LEADING EFFECTIVE AFROCENTRIC PARTICIPATION (LEAP) PROJECT PHASE I

Complementary Quantitative Stakeholders' Analysis: The Case Study of Malawi

A CASE STUDY REPORT

Martin Mwale, Helvi Petrus, James Stewart,
Marie Fricaudet, Dolapo Oluteye

February 2025

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List of Abbreviations

Abbreviation	Meaning
AfDB	African Development Bank
BAU	Business-As-Usual
CIA	Climate Impact Assessment
GFI	Green Finance Initiative
GHG	Greenhouse Gas
IMO	International Maritime Organization
MEPC	Marine Environment Protection Committee
OECD	Organisation for Economic Co-operation and Development
SADC	Southern African Development Community
UNCTAD	United Nations Conference on Trade and Development

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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.

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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.

About University of Malawi

The University of Malawi is the oldest institution of higher learning in Malawi, established in 1964 soon after independence. It was established by an act of parliament and accredited by the National Council of Higher Education (NCHE). The University has four constituent colleges: The Polytechnic, College of Medicine, Kamuzu College of Nursing and Chancellor College.

About Namibia University of Science & Technology

NUST seeks collaboration with other universities, industry and global partnerships to solicit opportunities for applied research towards widening evidence-based decision making.

Executive summary

Overview

Malawi is a land linked country with a dependence on maritime transport to export important goods like tobacco and import essential commodities like fertilizer and gasoline. The IMO's Revised Strategy on the Reduction of GHGs from Ships (IMO, 2023) has established a range of ambitious decarbonisation objectives for the international shipping sector that includes the elimination of GHG emissions by 2050. To achieve these objectives, four leading policy architectures are currently under consideration at the IMO, each expected to result in significant economic impacts for states such as Malawi. This paper presents an analysis on the possible impacts of these four leading policy architectures on three of Malawi's most economically significant merchandise trades.

Aims and objectives

The goal of the study is to present a thorough examination of the financial effects of various GHG reduction strategies on Malawi's trade-dependent economy. The study aims to educate policymakers on how to strike a balance between economic resilience and environmental responsibilities, enabling Malawi's interests to be appropriately represented throughout the critical IMO negotiations taking place in 2025.

Method

The IMO-led CIA process was undertaken throughout 2024 to understand possible economic consequences resulting from the introduction of midterm policy measures. Building on techniques pioneered throughout the CIA process, this analysis employs a structured six-step quantitative approach that includes the following steps:

- Merchandise trade analysis of key commodities.
- Identification of primary trade routes.
- Selection of representative vessels and operational parameters.
- Cost modeling under four policy scenarios.
- Integration of vessel- and cargo-side cost assumptions.
- Comparison with a Business-As-Usual (BAU) baseline to contextualize policy impacts.

Key findings

- The High Levy scenario imposes significant medium-term costs but stabilizes as technological advancements offset the financial impact;
- The flexibility mechanism minimizes immediate costs but lead to accelerated increases in the long term; and
- Cost increases are observed across all scenarios, with variations depending on the regulatory mechanisms and the stringency of the policy.

- Fertilisers and petroleum imports are significantly more impacted (up to 20% increase in the cost of goods at the port of import) than tobacco exports (up to 6% increase), which reflects the large share of transport cost in the cost of traded petroleum and fertilisers products.

Implications

- **Economic Vulnerability**: Malawi's strong reliance on maritime imports and exports makes it more susceptible to increases in shipping costs, which could have an impact on its economic stability and growth.
- **Policy Trade-offs**: Levy-based strategies promote long-term sustainability and technological innovation, while the flexibility mechanism offers temporary respite.

Recommendations

- **Adopt a Balanced Approach**: Combine levy-based strategies and a flexibility mechanism to mitigate immediate impacts while fostering long-term sustainability.
- **Capacity Building**: Improve Malawi's ability to effectively participate in international maritime policy discussions.
- **Tailored Strategies**: Create commodity-specific policies to address the unique cost patterns and vulnerabilities of various trade sectors.
- **Support Mechanisms**: Push for financial and technical assistance to lessen the financial strain on trade-dependent countries like Malawi. In this regard, the levy scenarios generate significant amount of revenues, part of which could be used to address some of those negative impacts (see LEAP task 2 and 3 reports).

1 Introduction

Global maritime trade is pivotal in connecting economies across the globe, even for landlocked countries like Malawi with a dependence on international transport for the import and export of essential commodities such as tobacco, petroleum, and fertilizer (UNCTAD, 2020). Adopted in 2023, the IMO's Revised GHG Strategy has established a goal of eliminating greenhouse gas (GHG) emissions from shipping by 2050 (IMO, 2023), with alternative policy architectures to achieve the strategy's targets currently under consideration at the IMO. However, the economic incentives required to drive such deep structural change will come with economic impacts across the maritime sector, making it urgent for countries such as Malawi to develop their political positions with respect to these objectives as soon as possible.

This report builds upon the DNV and Starcrest assessments produced as part of the IMO-led CIA process (DNV, 2024; Starcrest, 2024), applying analysis techniques pioneered in that research to understand the potential impacts of alternative decarbonisation policy architectures on three of Malawi's most economically significant trade flows. By expediting this study, the LEAP project ensures that Malawi and other African nations are well-informed and ready to actively participate in the IMO debates, advocating for policies that balance their economic interests with the global push for environmental sustainability in maritime trade.

Because of their unique economic structures, scarce resources, and reliance on maritime trade for economic stability, African nations—including Malawi—face difficulties while participating in the IMO debates on reducing GHG emissions. Due to a lack of technical expertise, data, and funding, many African policymakers find it difficult to participate in IMO negotiations. This difficulty is exacerbated by the region's susceptibility to the effects of climate change (International Maritime Organization, 2020; United Nations Conference on Trade and Development, UNCTAD, 2020). This disparity in capacity and involvement emphasizes the need for more focused, fact-based information to assist Malawi and other African nations in navigating the IMO's proposed policy frameworks, including the Basket of Mid-term Measures. To bridge the gap and enable more effective participation in forming international maritime policies, this analysis attempts to enlighten and enhance Malawi's comprehension of the possible economic ramifications of these policies by offering such data. This part will aid in setting the scene for the report, which evaluates how various marine policy scenarios may affect Malawi's main industries economically.

This report assesses potential economic impacts on three critical commodities—tobacco, petroleum and fertilizer—under the following leading policy options which are described in greater detail in Section 2.3: a flexible GFI compliance mechanism only (Scenario 24), a flexible GFI compliance mechanism in combination with a Low Levy of US$30-120 per tonne (Scenario 32), a High Levy of US$150-300 per tonne in isolation (Scenario 26), and a flexible GFI compliance mechanism in combination with a Feebate mechanism (Scenario 36). These scenarios, measured on a well-to-wake basis under a 'base' emissions trajectory, are assessed relative to a BAU baseline, assuming no midterm GHG reduction measures.

A flexibility mechanism does not incentivize reductions from operational changes or technical advancements, but it does permit ships using fuels with carbon intensity above the GFI limit to purchase permits from those using lower-carbon fuels. Similar to this, the Feebate system only applies to fuel carbon intensity; it does not incentivize ships to increase their energy efficiency; instead, it offers financial prizes to ships that use fuels below a certain baseline and penalties to those who exceed it. On the other hand, the High Levy scenario enforces harsher penalties, whereas the Low Levy scenario imposes financial costs depending on total carbon emissions.

Each policy approach carries distinct implications for shipping costs, trade routes, and economic stability over time, influencing both short-term costs and long-term resilience. These scenarios are especially relevant for Malawi, as the country is highly vulnerable to fluctuations in shipping costs, which have direct implications for its economic stability and growth.

Analysis of key commodities—tobacco, petroleum, and fertilizer—reveals that all four policy scenarios result in increased shipping costs relative to the baseline, with varying rates of increase depending on the extent of speed reduction and on the specific policies implemented. For example, both the GFI Flexibility Only and Feebate scenarios lead to slightly higher costs in the long term, but lower in the short-term, as the GFI Flexibility Only scenario tends to increase at a faster rate over time. Similarly, the High Levy and Low Levy scenarios show a clear connection between cost increases and the intensity of GHG regulation in the short-term, but in the long term, they show similar levels of cost increase, with the high levy scenario becoming slightly cheaper.

Malawi's reliance on maritime trade routes, facilitated through neighbouring coastal countries, emphasizes its vulnerability to changes in global shipping policies (UNCTAD, 2020). The significance of imports like petroleum and fertilizer, combined with the country's dependence on exports such as tobacco, makes it susceptible to any rise in shipping costs, which could undermine its economic resilience. This challenge is especially pressing for Malawi, a lower-middle-income nation with limited capacity to absorb shocks from fluctuations in global trade (African Development Bank, 2019).

As environmental policies continue to shape international trade, understanding their economic implications for Malawi is crucial (Organisation for Economic Co-operation and Development, OECD, 2020). This study aims to shed light on the potential trade-offs between immediate cost increases and long-term economic impacts under various GHG regulations, particularly regarding how these policies could affect Malawi's key sectors and overall economic health.

1.1 Aim and research questions

The goal of the study is to present a thorough examination of the financial effects of various GHG reduction tactics on Malawi's trade-dependent economy. To ensure effective involvement in international maritime talks, it aims to educate policymakers on how to strike a balance between economic resilience and environmental responsibilities.

2 Methodology

In order to ensure that the analysis can support evidence-based policymaking, especially for African stakeholders hoping to participate effectively in the IMO GHG Marine Environment Protection Committee (MEPC) debates, this approach primarily draws from the UNCTAD Climate Impact Assessment (CIA) framework and , a structured six-step approach based on the methodology presented in (Starcrest, 2024) was employed to assess the economic effects of alternative policy architectures on three of Malawi's main trade flows. Further details regarding the employed methodology can be found in Annex I.

A thorough description of each stage and its significance is provided below:

Merchandise Trade Analysis: The first step involves analyzing Malawi's merchandise trade statistics to evaluate the annual values and volumes of key export commodities, such as uranium, fish, salt, copper, and diamonds. It also examines the extent to which these commodities rely on international shipping. This step is crucial for understanding the economic importance of these goods and their sensitivity to changes in global shipping regulations, including potential cost increases due to GHG reduction policies.

Selection of Key Commodity Flows: Based on the initial trade analysis, three key commodity flows were selected for further in-depth examination. This step identifies the trade partners, annual traded values, and typical volumes associated with these commodities, helping to pinpoint which trade relationships are most critical to Malawi's economy and could be most affected by the introduction of new maritime emission regulations.

Trade Route Identification: The third step focuses on mapping the primary trade routes for each of the selected commodity flows. This includes identifying all relevant port stops and typical distances between them. Understanding the specific routes associated with Malawi 's exports is critical for assessing the potential impact of GHG reduction policies on shipping costs, as each route may be subject to different regulations and cost factors.

Vessel Selection and Speed Analysis: For each identified trade route, a representative vessel type was selected, and its average design speed was evaluated. This helps estimate the time and fuel consumption required for shipments along these routes. The vessel type and speed analysis provide insights into the operational dynamics of shipping, which can influence fuel usage and the costs associated with meeting new emission reduction targets.

Vessel-Side Cost Assumptions: In this step, vessel-side cost assumptions are made by applying the four policy scenarios selected from the DNV models under the CIA Task 2 process (DNV, 2024). Freight rates for each trade route were derived from the UNCTAD Trade and Transport dataset (UNCTAD, 2024c), which offers a valuable source of experimental data on global shipping costs. These assumptions help calculate the potential increase in transportation costs that could result from stricter GHG regulations. It is important to note that the dataset used covers historical years up to 2021, and for the purposes of this study, we assumed that the rate remains constant from 2021 to the base year, 2023.

Cargo-Side Cost Assumptions: The final step calculates cargo-side cost assumptions by estimating the interest, depreciation, and insurance rates for each commodity-route pair. Given the limited availability of specific data for Malawi, this applied the same basic assumptions as outlined in (Starcres, 2024). These assumptions are designed to provide a general understanding of the costs incurred on the cargo side of the trade equation, which is essential for determining the full economic impact of new maritime regulations.

By combining the vessel-side and cargo-side cost assumptions, this methodology generates a comprehensive assessment of the overall cost impacts on Malawi's key commodity flows. This approach closely follows the methodology developed in (Starcrest 2024), offering reliable data that can be used by policymakers and government officials to develop informed intervention notes for the IMO GHG MEPC debates. It ensures that Malawi's specific economic context is considered, while also aligning with global best practices, thereby providing a robust and credible analysis for the country's participation in international discussions on maritime emissions and trade sustainability.

2.1 Limitations and Assumptions

A number of limitations in the applied methodology do exist. Documented in full in Annex I, limitations include:

1. **Data Availability**: Because real-time variations or regionally unique elements are not fully captured, the use of historical ad-valorem freight rates and baseline assumptions for cargoside costs may introduce inaccuracy to estimations.

2. **Cargo-side assumptions**: By oversimplifying changes brought on by market conditions or policy shocks, the fixed interest, depreciation, and insurance rates may either overestimate or underestimate the effects on the cargo side.

3. **Policy Situations**: The scenarios examined use the assumption that policies are applied consistently across boats and routes, which may not accurately represent the varied effects on smaller economies such as Malawi.

4. **At the time of writing**, the detailed DNV estimates of the cost-intensity changes were not available, so the aggregated results for the whole fleet were used.

5. The model ignores which of the importer or the exporter will bear the cost increase. In practice, they would fall either on the importer or the exporter, or partly on both. This means that the results correspond to a worst-case scenario, where Malawi bears all the price shock.

6. The modelling only covers the shipping leg of the supply chain to Malawi. Therefore, the results should be understood as the increase in costs of imported goods when they reach the port of imports.

Notwithstanding these drawbacks, the methodology provides a thorough framework that government representatives and policymakers can use with assurance to create intervention plans and promote Afrocentric viewpoints in IMO GHG negotiations. The paper offers a solid foundation for evaluating the economic effects of marine policy decisions for Malawi by firmly establishing the analysis in internationally accepted methodologies.

2.2 Data

To guarantee a thorough and contextually appropriate evaluation of Malawi's main trade commodities and the related economic effects, the analysis drew on several datasets and approaches.

Commodities were chosen based on their economic significance to Malawi. Given that it is Malawi's top export and a major source of foreign exchange earnings as well as the livelihoods of millions of people, especially in rural farming communities, tobacco was selected. Malawi is a producer of both raw and processed tobacco, which it mostly exports to the US, Belgium, and Germany. Because they assist agricultural output and power the economy, respectively, fertilizer and petroleum were chosen as essential imports. Malawi's agricultural output and energy security, which are essential to the nation's economic resiliency, are directly impacted by these commodities. The UN Comtrade database, which offered information on important origin and destination markets for Malawi's imports and exports, was used to find trading partners for these goods (UNCTAD, 2024b).

Copilot AI was used to identify important port stops and typical distances between origin and destination pairings to construct representative trade routes for the chosen commodities. The information from seadistances.org was added to this data. An internet search was done to find typical vessels utilized for each commodity's transportation, and information from the 4th IMO GHG Study was used to guide the selection of these vessels, including average design speeds (Faber et al, 2020). By taking these precautions, Malawi's commerce flows and related maritime activities were accurately depicted.

The ‘ad-valorem’ freight rates for each trade route were sourced from the publicly available UNCTAD

Trade and Transport dataset (UNCTAD, 2024c). Although this dataset covers only the years 2016– 2021, the rates were assumed to remain constant through the base year 2023, acknowledging this as a limitation while maintaining consistency. Cargo-side cost assumptions, including interest, depreciation, and insurance rates, were replicated from the methodology employed in (Starcrest, 2024). By combining these datasets and methodologies, the analysis provided a robust framework for calculating vessel-side and cargo-side cost impacts for each commodity-route pair. This approach ensures the findings are both reliable and applicable for policymakers seeking to understand the implications of IMO GHG policies on Malawi’s trade and economy.

2.3 Scenarios Considered

Four policy scenarios were identified as representing the leading policy architecture options currently under consideration and selected for analysis the three key commodities. The scenarios included:

GFI Flexibility Only (Scenario 24): A GFI compliance mechanism assigns an upper limit to the amount of emissions produced by consumption of a fuel for a given amount of energy production, exceedance of which will result in financial penalties for the vessel’s owner or operator. The term ‘flexibility’ refers to the possibility for the underperformance of vessels to be offset by aggregating compliance across a group of ships (‘pooling’) or the sale of compliance and remedial units.

Low Levy (Scenario 32): The Low Levy scenario introduces a flexible GFI compliance mechanism in combination with a tax of US$30-120 for each tonne of GHG emissions.

High Levy (Scenario 26): The High Levy scenario introduces a tax of US$150-300 per tonne of GHG emissions in isolation from a flexible GFI compliance mechanism.

Feebate (Scenario 36): A feebate mechanism first collects a fee on each tonne of GHG emissions generated by a vessel throughout the year, then calculates and redistributes a rebate to each vessel based on its uptake of eligible e-fuels. The Feebate scenario modelled here introduces a flexible GFI compliance mechanism in combination with a feebate mechanism.

Each policy scenario, measured on a well-to-wake basis under a 'base' emissions trajectory, is compared to a BAU baseline, which assumes no implementation of GHG reduction measures. The BAU scenario serves as a reference point, highlighting the cost and environmental implications of maintaining the status quo versus adopting proactive measures. These comparisons offer critical insights into the trade-offs and benefits associated with each policy, guiding stakeholders in making informed decisions about sustainable maritime practices.

2.4 Overview of the report

The rest of the report is structured as follows, section 3 outlines the results from the analysis, section 4 provides detailed discussion of the results which is followed by recommendation and conclusion sections.

3 Findings

The results of the modelling undertaken in this research describe the likely change in total costs of a traded good, given as a percentage of the trade's value. Further details on the methodology and how the results may be interpreted are given in Annex I.

3.1 Tobacco

Tobacco serves as a crucial export commodity for Malawi, contributing significantly to the country's economy and foreign exchange earnings. In the base year 2023, an ad-valorem freight rate of 6.80% was applied. The analysis of cost impacts across the four policy scenarios reveals important trends that highlight the economic challenges associated with GHG reduction measures.

The results show that all four policy scenarios lead to increasing costs over time compared to the baseline. However, the rate and pattern of cost increases vary by scenario, reflecting differences in the regulatory approaches.

In the base year, the GFI Flexibility Only scenario exhibited the smallest cost increase at 2.75%, while the Feebate scenario resulted in a slightly higher increase of 3.90%. This indicates that a flexibility mechanism can initially alleviate the economic burden on tobacco exports by allowing businesses to adapt gradually to GHG reduction measures. However, this short-term relief comes with trade-offs. Over time, the GFI Flexibility Only scenario experiences accelerated cost growth, eventually converging with the costs under the Feebate scenario. This pattern underscores the diminishing effectiveness of the flexibility mechanism in the long term as cumulative compliance requirements intensify.

In contrast, the Low Levy and High Levy scenarios demonstrate more consistent and predictable cost increases over the analysis period. The High Levy scenario imposes the most significant mediumterm costs, reflecting its stringent financial incentives for adopting low-emission technologies. However, it also shows signs of stabilization in the long term as efficiency gains, driven by technological advancements and operational improvements on the fleet, offset the initial cost burden (DNV, 2024).

Cost Trends Across Scenarios

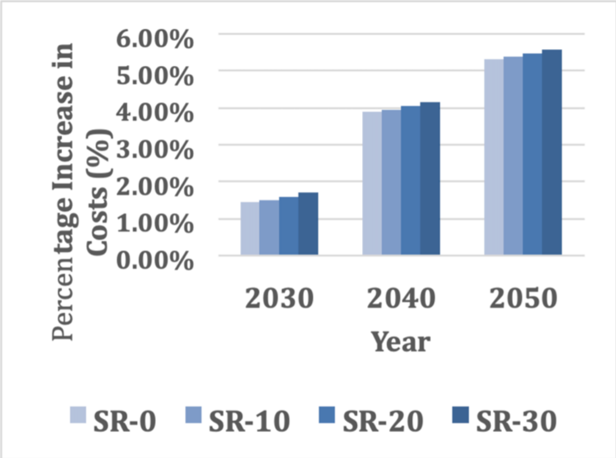

Figure 1: Impact of Low Levy (Scenario 32) on tobacco export costs.

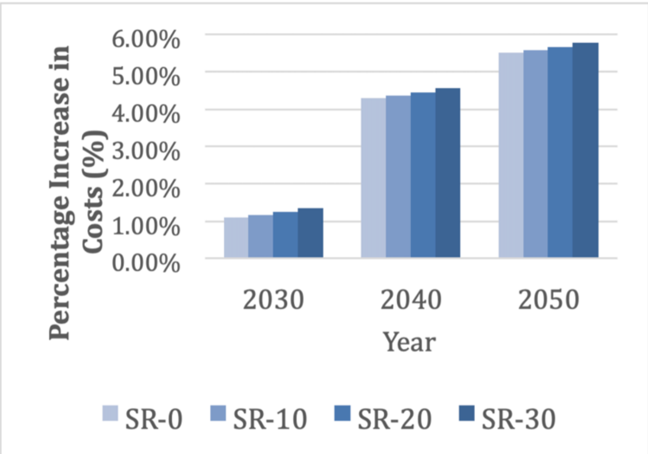

Figure 2: Impact of GFI Flexibility Only (Scenario 24) on tobacco export costs.

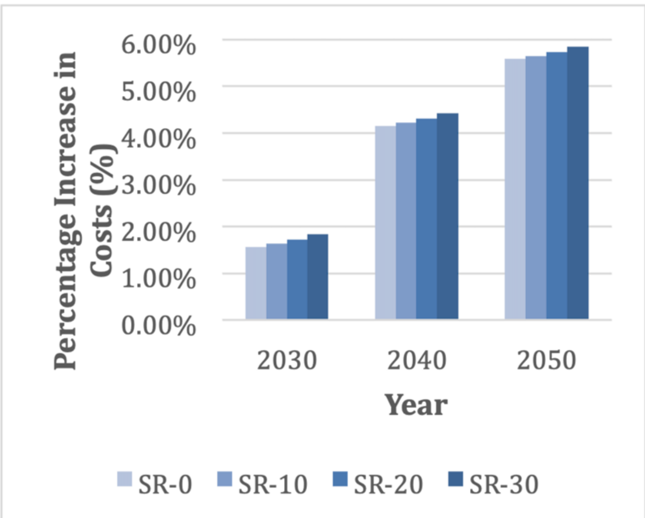

Figure 3: Impact of Feebate (Scenario 36) on tobacco export costs.

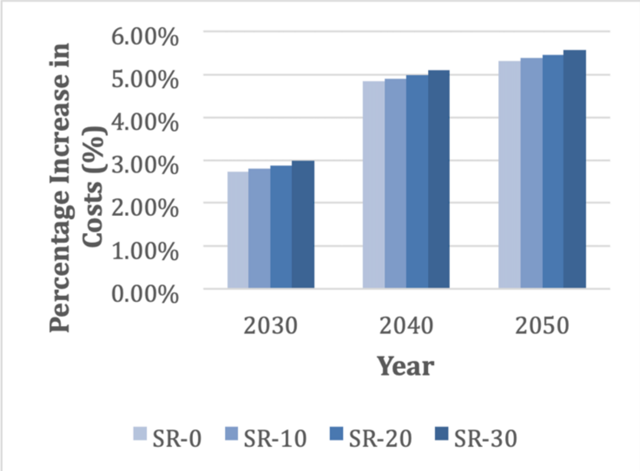

Figure 4: Impact of High Levy (Scenario 26) on tobacco export costs.

3.2 Petroleum

Petroleum is a critical import for Malawi, playing a key role in its transportation and industrial sectors. For the base year 2023, an 'ad-valorem' freight rate of 24.50 % was applied to petroleum imports. The analysis examined the impacts of four greenhouse gas (GHG) reduction policy scenarios: GFI Flexibility Only, Low Levy, High Levy, and Feebate, on the combined vessel-side and cargo-side costs of petroleum imports as shown in the following graphs.

The results indicate that all four policy scenarios lead to increasing costs over time relative to the baseline. At each interval, costs rise in correlation with the degree of vessel speed reduction. However, the rate of cost increase varies across scenarios, reflecting differences in the regulatory mechanisms applied.

In the base year, the cost increase under the GFI Flexibility Only scenario was relatively modest at 3.92%, while the Feebate scenario resulted in a higher initial increase of 5.64%. This indicates that the flexible GFI compliance can effectively mitigate short-term cost impacts, providing businesses with the opportunity to adapt incrementally to greenhouse gas (GHG) reduction measures. By allowing for avoiding the implementation of a carbon pricing in the short term, this scenario minimizes immediate economic disruptions compared to the stricter and more directive Feebate model.

However, the long-term cost dynamics reveal a different trend. The GFI Flexibility Only scenario experiences an accelerated rate of cost increase over time, ultimately converging with and slightly exceeding the costs of the Feebate scenario. This suggests that the initial advantages of flexibility diminish as cumulative regulatory pressures and compliance costs escalate.

Meanwhile, the Low Levy and High Levy scenarios exhibit steadier and more predictable cost growth over the analysis period. The High Levy scenario imposes the greatest medium-term financial burden due to its stringent pricing structure, but it begins to stabilize in the long term as operational efficiency improvements and technological advancements on the fleet offset some of the initial cost increases.

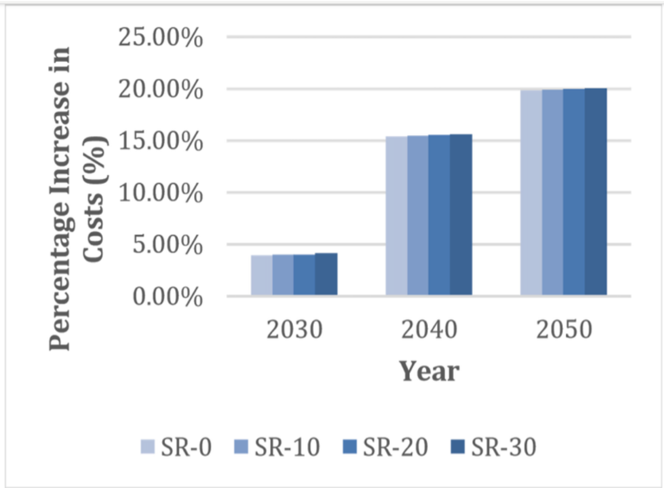

Figure 5: Impact of GFI Flexibility Only (Scenario 24) on petroleum import costs.

Figure 6: Impact of Low Levy (Scenario 32) on petroleum import costs.

Figure 7: Impact of High Levy (Scenario 26) on petroleum import costs.

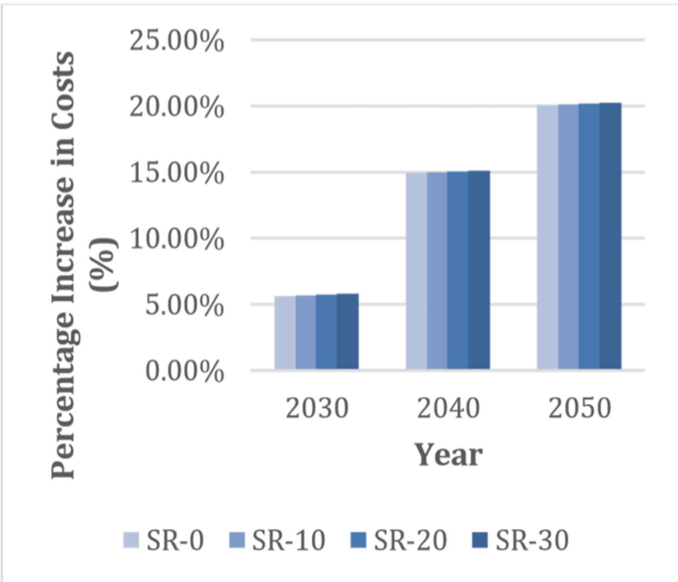

Figure 8: Impact of Feebate (Scenario 36) on petroleum import costs.

3.3 Fertilizer

Fertilizer is another vital import for Malawi, essential for supporting its agricultural sector, which underpins the livelihoods of a significant portion of the population. For the base year 2023, an 'advalorem' freight rate of 24.10% was applied. The final cost impacts from the combined vessel-side and cargo-side costs for each of the four policy scenarios are shown in the following graphs.

The results show that all four policy scenarios lead to increasing costs over time compared to the baseline. Costs generally rise with reductions in vessel speed, but the rate of increase varies across scenarios due to differences in policy structures.

In the base year, the GFI Flexibility Only scenario exhibited the lowest cost increase at 3.85%, while the Feebate scenario resulted in a comparatively higher increase of 5.50%. This disparity highlights the immediate economic advantages of adopting a flexibility mechanism, which allow for incremental adjustments without imposing significant financial pressure. By minimizing initial cost burdens, the GFI Flexibility Only scenario proves particularly appealing for sectors that are sensitive to short-term economic disruptions. In contrast, the Feebate scenario, with its combination of fees and rebates, imposes a higher upfront cost but creates stronger incentives for adopting low-emission technologies. These findings suggest that the flexibility mechanism can serve as a transitional strategy, offering short-term relief while industries adapt to the financial and operational demands of GHG reduction policies.

Over the analysis period, the cost dynamics shift considerably. The GFI Flexibility Only scenario, despite its initial advantages, shows a faster rate of cost increase over time, eventually aligning closely with the Feebate scenario by the end of the analysis period. This indicates that the benefits of flexibility diminish as cumulative regulatory impacts and compliance costs intensify. The accelerating costs under the GFI Flexibility Only scenario reflect the challenges of delayed implementation of more efficient technologies and operational practices.

Meanwhile, the Low Levy and High Levy scenarios exhibit steadier, more predictable cost increases. The Low Levy scenario provides a moderate financial incentive for emissions reductions, resulting in manageable cost growth over time. On the other hand, the High Levy scenario generates the highest medium-term costs because of its aggressive approach to driving emissions reductions. However, as efficiency gains and technological advancements take hold, the High Levy scenario eventually stabilizes, suggesting that the upfront financial pressure can lead to long-term economic and environmental benefits.

Evaluated across 0, 10, 20 and 30% speed reduction scenarios (SR-0 to SR-30), cargo-side cost impacts are observed to contribute relatively little to total cost impact compared to the vessel side. Exports of Uranium are the exception, driven by its small vessel-side cost impacts. Data from (DNV, 2024) indicates that vessel speeds are expected to reduce by between 6-20% in response to the introduction of midterm measures, with a median speed reduction just over 10%.

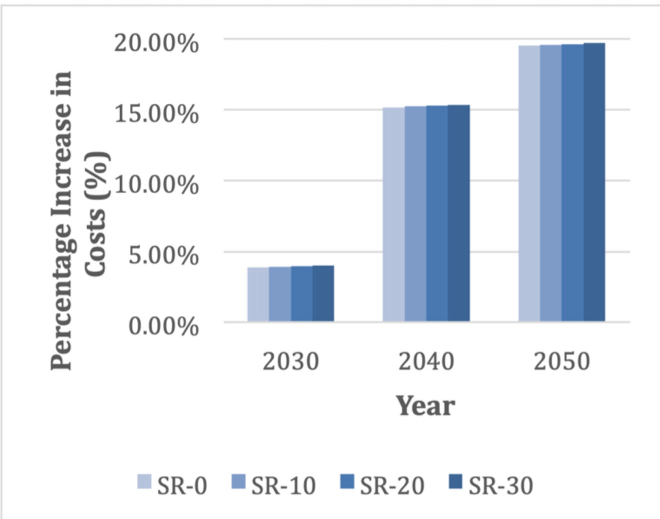

Figure 9: Impact of GFI Flexibility Only (Scenario 24) on fertilizer import costs.

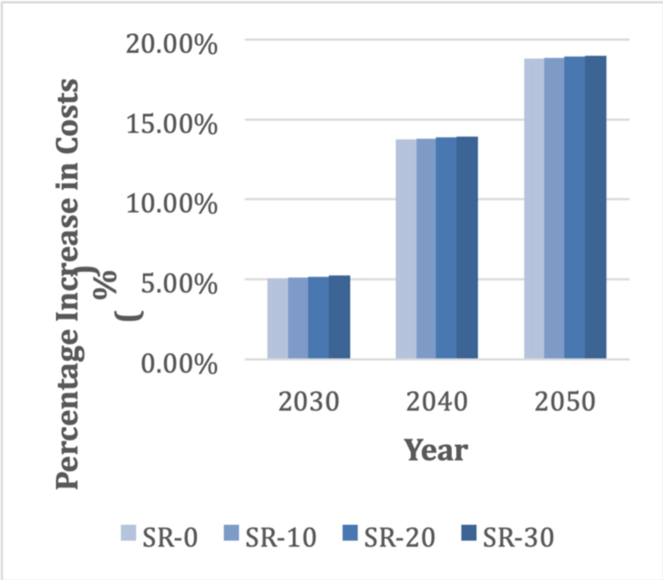

Figure 10: Impact of Low Levy (Scenario 32) on fertilizer import costs.

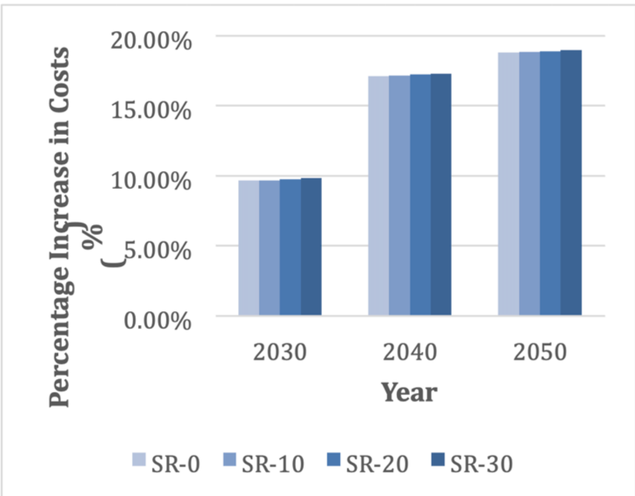

Figure 11: Impact of High Levy (Scenario 26) on fertilizer import costs.

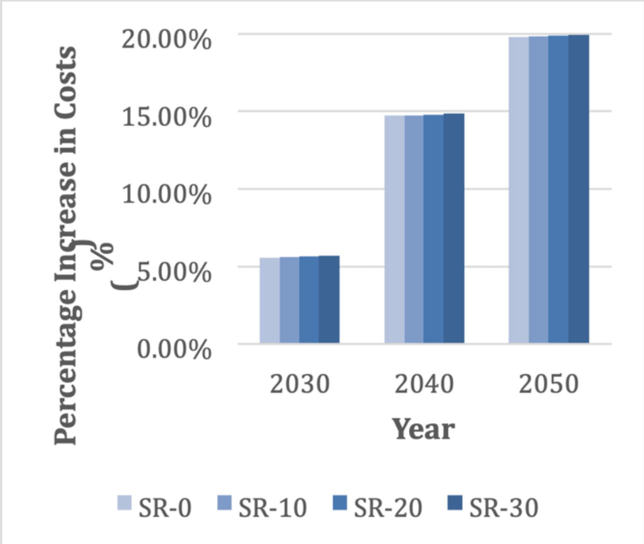

Figure 12: Impact of Feebate (Scenario 36) fertilizer import costs.

4 Discussion

The evaluation of greenhouse gas (GHG) reduction policy scenarios for tobacco, petroleum, and fertilizer reveals that all scenarios increase logistics costs relative to the 2023 Business-As-Usual (BAU) baseline. This cost rise across key commodities underscores the broader economic implications of implementing GHG reduction measures, where changes in freight rates, levies, and feebates significantly influence import and export costs. These findings provide valuable insights for policymakers aiming to balance environmental objectives with economic resilience.

All four policy scenarios lead to rising logistics costs over time compared to the baseline. The GFI Flexibility Only scenario offers short-term cost relief but converges with alternative policies, such as the Feebate, over the long term. This diminishing advantage emphasizes the need for policymakers to carefully weigh short-term flexibility against long-term sustainability. In contrast, the levy-based scenarios show steady cost increases but stabilize over time, offering a predictable trajectory that facilitates economic planning. Furthermore, levy scenarios would in addition generate revenue which could potentially benefit Malawi's economy (UNCTAD, 2024a; see task 2 and task 3 reports), but this impact was not included in this analysis.

While speed reduction contributes to higher costs, cargo-side cost impacts are not the primary driver. Instead, compliance costs and operational adjustments on the vessel-side play the most significant role. This finding suggests that prioritizing vessel-side efficiencies and streamlined regulatory approaches may better address cost concerns while advancing environmental goals.

The cost trajectories of petroleum and fertilizer reflect shared characteristics, including dependency on oil and gas derivatives and overlapping trade routes. Tobacco, on the other hand, exhibits distinct cost patterns influenced by unique trade routes and export dynamics. These variations highlight the importance of tailoring GHG reduction strategies to the specific profiles of different commodities. For instance, policies imposing high initial costs may be less suitable for sensitive exports like tobacco, while imports such as fertilizer could adapt more readily to levy-based scenarios.

This analysis relies on constant 'ad-valorem' freight rate assumptions for 2023, which may oversimplify dynamic factors like market fluctuations and geopolitical influences. Future research should incorporate variable freight rates and examine how regional contexts, such as Malawi's landlocked status, shape outcomes. Utilizing global models, such as that presented in (Starcrest, 2024), could enhance the study's credibility by providing benchmarks and incorporating Malawi's unique trade dependencies.

5 Conclusion

This analysis demonstrates that all four GHG reduction policy scenarios lead to increased logistics costs relative to the baseline, affecting Malawi's primary import and export sectors. Across tobacco, petroleum, and fertilizer, costs rise with reductions in vessel speed, although final impact projections are almost entirely driven by changes in vessel-side costs. The GFI Flexibility only scenario initially mitigate costs but converge with alternative policies over time, indicating that gradual policies may alleviate short-term impacts but ultimately lead to cumulative costs that require careful economic planning. However, levy scenarios would in addition generate revenue which could potentially benefit Malawi's economy (UNCTAD, 2024a), but this impact was not included in this analysis.

Our findings suggest Malawi may benefit from a balance of flexibility mechanism and levy-based strategies to reduce the economic impact on key imports while still meeting GHG reduction goals. A balanced, commodity-specific policy approach could help maintain trade viability and economic resilience while advancing sustainability objectives in global trade and transportation.

However, Malawi's unique position as a landlocked country significantly influences the economic dynamics explored in this study. While maritime trade is a central concern for Malawi, the country's reliance on neighboring ports for access to global markets introduces additional costs and complexities not typically faced by coastal economies. These logistical challenges—such as higher transportation costs, dependency on external infrastructure, and vulnerability to regional bottlenecks—make Malawi's case distinct. Consequently, the applicability of these findings to other landlocked nations, such as Botswana or Zimbabwe, requires careful consideration of local infrastructural realities and trade networks.

Landlocked countries face constraints not only in terms of physical access to global markets but also in the logistical challenges posed by regional trade corridors. Malawi's proximity to South Africa and reliance on ports such as Durban influence the cost and feasibility of various GHG reduction policies. However, for other landlocked countries in Africa or beyond, these logistical concerns could differ based on their access to regional ports and the available infrastructure for cross-border transport. While the conclusions drawn from Malawi's case are valuable, they should not be directly transposed to other landlocked countries without adapting the models to reflect differences in regional trade infrastructure, transportation networks, and economic dependencies.

The study highlights the critical need for tailored maritime GHG reduction policies that consider the specific economic vulnerabilities of landlocked, trade-dependent countries like Malawi. For instance, the similarity in cost trends for petroleum and fertilizer imports underscores the shared challenges faced by import-dependent sectors. These findings call for greater support to enable Malawi and similar nations to participate effectively in global policy discussions, ensuring that their unique economic contexts are recognized and addressed.

It is also essential to acknowledge the study's limitations. The analysis focuses on three key commodities, which, while significant, do not capture the full spectrum of Malawi's trade portfolio. Additionally, the assumptions used for cost projections, such as constant ad-valorem freight rates and fixed interest rates, may influence the outcomes. Future studies could expand on these findings by incorporating more diverse commodities and refining methodological assumptions to improve accuracy.

Moreover, the results emphasize the broader implications for international maritime policy. Policymakers must consider the cumulative long-term impacts of GHG strategies on trade-dependent economies, striking a balance between environmental objectives and economic resilience. This study reinforces the need for region-specific strategies that align with global climate goals while safeguarding the economic stability of vulnerable nations like Malawi.

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Annex I – Technical Annex

Annex I 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 Comprehensive Impact Assessment 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 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.

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

*Commodity-side Task 4 TCCIsr Change, % (daily) = Delay10|20|30 * ValueTrade, CIF * (Cint + Cdep + Cins) / 365.25 [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.

*Commodity-side Task 4 TCCIsr Change, % (total) = Delay10|20|30 * Commodity-side Task 4 TCCIsr Change, % (daily) [O2b]*

*Commodity-side Task 4 TCCIsr Change, % (total) = (Delay10|20|30) 2 * ValueTrade, CIF * (Cint + Cdep + Cins) / 365.25 [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 TCCIsr 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.

Total Expected Cost Intensity Change, TCCI =
Ship-side Task 2 Freight-Rate Adjusted Commodity Cost Intensity (FRACCI) + Commodity-side Task 4 TCCIsr 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 containerised 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:

*Commodity-side Task 4 TCCIsr Change, % (daily) = ValueTrade, CIF * (Cint + Cdep + Cins) / 365.25 [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.

*Commodity-side Task 4 TCCIsr Change, % (total) = Delay10|20|30 * ValueTrade, CIF * (Cint + Cdep + Cins) / 365.25 [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 TCCIsr 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.

Total Expected Cost Intensity Change, TCCI =
Ship-side Task 2 Freight-Rate Adjusted Commodity Cost Intensity (FRACCI) + Commodity-side Task 4 TCCIsr Change, % (total) [U3]

I.iii Discussion

It should be noted that the finalised 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 utilised in the development of the alternative methodology applied in this research.

Commodity, Route and Vessel Selection

Both the 'official' and 'unofficial' methodologies utilise 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.

DNV's disaggregated data of modelled Ship-side Task 2 CI Change, % across details vessel classes was made available to the UCL team, facilitating application of differentiated Ship-side Task 2 CI Changes, % by vessel type, size class and age range, as opposed to the application of generalised rates. 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 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, 2022). These rates have been primarily based on CIF-FOB margins recorded in the Comtrade database, specifically featuring infilling of FOB values they are missing, using modelling trained on other areas of presenting data. In this sense, most of the ad-valorem 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) who's underpinning methodological note (UNCTAD, 2022) 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 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 Ad-valorem 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 utilised 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 (Transit $\text{Times}_{GSA\text{-}X}$ = Distance # / $\text{Speed}_{GSA\text{-}X}$). 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) (GDP Impact = Commodity Total Export Value / 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%) (Interest Cost = (Export Value x Interest Rate) * (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) (Depreciation Cost = (Export Value x Depreciation Rate) x (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%) (Insurance Cost = (Export Value x Insurance Rate) x (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).

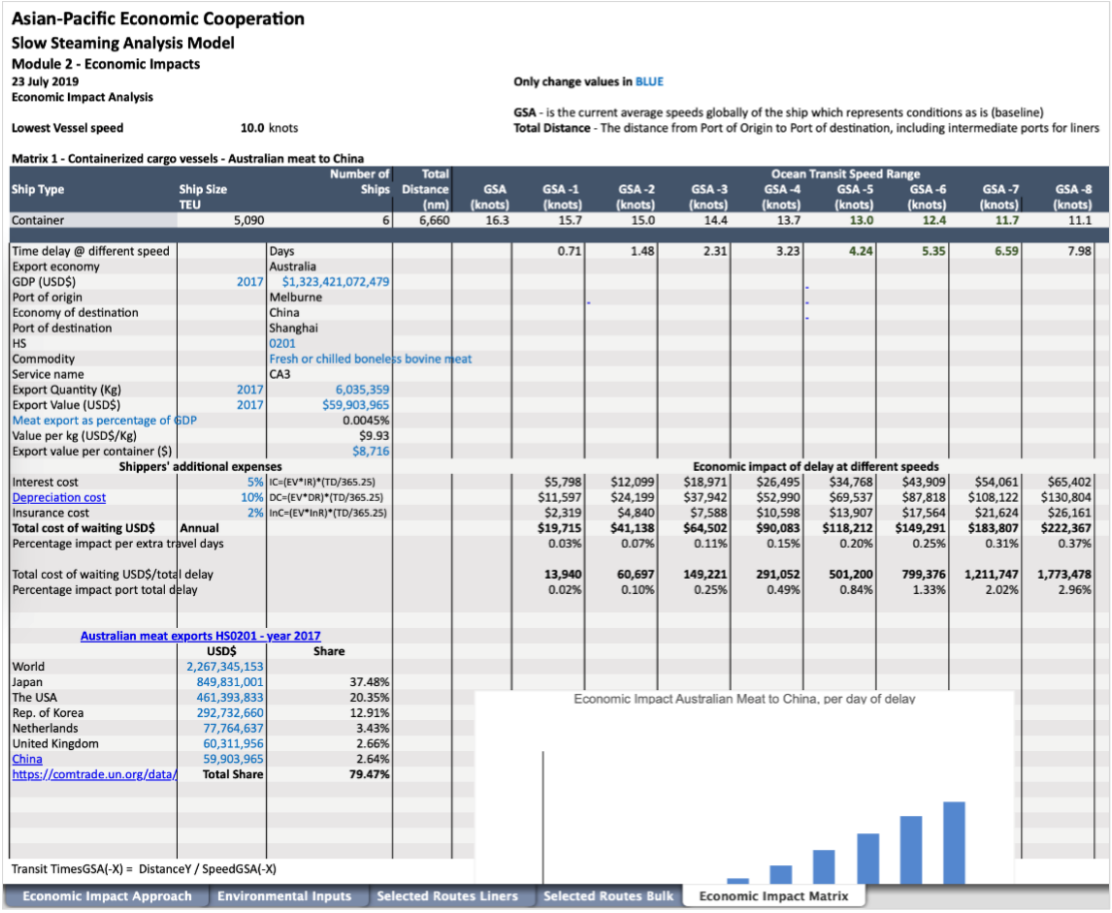
The official Task 4 method considers the costs of interest, depreciation and insurance, assuming that each result in a percentage loss of cargo per day of delay. (APEC, 2019) states that "the interest, depreciation and insurance cost estimates were developed by multiplying the rates for each of the three 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:

*Commodity-side Task 4 TCCIsr Change, % (daily) = ValueTrade, CIF * (Cint + Cdep + Cins) / 365.25*

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

Commodity-side Task 4 TCCIsr Change, % (total) = Delay10|20|30 * ValueTrade, CIF * (Cint + Cdep + 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)	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										
Shippers' additional expenses					**Economic impact of delay at different speeds**							
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*InR)*(TD/365.25)			$2,319	$4,840	$7,588	$10,598	$13,907	$17,564	$21,624	$26,161
Total cost of waiting USD$	**Annual**				**$19,715**	**$41,138**	**$64,502**	**$90,083**	**$118,212**	**$149,291**	**$183,807**	**$222,367**
Percentage impact per extra travel days					0.03%	0.07%	0.11%	0.15%	0.20%	0.25%	0.31%	0.37%
Total cost of waiting USD$/total delay					**13,940**	**60,697**	**149,221**	**291,052**	**501,200**	**799,376**	**1,211,747**	**1,773,478**
Percentage impact port total delay					0.02%	0.10%	0.25%	0.49%	0.84%	1.33%	2.02%	2.96%

Australian meat exports HS0201 - year 2017

	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%
https://comtrade.un.org/data/	**Total Share**	**79.47%**

Transit TimesGSA(-X) = DistanceY / SpeedGSA(-X)

Economic Impact Approach | Environmental Inputs | Selected Routes Liners | Selected Routes Bulk | Economic Impact Matrix

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', TCCIsr, is scaled by the delay term, Delay10|20|30, therefore resulting in the following equation:

*Commodity-side Task 4 TCCIsr Change, % (daily) = Delay10|20|30 * ValueTrade, CIF * (Cint + Cdep + 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:

*Commodity-side Task 4 TCCIsr Change, % (total) = Delay10|20|30 * Delay10|20|30 * ValueTrade, CIF * (Cint + Cdep + Cins) / 365.25*

*Commodity-side Task 4 TCCIsr Change, % (total) = (Delay10|20|30) 2 * ValueTrade, CIF * (Cint + Cdep + 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 TEU	Number of Ships	Total Distance (nm)	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)
								Ocean Transit Speed Range				
Container	5,090	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	$1,323,421,072,479										
Port of origin		Melburne										
Economy of destination		China										
Port of destination		Shanghai										
HS		0201										
Commodity		Fresh or chilled boneless bovine meat										
Service name		CA3										
Export Quantity (Kg)	2017	6,035,359										
Export Value (USD$)	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										
Shippers' additional expenses								**Economic impact of delay at different speeds**				
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
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
Insurance cost	2%	InC=(EV*InR)*(TD/365.25)			$2,395	$5,057	$8,032	$11,378	$15,171	$19,505	$24,507	$30,342
Total cost of waiting USD$	**Annual**				**$20,361**	**$42,984**	**$68,268**	**$96,714**	**$128,951**	**$165,795**	**$208,306**	**$257,903**
Percentage impact per extra travel days					0.03%	0.07%	0.11%	0.16%	0.22%	0.28%	0.35%	0.43%

Australian meat exports HS0201 - year 2017

	USD$	
World	2,267,345,153	
Japan	849,831,001	37.48%
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%
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https://comtrade.un.org/data/	**Total Share**	**79.47%**

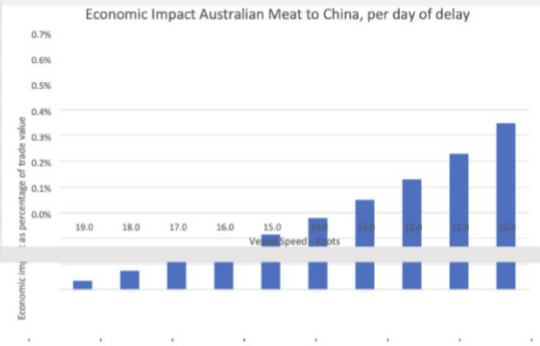

Figure 15: Alternative screenshot of the Economic Impact Matrix model for Australian Meat to China presented unreferenced as the penultimate page of Appendix B in (APEC, 2019).

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 'advalorem' 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. A more balanced contribution across vessel-side and cargo-side cost impacts can be expected.