 1 | 5.16 | 4.12 | 6.44 |
| Guyana | 1 | 8.15 | 6.53 | 10.97 |
| Haiti | 3 | 5.40 | 1.24 | 10.08 |
| Jamaica | 2 | 15.69 | 2.11 | 32.65 |
| Montserrat | 1 | 2.75 | 1.84 | 3.36 |
| Netherlands Antilles | 5 | 6.83 | 3.18 | 9.58 |
| Puerto Rico | 2 | 11.38 | 1.92 | 16.93 |
| St. Kitts and Nevis | 3 | 3.34 | 1.84 | 5.05 |
| St. Lucia | 2 | 4.73 | 2.82 | 5.73 |
| St. Vincent | 2 | 4.27 | 1.74 | 5.62 |
| Suriname | 1 | 7.79 | 6.50 | 10.54 |
| Trinidad and Tobago | 2 | 11.49 | 6.85 | 17.27 |
| US Virgin Islands | 3 | 3.75 | 1.04 | 4.72 |
| American Samoa | 1 | 6.79 | 5.32 | 9.60 |
| Cook Islands | 2 | 1.94 | 0.64 | 3.09 |
| Federated States of Micronesia | 4 | 2.11 | 1.31 | 3.90 |
| Fiji | 2 | 10.13 | 7.29 | 13.92 |
| French Polynesia | 2 | 8.86 | 0.81 | 13.16 |
| Guam | 1 | 8.67 | 7.48 | 9.42 |
| Kiribati | 1 | 3.72 | 1.84 | 4.87 |
| Marshall Islands | 2 | 3.54 | 1.55 | 6.59 |
| Nauru | 1 | 1.88 | 1.19 | 2.48 |
| New Caledonia | 2 | 10.64 | 2.38 | 13.91 |
| Niue | 1 | 1.33 | 1.19 | 1.61 |
| Northern Mariana Islands | 1 | 4.29 | 1.86 | 7.45 |
| Palau | 1 | 3.14 | 2.23 | 3.65 |
| Papua New Guinea | 14 | 5.48 | 0.74 | 14.64 |
| Samoa | 1 | 7.11 | 5.97 | 9.69 |

| | | | | |
|---|---|---|---|---|
| Solomon Islands | 2 | 6.59 | 2.79 | 10.86 |
| Timor-Lest | 1 | 3.07 | 0.72 | 6.76 |
| Tonga | 2 | 4.69 | 1.19 | 7.40 |
| Tuvalu | 1 | 1.97 | 0.58 | 3.32 |
| Vanuatu | 2 | 5.48 | 1.84 | 8.50 |
| Bahrain | 1 | 17.73 | 6.27 | 29.91 |
| Cape Verde | 6 | 4.08 | 0.80 | 6.69 |
| Comoros | 2 | 4.99 | 1.35 | 6.58 |
| Guinea Bissau | 1 | 4.52 | 3.31 | 5.76 |
| Maldives | 1 | 5.09 | 2.58 | 7.49 |
| Mauritius | 2 | 17.49 | 0.90 | 28.80 |
| Sao Tome and Principe | 1 | 5.00 | 1.82 | 6.89 |
| Seychelles | 2 | 6.03 | 2.02 | 8.81 |
| Singapore | 2 | 105.07 | 8.99 | 128.10 |

Additional analysis of this data reveals that for most SIDS the PLSCI is increasing relative to previous years. However, even if it is increasing, it is increasing from a very low base. For SIDS with multiple ports, the risk of low connectivity is smaller as there are more options available.

## 6.4. Main trading partners and distance

A related concern regarding SIDS revolves around a potential increase in freight rates as a result of the measures or the degradation of the connectivity with the main markets. In this section we present data collected from the International Trade Statistics database (COMTRADE[17]) as cleaned by the BACI [18] team of CEPII. In Table 7 we show the value of exports and imports for 2017 (the most recent available data), and we provide the top two trading countries for each of the SIDS to draw the picture of their trade.

[17] https://comtrade.un.org/labs/data-explorer/
[18] http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=37

**Table 7: SIDS main trading partners. Source: COMTRADE.**

| SIDS | Exports USD million | Destination (% of value) | | Imports USD million | Origin (% of value) | |
|---|---|---|---|---|---|---|
| | | 1st | 2nd | | 1st | 2nd |
| Anguilla | 9.6 | USA (40) | France (13) | 77.4 | USA (56) | France (22) |
| British Virgin Islands | 353 | Cyprus (33) | Switzerland (11) | 829 | USA (25) | Italy (18) |
| Comoros | 74 | India (33) | France (29) | 295 | Tanzania (30) | China (22) |
| Dominica | 40.5 | Indonesia (32) | Netherlands (7.3) | 275 | USA (48) | China (12) |
| Grenada | 36.3 | USA (32) | Germany (9.5) | 187 | USA (35) | UK (6.8) |
| Montserrat | 8.92 | Antigua-Barbuda (61) | France (9) | 14.3 | USA (46) | UK (14) |
| St. Kitts and Nevis | 71.9 | USA (58) | Turkey (8.8) | 385 | USA (52) | Germany (10) |
| St. Lucia | 77.6 | Suriname (39) | UK (9.6) | 1710 | Colombia (35) | USA (26) |
| St. Vincent | 258 | France (39) | Jordan (29) | 372 | USA (34) | Trinidad and Tobago (14) |
| Cook Islands | 38.9 | Japan (44) | China (14) | 108 | New Zealand (48) | Fiji (12) |
| Federated States of Micronesia | 29.8 | China (38) | Philippines (26) | 154 | South Korea (33) | USA (22) |
| Fiji | 950 | USA (28) | Australia (17) | 2440 | Singapore (18) | New Zealand (17) |
| Kiribati | 51.5 | Mexico (35) | Philippines (19) | 92.4 | Fiji (24) | Australia (17) |
| Marshall Islands | 325 | Netherlands (22) | Indonesia (18) | 8790 | South Korea (78) | Germany (5.1) |
| Nauru | 24.7 | Australia (24) | Japan (24) | 35.6 | Australia (63) | Fiji (12) |
| Niue | 63.3 | Indonesia (98) | South Africa (0.4) | 11.1 | New Zealand (75) | UK (15) |
| Palau | 24 | Japan (81) | Turkey (4.8) | 159 | USA (33) | Singapore (14) |
| Timor-Lest | 108 | Singapore (62) | USA (9.6) | 651 | Indonesia (31) | China (17) |
| Tonga | 15 | USA (28) | South Korea (23) | 103 | New Zealand (29) | China (27) |
| Tuvalu | 4.02 | Japan (50) | France (22) | 35.6 | China (30) | Fiji (27) |
| Comoros | 74 | India (33) | France (20) | 295 | Tanzania (30) | China (22) |
| Sao Tome and Principe | 15.7 | Poland (24) | Netherlands (11) | 140 | Portugal (56) | China (6.9) |
| Vanuatu | 207 | Mauritania (34) | Japan (32) | 244 | China (27) | Australia (17) |

Potential inaccuracies of the above data notwithstanding, certain observations can be made regarding the big picture. All SIDS have a trade deficit which for certain states is very significant. The imports are usually from major economies that either are closer geographically, or have historical ties. For most SIDS, major imports include food, pharmaceuticals, machinery, vehicles and refined petroleum products to cover their energy requirements. When it comes to energy imports these are typically sourced from a small number of major economies with which they have geographically or historically close ties (Pacific SIDS source from Australia New Zealand, Southeast Asia and USA, Caribbean SIDS source from USA, Brazil, Colombia, etc.). Storage of fuels is however an issue as several Pacific SIDS that do not have ability to stockpile regularly run out of fuel if no ship arrives in time. Most fuel is imported through Southeast Asia and transshipped through Fiji.

Exports are typically local agricultural products, timber, minerals, and recreational and harbor craft boats. Many are heavily exporting fish products (for example Cook Islands 65.1%, Kiribati 79.9%, Tuvalu 50%). In general we believe that SIDS that are heavily trading with a small number of countries could be more vulnerable if the freight rates increase disproportionally for these pairs.

## 6.5. Illustrative freight rates for five countries

In this section we present some illustrative freight rates for unitized shipments between some of the SIDS, and their major trading partners as listed in Table 8. These freight rates are estimates provided by "World Freight Rates[19]" as collected during December 2019. These should only be used for illustrative and comparison purposes.

**Table 8: Illustrative freight rates (USD/TEU). Source: World Freight Rates.**

| | Export Freight Rate | | Import Freight Rate | |
|---|---|---|---|---|
| Anguilla | USA (Miami) 1050 | France 1700 | USA (Miami) 1020 | France 650 |
| Comoros | India 2300 | France 2750 | Tanzania 3500 | China 850 |
| Cook Islands | Japan (reefer) 2900 | China (Shanghai) 2850 | New Zealand 1300 | Fiji 1000 |
| Fiji | USA (LA) 2750 | Australia 680 | Singapore 2050 | New Zealand 1400 |
| Tuvalu | Japan (reefer) 2700 | France 2400 | China 2450 | Fiji 1000 |
| Vanuatu | Mauritania 3350 | Japan 2700 | China 2350 | Australia 1050 |

We can observe that for the Pacific SIDS exporting fish to Japan, the freight rates are quite significant. In general, freight rates are higher when there is transshipment taking place, as this can significantly increase the transportation cost (which agrees with the overall assessment that a low connectivity index results in higher transportation costs). A noteworthy example is the case of Comoros. For Comoros, it is much more expensive to ship from Tanzania (535 NM) than it is from China (6300 NM). At the same time, sending a container from China to Tanzania would cost approximately USD850, which shows that the freight rates are not always strictly correlated with distances. In the Pacific, it is more expensive to ship from Fiji to Tonga, a distance of 417 NM (USD 5.68

[19] https://worldfreightrates.com/

per NM and FEU) than from Singapore to Fiji, a distance of 4,751 NM (USD 0.45 per NM and FEU)[20].

## 6.6. Potential negative impacts

In terms of the potential negative impacts identified in Chapter 4, and on the basis of the exposition as described in the previous sections, Table 9 is an attempt to synthesize the above results into our (qualitative) assessment of these impacts for LDCs/SIDS, on the following (probability, consequence) scale.

0: very low or 0
1: low
2: moderate
3: high
4: very high

Again, and as with Table 3, it should be noted that the numbers in Table 9 by necessity entail a degree of subjectivity, and they reflect the best possible mapping of the authors' opinion based on all available information as outlined in the previous sections of this chapter.

**Table 9: Potential negative impacts on LDCs/SIDS**

| Potential negative impact | Probability | Consequence |
|---|---|---|
| Undesirable degradation in the quality of the cargo | 2 | 3 |
| Increased cargo in-transit inventory costs | 1 | 1 |
| Cargo shifts to faster modes of transport | 1 | 1 |
| Higher freight rates | 2 | 3 |
| Decrease of product FOB prices and/or increase of product CIF prices | 2 | 3 |
| Loss of market share to competitors who are closer to target markets | 2 | 3 |
| Change of stock levels | 2 | 2 |
| Higher lifecycle GHG emissions | 1 | 2 |
| Difficulty to finance retrofitting of old ships or investment in new ships | 3 | 3 |

In our view, a disproportionately negative impact would have to score at least 3 in both probability and consequence. In Table 9, one can see that this is the case as regards the *difficulty to finance retrofitting of old ships or investment in new ships*, a case that was recognized to entail a risk, particularly since most of the external trade of SIDS falls onto shipowners of other countries serving these SIDS (as per Section 6.2).

[20] Unpublished data Fiji collected from 30 freight companies in 2018.

Again, it should be emphasized that due to the various uncertainties and other difficulties as those were identified in Section 2.2, such an assessment is by necessity qualitative and is subject to review once additional information or other data that may alleviate these uncertainties becomes available. This is all the more relevant for the LDCs/SIDS case study for which data availability and reliability can sometimes be problematic. In that sense, further analysis, supported by appropriate and reliable data, may be necessary so as to obtain a more accurate assessment of the potential negative impacts of Table 9.

Perhaps a more important issue that should be emphasized is that, for the same reasons as stated above, the degree of share (or responsibility) of the goal-based measure with respect to the potential negative (and disproportionately negative) impacts of Table 9, vis-à-vis the share of the many other factors that may contribute to these impacts, cannot be precisely ascertained. In fact, and on the basis of all information at our disposal, our conjecture is that such share is low, and, in that sense, the hypothesis that LDCs or SIDS would face negative (and disproportionately negative) impacts from the goal-based measure is not proven by evidence or other information at our disposal. However this is only a conjecture, and the opposite hypothesis, namely that we can be certain that LDCs or SIDS would *not* face negative (or disproportionately negative) consequences from the goal-based measure, is not irrefutably proven either. Additional data and analysis are necessary to shed more light on this issue.

To provide an example in support of the above conjecture and which can help putting this issue in perspective, the consequences of the implementation of the 0.5% global sulphur cap as of 1.1.2020, something that has nothing to do with the goal-based measure but which would impact fuel prices, fleet composition, fleet deployment, ship speeds, freight rates and therefore prices of imports or exports (among other things), might lead to far more serious impacts on LDCs or SIDS than any potential impact of the goal-based measure per se. As stated in Section 5.5, an increase in fuel price by USD100/ton could translate in an increase of USD64/TEU, something that would increase CIF prices and/or reduce FOB prices. Again, estimating the impacts of the global cap is beyond the scope of this document and certainly cannot be attributed to the goal-based measure.

On the other hand, and as already argued in docs MEPC 74/7/4 and ISWG-GHG 6/2/1, the adoption of the goal-based measure would likely entail significant benefits, mainly in the form of reduction of fuel consumption and hence fuel costs and freight rates. These benefits would translate into a reduction of prices of imports or an increase of prices of exports, or both, something very important for LCDs/SIDS. It is acknowledged that in the sectors of the shipping market where monopolistic/oligopolistic situations exist, these might hamper the full realization of such benefits[21]. However, as it is unreasonable to

[21] As stated earlier, such situations are more likely in the liner shipping market where the carriage of unitized cargoes may involve a number of transshipments, and less likely in the tramp shipping market where bulk shipments typically follow direct routes and in which freight rate formation is typically competitive.

ascribe such situations to the goal-based measure itself, potential measures to alleviate these situations should be considered as falling outside the scope of the goal-measure.

In addition, and as already argued in Section 2.1, one of the advantages of the goal-based approach vis-à-vis prescriptive approaches or approaches focusing only on technical solutions is that a wider set of the choices is available to ship operators and such flexibility maximizes the feasible solution space and hence provides both a higher likelihood for reaching both the 2030 and the 2050 IMO targets vis-à-vis other proposals and higher potential benefits to LDCs/SIDS.

Moreover, and as the costs of inaction as regards climate change far outweigh the costs of action, it would be unfair to attribute to the goal-based measure more than its fair share of responsibility for whatever negative impacts are manifested. Whatever these negative impacts might be, they should be weighed against the impacts to these states if no action is taken.

By the same token, in the event that mitigation action is considered so as to balance out these negative impacts, it should be considered in a holistic fashion and outside the framework of the goal-based measure, and possibly also outside the framework of the IMO. The section that follows provides some suggestions.

## 6.7. Potential mitigation measures

At the time of writing this report, the scope of application of the goal-based measure was not yet finalized. The widest scope of the measure is based on ISWG 6/2/11 with application to existing and new ships at 400 GT and above. But this could also be set at 5,000 GT and above if the measure is to be more consistent with the IMO Data Collection System. Ships solely engaged in domestic trades are to be excluded from the measure, and various special cases are to be granted temporary exemptions, such as for instance (among others) ships conducting trials for the development of ship emission reduction and control technologies and engine design programs. Other than those, possible exemptions to the goal-based measure to ships serving LDCs/SIDS should be avoided, as these are likely to make the competition situation worse and would not incentivize technological innovation. Such exemptions would violate the principle that all ships should be treated equally, might introduce loopholes and other distortions that could lead to carbon leakage and possibly fraud, and would condemn LDCs/SIDS to being served by ships that will eventually become technologically and economically obsolete. This is actually what has been identified in Table 9 as a disproportionately negative impact.

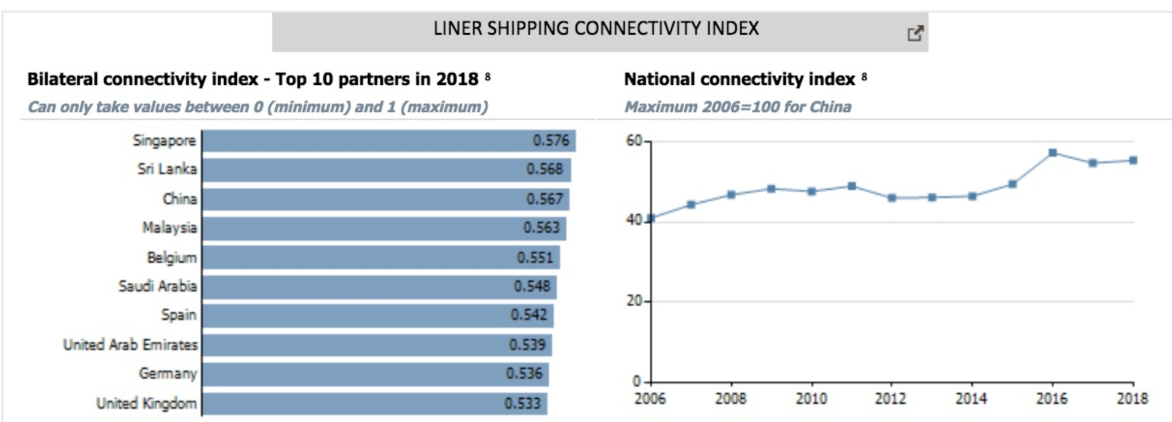
In terms of IMO's mandate, potential mitigation measures can be considered in terms of capacity building, technical assistance, R&D support and financial assistance to LDCs/SIDS. However, these cannot happen in the context of the goal-based measure per se, but would need to be discussed and designed through other appropriate fora and instruments.

# 7. THE INDIAN CASE STUDY

## 7.1. Introduction

In this chapter we focus on India as one of the largest developing countries, whose economy depends quite considerably on international trade. Among India's major export commodities, pharmaceuticals (including packaged medicaments) and electronic devices (such as telephones, computers) are the top commodities, whose annual export volume is among the highest and at the same time might be sensitive to changes in transit time to ship these products. Specifically, according to the COMTRADE database, packaged medicaments are among the top 3 export commodities which amount to 4.5% of the total India's export values, which is equivalent to 13.2 Billion USD. Furthermore electronic devices and machinery are also among the top commodities which annual export value reaches 11.8 billion USD or 3.6% of the total India's export.

Fig. 13 shows India's connectivity index, which shows an upward trend in the period 2006-2018. In 2018, their connectivity index is 55.3, which represents an 18% increase compared to their connectivity level in 2008. Hence, similar to the observed trends in Southern American countries, India's connectivity also indicates a growing level of competition in liner shipping companies serving their trade. This also implies that the potential for increase in freight rate is rather unlikely unless there is a disproportionate negative impact from the introduction of a measure.




Source: UNCTADstat (http://unctadstat.unctad.org)

**Fig. 13: India's connectivity index. Source: UNCTADSTAT.**

## 7.2. Modal shift analysis

Changes in the transit time of maritime transport might affect the preferred mode to transport medicaments and electronic devices. Some medicaments have a specific and sometimes short lifetime. Hence, a longer transit time for this commodity might reduce its economic values and marketability. Since the US is the largest importer of packaged medicaments from India, the most likely used mode of transport would be air and maritime transport. On the other hand, electronic devices (such as smartphones, video games) might have some seasonality where their availability has to be ensured during a certain event (e.g. the launch of new products). In the event where reduction in speed of maritime transport is applied, there is a plausible chance that these products would be shipped by air to help ensure their timely availability in the market.

To analyze the impact of speed reduction on the modal shift of these two commodities, a global mode choice model is deployed. This model is specifically designed to predict the decision of the shippers as regards the preferred modes to transport commodities in international trade. The model takes into account variables associated with the commodities, trade activities such as geographic (such as travel distance, time, socio-economic factors (such as GDP, trade agreement, commodity specific variable) and the characteristics of each available mode, including their costs components which include both time related and operational related costs. Specifically, a commodity- specific variable is used to represent the sensitivity of different commodities to change in time. The estimation of the value of time is originally presented in the earlier version of the model in (Martínez et al., 2015).

The model used in this analysis is based on the further development of the model as presented in Halim et al. (2019). This model estimated modal shares for international freight across four major modes: air, road, rail, sea with a good fit. The model was estimated based on the observed volume of commodities and mode of transport registered in the Eurostat and ECLAC (Economic Commission for Latin America and the Caribbean) datasets. Baseline data on socioeconomic variables such as GDP, trade agreement, and population, are obtained from the CEPII database[22] and growth rates of these variables are retrieved from the OECD economic outlook (OECD, 2019). The mode choice model is validated by ensuring the modal share of the volume of goods transported is similar to the observed mode share for international transport in 2011 by weight. These observed data are obtained from reports of various organizations such as the UNCTAD, the International Civil Aviation Organization (ICAO), and the World Bank.

We analyze similar speed reduction scenarios as what are studied in the Chilean case study. However, in this analysis we also consider all trading partners of India worldwide and all the available modes to ship the cargo. Three different sailing speeds are considered: 15.2 (baseline speed), 14 and 12.5 knots, while we assume that the speed and characteristics of the other available modes to follow the business as usual assumptions. These speed reductions translate to an approximate increase in transit time of 8% and 22% between India to all its trading partners. We also assume that packaged medicaments and electronics are typically transported using containers.

[22] http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele.asp

Table0 presents the result of the mode choice analysis for packaged medicaments while Table 11 presents the result for electronic devices.

**Table 10: Modal shift analysis for packaged medicaments.**

| **Scenario** | **Maritime** | | **Road** | | **Rail** | | **Air** | | **Total Chain** |
|---|---|---|---|---|---|---|---|---|---|
| | Market Share (%) | Additional time | Market Share (%) | Days | Market Share (%) | Days | Market Share (%) | Days | $CO_2$ (tons) |
| Baseline Sailing Speed 15.2 knots | 87.2 | baseline | 9.351 | baseline, distance, and country dependent | 3.067 | baseline, distance, and country dependent | 0.382 | baseline, distance, and country dependent | 17,077,193 |
| New Sailing speed 14 knots | 87.17 | 8% | 9.363 | | 3.075 | | 0.384 | | 17,117,147 |
| New Sailing speed 12.5 knots | 87.144 | 22% | 9.381 | | 3.088 | | 0.387 | | 17,175,166 |

**Table 11: Modal shift analysis for electronic devices**

| **Scenario** | **Maritime** | | **Road** | | **Rail** | | **Air** | | **Total Chain** |
|---|---|---|---|---|---|---|---|---|---|
| | Market Share (%) | Additional time | Market Share (%) | Days | Market Share (%) | Days | Market Share (%) | Days | $CO_2$ (tons) |
| Baseline Sailing Speed 15.2 knots | 80.303 | baseline | 15.059 | baseline, distance, and country dependent | 4.273 | baseline | 0.365 | baseline, distance, and country dependent | 4,434,099 |
| New Sailing speed 14 knots | 80.246 | 8% | 15.093 | | 4.293 | | 0.368 | | 4,449,685 |
| New Sailing speed 12.5 knots | 80.165 | 22% | 15.141 | | 4.322 | | 0.372 | | 4,472,382 |

Based on the results of the analysis, it is evident that the reductions in sailing speed affect modal preference of the shippers marginally for both packaged medicaments and electronic devices. The reduction in the market share of maritime transport for packaged medicaments is at worst less than 0.06% with a very slight increase in the share of air transport. For electronic devices, a reduction of sailing speed to 12.5 knots would also only reduce the share of maritime transport by less than 0.2%. Therefore from modal shift perspective, the economic impacts of the speed reductions on India's export commodities would be marginal.

In the context of analyzing the negative impacts, the analysis on the total $CO_2$ emissions shows that there can be a considerable increase in emissions due to the modal shift for packaged medicament. Specifically, in the scenario where sailing speed is reduced to 12.5 knots, the total increase in $CO_2$ emissions may reach almost 100,000 tons. Although this scenario might be plausible, it is noteworthy that the aim of the goal-based measure is to reduce emissions from ships using available measures and technologies. This implies, when ships successfully attain the goal, it is very likely that the total $CO_2$ emissions would be lower since maritime transport would still be the dominant mode with the highest share.

## 7.3. Potential negative impacts

We synthesize the potential negative impacts as identified in Chapter 4 based on the analysis on India's case study. Table 12 provides the overview of the probability and the consequence of the impacts with the following scale:

0: very low or 0
1: low
2: moderate
3: high
4: very high

Again, and as with Tables 3 and 9, it should be noted that the numbers in Table 12 by necessity entail a degree of subjectivity, and they reflect the best possible mapping of the authors' opinion based on all available information as outlined in the previous sections of this chapter.

**Table 12: Potential negative impacts on India**

| Potential negative impact | Probability | Consequence |
|---|---|---|
| Undesirable degradation in the quality of the cargo | 1 | 1 |
| Increased cargo in-transit inventory costs | 0 | 0 |
| Cargo shifts to faster modes of transport | 0 | 2 |
| Higher freight rates | 1 | 1 |
| Decrease of product FOB prices and/or increase of product CIF prices | 1 | 1 |
| Loss of market share to competitors who are closer to target markets | 0 | 2 |

| | | |
|---|---|---|
| Change of stock levels | 2 | 1 |
| Higher lifecycle GHG emissions | 1 | 2 |
| Difficulty to finance retrofitting of old ships or investment in new ships | 1 | 1 |

Again, a disproportionately negative impact would have to score at least 3 in both probability and consequence. In that sense, Table 12 shows no disproportionately negative impacts for India. It should be again clarified that due to the various uncertainties and other difficulties as those were identified in Section 2.2, such an assessment is by necessity qualitative and is subject to review once additional information or other data that may alleviate these uncertainties becomes available.

It is also noteworthy that the assessment of the negative impacts above is focused on the impact of increased sailing time as a most likely response that we foresee due to the introduction of the goal based measure. In this context, we further investigate the impact of this speed reduction on the modal shift of India's major export products. The analysis concludes that the negative impact of reduced sailing speeds on modal shift would be marginal. This also implies that the increase in the average freight rate across all modes or the increase in products CIF prices would be low. A further implication of this is that the broader economic consequences such as loss of market share would be unlikely.

Another potentially negative impact from the reduction in sailing speed is the change in the stock levels of both packaged medicaments and electronic devices. The longer transit time to reach destination may affect companies' replenishment strategy to ensure that there are enough stocks to supply the demand of their products, especially for electronic products. Although this may initially increase inventory costs, we envision that the impact of the change in these costs would be low. Furthermore, in the long run, we expect that the companies would be able to adapt to the new transit time and normalize their supply chain process.

Based on the analysis above, and as we do not foresee disproportionately negative impacts, we also do not consider any potential mitigation measures.

# 8. CONCLUSIONS (SUMMARY)

“Conclusions” may not be the right word as regards the results of this study, mainly due to uncertainty as regards the data and other factors that may influence these results. The purpose of this document has been to provide insights and analysis as regards the detailed impact assessment of the goal-based measure proposed by the co-sponsors. The challenges of a detailed impact assessment were highlighted and were seen to be mainly due to many uncertain factors that are relevant and to the lack of relevant data. After a selected set of case studies was looked at, the analysis conjectures that even though negative and disproportionately negative impacts are unlikely for South American countries and for India, for LDCs/SIDS a risk for such impacts exists and that appropriate mitigation measures are warranted. The main issue that was seen to involve a risk of disproportionate negative impact was as regards the difficulty to finance retrofitting of old ships or investment in new ships, particularly since most of the external trade of SIDS falls onto shipowners of other countries serving these SIDS.

At the same time, the degree of share (or responsibility) of the goal-based measure with respect to such potential negative impacts, vis-à-vis the share of other factors contributing to these impacts, cannot be precisely ascertained. On the basis of all information at our disposal, our conjecture is that such share is low, and, in that sense, the hypothesis that LDCs or SIDS would face negative (and disproportionately negative) impacts from the goal-based measure is not proven by evidence or other information at our disposal. However this is only a conjecture, and the opposite hypothesis, namely that we can be certain that LDCs or SIDS would *not* face negative (or disproportionately negative) consequences from the goal-based measure, is not irrefutably proven either. Additional data and analysis are necessary to shed more light on this issue. For LDCs and SIDS negatively affected, the study suggests that any mitigation action should be considered outside the strict mandate of the goal-based measure as far as the IMO is concerned, and maybe should also be considered in the context of other international bodies.

In terms of IMO’s mandate, potential mitigation measures can be considered in terms of capacity building, technical assistance, R&D support and financial assistance to LDCs/SIDS. However, these cannot happen in the context of the goal-based measure per se, but would need to be discussed and designed through other appropriate fora and instruments. .

# ACKNOWLEDGMENTS

Authors' contributions:
Harilaos N. Psaraftis: Chapters 1, 2, 3, 4, 5, 6, 8, overall report responsibility.
Thalis Zis: Chapters 3, 5, 6, 8, internal review of entire report.
Ronald A. Halim: Chapter 7, internal review of entire report.
The work of Harilaos N. Psaraftis and Thalis Zis has been in the context of a project on impact assessment commissioned by the Danish Maritime Authority to the Technical University of Denmark (DTU) and supported by the Danish Maritime Fund under the umbrella project "Maritime DTU, Forskningsbaseret maritim rådgivning 2019-2020." The authors would like to thank the following colleagues, whose comments and other input helped improve the report: (in alphabetical order) Lau Blaxekjær, Daniel Eyre, Jan Hoffmann, Alison Newell, Peter Nuttall, Isabelle Rojon and Orestis Schinas.

# REFERENCES


Adelman, S., 2016, Climate justice, loss and damage and compensation for small island developing states. *Journal of Human Rights and the Environment*, *7*(1), 32-53.

APEC, 2019, Analysis of the Impacts of Slow Steaming for Distant Economies, APEC Transportation Group, APEC Project: TPT 03 2018A, Produced by Starcrest Consulting Group for the Asia-Pacific Economic Cooperation Secretariat, December.

Bouman, E. I., Lindstad, E., Rialland, A. I., and Strømman, A. H., 2017, "State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping – A review", *Transportation Research Part D*. 52, 408–421.

Briguglio, L, Cordina, G., Vella, S., and Vigilance, C., 2010, Profiling vulnerability and resilience: a manual for small states. Commonwealth Secretariat and the Islands and Small States Institute, University of Malta, London.

CE Delft, 2017, Regulating speed: a short term measure to reduce maritime GHG emissions, study by CE Delft for the Clean Shipping Coalition, 18 October.

Chatzinikolaou, S. and Ventikos, N. 2016, Critical analysis of air emissions from ships: lifecycle thinking and results, in Psaraftis, H.N. (ed.), *Green transportation logistics: the quest for win-win solutions,* Springer, Cham, Switzerland.

de Kat, J. O., and Mouawad, J, 2019, Green Ship Technologies, in Psaraftis, H.N. (ed.), *Sustainable shipping: a cross-disciplinary view*, Springer, Cham, Switzerland.

DNV, 2009, Pathways to Low Carbon Shipping, DNV report, 2009.

Eide, M.S., Endresenm Ø. Skjong, R., Longva, T., and Alvik, S., 2010, Cost-effectiveness assessment of CO2 reducing measures in shipping, *Maritime Policy and Management* Vol. 36, No. 4, 367 - 384.

EU, 2019, Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions "the European Green Deal" (Com/2019/640 Final)

Fugazza, M. and Hoffmann, J., 2017, Liner shipping connectivity as determinant of trade, *Journal of Shipping and Trade* 2:1, DOI 10.1186/s41072-017-0019-5.

Halim, R. A., Kirtsein, L., Merk, O., and Martinez, L., 2018, Decarbonization Pathways for International Maritime Transport: A Model-Based Policy Impact Assessment. *Sustainability,* 10**,** 2243.

Halim, R. A., Smith, T., and Englert, D., 2019, Understanding the Economic Impacts of Greenhouse Gas Mitigation Policies on Shipping: What Is the State of the Art of Current Modeling Approaches? Policy Research paper 8695, World Bank Group, January.

Hoffmann, J., Saeed, N., and Sødal, S., 2019, Liner shipping bilateral connectivity and its impact on South Africa's bilateral trade flows, *Maritime Economics & Logistics,* DOI10.1057/s41278-019-00124-8.

ICS, 2018, Reducing CO2 Emissions to Zero: The 'Paris Agreement for Shipping' Implementing the Initial Strategy on Reduction of GHG Emissions from Ships (adopted by the UN International Maritime Organization), International Chamber of Shipping, London, UK.

IMAREST, 2011, Marginal Abatement Costs and Cost Effectiveness of Energy-Efficiency Measures, IMO doc. MEPC 62/INF.7.

Imb, J. and Mejean, I., 2017, Trade Elasticities, *Review of International Economics*, Vol. 25, Issue 2, 383-402.

Krammer, P. and Smith, T., 2017, Impact assessment of IMO Greenhouse Gas Reduction Strategies on New Zealand's economy, UCL Energy Institute, London, UK, November.

Lindstad, E., Borgen, H., Eskeland, G., Paalsson, C., Psaraftis, H.N., and Turan, O., 2019 The Need to Amend IMO's EEDI to Include a Threshold for Performance in Waves (Realistic Sea Conditions) to Achieve the Desired GHG Reductions, *Sustainability* 11, 3668; doi:10.3390/su11133668.

Lucena, A. F. P., 2018, Impact of carbon reduction policies on international maritime transport: contributions to the sustainability and competitiveness of Brazilian foreign trade, presented at a workshop organized by the Carbon Pricing Leadership Coalition, UNCTAD, Geneva, Switzerland, November.

Lun, V. and Hoffmann, J. 2016, Connectivity and trade relativity: the case of ASEAN, *Journal of Shipping and Trade* 1:11 DOI 10.1186/s41072-016-0015-1

Martinez, L.M., Kaupilla, J., and Castaing, M., 2015, International Freight and Related Carbon Dioxide Emissions by 2050: New Modeling Tool. *Transportation Research Record: Journal of the Transportation Research Board*, 58-67.

Mills, J., Donnison, A., and Brightwell, G. 2014. Factors affecting microbial spoilage and shelf-life of chilled vacuum-packed lamb transported to distant markets: A review. *Meat Science*, 98(1), 71-80.

NZIER, 2018, MARPOL IV and VI: Assessing the economic and environmental impact of international maritime measures on New Zealand. NZIER report to Ministry of Transport, November.

OECD, 2018, Decarbonising Maritime Transport. Pathways to zero-carbon shipping by 2035, Report of the Organisation for Economic Cooperation and Development, International Transport Forum, Paris, France, March.

OECD, 2019. *OECD Economic Outlook No. 106 (Edition 2019/2): Statistics and Projections (database).* [Online] Available at: http://doi.org/10.1787/eo-data-en. [Accessed 1 January 2020].

Panagakos, G., de Sousa Pessoa, T., Barfod, M., Desypris, N., and Psaraftis, H.N., 2019, Monitoring the Carbon Footprint of Dry Bulk Shipping in the EU: An Early Assessment of the MRV Regulation, *Sustainability,* 11, 5133; doi:10.3390/su11185133.

Parry, I., Heine, D., Kizzier, K., and Smith, T. 2018, Carbon Taxation for International Maritime Fuels: Assessing the Options, IMF working paper WP 18/2013, International Monetary Fund, Washington, DC.

Polakis, M.; Zachariadis, P.; and de Kat, J.O., 2019, The Energy Efficiency Design Index (EEDI). in Psaraftis, H.N. (ed.), *Sustainable shipping: a cross-disciplinary view*, Springer, Cham, Switzerland.

Psaraftis, H.N., 2019, Speed Optimization vs Speed Reduction: are speed limits better than a bunker levy? *Maritime Economics and Logistics*, doi.org/10.1057/s41278-019-00132-8.

Psaraftis, H.N. and Kontovas, C.A., 2010. Balancing the Economic and Environmental Performance of Maritime Transportation. *Transportation Research Part D* 15(8), 458-462.

Psaraftis, H. N. and Woodall, P., 2019, Reducing GHGs: the MBM and MRV agendas, chapter in *Sustainable shipping: a cross-disciplinary view*. H.N. Psaraftis (ed.), Springer.

Scobie, M., 2013, Climate regulation: implications for trade competitiveness in Caribbean states. In *Climate-Smart Technologies*. Springer, Berlin, Heidelberg.

Shi, Y., 2016. Reducing greenhouse gas emissions from international shipping: Is it time to consider market-based measures?, *Marine Policy*, *64*, 123-134.

UNCTAD, 2014, Closing the distance: partnerships for sustainable and resilient transport systems in SIDS, United Nations Conference on Trade and Development, Geneva, Switzerland.

UNCTAD, 2017, Review of Maritime Transport 2017, United Nations Conference on Trade and Development, Geneva, Switzerland.

UNFCCC, 2005, Climate change, small island developing states. Issued by the Climate Change Secretariat (UNFCCC), Bonn, Germany.

Vilas, R., F., 2018. Container shipping performance: a case study on a transpacific service, M.Sc. thesis, Technical University of Denmark, July 2018.

Wilmsmeier, G. and Hoffmann, J. 2008, Liner Shipping Connectivity and Port Infrastructure as Determinants of Freight Rates in the Caribbean, *Maritime Economics and Logistics,* 10, (130–151)

Zis, T., and Psaraftis, H. N., 2017, The implications of the new sulphur limits on the European Ro-Ro sector. *Transportation Research Part D: Transport and Environment*, *52*, 185-201.

Zis, T. and Psaraftis, H. N., 2018, Operational measures to mitigate and reverse the potential modal shifts due to environmental legislation, *Maritime Policy and Management*, DOI: 10.1080/03088839.2018.1468938

# AUTHORS' BIOS

**Harilaos N. Psaraftis** is Professor at the Technical University of Denmark (DTU) since 2013, and is currently at the Management Science division of DTU Management. He has a diploma from the National Technical University of Athens (NTUA, 1974), two M.Sc. degrees (1977) and a PhD (1979) from the Massachusetts Institute of Technology (MIT). He was Assistant and Associate Professor at MIT from 1979 to 1989 (Department of Ocean Engineering) and Professor at NTUA from 1989 to 2013 (School of Naval Architecture and Marine Engineering). His main interests are in maritime, port and intermodal logistics, with a recent focus on green logistics. At MIT he headed some 11 projects on various transport subjects. At NTUA he has been project manager of some 30 projects in practically all areas of maritime transport, of which 6 on ship emissions. At DTU he has been involved in 10 projects, of which 5 on ship emissions. Among the 25 EU projects he has been involved in, he has coordinated 3 multi-partner EU consortia, including project SuperGreen on Green Corridors. His latest book is *Sustainable Shipping: A Cross-Disciplinary View* (Springer, 2019). Since 2006 he has participated in many meetings of the IMO (MSC and MEPC). He has served as chairman of various IMO/MEPC correspondence and working groups on environmental risk evaluation criteria, with a specific focus on oil pollution. He was also a member of the IMO expert group on Market Based Measures (MBMs) for the reduction of GHG emissions. He and his group have received various academic and industry awards, including two from Lloyds List. In addition to his academic duties, he has served as CEO of the Piraeus Port Authority from 8/1996 to 3/2002.

**Thalis Zis** is currently a Senior Researcher at the Technical University of Denmark (DTU), Department of Management. He holds a diploma in Mechanical Engineering from the National Technical University of Athens (2008) and an MSc in Transport from Imperial College London (2010). Prior to joining DTU, he completed his Ph.D. thesis on the environmental impact of port operations at Imperial College London, while also working as a Research Assistant in two European funded research grants. His research interests are catholic, spanning ports and maritime logistics, weather routing, transport network modelling, traffic engineering, optimization problems, game theory, and emissions modelling. He has published extensively in the field of maritime transport and on green port operations, with notable contributions on the effects of sulphur regulation in shipping. He has received scholarships at all levels (undergraduate, postgraduate, doctoral) of studying, and has been awarded with several research grants in subjects related with Maritime Logistics and Sustainable Transport. He serves as an International member on the Standing Committees on Marine Environment and on Ports and Channels of the Transportation Research Board (TRB). Thalis has over 10 years of research experience in transportation and logistics, and more than 50 peer reviewed publications in leading academic journals and international conferences. He currently works on applications of game theory as regards the enforcement of the global sulphur cap, and has been recently awarded with a research grant on the role of ports in the decarbonization of international maritime transportation.

**Ronald A. Halim**, PhD. is a transport and logistics specialist with 10 years experience in quantitative policy analysis. Ronald has had the experience of working in private, public, academic sectors, as well as for international organizations such as the OECD and the World Bank. Currently, he serves as the founder of an independent advisory company specialized in freight and maritime transport - Equitable Maritime Consulting, where he also works as the principal transport economist. He has undertaken various advisory projects in the domain of freight transport decarbonization across different modes of transport and countries globally such as Indonesia, the UK, and Europe. He is the main of the author of the following publications:

1. Decarbonization Pathways for International Maritime Transport: A Model-Based Policy Impact Assessment as part of his work at the ITF/OECD on Decarbonizing maritime transport. The work was presented at the 3rd IMO's ISWG-GHG meeting.
2. The World Bank report: "Understanding the Economic Impacts of Greenhouse Gas Mitigation Policies on Shipping: What Is the State of the Art of Current Modeling Approaches?" which was submitted to the IMO's 74th MEPC.

Ronald obtained his doctoral degree in modeling global container transport system and his MSc in Systems Engineering, Policy Analysis, and Management from Delft University of Technology. He is specialized in model-based impact assessment of transport policies. Specifically he has an extensive experience in modeling and simulation of global freight transport systems, transport demand forecasting, design of large-scale multi-modal network, optimization models, data visualization, and data science techniques.