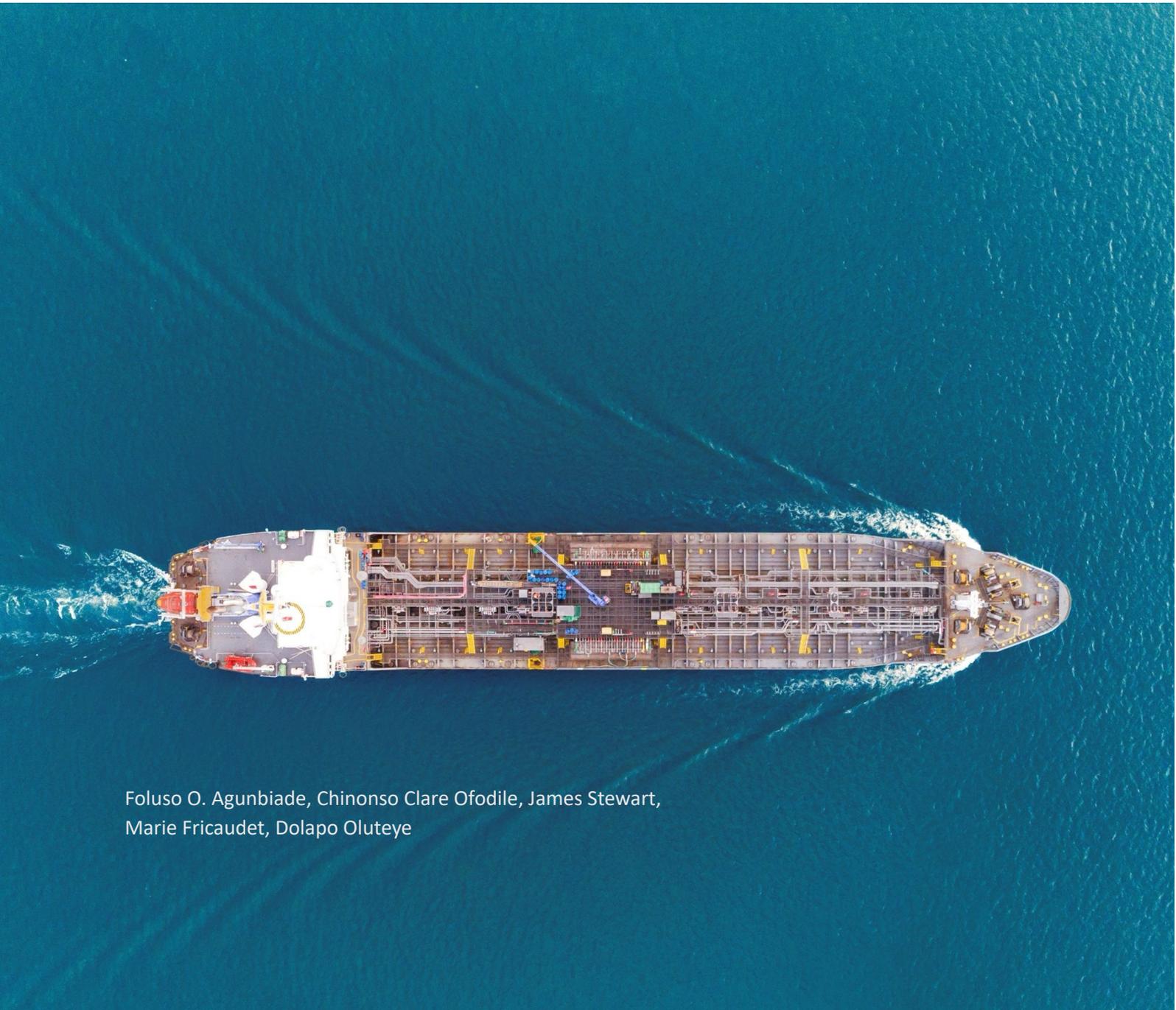


LEADING EFFECTIVE AFROCENTRIC PARTICIPATION (LEAP) PROJECT PHASE I

# Impact Assessment of the IMO basket of candidate mid-term GHG reduction measures: The Nigeria Case Study

A CASE STUDY REPORT

Foluso O. Agunbiade, Chinonso Clare Ofodile, James Stewart,  
Marie Fricaudet, Dolapo Oluteye



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April 2025

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## List of Abbreviations

AfCFTA	African Continental Free Trade Agreement
AfDB	African Development Bank
BAU	Business as Usual
CBAM Carbon	Border Adjustment Mechanisms
CI	Cost Intensity
CIA	Comprehensive Impact Assessment
CIF	Cost, Insurance and Freight
DNI	Disproportionately Negative Impact
DNV	Det Norske Veritas
ETS	Emissions Trading System
EU	European Union
FOB	Free-on-Board
FRACCI	Freight-rate Adjusted Commodity Cost Intensity
GATT	General Agreement on Tarrifs and Trade
GDP	Gross Domestic Product
GFI	GHG Fuel Intensity
GHG	Greenhouse Gas
GVC	Global Value Chain
HS	Harmonized System
IMO	International Maritime Organisation
ISWG-GHG	Inter-Sessional Working Group on Greenhouse Gases
LDCs	Least Developed Countries
LEAP	Leading Afro-centric Participation
LLDC	Land-locked Developing Countries
MEPC	Marine Environmental Protection Committee

NBS	National Bureau of Statistics
NIMASA	Nigerian Maritime Administration and Safety Agency
NPA	Nigerian Ports Authority
PMS	Petroleum Motor Spirit
RU	Remedial Units
SDG	Sustainable Development Goal
SIDS	Small Island Developing States
SR	Speed Reduction
SU	Surplus Units
TCCI	Total Expected Commodity Cost Intensity Change
TtW	Tank-to-Wake
UCL	University College London
UNCTAD	United Nations Committee on Trade and Development
UNECA	United Nations Economic Commission for Africa
WMU	World Maritime University
WTO	World Trade Organization
WtW	Well-to-Wake
ZNZ	Zero and Near-Zero

## Glossary

**Forward Global Value Chain (GVC) Linkages** - Forward GVC linkages refer to a country's role in supplying raw materials, intermediate goods, or components that are further processed or used in production by other countries before reaching the final consumer.

**Backward Global Value Chain (GVC) Linkages** refer to a country's reliance on imported inputs, raw materials, or intermediate goods for its production and exports. This means that a significant portion of a country's exports depends on foreign-sourced components. Here, inputs are imported to support domestic production and value-added trade.

**Forex Illiquidity** - Foreign exchange illiquidity refers to a shortage of foreign currency (e.g. US dollars, etc) in a country's system necessary for trade, investments, or debt payments, making cross-border commercial activities challenging.

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## About The Professional African Technical Network Advisory (PATNA) Initiative

The PATNA Initiative is a non-profit network of 100+ African experts, policymakers, researchers, and advocates, formed to amplify Africa's voice in global energy transition and climate action. PATNA leverages evidence-based research to inform policies that balance economic growth with environmental protection. Bringing together academics, technical experts, government professionals, and private-sector cohorts, we ensure that African perspectives are represented in global policy and climate matters. For more information, please visit [www.thepatna.org](http://www.thepatna.org).

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The UCL Energy Institute hosts a world leading research group which aims to accelerate the transition to an equitable and sustainable energy and trade system within the context of the ocean. The Shipping and Oceans Research Group's multi-disciplinary work on the shipping and ocean system leverages advanced data analytics, cutting-edge modelling, and rigorous research methods, providing crucial insights for decision-makers in both policy and industry. The group focuses on three core areas: analyzing big data to understand the drivers of shipping emissions, developing models and frameworks to explore the path toward zero-emission shipping, and conducting social science research to examine the policy and commercial structures that enable the decarbonization of the shipping sector. For more information visit [www.shippingandoceans.com](http://www.shippingandoceans.com).

## About University of Lagos

The University of Lagos ([www.unilag.edu.ng](http://www.unilag.edu.ng)) was established over six decades ago (1962). The University of Lagos has been a beacon of qualitative and research-oriented education for thousands of knowledge seekers who come to its domain from Nigeria and Abroad. The University has over 65,000 Undergraduate and Postgraduate students across Faculties and Programmes. UNILAG's vibrant community sprouts from a fountain of distinction, which produces top-tier graduates and academia whose impactful contributions continue to shape Nigeria's growth and development.

## Executive Summary

The Fourth International Maritime Organization (IMO) Greenhouse Gas (GHG) Study, published in 2020, estimated that the maritime industry contributed 2.89% to global anthropogenic GHG emissions in 2018 (Faber et al, 2020). By 2050, these emissions could increase to between 90% and 130% of 2008 levels. In response, the 2023 IMO GHG Strategy aims to strengthen the IMO's role in global emission reduction efforts by addressing GHG emissions from international shipping, identifying actions for the sector, considering impacts on States, promoting incentives for research and development, and monitoring emissions (IMO, 2023).

For a truly global discussion, empirical evidence from Africa is necessary for informing policy decisions. In response, the Leading Effective Afro-centric Participation (LEAP) project initiative was developed to provide a technical toolkit with four key workstreams necessary for supporting the African member states. One of the four is a case study workstream of six African IMO member states, namely Ghana, Kenya, Liberia, Malawi, Namibia and Nigeria. Thus, with an analytical 'Qualitative/Quantitative Stakeholders Case Study' approach, this workstream sets out to assess each country's vessel-side, cargo-side, and combined cost impacts of the IMO's Strategy under four ship speed reduction Scenarios (0%, 10%, 20%, and 30%) for three time horizons that align with the Strategy's checkpoints: 2030, 2040, and 2050 (Starcrest, 2024).

Findings from Nigeria's case study suggests compliance cost challenges when combining vesselside and cargo-side costs for sectors such as oil and gas, agricultural products, manufactured goods, and raw materials. The report highlights that vessel-side costs contribute more to the overall cost increase at varying degrees associated with the Ad-valorem Interest Rate used for each commodity. The cargo-side cost increases were generally lower, except in the case of perishable goods like sesamum seed at a depreciation value of 30%. The 'Low Levy - Scenario 32' was identified as an advantageous option in the short- and long-term for all Nigeria's modelled commodities.

By 2050, combined cost impacts across all speed reduction (SR) Scenarios were estimated at approximately 4% for Crude Oil exports and Petroleum Motor Spirit (PMS) imports; 6% for agricultural goods and up to 10% for herbicide imports, particularly under the 30% SR Scenario. Findings indicate these cost impacts are attributable mainly to the vessel-side impacts (e.g., the payment of carbon price, the use of more expensive fuels, the additional investment onboard ships) but also to longer travel times at sea, which negatively affect the quality of perishable goods, like agricultural products, by increasing depreciation costs and raising cargo-side expenses. Added to this consideration are factors such as the time value of money, and the frequency of ship operations in evaluating the implications of ship speeds in specific cargo types. Overall, a reduction in ship speed by 10% or 20% resulted in minimal cost increases across the board.

Finally, the analysis highlights that increased shipping costs over time could have economic implications, such as higher export and import prices, reduced global competitiveness of exports, lower trade volumes, and increased consumer prices. These impacts could lead to a decline in Gross Domestic Product (GDP) and have broader implications for Africa's trade competitiveness, which is critical for developing and emerging economies. The extent of these effects is contingent on the persistence of negative impacts and the interventions within each Scenario, such as levy requirements and the inclusion of revenue disbursement mechanisms. As such, strategic and evidence-based interventions are imperative to mitigating these challenges and ensuring a just and equitable approach is applied to decarbonizing international shipping.

Measures' architecture that supports sustainable trade and promotes economic growth will prevent leaving African States behind in the global energy transition efforts.

## Abbreviations

AfCFTA	African Continental Free Trade Agreement
AfDB	African Development Bank
BAU	Business as Usual
CBAM	Carbon Border Adjustment Mechanisms
CI	Cost Intensity
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exports depends on foreign-sourced components. Here, inputs are imported to support domestic production and value-added trade.

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## 1. Introduction

Ongoing efforts and discussions at the IMO focus on strategies to reduce GHG emissions in the maritime industry. Several mid- and long-term measures have been proposed. The Fourth IMO GHG Study, published in 2020, estimated that the maritime industry contributed 2.89% to global anthropogenic GHG emissions in 2018 (Faber et al, 2020). By 2050, these emissions could increase to between 90% and 130% of 2008 levels. In response, the 2023 IMO GHG Strategy aims to achieve net-zero GHG emissions by 2050, with the following intermediate targets at three checkpoints compared to 2008 emissions levels: a 20% emissions reduction by 2030, striving to reach 30%; 70% reduction, striving for 80% by 2040; and net zero by 2050 (IMO, 2023).

The strategy consists of two key components: technical and economic measures. The technical element establishes a goal-based marine fuel standard to regulate the gradual reduction of GHG intensity in marine fuels. The economic element implements market-based mechanisms, centered on a pricing system for maritime GHG emissions (IMO, 2023): In achieving this, the strategy further aims to identify actions for the sector, address impacts on states, and promote incentives for research and development and monitoring emissions.

To inform Africa's policy decisions that ensure the principles of justice and equity are upheld, promoting, supporting and leveraging empirical evidence derived directly from the region when addressing these impacts is critical. It is in this sense that the LEAP Project initiative was developed to support six African member states at the IMO. These countries are namely: Ghana, Kenya, Liberia, Malawi, Namibia and Nigeria. This report presents the case study undertaken for Nigeria supported under the directive of the Minister for Marine and Blue Economy.

Thus, this case study report analyses the cost impacts of the 2023 IMO GHG Reduction Strategy on a selection of Nigeria's most important traded commodities. The primary objectives are to assess vessel-side, cargo-side, and combined cost impacts on traded commodities under four ship SR scenarios at 0%, 10%, 20%, and 30% (SR-0, SR-10, SR-20, and SR-30) and four of the policy Scenarios under consideration at the IMO: scenarios 24, 32, 26 and 36. These scenarios include a basket of candidate measures including GHG Fuel Intensity (GFI) requirement, GFI flexibility mechanism, a levy and reward, feebate and revenue disbursement.

The GFI requirement regulates ships' annual well-to-wake (WtW) or tank-to-wake (TtW) GHG emissions per energy unit, setting GFI targets in line with sustainability criteria. Compliance can be achieved through a flexibility mechanism, allowing ships with lower emissions (positive compliance balance) to sell surplus units (SU) either to higher-emitting ships (negative compliance balance) or to a revenue body at a set price. Ships exceeding the required GFI must purchase remedial units (RU) from the revenue body at a predetermined price set by the IMO, based on the cost gap between fossil and non-fossil fuels.

The levy and reward mechanism applies a levy on all GHG emissions from ships, with revenues used to reward vessels using approved low-carbon fuels. Similarly, the feebate mechanism imposes a fee per tonne of CO<sub>2</sub> emitted while offering rebates to ships adopting eligible fuels, creating financial incentives for decarbonization (DNV, 2024). The basket of measures will generate revenue which can be allocated across designated disbursement categories to support the uptake of Zero and Near-Zero (ZNZ) fuels. Four of the policy scenarios modelled in this case study are:

- Scenario 24: WtW, GFI flexibility, no levy, no feebate, without revenue disbursement
- Scenario 26: WtW, no flexibility, high levy, no feebate, with revenue disbursement
- Scenario 32: WtW, GFI flexibility, low levy, no feebate, with revenue disbursement
- Scenario 36: WtW, GFI flexibility, no levy, feebate, without revenue disbursement

The analysis spans three-time horizons: 2030, 2040, and 2050, forming part of the LEAP Project Phase 1. Utilizing a qualitative/quantitative stakeholders' analysis and case study approach, this report provides critical insights into the implications of these measures on four of Nigeria's most important commodity flows. It incorporates vessel-specific details, such as capacity and average design speed, to evaluate the impacts across the selected Scenarios.

## 2. Methodology

This case study aims to closely follow the approach employed by Starcrest Consulting Group for undertaking Task 4 of the IMO-led Comprehensive Impact Assessment (CIA) of the basket of candidate midterm measures (Starcrest, 2024). The CIA was conducted to evaluate likely future impacts of the midterm measures, specifically considering economic impacts on the fleet in Task 2

(DNV, 2024) and on states in Task 3 (UNCTAD, 2024a). Task 4 of the CIA provided 'complementary qualitative and quantitative stakeholders analysis' on specific commodity flows for states not well represented in Task 3 (Starcrest, 2024).

Described in full in the Technical Annex, the methodology applied in this research employed data sourced from the National Bureau of Statistics (NBS). Merchandise trade statistics characterizing Nigeria's main export and import commodities, their weights, trade partners and economic values, were sourced from the UN Comtrade database (UNCTAD, 2024b) and shipping and freight companies. In addition to this data, desk research, expert input, and in-country consultations helped assess key factors such as nautical miles, average ship speeds, interest rates, insurance rates, and cargo depreciation.

The study integrated transport cost rates from UNCTAD's Trade and Transport database (UNCTAD, 2024c) and cost intensity projections presented in DNV's Task 2 analysis of the official CIA process (DNV, 2024) into a modified version of the model presented in (APEC, 2019), adapted by the UCL team for the purposes of modelling midterm measures impact. Task 2 CIA Scenarios for this case study included 24, 32, 26, and 36 which are 'GFI Flex Only' (Scenario 24), 'Low Levy' (Scenario 32), 'High Levy' (Scenario 26) or 'Feebate' (Scenario 36) (DNV, 2024). These 4 scenarios were used to model potential impacts of the midterm measures on Nigeria's exports of crude, exports of Sesamum seeds, imports of Petroleum Motor Spirit (PMS) and imports of herbicides. These commodities were selected because they are the commodities with the largest trade volume (in tonnes) in 2023 which implies they are of substantial importance to the national economy.

Two cost components were evaluated individually and their results combined to represent the total cost impact of the midterm measures. On the vessel-side, the transport cost rate was first identified from (UNCTAD, 2024c) and then magnified by the cost intensity ratio associated with the specific policy combination and future year derived in (DNV, 2024). Analysis of cargo-side impact was computed using assumed rates of interest, depreciation and insurance. The model evaluated the differences in leg time ( $\Delta_{leg}$

time) associated with vessel speed reductions of 0%, 10%, 20%, and 30%. The differences in leg time were then combined with the assumed rates of interest, depreciation and insurance to understand the costs associated with each cargo-side element, and the sum of all three was taken as the full cargo-side cost. Interest and insurance rates of 5% and 2% were assumed, respectively, whilst the depreciation rates for non-perishable and perishable commodities were assumed to be 10% and 30%.

## Commodities and Trade Data

Nigeria's majorly traded commodities are summarized in Table 1. The table covers imports and exports with various trading partners, commodity classification using the Harmonized System (HS) 10 system and categories and the net weight of the trades is presented in tonnes. Nigeria's trade is largely driven by a few key commodities, with crude oil and agricultural products comprising the bulk of exports, while refined petroleum products, manufactured goods, and agricultural imports dominate the import segment. In Q3 2024, crude oil—Nigeria's primary export—accounted for 65.44% of total exports, while natural gas contributed 10.29%. During the same period, PMS made up 22.63% of total imports.

For this study, we selected commodities across different trade categories and key trade partners to examine cost impacts on major traded goods. The selected commodities include crude oil and sesamum seeds in the export segment, and PMS and herbicides in the import segment. Although herbicides fall under the category of manufactured goods, they are crucial for agricultural activity, underscoring their significance to the sector's productivity.

Table 1: Nigeria's majorly traded commodities Source: National Bureau of Statistics, UN COMTRADE (UNCTAD, 2024b)

S/N	Commodity	HS 10	Category	Origin/Des tination	Net weight (tonnes)
<b>EXPORTS</b>					
1	Petroleum oils and oils obtained from bituminous minerals, crude.	2709000000	Crude Oil	World	8,976,963.93
2	Natural gas	2711110000	Crude Oil	World	193,365.48
3	Sesamum seeds	1207400000	Agriculture	World	74,126.78
4	Superior quality Cocoa beans	1801001100	Agriculture	World	502.99
5	Petroleum oils and oils obtained from bituminous minerals, crude.	2709000000	Crude Oil	Within Africa	3,231,835.50
S/N	Commodity	HS 10	Category	Origin/Des tination	Net weight (tonnes)

IMPORTS					
1	Other Herbicides, antisprouting products and plants	3808939000	Manufactured goods	World	82,788.41
2	Motorcycles and cycles fitted with auxiliary motor, petrol fuel, capacity >50<250cc, CKD	8711201000	Manufactured goods	World	51,690.26
3	Used Vehicles, with diesel or semi diesel engine, of cylinder capacity >2500cc	8703332000	Manufactured goods	World	153,034.45
4	Motor spirit, ordinary	2710125000	Other oil/Other petroleum products	World	4,968,122.31
5	Gas oil	2710192100	Other oil/Other petroleum products	World	9,590.13
6	Sheets for veneering (including those of Other	4408390000	Raw Material	World	360,292.50
7	Cane sugar specified in Subheading Note 2 to Chapter 17, Meant for sugar refinery	1701141000	Agricultural Raw Material	World	777,801.19

### 3. Impact Analysis

This section analyses the vessel-side, cargo-side, and combined cost impacts on majorly traded export and import commodities.

#### 3.1 Crude Oil Export

##### 3.1.1 Crude Oil Cargo-side Cost Impact

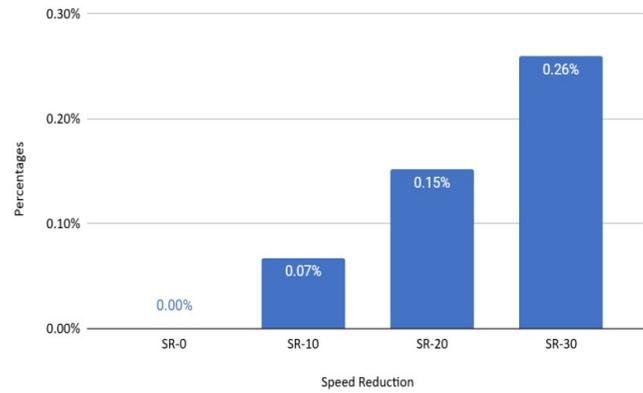
Figure 1(A - D) illustrates the economic effects of vessel speed reduction on exports of crude oil from Nigeria to the Netherlands. Across a distance of 4,779 nm, a representative tanker travelling at 15.5 knots was assumed to facilitate the trade, reducing its speed to 14.0, 12.4 and 10.9 knots under 10%, 20% or 30% speed

reduction scenarios, and resulting in leg time differences of 34.3 hours, 77.1 hours and 132.1 hours, respectively. Combined with assumptions of 5%, 10% and 2.25% for the rates of interest, depreciation and insurance costs, final cargo-side cost impacts associated with each of the speed reduction scenarios (and independent of the policy scenario) were evaluated to be 0.07%, 0.15% and 0.26%, respectively.

A clearer picture of this indicative cost increase is seen when percentages are converted to values based on trade value for the year. Using the data of the Crude Oil trade value obtained for year 2023 in Nigeria, placed at approximately \$7.594 billion, the cost increase was \$5.32 million for 10% SR; \$11.39 million for 20% SR and \$19.74 million for 30% SR. The higher costs of the commodities may lead to motivation for investment in research, development and deployment (RD&D) towards making renewable, zero-carbon energy sources a cheaper alternative and a priority. The lower cost of non-renewable, GHG-emitting fossil fuel has been a disincentive to research and development towards cheaper, cleaner burning and renewable alternative(s).

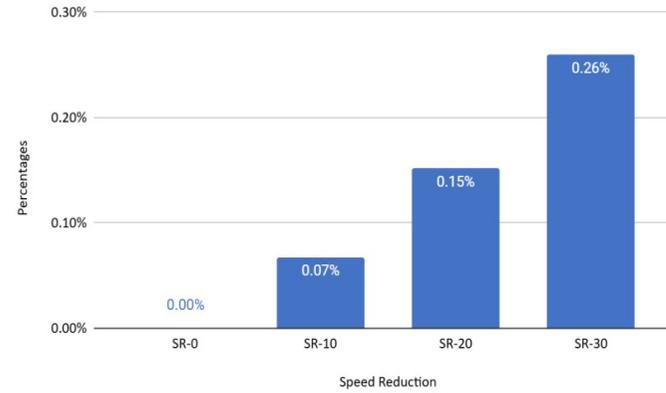
A. GFI Flex Only (Scenario 24)

Crude Oil Scenario 24 - Cargo-side Cost Impacts, %



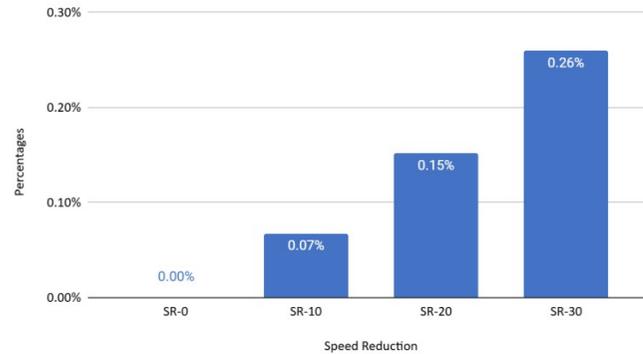
B. Low Levy (Scenario 32)

Crude Oil Scenario 32 - Cargo-side Cost Impacts, %



C. High Levy (Scenario 26)

Crude Oil Scenario 26 - Cargo-side Cost Impacts, %



D. Feebate (Scenario 36)

Crude Oil Scenario 36 - Cargo-side Cost Impacts, %

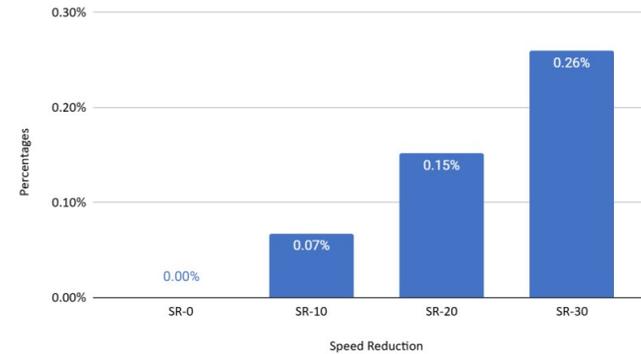


Figure 1: Impact of ship speed reductions on Crude Oil Trade - Four Scenarios' Cargo-side costs

### 3.1.2 Crude Oil Vessel-Side Cost Impact

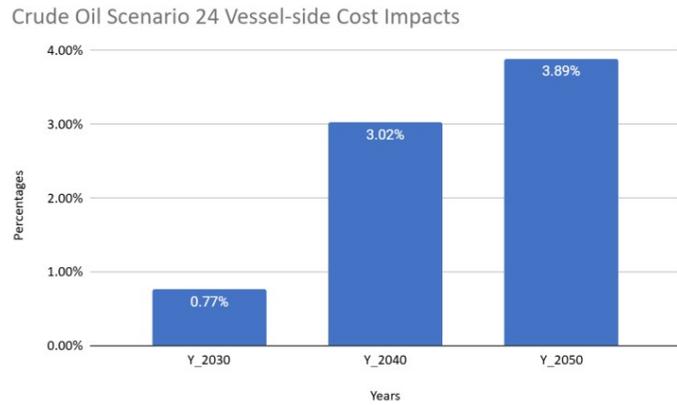
Figure 2 (A - D) demonstrates the increase in vessel-side costs projected for exports of crude oil from Nigeria to the Netherlands. The analysis was conducted under the 4 Scenarios: 24, 32, 26, and 36, with variation in vessel-side impact expected depending on the specific policy scenario and future year considered. The highest impact in the short-term was observed under the High Levy - Scenario 26 where the vessel-side cost impact is expected to increase by 1.92%. The least impact in the short-term is expected under the GFI Flex Only - Scenario 24.

In the medium-term year (2040), there were generally remarkable increases in the impacts relative to the short-term impacts. In all cases except the High Levy - Scenario 26, vessel-side cost impacts were observed to treble between 2030 and 2040. The High Levy - Scenario 26 exhibited the highest vessel-side cost increase, reaching 3.41% in 2040. This was followed by GFI Flex Only - Scenario 24, which recorded a 3.02% increase. Conversely, Low Levy - Scenario 32 demonstrated the lowest vessel-side cost impact.

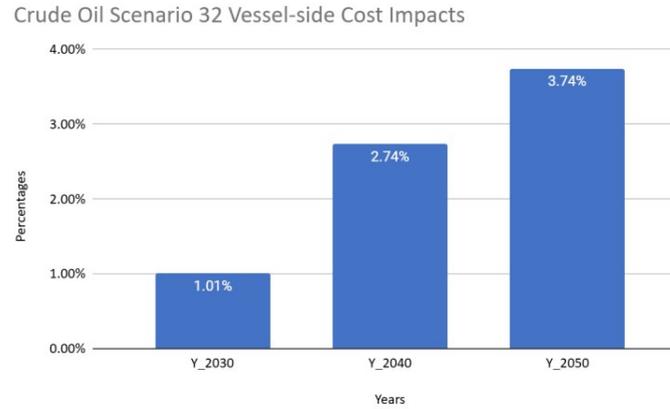
The modelling results associated with long-term vessel-side cost impacts in 2050 reveal a lower margin of increase relative to 2040 as was observed between 2040 and 2030. The results of the four Scenarios were closely related with only a 0.2% difference (3.74 - 3.94%) between them. The highest long-term impact was associated with the Feebate - Scenario 36 where a vessel-side cost impact projected a 3.94% increase. The High Levy - Scenario 26 and Low Levy - Scenario 32 scenarios result in the same vessel-side cost impact projected for 2050 (3.74%), that is the lowest of any of the scenarios modelled. This implies that Scenario 26 had a high immediate short-term impact but a relatively low impact in the long term as compared with alternative Scenarios.

Overall, a comparison of all the Scenarios and their vessel-side impacts in the short-, medium- and long-term indicates that the Low Levy - Scenario 32 may be the most preferable option when considering vessel-side cost impacts on exports of crude from Nigeria to the Netherlands. This is due to the lesser impacts expected in the medium- and long-term, whilst exerting only a moderate short-term (2030) impact. Putting real values to these percentages to fully understand the scale of these vessel operations' cost impacts may be necessary for the purposes of engaging vessel operators' understanding of the decarbonization policies. It is critical to note that the increase in vessel-side costs will almost certainly be transferred to commodity prices, with resultant effects on the buying power of consumers, trade volumes, production and other socioeconomic effects.

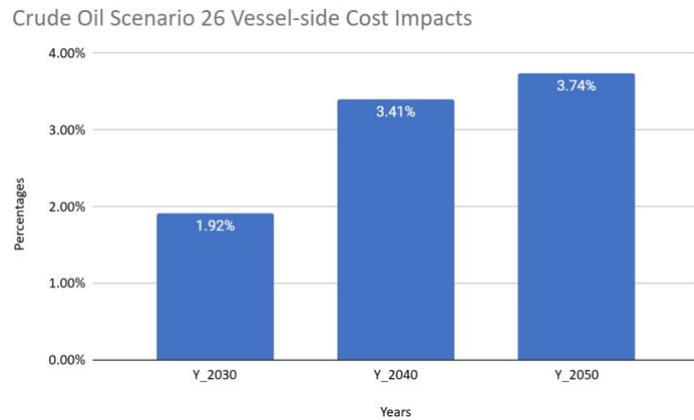
A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)



D. Feebate (Scenario 36)

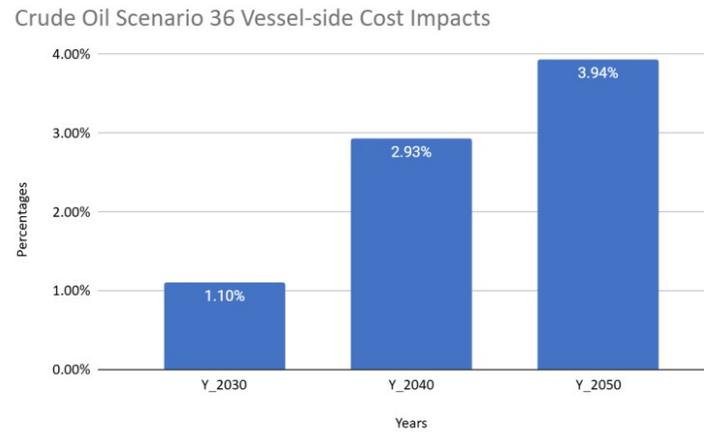


Figure 2: Impact of ship speed reductions on Crude Oil Trade - Four Scenarios' Vessel-side costs

### 3.1.3 Crude Oil's Total Expected Cost Intensity Changes

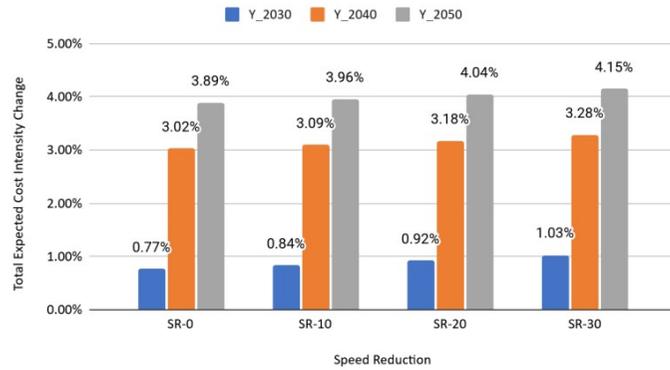
The figures labelled 3 (A-D) illustrate the cumulative impacts of cargo-and vessel-side costs for exports of crude oil from Nigeria to the Netherlands based on the modelled Scenarios (24, 32, 26, 36) relative to 2023. The highest short-term impacts were witnessed under a High Levy - Scenario 26, while the lowest was observed under the GFI Flex Only - Scenario 24.

A remarkable increase in impacts of the proposed interventions was observed in the transition between the short-term (2030) and the medium-term (2040), driven by vessel-side costs. The maximum impact observable on the total cost of cargo and vessel operations was a 4.20% increase under the Feebate - Scenario 36 when adopting a 30% SR over the long term till 2050. Values of the impact may be known if the percentages are multiplied by the annual trade monetary values.

Comparatively, the GFI Flex Only - Scenario 24 presents as the least cost impact option in the short term, making it the most commercially friendly option. However, the Low Levy - Scenario 32 presents as the more favourable option over a medium- (2040) to long-term (2050) due to its consistently lower percentage cost increases across all the speed reduction scenarios. The Low Levy - Scenario 32, whilst demonstrating an approximately 0.25% higher short-term impact compared to GFI Flex Only - Scenario 24, results in significantly lower medium- and long-term impacts, making it an overall least-cost impact choice for adoption, offering a balanced approach to economic sustainability and emissions reduction goals.

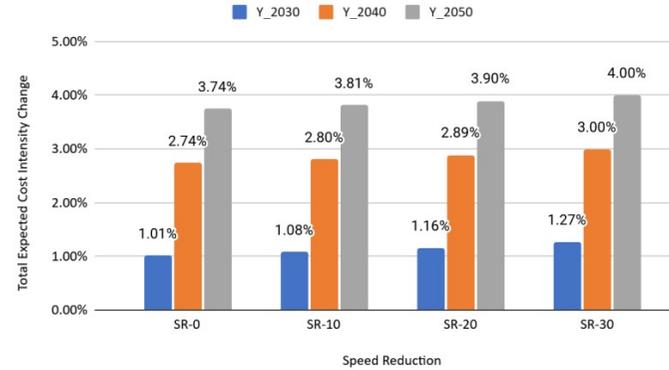
A. GFI Flex Only (Scenario 24)

Crude Oil Scenario 24 Combined Cost - Vessel Side and Cargo side



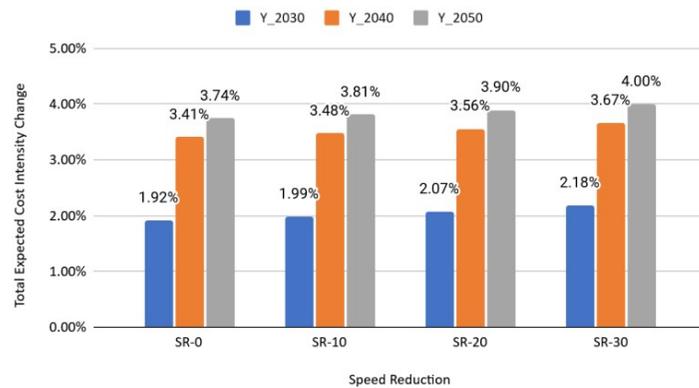
B. Low Levy (Scenario 32)

Crude Oil Scenario 32 Combined Cost - Vessel Side and Cargo side



C. High Levy (Scenario 26)

Crude Oil Scenario 26 Combined Cost - Vessel Side and Cargo side



D. Feebate (Scenario 36)

Crude Oil Scenario 36 Combined Cost - Vessel Side and Cargo side

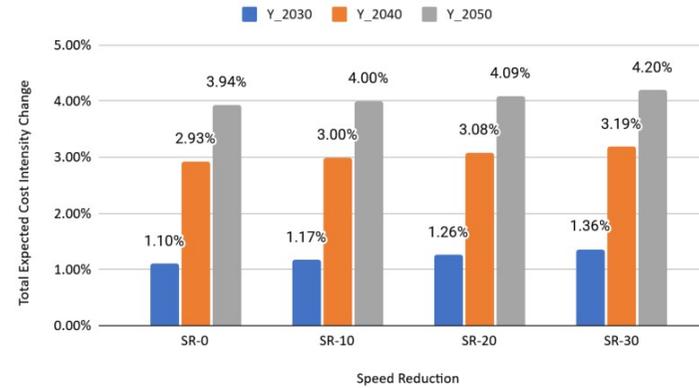


Figure 3: Impact of ship speed reductions on Crude Oil Trade - Four Scenarios for the Combined cost impacts (Vessel side and cargo -side)

## 3.2 Petroleum Motor Spirit (PMS) Import

### 3.2.1 PMS Cargo Side Cost Impact

Figure 4(A - D) illustrates the economic effects of vessel speed reduction on imports of PMS from Belgium. Across 4,653 nm, a representative tanker travelling at 15.5 knots was assumed to facilitate the trade, reducing its speed to 14.0, 12.4 and 10.9 knots under 10%, 20% or 30% speed reduction scenarios, and resulting in leg time differences of 33.4 hours, 75.0 hours and 128.7 hours, respectively. Combined with assumptions of 5%, 10% and 2.25% for the rates of interest, depreciation and insurance costs, final cargo-side cost impacts associated with each of the speed reduction scenarios (and independent of the policy scenario) were evaluated to be 0.07%, 0.15% and 0.25%, respectively. There was only a slight difference of 0.01% for PMS (0.25%) compared for Crude Oil (0.26%) under a 30% speed reduction scenario.

PMS trade value for year 2023 in Nigeria was placed at approximately \$4.97 billion. Therefore, expressing the cargo-side cost impacts in monetary terms, a 0.07% PMS cost increase equates to approximately \$3.48 million for 10% SR, while the 0.15% cargo cost increase will translate to \$7.46 million for 20% SR and \$12.43 million for 30% SR at an increase of 0.25%.

### 3.2.2 PMS Vessel-side Cost Impact

The results of modelling the effects of proposed interventions on vessel-side costs for imports of PMS from Belgium, based on 2023 trade data, are presented in Figures 5 (A-D). The analysis indicates variations in the extent of vessel-side cost impacts across four Scenarios. The observed trends were consistent with those noted for Crude Oil as discussed in Section (3.1.2) above.

In the short-term, modelling results project that the highest vessel-side cost impact will be associated with the High Levy - Scenario 26, amounting to 1.72%, and reflecting a significant cost increase compared to other Scenarios (ranging between 0.69 - 0.99%). The GFI Flex Only - Scenario 24 showed the least short-term impact. This similarity between the Crude Oil and PMS trade cost impact may be attributed to the geographical proximity of the port of arrival (Amsterdam) for the Crude Oil exported from Nigeria and the port of loading (Antwerp, Belgium) for the PMS imported into Nigeria, plus the similarity of the commodities as depicted in their HS10 code with prefix 27 (Table 1) which results in similar ad valorem rates.

In sum, the Low Levy - Scenario 32 emerges as the preferable option for consideration in the medium and long term, as it demonstrates the lowest percentage increase in 2040 and 2050 vesselside cost modelling results. Its comparatively lower cost impact may better serve commercial stakeholders by providing an improved balance between economic feasibility and decarbonization intentions.

### 3.2.3 PMS Total Expected Cost Intensity Changes

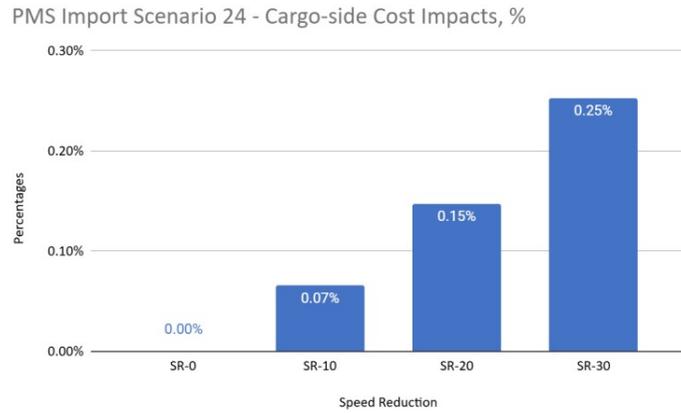
The figures labelled 6 (A-D) represent the results of the cumulative impact of cargo- and vessel-side costs for the import of PMS from Belgium to Nigeria based on the four modelled Scenarios: 24, 32, 26, 36, and relative to 2023. The results suggest a maximum impact of 3.78% associated with a Feebate - Scenario 36 and 30% speed reduction scenario in 2050.

Comparatively, the Feebate - Scenario 36 also has the highest increase of all the Scenarios in the long-term (2050), followed by the GFI Flex Only - Scenario 24. Conversely, the Low Levy - Scenario 32 demonstrates the least long-term increase across all speed reductions, making it the most commercially friendly option in the

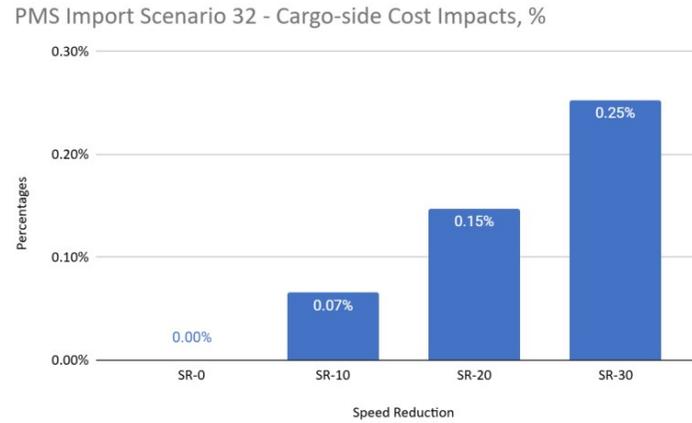
medium to long term. However, it is worth noting that the Low Levy - Scenario 32 shows a slightly higher increase than the GFI Flex Only - Scenario 24 in the short term.

This trend mirrors results from the analysis of Nigerian Crude Oil exports to the Netherlands, suggesting that the proposed interventions may exert similar impacts on Nigeria's energy sector. Given ongoing challenges surrounding energy costs in Nigeria, especially concerning imports of PMS, opting for a scenario that offers a lower rate of total cost impact would be most prudent.

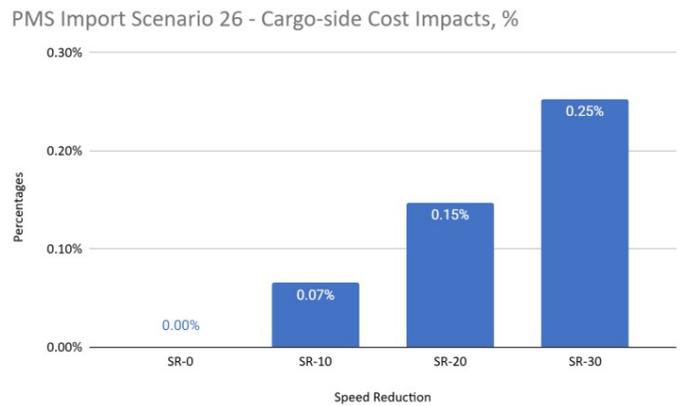
A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)



D. Feebate (Scenario 36)

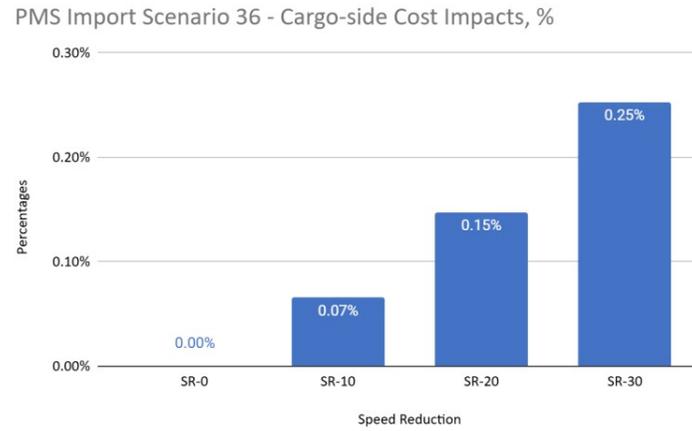
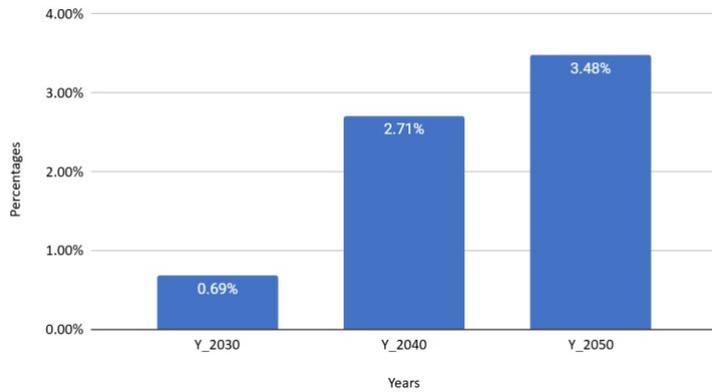


Figure 4: Impact of ship speed reductions on PMS Trade - Four Scenarios' Cargo -side cost

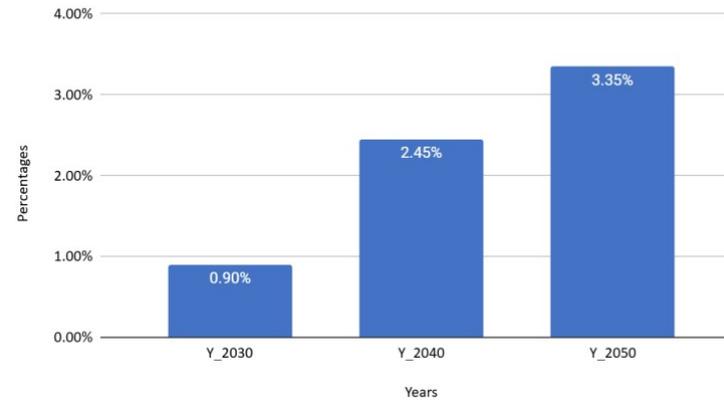
A. GFI Flex Only (Scenario 24)

PMS Import Scenario 24 Vessel-side Cost Impacts



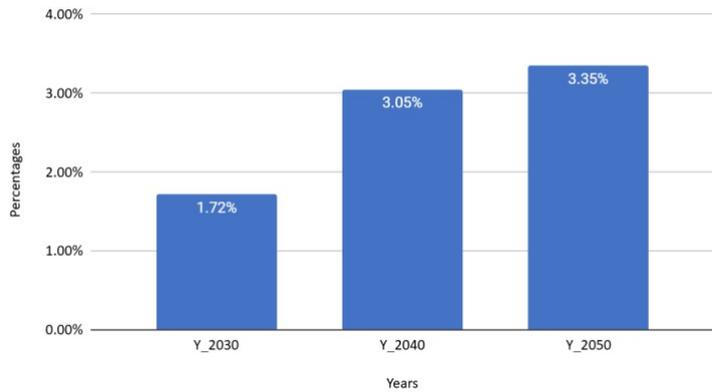
B. Low Levy (Scenario 32)

PMS Import Scenario 32 Vessel-side Cost Impacts



C. High Levy (Scenario 26)

PMS Import Scenario 26 Vessel-side Cost Impacts



D. Feebate (Scenario 36)

PMS Import Scenario 36 Vessel-side Cost Impacts

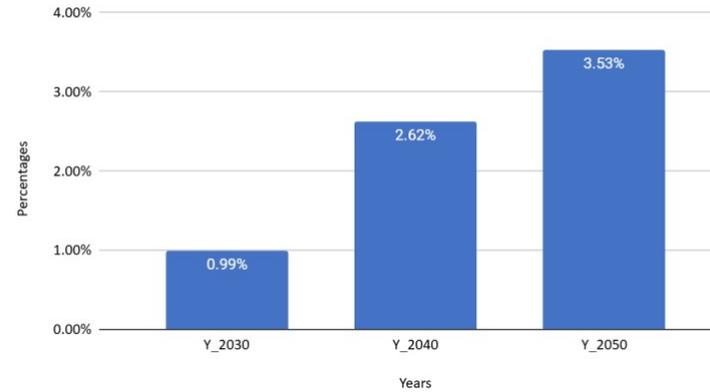
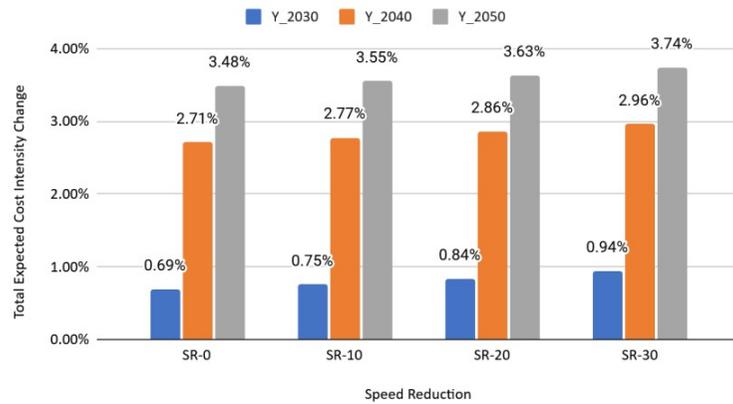


Figure 5: Impact of ship speed reductions on PMS Trade - Four Scenarios' Vessel-side cost

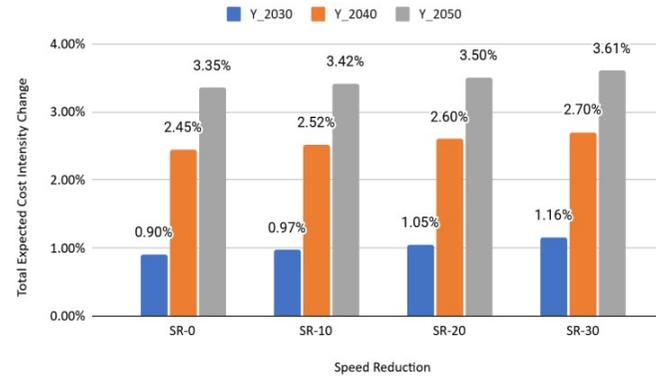
A. GFI Flex Only (Scenario 24)

PMS Import Scenario 24 Combined Cost - Vessel Side and Cargo side



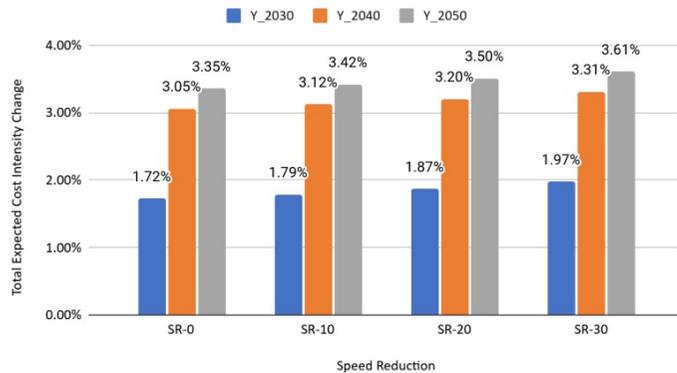
B. Low Levy (Scenario 32)

PMS Import Scenario 32 Combined Cost - Vessel Side and Cargo side



C. High Levy (Scenario 26)

PMS Import Scenario 26 Combined Cost - Vessel Side and Cargo side



D. Feebate (Scenario 36)

PMS Import Scenario 36 Combined Cost - Vessel Side and Cargo side

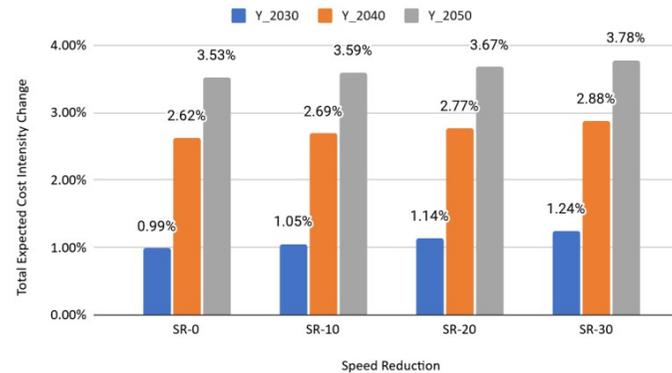


Figure 6: Impact of ship speed reductions on PMS Trade - Four Scenarios for the Combined cost impacts (Vessel side and cargo side)

### 3.3 Sesamum Seed Exports

The first two commodities reported above are energy-related and selected to illustrate the impact of the proposed interventions on the export and import trades. The next two commodities presented in this Section (3.3) and subsequent Section (3.4) focus on commodities associated with food production and agricultural goods. Section (3.3) presents the model results for sesamum seed export, while Section (3.4) presents results for herbicide imports. Although they are classified as manufactured goods, they play a significant role in supporting agricultural production.

#### 3.3.1 Sesamum Seed Export Cargo-Side Cost Impact

Figure 7(A - D) illustrates the economic effects of vessel speed reduction on exports of sesamum seeds to China. Across 11,168 nm, a representative general cargo vessel travelling at 14.0 knots was assumed to facilitate the trade, reducing its speed to 12.6, 11.2 and 9.8 knots under 10%, 20% or 30% speed reduction scenarios, and resulting in leg time differences of 88.6 hours, 199.4 hours and 341.9 hours, respectively. Combined with assumptions of 5%, 30% and 2.25% for the rates of interest, depreciation and insurance costs, final cargo-side cost impacts associated with each of the speed reduction scenarios (and independent of the policy scenario) were evaluated to be 0.38%, 0.85% and 1.45%, respectively.

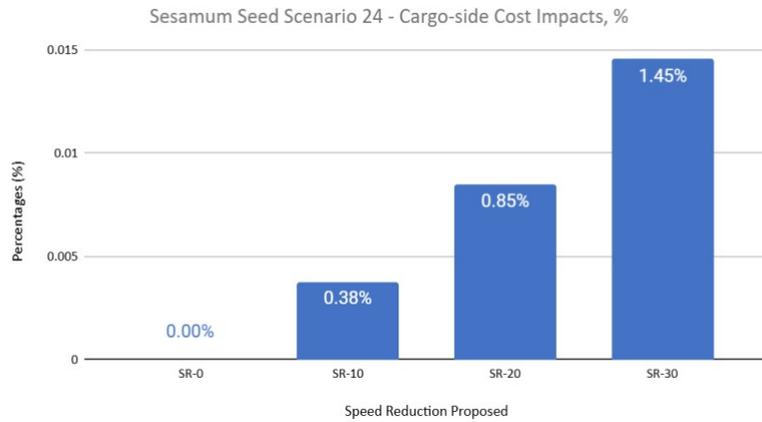
The percentage point increases in the cargo costs in the model for sesamum seed were higher than for Crude Oil and PMS (Figures 1 and 4 respectively), a finding attributable to the increased assumed depreciation rate. Furthermore, the risk of loss rises with speed reduction, as longer shipping durations elevate the potential for commodity spoilage. Thus, the cargo cost increase for Sesamum Seeds is estimated to range between \$0.52 million and \$1.99 million based on the 2023 trade value of this commodity type.

#### 3.3.2 Sesamum Seed Export Vessel-Side Cost Impact

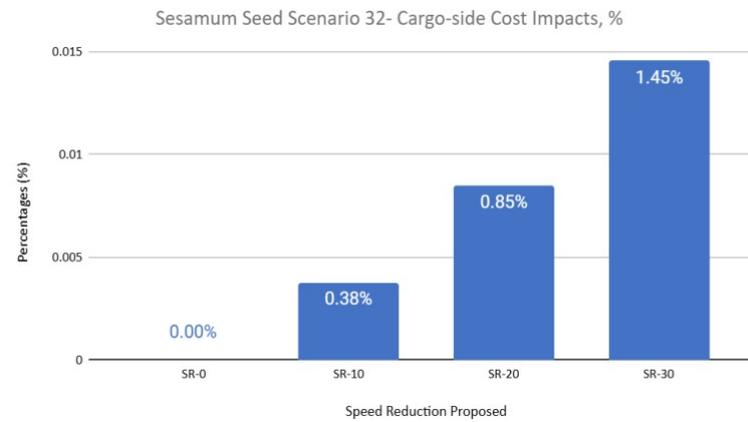
Figures 8 (A-D) presents the results of the vessel-side cost increases for exports of sesamum seeds to China relative to 2023 data. The results suggest a progressive rise in vessel-side costs across the years 2030, 2040, and 2050. The highest impact in the short-term was observed to occur under the High Levy - Scenario 26 where the vessel-side cost impact is expected to be 2.08%. The least impact in the short-term is projected to occur under the GFI Flex Only - Scenario 24, amounting to 0.83%. A sharper vessel-side cost increase is estimated for the medium term relative to short term, as compared to the long term versus the medium term.

Overall, the trends of vessel-side cost increases for exports of Sesamum Seed to China mirror those observed for other commodities modelled in this paper. Specifically, the Low Levy - Scenario 32 continues to represent the favourable option in the medium and long term due to its comparatively low costs, while the GFI Flex Only - Scenario 24 has the least short-term impact.

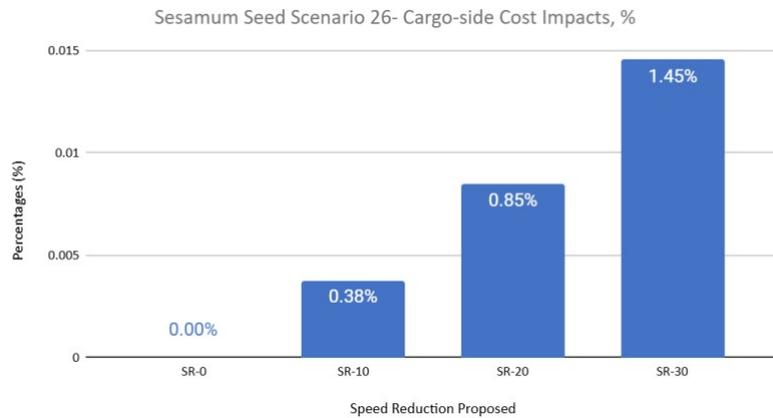
**A. GFI Flex Only (Scenario 24)**



**B. Low Levy (Scenario 32)**



**C. High Levy (Scenario 26)**



**D. Feebate (Scenario 36)**

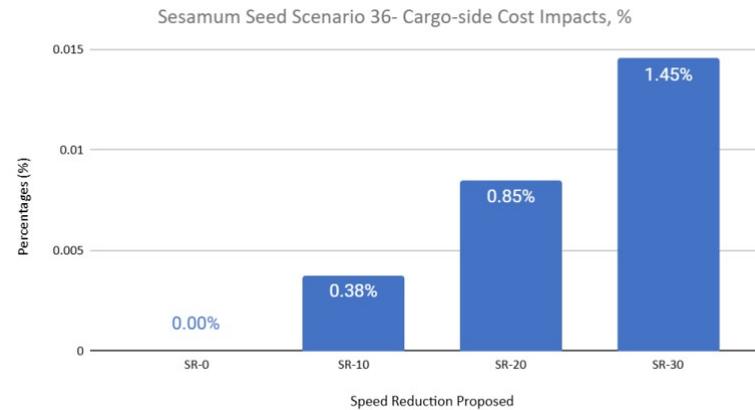
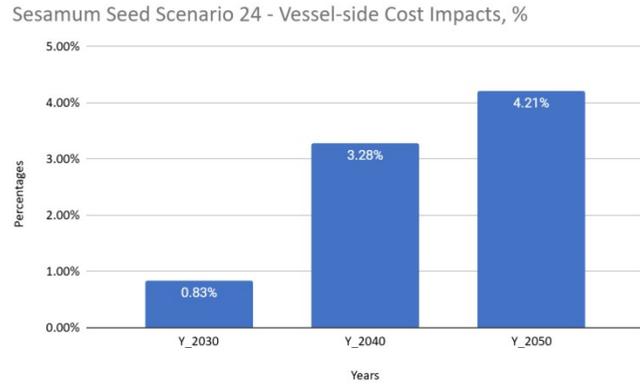
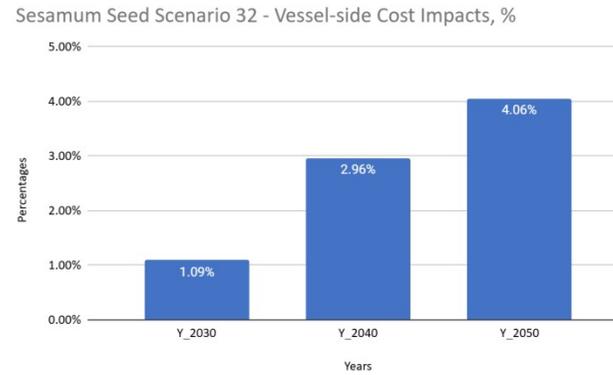


Figure 7: Impact of ship speed reductions on Sesamum seed export trade - Four Scenarios' Cargo-side costs

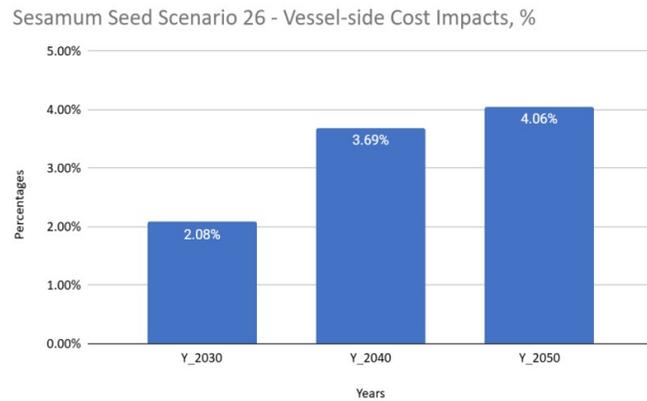
**A. GFI Flex Only (Scenario 24)**



**B. Low Levy (Scenario 32)**



**C. High Levy (Scenario 26)**



**D. Feebate (Scenario 36)**

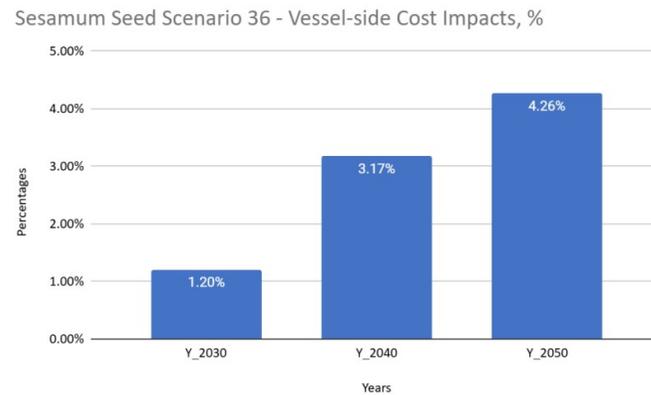


Figure 8: Impact of ship speed reductions on Sesamum seed export trade - Four Scenarios' Vessel- side costs

### 3.3.3 Sesamum seed's Total Expected Cost Intensity Changes

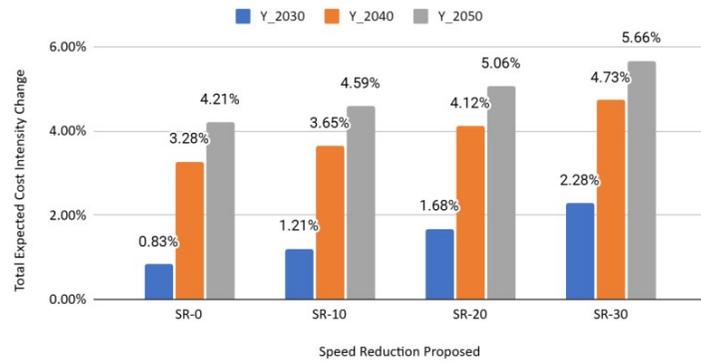
The combined impact of cargo-side and vessel-side cost impacts relative to 2023 on exports of Sesamum seeds from Nigeria to China is illustrated in Figures 9 (A-D). The outcomes across the four modelled Scenarios suggest significant impacts in the GFI Flex Only and Feebate - Scenarios 24 and 36 in the long term (2050), with percentage increases ranging from 4.21% to 5.72% across proposed speed reductions.

In the short-term (2030), the GFI Flex Only - Scenario 24 showed the least impact, while the High Levy - Scenario 26 recorded the greatest impact. However, by the medium term (2040), the total cost impact of the GFI Flex Only - Scenario 24 exceeded that of both Levy scenarios - Scenarios 32 and 26. In the long-term (2050), both Levy scenarios - Scenarios 26 and 32 presented identical results, although the High Levy - Scenario 26 exhibits a notably higher cost impact than the Low Levy - Scenario 32 in the short and medium terms.

Comparatively, the Low Levy - Scenario 32 remains the most cost-effective option in the medium- and long-term, although its short-term cost increase is comparable to, or slightly higher than, the GFI Flex Only - Scenario 24. As such, the relatively higher overall percentage cost increase of sesamum seed exports over Crude Oil exports can be attributed to the higher depreciation rate of 30%, reflecting its status as a perishable commodity.

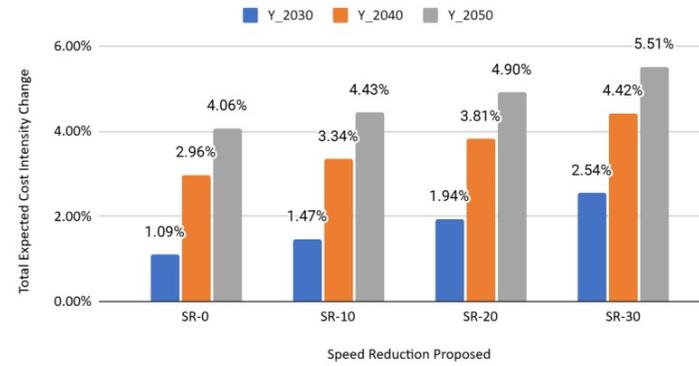
**A. GFI Flex Only (Scenario 24)**

Sesamum Seed Scenario 24 Combined Cost - Vessel Side and Cargo side



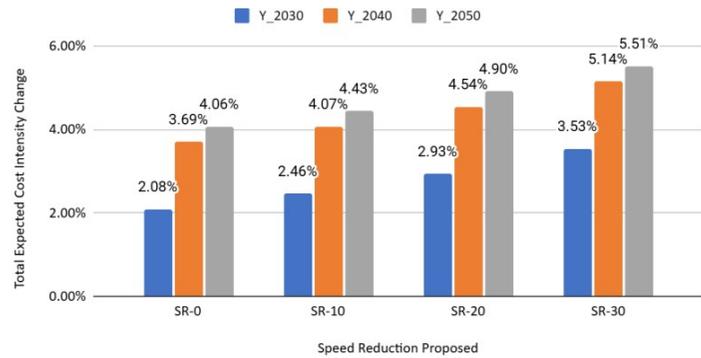
**B. Low Levy (Scenario 32)**

Sesamum Seed Scenario 32 Combined Cost - Vessel Side and Cargo side



**C. High Levy (Scenario 26)**

Sesamum Seed Scenario 26 Combined Cost - Vessel Side and Cargo side



**D. Feebate (Scenario 36)**

Sesamum Seed Scenario 36 Combined Cost - Vessel Side and Cargo side

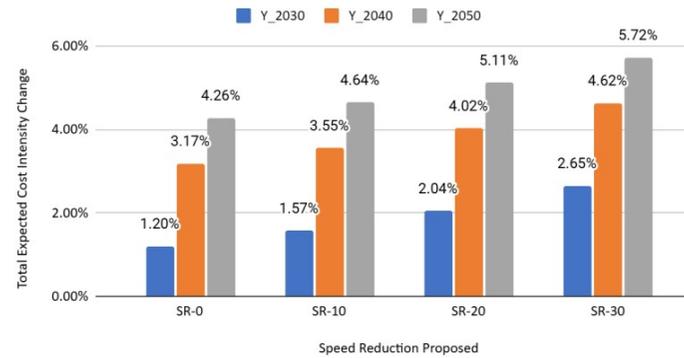


Figure 9: Impact of ship speed reductions on Sesamum seed export trade - Four Scenarios for the Combined cost impacts (Vessel side and cargo side)

### 3.4 Herbicides as Crop Production Input Import

The selection of herbicides in this section of the case study serves a dual purpose: to model the cost impact of the proposed intervention on the import of manufactured goods and to assess the potential implications for food and agricultural production, given the critical role herbicides play in enhancing agricultural productivity.

#### 3.4.1 Herbicides Import Cargo-Side Cost Impact

Figure 10(A - D) illustrates the economic effects of vessel speed reduction on imports of herbicides from China. Across 11,168 nm, a representative general cargo vessel travelling at 14.0 knots was assumed to facilitate the trade, reducing its speed to 12.6, 11.2 and 9.8 knots under 10%, 20% or 30% speed reduction scenarios, and resulting in leg time differences of 88.6 hours, 199.4 hours and 341.9 hours, respectively. Combined with assumptions of 5%, 10% and 2.25% for the rates of interest, depreciation and insurance costs, final cargo-side cost impacts associated with each of the speed reduction scenarios (and independent of the policy scenario) were evaluated to be 0.17%, 0.39% and 0.67%, respectively.

These increases were notably lower than those observed for Sesamum Seed exports, despite both commodities (Herbicides and Sesamum Seed) being traded with China. This discrepancy can be attributed to differences in the depreciation rates applied to the two commodities. However, the increase in cargo-side costs for Herbicides was higher than those observed in the Crude Oil and PMS trades, ranging from 0.07 to 0.26%. This difference is primarily associated with variations in trade routes, depreciation and other cost factors, as well as the average vessel speed.

#### 3.4.2 Herbicides Import Vessel-Side Cost Impact

The results of the modelling of vessel-side cost impacts associated with imports of Herbicides from China are presented in Figures 11(A-D). These results reveal that the importation of Herbicides experienced the highest percentage increase in vessel-side costs among all the traded commodities analyzed in this study. This is largely attributed to the higher ad-valorem transport cost rate (12.2%) applied to this trade.

A notable trend emerged, with short-term (2030) impact showing a high increase of 4.88% in the High Levy - Scenario 26. The other scenarios indicated percentage increases ranging between 1.95% - 2.81%, with the GFI Flex Only - Scenario 24 having the least impact. Following this, a significant rise in the vessel-side costs was observed in the medium-term, with impacts approximately three to four times higher than the short-term outcomes across all policies except for the Feebate mechanism - Scenario 36.

The modelling results indicate that the Low Levy - Scenario 32 remains the most cost-effective option when considering vessel-side cost impacts on imports of Herbicides from China, demonstrating the least medium-term (6.95%) and long-term (9.52%) impact. These results suggest the Low Levy - Scenario 32 is a preferable choice for mid- and long-term intervention.

#### 3.4.3 Herbicides Import's Total Expected Cost Intensity Changes

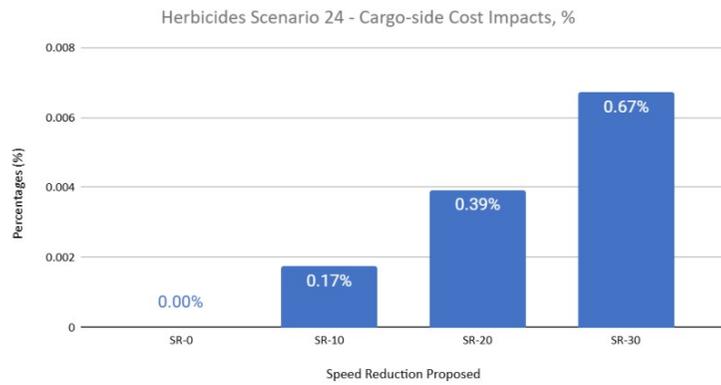
The results presented in Figures 12(A-D) summarize the combined impact of vessel-side and cargo side costs on the importation of herbicides into Nigeria from China, relative to 2023. The Feebate scenario - Scenario

36 indicated the highest long-term impact regardless of speed reduction, while the High Levy - Scenario 26 demonstrated the highest impacts in the short- and medium-terms.

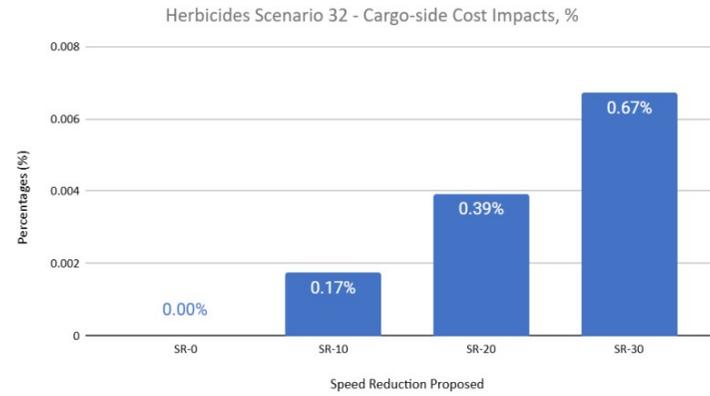
It is noteworthy that the overall impact on imports of Herbicides from China is significant, representing 10% of total import prices. Driven by its comparatively greater ad-valorem transport cost rate, this is the largest total cost impact projected across any of the commodities studied in this paper. These findings warrant attention as Herbicides play a critical role in Nigeria's food system of which agricultural production is primary. Potential direct implications on food security highlights the broader economic and social significance of these emission reduction interventions and their extension beyond the immediate maritime context. Thus, there is a social dimension to the total cost increase impact on Herbicides that should be considered due to its direct relationship with food security.

In addition, the long-term impacts of both Levy scenarios - Scenarios 26 and 32 were identical. Consistent with trends observed in other commodities modelled, the Low Levy - Scenario 32 has emerged as the least impactful option when considering these options in the medium- and long term. Therefore, this study recommends a Low Levy - Scenario 32 for consideration and adoption, due to its minimal overall cost impact on herbicides' importation.

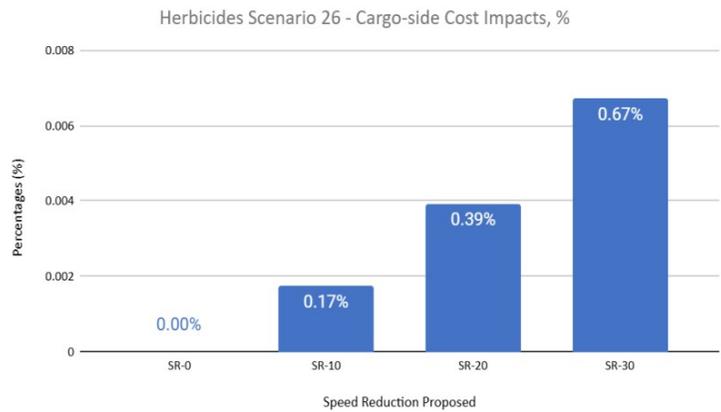
A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)



D. Feebate (Scenario 36)

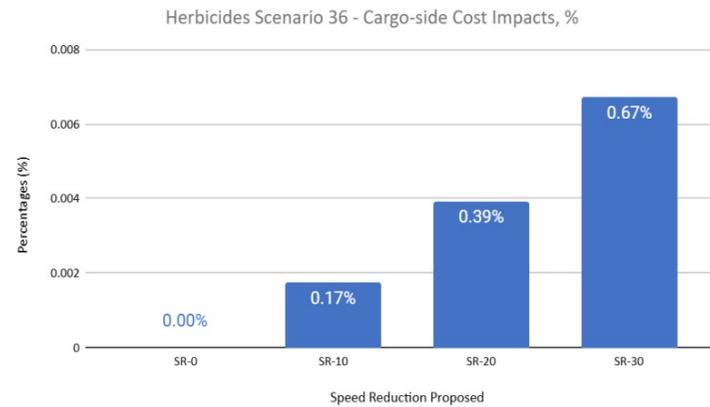
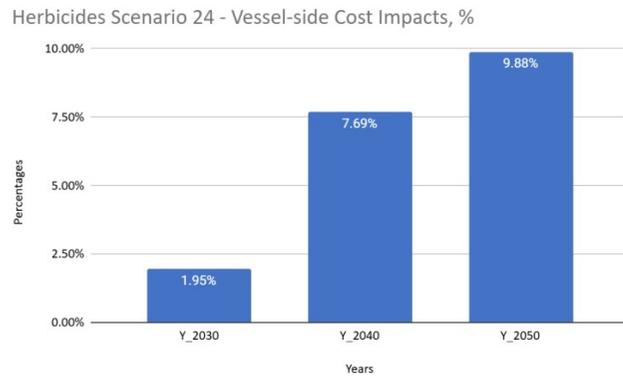
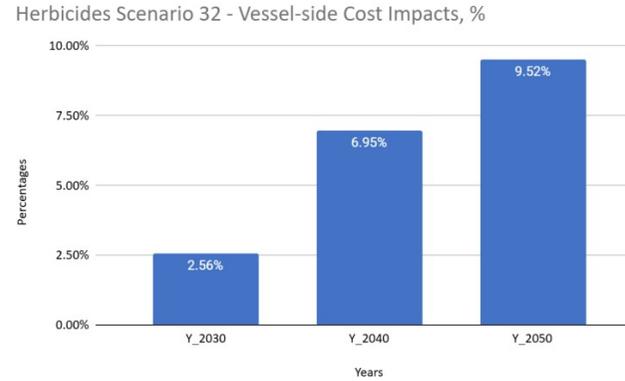


Figure 10: Impact of ship speed reductions on Herbicide import trade - Four Scenarios' Cargo-side cost

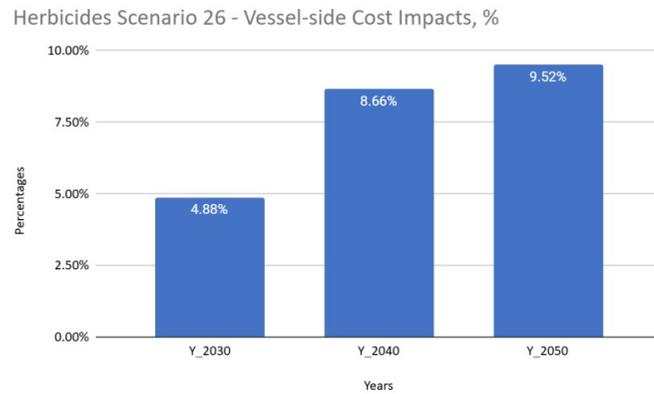
A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)



D. Feebate (Scenario 36)

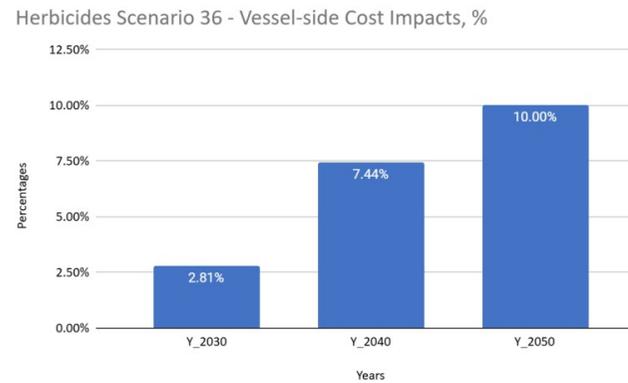
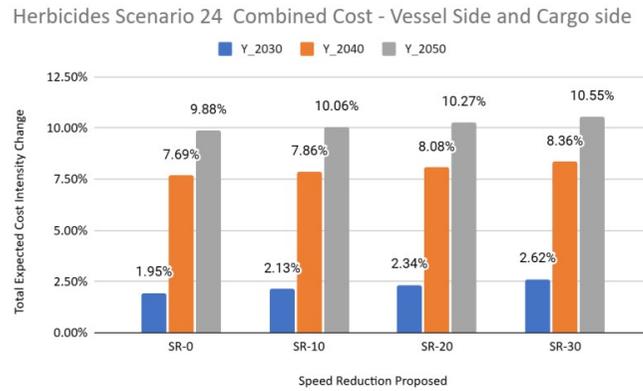
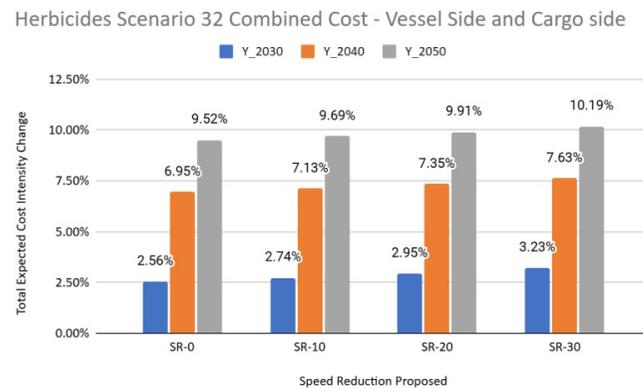


Figure 11: Impact of ship speed reductions on Herbicide import trade - Four Scenarios' Vessel- side costs

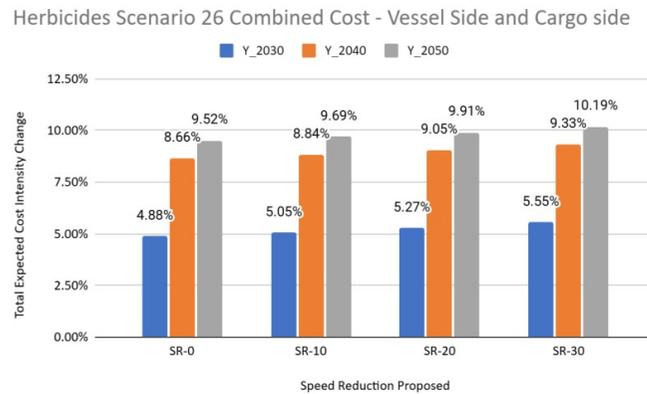
**A. GFI Flex Only (Scenario 24)**



**B. Low Levy (Scenario 32)**



**C. High Levy (Scenario 26)**



**D. Feebate (Scenario 36)**

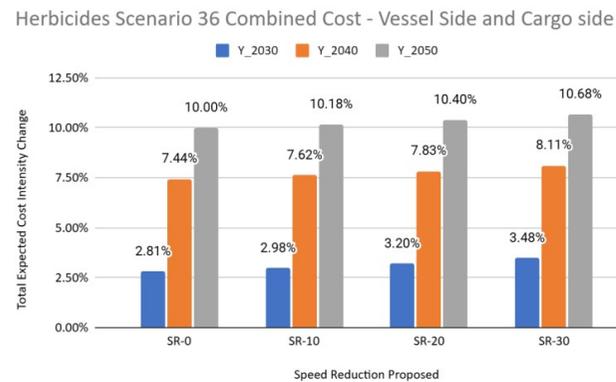


Figure 12: Impact of ship speed reductions on Herbicide import trade - Four Scenarios for the Combined cost impacts (Vessel side and cargo side)

## 4 Potential Implications for Nigeria's Trade

The implementation of the IMO's mid-term GHG reduction measures is expected to have significant trade implications for Nigeria, given its position as a major exporter of crude oil and agricultural commodities and its reliance on imported refined petroleum products and manufactured goods. The analysis highlights the cost impacts across key sectors, including oil and gas, agriculture, and manufacturing, with broader consequences for trade competitiveness, food security, and economic stability. These impacts will vary across short-, medium-, and long-term horizons, necessitating strategic adjustments in fiscal policies, trade policies and industrial planning.

Nigeria's oil and gas sector, which accounts for the bulk of its export earnings (65.44% of its total exports in Q3, 2024; NBS, 2024) and its position as Africa's leading oil producer as of 2023 (Statista, 2025), is particularly vulnerable to increased shipping costs. The analysis shows that ship speed reductions will lead to rising cargo and vessel-side costs, with overall increases reaching up to 4.2% under the most severe scenarios by 2050. In the short term, cost increases may be manageable, but in the medium term, when vessel operation costs are projected to triple, the industry could face significant profitability constraints. Over the long term, Nigeria's crude oil exports could become less competitive, particularly as global energy markets transition towards ZNZ alternatives. This may accelerate the country's need to diversify its economy and invest in renewable energy to maintain trade stability.

Energy security is also a major concern, as Nigeria remains highly dependent on petroleum imports for localized power supply, such as that used in generators. The report indicates that a 30% speed reduction could add an estimated \$12.43 million to the cost of PMS imports in the short term, a figure that is expected to grow over time. Higher import costs for refined fuel may contribute to domestic inflation, increasing transportation, manufacturing, and household costs. In the short to medium term, these pressures could exacerbate Nigeria's existing fuel subsidy challenges and fiscal instability. Over the long term, unless Nigeria significantly expands its domestic refining capacity, building on the momentum from the start of operations at the Dangote refinery, and actively pursues a transition to alternative renewable energy and fuel sources from the short to long term, the country risks continued dependence on costly petroleum imports and heightened macroeconomic vulnerability exposure to external supply chain disruptions in the long term and volatile global oil markets.

The agricultural sector, particularly sesame seed exports, is also set to experience rising trade costs. Unlike crude oil, agricultural commodities are more sensitive to delays, with increased shipping times heightening the risk of spoilage and depreciation. The analysis shows that a 30% speed reduction could increase shipping costs by up to 5.72% in the long term. In the short term, exporters may absorb some of these costs, but in the medium term, declining profit margins could lead to reduced export volumes and loss of market share. Over the long term, sustained cost increases may discourage investment in agricultural export value chains, potentially undermining Nigeria's efforts to expand its role in global agricultural markets.

Beyond exports, food security is another pressing issue, particularly due to Nigeria's reliance on imported agricultural inputs such as herbicides. The analysis finds that while cargo-side cost increases are relatively low, vessel-side costs could surge by up to 9.52% by 2050. In the short term, these added costs may be marginal, but in the medium term, rising input prices could reduce access to essential agricultural chemicals,

affecting domestic food production. Over the long term, this could result in lower crop yields and increased food prices, further straining household incomes, food security and economic stability.

Manufactured goods, including machinery and vehicles, are also expected to see rising import costs, though the extent of the impact varies depending on trade routes and depreciation rates. Higher costs for imported goods could slow industrial development and infrastructure projects, particularly if domestic industries remain heavily reliant on foreign equipment and inputs. In the short term, businesses may attempt to adjust by absorbing costs, but in the medium term, inflationary pressures could drive up consumer prices. Over the long term, Nigeria may need to intensify efforts to develop local manufacturing capabilities to reduce dependency on costly imports.

Overall, the trade implications of the IMO's mid-term measures highlight the need for Nigeria to adopt a proactive approach in mitigating economic risks. In the short term, strategies such as targeted subsidies and trade negotiations may help cushion immediate cost increases. In the medium term, policy interventions should focus on enhancing domestic refining, expanding agricultural processing industries, and supporting infrastructure for greener energy and shipping. Over the long term, a shift towards clean energy investments, increased trade diversification, and regional trade integration through the African Continental Free Trade Area (AfCFTA) could position Nigeria more competitively in a rapidly evolving global sustainable trade environment (APR 2024).

#### **4.1 Broader Potential Economic Impacts, Consequences for Trade and Risks**

As African countries work to align with the transition to ZNZ emissions shipping, it is crucial to understand the broader economic impacts of the 2023 IMO GHG Reduction Strategy beyond the maritime sector. This understanding is critical and a significant part of ensuring a just and equitable transition that supports sustained economic growth and development, especially in Africa, home to numerous emerging and resource-dependent economies. Notably, 83% of African countries are commodity-dependent, representing 45% of such nations globally with commodities making up over 60% of total merchandise exports, exposing these economies to significant risks from global commodity price fluctuations (UNCTAD, 2022a). Therefore, to achieve a just and equitable transition, it is imperative that the IMO, in collaboration with African nations, thoroughly evaluates the wider economic implications of its GHG emissions reduction strategy on these economies. This approach will better enable Africa to meet global shipping emissions reduction targets while safeguarding economic stability and addressing the unique challenges of its development needs.

The maritime sector is critical to global trade, with approximately 80% of international goods transported by sea, and developing countries accounting for 70% of world maritime trade by volume (UNCTAD, 2021). Given this significance, it is imperative to evaluate the broader implications of cross-border trade and the potential spillover effects on other sectors. Shifts within maritime operations, such as those driven by decarbonization efforts, can influence trade costs, infrastructure development, and global supply chains, with cascading effects on industries like mining, manufacturing, agriculture, and energy exports.

For African nations, like Nigeria, whose economies are often closely linked to energy resource extraction and international trade, these impacts could be profound. This interconnected nature of maritime trade and other economic sectors highlights the need for a holistic approach to understanding and managing the transition. Without careful planning, efforts to reduce emissions may inadvertently increase trade costs,

disrupt critical supply chains, and deepen existing inequalities, thus, posing risks to economic growth and development.

By examining these wide-reaching consequences, policymakers can better anticipate associated risks and opportunities with the transition to green maritime operations. A comprehensive appreciation of the scope of impact will enable the development of strategies for mitigating potential negative impacts, fostering resilience, and ensuring that decarbonization efforts in shipping align with Sustainable Development Goals (SDGs). This informed approach is crucial for balancing environmental commitments with the economic needs of developing countries, ensuring a fair and equitable transition for all.

## **4.2 Economic Impacts - Impact on prices, trade volume and macroeconomic stability**

One of the broader consequences of the IMO's GHG emissions reduction measures is their potential effect on macroeconomic variables, particularly trade. Understanding how different policy scenarios within the IMO's strategy might influence trade and economic outcomes is crucial. Some policy scenarios—like Scenario 24 and 32 used in the analysis have a GFI flexibility mechanism, have low or no levy requirements, no feebate and may include revenue disbursement mechanisms. Under those scenarios, the ships still adopt cleaner fuels and technologies, but as they pay less regulatory cost across the fleet than in the high levy scenario (carbon price and SU), shipping cost increases less in the short term compared to a high levy scenario. However, in scenarios such as Scenario 26 and Scenario 36, where higher levies are imposed and/or no revenue disbursements occur, there could be significant effects on both the price and volume of traded goods. Short- and medium-term results from Scenario 26 indicate these noticeable cost impacts across all analyzed commodities. However, in the long term, Scenario 26 results in the lowest cost impact (along with Scenario 32), likely due to the industry's transition to cleaner fuels which are cheaper in the long term, an improvement of energy efficiency, and the adoption of greener technologies. It also leads to the redistribution of revenue from high levies, which could help mitigate cost pressures. In contrast, Scenario 36 shows the highest cost impact in the long term. Higher shipping costs may increase export and import prices, causing inflation and potentially undermining a country's competitiveness in the global market.

Additionally, changes in trade volumes could affect African countries' ability to participate in forward and backward global value chains (GVCs), potentially hindering their continued integration and participation in international trade and reducing foreign exchange earnings, which could contribute to high exchange rates. A significant change in the quantity traded of agricultural products may also lead to food security issues domestically and globally. Furthermore, an increase in the prices of traded goods may lead to an increase in inflation rates, particularly in countries with higher inflation rates.

## **5 Conclusions**

### **5.1 Decarbonizing International Shipping: Further Impacts on Africa's Trade Competitiveness**

Maritime logistics costs have been rising globally, impacting all economies; however, Small Island Developing States (SIDS) and Least Developed Countries (LDCs) are disproportionately affected due to their heavy reliance on maritime transport for trade (UNCTAD, 2023). Developing economies, including SIDS and LDCs, often pay more for shipping than wealthier nations. UNCTAD reports that the transport work intensity per dollar of maritime trade in these regions is twice that of developed economies, making trade more expensive

and less competitive (UNCTAD, 2024d). For SIDS and LDCs, increasing freight costs threaten trade competitiveness and economic stability. Over the past decade, SIDS have experienced a 9% decline in maritime connectivity, further amplifying their vulnerability to freight rate fluctuations. (UNCTAD, 2024e).

Evidence suggests Africa conducts approximately 80% of its trade with the rest of the world rather than within the continent, whilst Africa's share of total global trade remains below 3% (UNECA, 2023). This limited trade footprint highlights continental vulnerabilities to disruptions in global trade. As such, any significant impact on trade competitiveness, such as increased costs or regulatory changes, could further reduce Africa's trade volumes and undermine growth and development prospects that protect and enhance Africa's trade resilience in the face of global economic transitions.

Many African countries are primarily engaged in forward GVC trade, exporting natural resources and raw materials while heavily relying on imports for manufactured goods. According to the African Development Bank (AfDB), between 2011 and 2013, manufactured goods constituted only 18.5% of Africa's exports, whereas they accounted for 62% of the continent's imports (AfDB, 2015). Policy Scenarios that elevate transportation and logistics costs could amplify economic pressures on such goods.

Task 3 of the CIA indicates that the maritime transport margin as a proportion of Cost, Insurance and Freight (CIF) prices is notably higher for agricultural, fishing, and mining products compared to other commodity groups (UNCTAD, 2024a). Consequently, economies heavily dependent on trade flows associated with these sectors are likely to face steeper price increases than those focused on manufactured goods, petroleum products, and non-metallic mineral products (UNCTAD, 2024a). The data presented in Table 1 demonstrates that Nigeria is heavily dependent on such commodity flows and therefore, for countries like Nigeria and Ghana where this is the case, implications could be particularly pronounced, affecting sector productivity, trade competitiveness and economic stability.

Prices of exported goods, especially those traded under CIF contracts, where the seller is responsible for transportation costs, could rise significantly if shipping and logistics expenses increase. Exporters would bear the additional costs, leading to higher export prices that may reduce their competitiveness in international markets. This, in turn, could result in increased prices for importers, potentially dampening demand for African exports. For African countries heavily reliant on exporting raw materials, agricultural products, and natural resources, such price increases could lead to a loss of market share as buyers may shift to cheaper exporters where they are closer.

Scenarios with prolonged negative impacts on export volumes could severely impact African economies, particularly those where forward GVC linkages represent a substantial share of total exports. Forward GVC linkages refer to a country's role in supplying raw materials, intermediate goods, or components that are further processed or used in production by other countries before reaching the final consumer. This is common in resource-rich economies, where exports like minerals or agricultural products serve as inputs for manufacturing in other regions. On imports, African countries may face an even more complex set of challenges. While the initial direct impact on import prices might be minimal, other factors, such as currency depreciation, high inflation, and foreign exchange illiquidity, issues prevalent across many African economies, could exacerbate the effects. Foreign exchange illiquidity refers to a shortage of foreign currency (e.g. US dollars, etc) in a country's system necessary for trade, investments, or debt payments, making cross-border commercial activities challenging. This could lead to steeper transaction costs for importers in these countries, exerting inflationary pressure and raising costs for end consumers. Such impacts would be

especially acute in economies already grappling with macroeconomic instability, further straining growth and household purchasing power.

## 5.2 Evaluating Additional Impacts of Various Trade-Related Environmental Policies

When implementing the IMO's GHG emissions reduction strategy, African countries must carefully evaluate the alignment and interactions of environmental policies with global environmental and climate-related trade frameworks, including the EU Emissions Trading System (EU ETS) which now includes emissions from shipping and the EU Carbon Border Adjustment Mechanisms (CBAM) compounding the increase in trade costs. Engaging experts to assess these alignments, synergies and is vital for understanding the implications on trade relationships with global trade partners.

Environmental protection and climate policies introduced by multilateral organizations, regions, and countries may overlap, conflict or interlink with the IMO's strategy. Without effective coordination, the need to comply with multiple policies could intensify the disproportionate negative impacts (DNI) on developing countries. Such complexities risk further marginalizing Africa in global trade networks.

Many of these policies may fall under WTO's general exceptions under the GATT Article XX, paragraphs (b) and (g), granting them validity despite the challenges. This underscores the importance of harmonizing trade and environmental policies to ensure Africa complies with global standards while minimizing trade disruptions and disproportionate economic burdens. Additionally, leveraging regional trade frameworks, such as the (AfCFTA), could serve as a tool to enhance trade resilience, potentially reducing some of the economic pressures stemming from external trade-related environmental measures. In conclusion, Africa must engage strategically in IMO negotiations, ensuring policies support both climate goals, trade competitiveness and sustainable economic growth.

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## Annex I - Technical Annex

The Technical Annex presents supplementary information regarding the development of the modelling approach applied within the research above. Specifically, the Annex explores the assumptions and limitations of the modelling approaches associated with the ‘official’ Task 4 methods employed under the IMO-led CIA of short-term and midterm measures, as well as those of the ‘unofficial’ approach developed by UCL for the purposes of assessing midterm measure impacts. Discrepancies between approaches are also explored, including those owing to differences in the availability of input data and those owing to uncertainties in the official IMO-led methodology.

### I.i Official CIA Task 4 Methodology

The official approach seeks to understand the potential impacts of the midterm measures on three or more specific commodity flows.

#### Commodity, Route and Vessel Selection

Analysis of merchandise trade context and selection of the individual commodity flows for analysis constitute the first two steps of the method and both primarily make use of the Comtrade platform for this data. The third and fourth stages of the methodology identify the trade routes and vessels that facilitate the commodity flow, including the number and location of any port stops, the minimum, maximum and average distances associated with each assumed voyage leg and the types, sizes and transit speeds of vessels that operate on the route.

#### Vessel-side Cost Calculations

The vessel-side cost-calculation makes use of the two variables presented below:

1. **Ship-side Task 2 cost intensity (CI) Change, %** - Ratio of projected Cost Intensity in a future year (2030, 2040 or 2050) versus the reference Business as Usual (BAU) cost intensity in that year, differentiated by vessel type, size class and age range. Unit: Dimensionless.
2. **Ad-valorem Freight Rate, %** - Typical percentage of value paid for transportation of the goods and compared with the value of the goods themselves. Unit: Dimensionless.

The product of the two variables, referred to as the ‘Ship-side Task 2 Freight-rate Adjusted Commodity Cost Intensity (FRACCI)’, is used to represent the final vessel-side cost estimate, and is evaluated as described in Equation O1.

$$\text{Ship-side Task 2 Freight-Rate Adjusted Commodity Cost Intensity (FRACCI)} = \text{Ship-side Task 2 CI Change, \%} \times \text{Ad-valorem Freight Rate, \%} \quad [O1]$$

#### Cargo-side Cost Calculations

The cargo-side cost-calculation makes use of five variables which are presented and discussed below.

1. **Delay10|20|30** - Number of days of delay caused by slow-steaming, given in relation to a 10%, 20% or 30% speed reduction scenario. Unit: days.
2. **ValueTrade, CIF** - Annually traded value of the commodity associated with the specific route. Unit: US\$.
3. **Cint** - Cost of finance/interest, as a percentage of cargo value per day of delay. A value of 5% is typically assumed. Unit: Per day.
4. **Cdep** - Cost of depreciation, as a percentage of cargo value per day of delay. The following depreciation rates are typically assumed: i) 5% for dry bulk cargo; ii) 10% for non-perishable containerized cargo; or iii) 30% for perishable cargo. Unit: Per day.
5. **Cins** - Cost of insurance, as a percentage of cargo value per day of delay. A value of 2% is typically assumed. Unit: Per day.

The spreadsheet model released as part of (APEC, 2019) demonstrates that cargo-side cost per day of delay is evaluated in alignment with Equation O2a below.

$$\text{Commodity-side Task 4 TCCLsr Change, \% (daily)} = \text{Delay10|20|30} * \text{ValueTrade, CIF} * (\text{Cint} + \text{Cdep} + \text{Cins}) / 365.25 \text{ [O2a]}$$

Multiplication of Equation O2a by the projected time delay (in days), Delay10|20|30, results in Equations O2b and O2c representing the total expected cargo-side cost change.

$$\text{Commodity-side Task 4 TCCLsr Change, \% (total)} = \text{Delay10|20|30} * \text{Commodity-side Task 4 TCCLsr Change, \% (daily)} \text{ [O2b]}$$

$$\text{Commodity-side Task 4 TCCLsr Change, \% (total)} = (\text{Delay10|20|30})^2 * \text{ValueTrade, CIF} * (\text{Cint} + \text{Cdep} + \text{Cins}) / 365.25 \text{ [O2c]}$$

### Total Cost Calculation

The total cost calculation makes use of the vessel-side and cargo-side cost components evaluated above:

1. **Ship-side Task 2 Freight-Rate Adjusted Commodity Cost Intensity (FRACCI)** - Expected total vessel-side cost change. Unit: Dimensionless.
2. **Commodity-side Task 4 TCCLsr Change, \% (total)** - Expected total cargo-side cost change. Unit: Dimensionless.

The total cost calculation is evaluated as the sum of the vessel-side and cargo-side cost components presented above, in alignment with Equation O3.

$$\text{Total Expected Cost Intensity Change, TCCI} =$$

*Ship-side Task 2 Freight-Rate Adjusted Commodity Cost Intensity (FRACCI) + Commodity-side Task 4 TCCLsr Change, % (total) [O3]*

## I.ii Unofficial UCL Task 4 Methodology

The unofficial approach mirrors the official approach in seeking to understand the potential impacts of the midterm measures on three or more specific commodity flows.

### Commodity, Route and Vessel Selection

Analysis of merchandise trade context and selection of the individual commodity flows for analysis constitute the first two steps of the method and both primarily make use of the Comtrade platform for this data. The third and fourth stages of the methodology identify the trade routes and vessels that facilitate the commodity flow, including the number and location of any port stops, the minimum, maximum and average distances associated with each assumed voyage leg and the types, sizes and transit speeds of vessels that operate on the route.

### Vessel-side Cost Calculations

The same vessel-side cost calculation is applied in the unofficial method, making use of two variables:

1. **Ship-side Task 2 CI Change, %** - Ratio of projected Cost Intensity in a future year (2030, 2040 or 2050) versus the reference BAU cost intensity in that year, differentiated by vessel type, size class and age range. Unit: Dimensionless.
2. **Ad-valorem Freight Rate, %** - Typical percentage of value paid for transportation of the goods and compared with the value of the goods themselves. Unit: Dimensionless.

The product of the two variables, referred to as the 'Ship-side Task 2 Freight-rate Adjusted Commodity Cost Intensity (FRACCI)', is used to represent the final vessel-side cost estimate, and is evaluated as described in Equation U1.

*Ship-side Task 2 Freight-Rate Adjusted Commodity Cost Intensity (FRACCI) =*

*Ship-side Task 2 CI Change, % x Ad-valorem Freight Rate, % [U1]*

### Cargo-side Cost Calculations

The 'unofficial' cargo-side cost-calculation makes use of the same five variables:

1. **Delay10|20|30** - Number of days of delay caused by slow-steaming, given in relation to a 10%, 20% or 30% speed reduction scenario. Unit: days.
2. **ValueTrade, CIF** - Annually traded value of the commodity associated with the specific route. Unit: US\$.
3. **Cint** - Cost of finance/interest, as a percentage of cargo value per day of delay. A value of 5% is typically assumed. Unit: Per day.

4. **Cdep** - Cost of depreciation, as a percentage of cargo value per day of delay. The following depreciation rates are typically assumed: i) 5% for dry bulk cargo; ii) 10% for non-perishable containerized cargo; or iii) 30% for perishable cargo. Unit: Per day.

5. **Cins** - Cost of insurance, as a percentage of cargo value per day of delay. A value of 2% is typically assumed. Unit: Per day.

However, a modification is made to the commodity-side cost calculation, in-line with the qualitative method described by Starcrest. The commodity-side cost per day of transit delay is expressed as Equation U2a below:

$$\text{Commodity-side Task 4 TCCLsr Change, \% (daily)} = \text{ValueTrade, CIF} * (\text{Cint} + \text{Cdep} + \text{Cins}) / 365.25 \quad [\text{U2a}]$$

Multiplication of Equation U2a by the projected time delay (in days), Delay10|20|30, results in Equation U2b representing the total expected cargo-side change.

$$\text{Commodity-side Task 4 TCCLsr Change, \% (total)} = \text{Delay10|20|30} * \text{ValueTrade, CIF} * (\text{Cint} + \text{Cdep} + \text{Cins}) / 365.25 \quad [\text{U2b}]$$

### Total Cost Calculation

The 'unofficial' total cost calculation remains unchanged from the 'official' methodology, making use of the vessel-side and cargo-side cost components evaluated above:

1. **Ship-side Task 2 Freight-Rate Adjusted Commodity Cost Intensity (FRACCI)** - Expected total vessel-side cost change. Unit: Dimensionless.

2. **Commodity-side Task 4 TCCLsr Change, \% (total)** - Expected total cargo-side cost change. Unit: Dimensionless.

The total cost calculation is evaluated as the sum of the vessel-side and cargo-side cost components presented above, in alignment with Equation U3.

$$\text{Total Expected Cost Intensity Change, TCCI} =$$

$$\text{Ship-side Task 2 Freight-Rate Adjusted Commodity Cost Intensity (FRACCI)} + \text{Commodity-side Task 4 TCCLsr Change, \% (total)} \quad [\text{U3}]$$

### **I.iii Discussion**

It should be noted that the finalized methodology developed by Starcrest for the economic impact assessment undertaken for Task 4 of the midterm measures CIA has not been made publicly accessible as was the case for the short-term measures CIA, even after request by member states of the IMO. The 'official' methodology presented in this Annex therefore represents a best-available interpretation based on the qualitative descriptions provided in Starcrest's final Task 4 report (Starcrest, 2024). Whilst intended to mirror the 'official' methodology as closely as possible, comprehensive validation has been infeasible. This

interpretation of the methodology is used to understand its limitations and utilized in the development of the alternative methodology applied in this research.

### Commodity, Route and Vessel Selection

Both the 'official' and 'unofficial' methodologies utilize the Comtrade platform (UNCTAD, 2024b) for analysis of merchandise trade and selection of three or more commodities. Where trade statistics have been reported to the platform by the country of interest, these trade records are likely to be reliable. If data hasn't been reported to the database, accuracy can be diminished as records instead tend to be compiled from 'partner-reported' records of the same trade flow. Overall, identification of the merchandise trade statistics from the Comtrade database is thought to introduce minimal uncertainty into final results.

Both methodologies make use of online resources to identify the routes and vessels which facilitate the selected commodity flows. The 'unofficial' methodology assumes a single trade route and vessel for each commodity of interest and represents a simpler approach to route and vessel selection as compared to the 'official' methodology where all identified routes are modelled and results are weighted accordingly. Some margin of uncertainty with respect to this data can therefore be expected, a margin likely exacerbated for smaller-scale routes and countries.

### Vessel-side Cost Calculations

The vessel-side cost calculation makes use of two variables which are presented and discussed below:

1. **Ship-side Task 2 CI Change, %** - Ratio of projected Cost Intensity in a future year (2030, 2040 or 2050) versus the reference BAU cost intensity in that year, differentiated by vessel type, size class and age range. Unit: Dimensionless.

At the time of developing the 'unofficial' methodology, DNV's disaggregated dataset of modelled

Ship-side Task 2 CI Change, % across details vessel classes wasn't available. The resulting cost intensities were found to vary significantly across the worldwide fleet, however only aggregated cost intensities were available and derived from summary tables of DNV's final report (DNV, 2024). Given values of Ship-side Task 2 CI Change, % were observed to vary up to 2-4x across the various aspects of the fleet, this source of uncertainty is understood to represent the single largest source of error in the model.

Other sources of uncertainty also exist within DNV's Task 2 modelling and include assumptions on fuel prices, feedstock supply, carbon storage capacity, technology costs, retrofit and newbuild capacity and modelling of the GFI flexibility mechanism. These uncertainties are discussed further in (DNV, 2024).

2. **Ad-valorem Freight Rate, %** - Typical percentage of value paid for the transportation of the goods and compared with the value of the goods themselves. Unit: Dimensionless.

Calculation of the Ad-valorem Freight Rate, % was conducted by UNCTAD and is documented in

(UNCTAD, 2022b). These rates have been primarily based on CIF-FOB margins recorded in the Comtrade database, specifically featuring infilling of Free-on-Board (FOB) values they are missing, using modelling

trained on other areas of presenting data. In this sense, the majority of the advalorem rates featured in the Trade-and-Transport database are therefore estimated 'synthetic' data.

*Ship-side Task 2 Freight-Rate Adjusted Commodity Cost Intensity (FRACCI) = Ship-side Task 2 CI Change, % x Ad-valorem Freight Rate, %*

The product of the two variables, referred to as the 'Ship-side Task 2 Freight-rate Adjusted Commodity Cost Intensity (FRACCI)' and evaluated in accordance with Equations O1 and U1, is used to represent the final vessel-side cost estimate. The two entities are both dimensionless, ensuring that consistency is maintained between units when multiplied, however combination of the two terms is not totally logical. The Ship-side Task 2 CI Change, % refers to a change in cost intensity relative to the BAU scenario, where cost intensity itself is defined as 'annual total cost divided by the total transport work in a specific year', with units of US\$/tonne-mile (DNV, 2024). The Ad-valorem Freight Rate, % is defined by the total costs paid for transportation of the goods compared with the value of the goods themselves, where both cost and value are provided in US\$. Therefore, the dimensionless units of the former are (US\$/tonne-mile) / (US\$/tonne-mile), whilst the latter are (US\$/US\$).

The discrepancy is magnified when considering what each entity represents. The Ship-side Task 2 CI Change, % considers vessel-side costs such as those associated with required investments into energy efficiency and propulsive technologies, retrofits and compliance. The Ad-valorem Freight Rate, % is defined in the official Task 4 methodology as 'the transportation cost percentage of a commodity's total cost', i.e. the CIF-FOB margin divided by the CIF value. These values are sourced from UNCTAD's Trade-and-Transport Dataset (UNCTAD, 2024c) whose underpinning methodological note (UNCTAD, 2022b) describes the application of CIF-FOB margins to derive transport cost projections. The CIF-FOB margin captures all cost elements along the transport supply-chain between the exporter (FOB-valued) and importer (CIF-valued), accounting for more costs exogenous to those considered in DNV's Task 2 analysis such as port dues, fees and profit margins, cargo handling charges, customs duties etc. Referring to this transport cost rate as the Advalorem Freight Rate, % is therefore inaccurate as it implies that the rate represents freight charges alone.

In evaluating the product of these entities, the Ad-valorem Freight Rate, % is scaled by a quantity that essentially considers less transport cost components and is therefore comparatively exaggerated. Detailed breakdowns of transport costs into their distinct components (for example share of freight costs in the CIF-FOB margin) are not currently available, however, and so the assumption is instead made that the magnitude of a change in the Ad-valorem Freight Rate, % will equate to the projected Ship-side Task 2 CI Change, %, ultimately leading to a systematic overestimation of the impact on the vessel-side. The cargo-side calculation method doesn't make use of the Ad-valorem Freight Rate, % and is therefore not exposed to this error.

In addition, UNCTAD typically refers to ad-valorem rates as the division of the CIF-FOB margin by the FOB value, whereas the changes in 'commodity cost' imply a change in relation to a good's CIF value. There is therefore the potential for uncertainty when quoting the modelling results of an order of magnitude roughly equal to the 'ad-valorem' transport cost rate itself (i.e. for an ad-valorem rate of 6%, the uncertainty would be around 0.5% is using a denominator at FOB value rather than CIF).

### Cargo-side Cost Calculations

The primary consideration of the cargo-side cost calculation module is to understand the likely economic impacts of vessels' slow-steaming in response to the introduction of midterm measures. There are multiple time-dependent inventorying cost components associated with any cargo in transit, each that would exert significant economic impacts should slow-steaming be utilized as a compliance mechanism.

Economic impact, or shippers' additional expenses, due to extra travel days is based in three variables, interest cost, depreciation cost and insurance cost. Variables used to measure the economic impact of slow steaming are:

- **Time delay:** number of hours or days that slow steaming will delay the cargo arrival at the destination port compared with total voyage days under current vessel speed ( $\text{Transit Times}_{\text{GSA-X}} = \text{Distance} \# / \text{Speed}_{\text{GSA-X}}$ ). Time delay is dependent on vessel speed assumptions; any changes in GSA will automatically modify the voyage time. Changes in speed are to be made in Module 1 – GHG Impacts, tab “Analysis Matrices”, column D”, rows 15 to 23.
- **GDP impact:** the reduction of product exports is measured as an impact on total economy Gross Domestic Product (GDP) ( $\text{GDP Impact} = \text{Commodity Total Export Value} / \text{Economy GDP}$ ). An economy's GDP is labelled blue; thus, the user can update and modify it.
- **Interest cost:** the financial cost of capital invested in inventory over time. This measures the impact of each hour or day of delay in the cost of the product due to cost of money or interest rate. (here assumed to be 5%) ( $\text{Interest Cost} = (\text{Export Value} \times \text{Interest Rate}) \times (\text{Time Delay}/365.25)$ ). Interest rate is labelled in blue font; thus, the user can modify it.
- **Depreciation cost:** is defined as the cost allocation of a product over its useful life. (for this economic analysis, it is assumed as 10% for containerized cargo, 30% for fresh perishable products, and 5% for dry bulk cargo) ( $\text{Depreciation Cost} = (\text{Export Value} \times \text{Depreciation Rate}) \times (\text{Time Delay}/365.25)$ ). The depreciation rate is labelled in blue font; thus, the user can modify it.
- **Insurance cost:** a cost paid by the shippers to protect their goods while in transit. (the percentage used in the economic analysis is 2%) ( $\text{Insurance Cost} = (\text{Export Value} \times \text{Insurance Rate}) \times (\text{Time Delay}/365.25)$ ). The insurance rate is labelled in blue font; thus, the user can modify it.

Figure 13: Explanation of cargo-side calculation methodology provided in (APEC, 2019).

The official Task 4 method considers the costs of interest, depreciation and insurance, assuming that each result in a percentage loss of cargo per day of delay. (APEC, 2019) states that “the interest, depreciation and insurance cost estimates were developed by multiplying the rates for each of the three cost items by the total [value] amount of products/commodities exported that year (2017) to each economy of destination, then dividing by 365.25 days per year to obtain the daily cost during the transit or during any extra voyage days due to slow steaming.” The implication of this statement in terms of a calculation is presented below:

$$\text{Commodity-side Task 4 TCCLsr Change, \% (daily)} = \text{ValueTrade, CIF} * (\text{Cint} + \text{Cdep} + \text{Cins}) / 365.25$$

Multiplication by the projected time delay (in days), Delay<sub>10|20|30</sub>, therefore, results in the following expression for the total expected cargo-side change:

$$\text{Commodity-side Task 4 TCCLsr Change, \% (total)} = \text{Delay}_{10|20|30} * \text{ValueTrade, CIF} * (\text{Cint} + \text{Cdep} + \text{Cins}) / 365.25$$

However, it's clear that a deviation from this calculation method has been implemented in the publicly accessible model presented in (APEC, 2019).

**Asian-Pacific Economic Cooperation**

**Slow Steaming Analysis Model**

**Module 2 - Economic Impacts**

23 July 2019

**Economic Impact Analysis**

Only change values in BLUE

GSA - is the current average speeds globally of the ship which represents conditions as is (baseline)

Total Distance - The distance from Port of Origin to Port of destination, including intermediate ports for liners

Lowest Vessel speed

10.0 knots

**Matrix 1 - Containerized cargo vessels - Australian meat to China**

Ship Type	Ship Size TEU	Number of Ships	Total Distance (nm)	Ocean Transit Speed Range								
				GSA (knots)	GSA -1 (knots)	GSA -2 (knots)	GSA -3 (knots)	GSA -4 (knots)	GSA -5 (knots)	GSA -6 (knots)	GSA -7 (knots)	GSA -8 (knots)
Container	5,090	6	6,660	16.3	15.7	15.0	14.4	13.7	13.0	12.4	11.7	11.1
Time delay @ different speed		Days			0.71	1.48	2.31	3.23	4.24	5.35	6.59	7.98
Export economy		Australia										
GDP (USD\$)	2017	\$1,323,421,072,479										
Port of origin		Melburne										
Economy of destination		China										
Port of destination		Shanghai										
HS		0201										
Commodity		Fresh or chilled boneless bovine meat										
Service name		CA3										
Export Quantity (Kg)	2017	6,035,359										
Export Value (USD\$)	2017	\$59,903,965										
Meat export as percentage of GDP		0.0045%										
Value per kg (USD\$/Kg)		\$9.93										
Export value per container (\$)		\$8,716										
<b>Shippers' additional expenses</b>				<b>Economic impact of delay at different speeds</b>								
Interest cost	5%	IC=(EV*IR)*(TD/365.25)		\$5,798	\$12,099	\$18,971	\$26,495	\$34,768	\$43,909	\$54,061	\$65,402	
Depreciation cost	10%	DC=(EV*DR)*(TD/365.25)		\$11,597	\$24,199	\$37,942	\$52,990	\$69,537	\$87,818	\$108,122	\$130,804	
Insurance cost	2%	INC=(EV*IR)*(TD/365.25)		\$2,319	\$4,840	\$7,588	\$10,598	\$13,907	\$17,564	\$21,624	\$26,161	
<b>Total cost of waiting USD\$</b>	<b>Annual</b>			<b>\$19,715</b>	<b>\$41,138</b>	<b>\$64,502</b>	<b>\$90,083</b>	<b>\$118,212</b>	<b>\$149,291</b>	<b>\$183,807</b>	<b>\$222,367</b>	
Percentage impact per extra travel days				0.03%	0.07%	0.11%	0.15%	0.20%	0.25%	0.31%	0.37%	
<b>Total cost of waiting USD\$/total delay</b>				<b>13,940</b>	<b>60,697</b>	<b>149,221</b>	<b>291,052</b>	<b>501,200</b>	<b>799,376</b>	<b>1,211,747</b>	<b>1,773,478</b>	
Percentage impact port total delay				0.02%	0.10%	0.25%	0.49%	0.84%	1.33%	2.02%	2.96%	
<b>Australian meat exports HS0201 - year 2017</b>												
	USD\$	Share										
World	2,267,345,153											
Japan	849,831,001	37.48%										
The USA	461,393,833	20.35%										
Rep. of Korea	292,732,660	12.91%										
Netherlands	77,764,637	3.43%										
United Kingdom	60,311,956	2.66%										
China	59,903,965	2.64%										
<a href="https://comtrade.un.org/data/">https://comtrade.un.org/data/</a>	<b>Total Share</b>	<b>79.47%</b>										

Figure 14: Screenshot of the Economic Impact Matrix model for Australian Meat to China from (APEC, 2019).

As presented above, the 'daily cost during the transit or during any extra voyage days', TCCLsr, is scaled by the delay term, Delay10|20|30, therefore resulting in the following equation:

$$\text{Commodity-side Task 4 TCCLsr Change, \% (daily)} = \text{Delay}_{10|20|30} * \text{ValueTrade, CIF} * (\text{Cint} + \text{Cdep} + \text{Cins}) / 365.25$$

Multiplication by the projected time delay (in days), Delay10|20|30, would therefore result in the following expression representing the total expected cargo-side change:

$$\text{Commodity-side Task 4 TCCLsr Change, \% (total)} = \text{Delay}_{10|20|30} * \text{Delay}_{10|20|30} * \text{ValueTrade, CIF} * (\text{Cint} + \text{Cdep} + \text{Cins}) / 365.25$$

$$\text{Commodity-side Task 4 TCCLsr Change, \% (total)} = (\text{Delay}_{10|20|30})^2 * \text{ValueTrade, CIF} * (\text{Cint} + \text{Cdep} + \text{Cins}) / 365.25$$

The implication of this deviation away from the stated methodology is that the commodity-side cost calculations are being evaluated proportionally to the 2nd power of the time delay for a given speed reduction. This leads to projections of a non-linearly increasing commodity-side cost component, resulting in inflated commodity-side cost impact projections, where interest, insurance and depreciation rates are not constant over time as is stated in the qualitative methodology note.

**Table B.21: Economic Impact Module Matrix inputs and outputs**

Matrix 1 - Containerized cargo vessels - Australian meat to China													
Ship Type	Ship Size	Number of Ships	Total Distance (nm)	GSA (knots)	GSA -1 (knots)	GSA -2 (knots)	GSA -3 (knots)	Ocean Transit Speed Range (knots)				GSA -7 (knots)	GSA -8 (knots)
Container	5,090 TEU	6	6,660	20.0	19.0	18.0	17.0	16.0	15.0	14.0	13.0	12.0	
Time delay @ different speed		Days			0.73	1.54	2.45	3.47	4.63	5.95	7.47	9.25	
Export economy		Australia											
GDP (USD\$)	2017	\$1,323,421,072,479											
Port of origin		Melburne											
Economy of destination		China											
Port of destination		Shanghai											
HS		0201											
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Value per kg (USD\$/kg)		\$9.93											
Export value per container (\$)		\$8,716											
<b>Shippers' additional expenses</b>				<b>Economic impact of delay at different speeds</b>									
Interest cost	5%	IC=(EV*IR)*(TD/365.25)		\$5,988	\$12,642	\$20,079	\$28,445	\$37,927	\$48,763	\$61,266	\$75,854	\$75,854	
Depreciation cost	10%	DC=(EV*DR)*(TD/365.25)		\$11,977	\$25,285	\$40,158	\$56,890	\$75,854	\$97,526	\$122,533	\$151,708	\$151,708	
Insurance cost	2%	INC=(EV*IR)*(TD/365.25)		\$2,395	\$5,057	\$8,032	\$11,378	\$15,171	\$19,505	\$24,507	\$30,342	\$30,342	
<b>Total cost of waiting USD\$</b>	<b>Annual</b>			<b>\$20,361</b>	<b>\$42,984</b>	<b>\$68,268</b>	<b>\$96,714</b>	<b>\$128,951</b>	<b>\$165,795</b>	<b>\$208,306</b>	<b>\$257,903</b>	<b>\$257,903</b>	
Percentage impact per extra travel days				0.03%	0.07%	0.11%	0.16%	0.22%	0.28%	0.35%	0.43%		
<b>Australian meat exports HS0201 - year 2017</b>													
	USD\$												
World	2,267,345,153												
Japan	849,831,001	37.48%											
USA	461,393,833	20.35%											
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United Kingdom	60,311,956	2.66%											
China	59,903,965	2.64%											
<a href="https://comtrade.un.org/data/">https://comtrade.un.org/data/</a>	<b>Total Share</b>	<b>79.47%</b>											

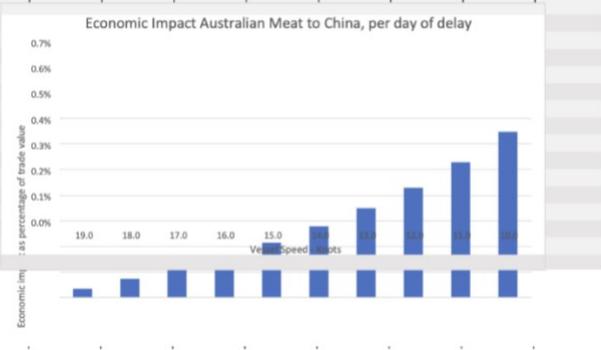


Figure 15: Alternative screenshot of the Economic Impact Matrix model for Australian Meat to China presented unreferenced as the penultimate page of Appendix B in (APEC, 2019).

Finally, included as an unreferenced figure in the penultimate page of (APEC, 2019) is the screenshot presented in Figure 15. The screenshot shows a similar spreadsheet model as Figure 14 in projecting impacts for Australian meat exports to China. However, final cost impacts are observed to be calculated via the ‘non-linear’ approach as described qualitatively in (APEC, 2019) and presented in Figure 13. It’s believed that the differences between Figures 14 and 15 demonstrate that there has been some uncertainty in the ‘official’ methodology to be applied in Task 4. Given these considerations, the former set of equations (Equations U1-U3) representing a linear application of cargo-side cost components, aligned with the qualitative methodology statement presented in Figure 13 and model presented in Figure 15, are implemented in the ‘unofficial’ analysis approach.

### Final Cost Calculation

The ‘official’ methodology therefore provides results in terms of a change in ‘cost intensity’ that necessitates detailed transport work information to interpret. Conversely, the ‘unofficial’ methodology evaluates both vessel- and commodity-side costs in proportion to the trade value itself (i.e. in ‘ad-valorem’ terms). Their summation to represent total cost impacts is therefore logical and enables easier interpretation of the results.

Consequently, the ‘unofficial’ methodology mildly overestimates vessel-side costs whilst simultaneously not inflating cargo-side impacts to the same degree as the ‘official’ methodology. The combination of these two factors results in results derived from the ‘unofficial’ methodology being driven by vessel-side costs, with

minimal contribution from the cargo-side. In reality, a more balanced contribution across vessel-side and cargo-side cost impacts can be expected.