LEADING EFFECTIVE AFROCENTRIC PARTICIPATION (LEAP) PROJECT

Impact Assessment of the IMO Basket of Candidate Mid-Term GHG Reduction Measures

THE LIBERIA CASE STUDY



DOLA OLUTEYE, FOLUSO AGUNBIADE, CLARE OFODILE, HARRY CONWAY

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By:

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Abbreviations

AfCFTA	African Continental Free Trade Agreement
BAU	Business as Usual
CBAM	Carbon Border Adjustment Mechanism
CI	Cost Intensity
CIF	Contract, Insurance and Freight
CIA	Comprehensive Impact Assessment
DNV	Det Norske Veritas
EU	European Union
FOB	Free-on-Board
FRACCI	Freight-rate Adjusted Commodity Cost Intensity
GDP	Gross Domestic Product
GFI	GHG Fuel Intensity
GHG	Greenhouse Gas
IMO	International Maritime Organisation
LEAP	Leading Afro-centric Participation
SR	Speed Reduction
TCCI	Total Commodity Cost Intensity
TtW	Tank-to-Wake
UCL	University College London
UN	United Nations
UNCTAD	United Nations Committee on Trade and Development
WtW	Well-to-Wake
ZNZ	Zero and Near-Zero

Executive Summary

The Fourth International Maritime Organisation (IMO) Greenhouse Gas (GHG) Study, published in 2020, estimated that the maritime industry contributed 2.89% to global anthropogenic GHG emissions in 2018. By 2050, these emissions could increase to between 90% and 130% of 2008 levels (Faber et al, 2020). In response, the 2023 IMO GHG Strategy has established the goal of achieving net-zero GHG emissions by 2050, with the following intermediate targets compared to 2008 levels: a 20% emissions reduction by 2030, striving to reach 30%; a 70% reduction, striving for 80% by 2040; and net zero by 2050 (IMO, 2023).

The policy architecture proposed to achieve these targets 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, centred on a pricing system for maritime GHG emissions. In achieving this, the strategy further aims to identify actions for the sector, address impacts on states, and promote incentives for research and development.

As it engages with the IMO, Member States from Africa need to ensure that the African continent's negotiating positions are informed by empirical evidence from the region to support robust policy interventions. It is within this context that the Leading Effective Afrocentric Participation (LEAP) project initiative has been developed to support six African member states of the IMO, namely Ghana, Kenya, Liberia, Malawi, Namibia and Nigeria. As part of Task 4 of the LEAP Project, this case study report analyses the likely cost impacts of achieving the 2023 IMO GHG Reduction Strategy targets on a selection of Liberia's most important traded commodities. The research presented in this report applies a methodology built upon the approach deployed by Starcrest Consulting Group as part of 'Task 4 - Complementary Qualitative/Quantitative Stakeholders' Analysis' of the official Comprehensive Impact Assessment (CIA) process. Full details of the applied methodology can be found in the Technical Annex.

The study's objectives are to individually assess the vessel-side (associated with increased fuel and technology cost) and cargo-side (associated with speed reduction) cost components associated with four of Liberia's most important merchandise trade flows by volume. The final cost impact, evaluated as the sum of cargo- and vessel-side costs, is derived under four scenarios representing major policy options currently under consideration at the IMO. Final cost impacts are evaluated across four ship speed reduction scenarios (0%, 10%, 20%, and 30%) for the years 2030, 2040 and 2050. The results of the Liberia case study indicate compliance cost challenges

for sectors such as oil and gas, agricultural products, manufactured goods, and raw materials. The report highlights that vessel-side costs dominate overall cost increases, themselves driven by the relative shares of transport costs in overall commodity values (represented by the 'ad-valorem' transport cost rate). The cargo side cost increases were generally much lower than the vessel-side impact, however cargo-side costs associated with exports of Cocoa seeds were found to be higher than those for alternative commodities as Timbers are perishable goods for which a depreciation rate of 30% per year was assumed.

The Low Levy and Feebate scenarios (Scenarios 32 and 36) were observed to be the least economically impactful when balancing results across the short-, medium- and long-term for the commodities studied. By 2050, all scenarios lead to similar cost increases (the levy scenarios, Scenarios 32 and 26, leading to the smallest increases) with combined cost impacts across all speed reduction scenarios ranging between 7.1-8.5% for exports of Iron Ores and Concentrates to France and imports of Petroleum Products from Cote d'Ivoire; approximately 5.4-5.6% for exports of Timbers to the Netherlands and 34.5-36.3% for imports of Food Products & Vegetable Oil from Cote d'Ivoire.

When these sectors face higher shipping costs over time, there could be potential economic impacts such as higher export and import prices, leading to reduced competitiveness of exports on the global market, reduced trade volumes, and higher consumer prices. Ultimately, these impacts could lead to a decrease in national Gross Domestic Product (GDP) and have broader implications for Liberia's trade competitiveness, which is critical for developing and emerging economies. The extent of these effects may be influenced by the exact nature of the policy interventions (i.e. the magnitude of a levy and extent of any subsequent revenue disbursement), as well as the overall persistence of negative impacts in future.

1.0 Introduction

The International Maritime Organization (IMO) has outlined a suite of mid- and long-term measures to reduce greenhouse gas (GHG) emissions in the maritime sector. These measures extend beyond environmental stewardship; they are equally critical trade, investment, and economic decisions. According to a 2020 IMO study, maritime operations contributed approximately 2.89% of global anthropogenic GHG emissions in 2018 (Faber et al., 2020). Projections indicate that, without substantial intervention, emissions from international shipping could rise to between 90% and 130% of 2008 levels by 2050. In response, the IMO's 2023 GHG Strategy establishes a pathway toward net-zero emissions by 2050, with intermediate reduction

targets relative to 2008 levels: 20% (aspiring to 30%) by 2030, 70% (aspiring to 80%) by 2040, and net-zero by 2050 (IMO, 2023). While the IMO Net-Zero Framework is essential to operationalize this strategy, its adoption and implementation must be guided by the principles of a just and equitable transition. The shift toward net-zero shipping operations will inevitably impact trade and economic activity, given that maritime transport underpins global commerce, and these impacts require careful quantification to inform policy and investment planning. Building on the recognition that shipping decarbonisation carries both environmental and economic implications, it is essential to examine the structural components of the IMO's strategy to understand how these impacts will materialize and be managed.

A thorough understanding of the IMO 2023 GHG Strategy, which is structured around two interdependent components: technical and economic, is therefore essential. The technical component establishes a goal-based standard for marine fuels, regulating the gradual reduction of GHG intensity across shipping operations. While this promotes environmental performance, it may also influence operational costs for vessel owners and operators. Complementing this, the economic component introduces market-based mechanisms, including a pricing system for maritime GHG emissions, to incentivize emissions reduction across the sector. The strategy further outlines actions to support implementation, assess the potential impacts on states, and encourage research, development, and monitoring initiatives to track progress and inform future policy adjustments. Understanding the structural components of the IMO's strategy is only meaningful if it is contextualized within regional realities, particularly in Africa, where the socio-economic implications of decarbonisation must be carefully considered.

African states have increasingly oriented their responses and policy decisions to ensure that the principles of justice and equity are upheld throughout the shipping decarbonisation process. In this context, leveraging empirical evidence derived directly from the region facilitates the assessment of the impacts of IMO measures on African economies and to provide policymakers with data-driven guidance for informed decision-making. This imperative informed the development of the LEAP Project, which aims to support six African member states at the IMO, namely, Ghana, Kenya, Liberia, Malawi, Namibia, and Nigeria, through targeted studies that provide actionable insights into the regional implications of GHG reduction measures.

In line with this initiative, this Liberia case study examines the cost implications of the 2023 IMO GHG Reduction Strategy on selected, important and high-volume traded commodities in Liberia. The study focuses on both cargo-side and vessel-side costs, as well as combined impacts, under

four vessel speed reduction scenarios (0%, 10%, 20%, and 30%) and four policy scenarios being considered at the IMO at the time of this research. Each scenario represents a distinct combination, or 'basket' of candidate mid-term measures, including the GHG Fuel Intensity (GFI) requirement, GFI flexibility mechanisms, levies and rewards, feebates, and revenue disbursement frameworks.

The GFI requirement establishes annual well-to-wake (WtW) or tank-to-wake (TtW) GHG emissions targets per unit of energy consumed, providing sustainability-aligned benchmarks for shipping operations. Compliance can be achieved through a flexibility mechanism, which allows ships with emissions below the target (positive compliance balance) to sell Surplus Units (SU) to ships exceeding targets (negative compliance balance) or to a central revenue body at a price determined by the IMO. Conversely, ships exceeding the GFI requirement must purchase Remedial Units (RU) from the revenue body, with prices reflecting the cost differential between fossil and alternative fuels.

The levy and reward mechanism imposes a charge on all GHG emissions from ships, with revenues directed to incentivize vessels using approved low-carbon fuels. Similarly, the feebate mechanism levies fees per tonne of CO_2 emitted while providing rebates to ships adopting eligible fuels, thereby creating financial incentives for decarbonisation (DNV, 2024). Revenues generated through these mechanisms can be allocated to designated disbursement categories to support the adoption of zero and near-zero (ZNZ) fuels. The four policy scenarios evaluated in this 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 temporal horizons: 2030, 2040, and 2050, representing Phase 1 of the LEAP Project. Employing a mixed-methods approach combining qualitative and quantitative stakeholders' analysis with case study techniques, the report provides critical insights into the implications of these measures on Liberia's four most significant commodity flows. By incorporating vessel-specific characteristics such as capacity and design speed, the study evaluates how policy and operational changes impact trade costs under each scenario.

2.0 Methodology

The methodology applied in this case study closely follows the approach developed by Starcrest Consulting Group for Task 4 of the IMO-led Comprehensive Impact Assessment (CIA) of mid-term measures. The CIA was designed to project potential future impacts of these measures, specifically considering economic effects on the fleet (Task 2) and on states (Task 3) (DNV, 2024; UNCTAD, 2024a). Task 4 complemented these assessments by providing qualitative and quantitative stakeholders' analysis for specific commodity flows in African states that were underrepresented in Task 3 (Starcrest, 2024).

As detailed in the Technical Annex, the study utilised merchandise trade data sourced from the United Nations (UN) COMTRADE Database, complemented by shipping and freight company records. This included information on Liberia's major exports and imports, their weights, trade partners, and economic values. In addition, desk-based research, expert input, and in-country consultations provided critical context for key parameters such as nautical miles, average ship speeds, interest rates, insurance rates, and cargo depreciation.

To estimate cost impacts, transport cost rates from UNCTAD's Trade and Transport Database (UNCTAD, 2024c) were combined with cost intensity projections from the Det Norske Veritas (DNV) Task 2 analysis within the CIA process (DNV, 2024). These inputs were integrated into a modified version of the APEC (2019) model, adapted by the University College London (UCL) team to evaluate the effects of mid-term measures. The four CIA-based policy scenarios applied in this study—'GFI Flex Only' (Scenario 24), 'Low Levy' (Scenario 32), 'High Levy' (Scenario 26), and 'Feebate' (Scenario 36)—were used to model potential impacts on Liberia's key commodity flows. Exports included Iron Ores and Concentrates to France and Timbers to the Netherlands, while imports included Petroleum Products and Food Products & Vegetable Oil from Côte d'Ivoire. These commodities were selected based on either trade volume or their strategic importance to critical sectors in Liberia, such as energy, infrastructure, housing, and food production.

The analysis considered two primary cost components: cargo-side and vessel-side impacts, which were subsequently combined to determine the total projected cost impact of the mid-term measures. Cargo-side costs were calculated using assumed interest, depreciation, and insurance rates, combined with differences in leg time (∆leg time) associated with vessel speed reductions of 0%, 10%, 20%, and 30%. Assumed rates for interest and insurance were 5% and 2%,

respectively. Depreciation rates varied by commodity type: 10% for non-perishable goods, 30% for perishable goods, and 20% for timber, reflecting its intermediate shelf-life characteristics.

Vessel-side costs were derived by applying the ad-valorem transport cost rate from UNCTAD (2024c) and scaling it using the cost intensity ratio associated with each policy scenario and projected future year, as provided in the DNV Task 2 analysis (DNV, 2024). This methodology ensures that both operational and cargo-specific financial impacts of the IMO mid-term measures are captured with precision, providing policymakers with a comprehensive, evidence-based assessment of potential economic consequences for Liberia.

2.1 Commodities and Trade Data

Liberia's principal traded commodities, as reported by the Central Bank of Liberia, are summarised in Table 1. The table provides a detailed overview of both imports and exports, including trading partners, commodity classifications according to the HS 10 system, broader commodity categories, and the net weight of each item in metric tonnes. Liberia's trade is heavily driven by mineral exports, particularly Iron and Concentrates, which constitute a substantial portion of the country's foreign exchange earnings. Agricultural commodities, especially cocoa beans and cocoa-derived products, also form an essential component of the export portfolio. On the import side, Liberia relies primarily on crude oil, Food Products & Vegetable Oils, and cement, reflecting the country's energy needs, food security considerations, and infrastructure development priorities.

Table 1 – Liberia's majorly traded commodities in 2023[+]

EXPORTS				
S/N	**Commodity**	**Category**	**Origin/ Destination**	**Metric Tonne**
1	Iron ore	Raw Material	France	5,205,000.00

2	Rubber	Agriculture	Spain	75,471.00
3	Crude Palm Oil	Agriculture	World	15,890.00
4	Timber	Agriculture	Netherlands, France and Spain	675,211.00
5	Cocoa & Coffee	Agriculture	Within Africa	3,611.00
		IMPORTS		
S/N	**Commodity**	**Category**	**Origin/ Destination**	**Metric Tons-2024**
1	Rice	Agriculture	World	
2	Petroleum Products (In Gallons)	Other oil/Other petroleum products	Cote d'Ivoire	46,728,134.70
3	Food /Animals Products, & Veg Oil	Agriculture	USA	

4	Machinery and Transport Equip	Manufactured goods	World
5	Manufactured goods and materials	Manufactured goods	World
6	Others	Manufactured goods	World

The export data were obtained from the Central Bank of Liberia (CBL) Financial and Economic Bulletin and 2024 Annual Report. The import data were derived from the CBL January 2025 Economic Review External Sector Statistics estimated (Four months) estimated to 12 months.

To assess the potential economic impacts of IMO mid-term measures, this study focuses on a representative subset of Liberia's trade flows that capture both the diversity and significance of the country's key traded commodities. For this study, commodities were selected across different trade categories and principal trading partners to evaluate the potential cost impacts on Liberia's major traded goods. The selected commodities include exports of Iron Ores and Concentrates to France, exports of Timber to the Netherlands, imports of Petroleum Products from Côte d'Ivoire, and imports of Food Products & Vegetable Oils from the United States. Exports of Iron Ores and Concentrates, along with imports of crude oil and Food Products & Vegetable Oils, were chosen to represent the mineral and raw materials trade, while exports of Timber were used to represent the agricultural trade. Although these commodities involve multiple trading partners, the selections reflect the highest-volume and highest-value partners, ensuring that the analysis captures the most economically significant trade flows for Liberia.

Having identified the representative commodity flows for Liberia, the next step is to quantify how IMO mid-term measures and operational adjustments, such as vessel speed reductions, may affect trade costs for these critical goods.

3.0 Impact analysis

This section presents the results of modelling the impacts of four proposed mid-term measures, combined with three levels of vessel speed reduction, on the cost of trade for Liberia's two most significant imports and two most significant exports, based on trade volume and economic importance. The analysis distinguishes between cargo-side, vessel-side, and combined cost impacts, providing a comprehensive view of the financial implications for each trade flow. The evaluation spans a spectrum of commodities, from critical minerals essential for manufacturing and construction, to food products and energy resources, thus highlighting the potential economic consequences of shipping decarbonisation measures on Liberia's key trading activities.

3.1 Exports of Iron Ores and Concentrates to France

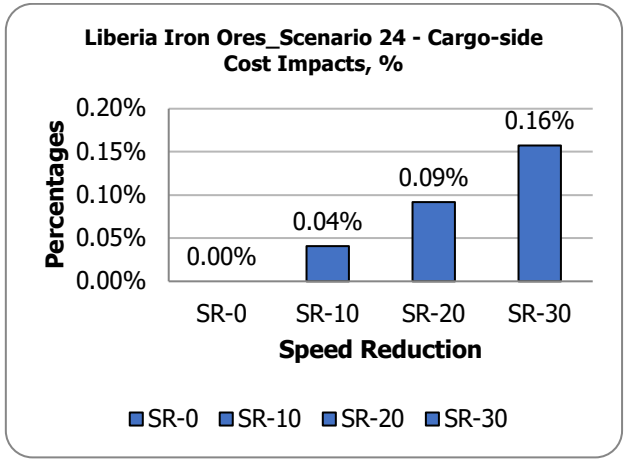
3.1.1 Cargo-side Cost Impact on Exports of Iron Ores and Concentrates

Figure 1 (A–D) illustrates the combined effects of vessel speed reductions and four mid-term policy measures on the export of Iron Ores and Concentrates from Liberia to France. Over a distance of 2,935 nautical miles, a representative bulk carrier operating at 15.5 knots was assumed to facilitate the trade. Under vessel speed reductions of 10%, 20%, and 30%, the carrier's speed decreased to 14.0, 12.4, and 10.9 knots, respectively, corresponding to leg time increases of 80.7, 181.5, and 311.1 hours. Using assumed rates of interest (5%), depreciation (10%), and insurance (2%), the resulting cargo-side cost impacts, calculated independently of the policy scenario, were 0.04%, 0.09%, and 0.16% of cargo value for the respective speed reductions.

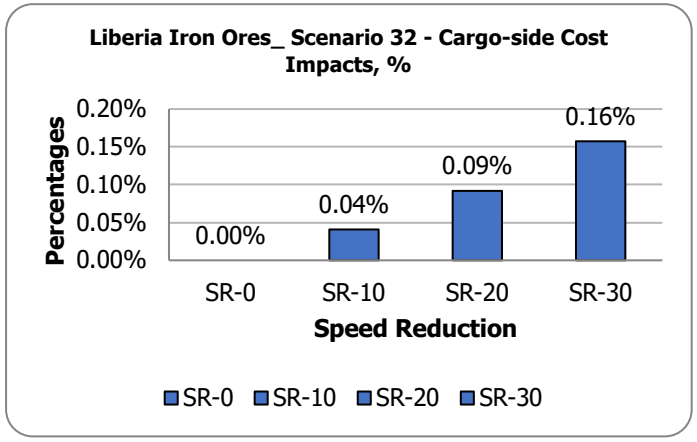
The cargo-side cost model assumes independence from the policy scenario, which is reflected in the identical results obtained across the four policy scenarios: GFI Flex Only (Scenario 24), Low Levy (Scenario 32), High Levy (Scenario 26), and Feebate (Scenario 36). While the percentage increase in costs may appear modest, the significance of iron as a critical mineral for infrastructure development and manufacturing means even small cost changes can have broader economic implications.

Comparatively, analysis of major commodities traded across West African countries indicates that Liberia's iron ore experienced the smallest cost increase. For instance, manganese exports from Ghana saw cost increases ranging from 0.16% to 0.60%, while crude oil exports from Nigeria increased between 0.07% and 0.26%, compared with 0.04% to 0.16% for Liberian iron ore. An important factor influencing these differences is the distance between trading partners, which directly affects vessel operating time and related costs

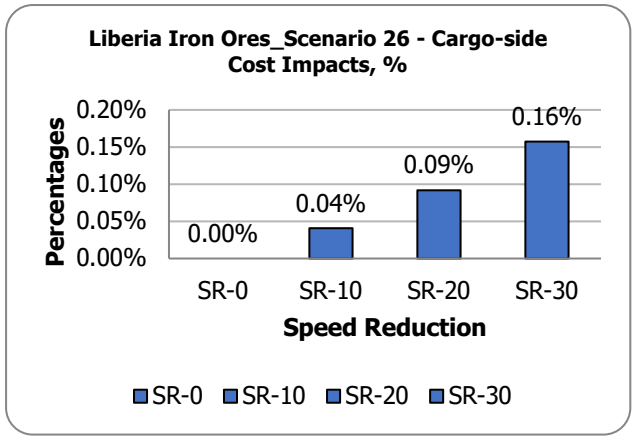
A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)



D. Feebate (Scenario 36)

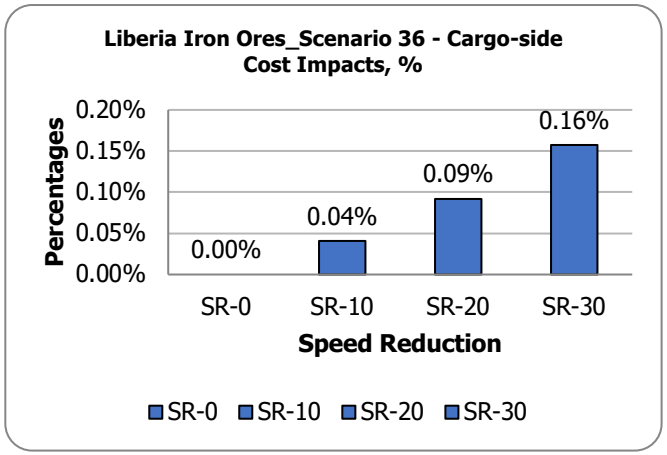


Figure 1: Cargo-side Cost Impact on Exports of Iron Ores and Concentrates to France – by Policy Scenario

3.1.2 Vessel-side Cost Impact on Exports of Iron Ores and Concentrates

Vessel-side costs capture the operational financial impacts of mid-term measures on shipping companies and provide a complementary perspective on trade cost dynamics as outlined in this section.

The results of the vessel-side cost analysis are presented in Figure 2 (A–D). This modelling evaluated changes in operational costs between a business-as-usual scenario and the introduction of alternative mid-term policy measures for Liberia's exports of Iron Ores and Concentrates to France, based on the four previously described scenarios. Unlike cargo-side costs, vessel-side costs were influenced differently across scenarios, reflecting the direct operational impacts of policy interventions on ship operations.

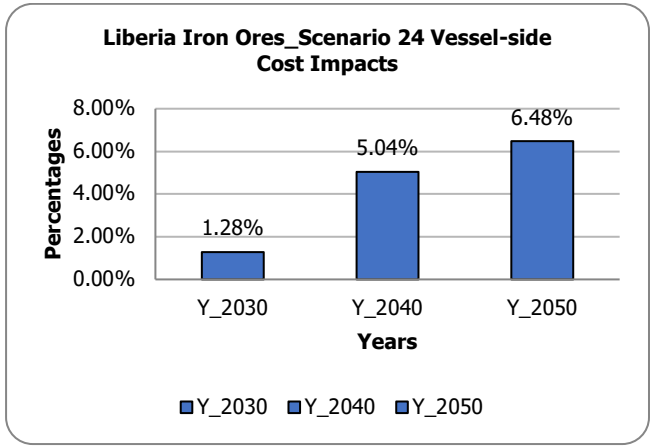
Across the short-term (2030) to long-term (2050), vessel-side impacts ranged from 1.28% under a GFI Flex Only scenario (Scenario 24) in 2030 to 6.56% under a Feebate scenario (Scenario 36) in 2050, representing the maximum projected impact for all scenarios. In the short-term, the highest cost increase is anticipated under the High Levy scenario (Scenario 26), where vessel-side costs are projected to rise by 3.20%. The ranking of short-term impacts follows the pattern: GFI Flex Only (Scenario 24) < Low Levy (Scenario 32) < Feebate (Scenario 36) < High Levy (Scenario 26), suggesting that while the GFI Flex Only scenario may offer modest short-term benefits, it carries higher long-term costs relative to some alternatives.

The analysis indicates a substantial escalation in costs between the short-term (2030) and medium-term (2040) horizons. For example, under Scenario 24, vessel-side costs are projected to increase from 1.28% to 5.04%, representing a fourfold rise. In other scenarios, vessel-side costs approximately doubled over the same period. The High Levy scenario (Scenario 26) demonstrates the highest medium-term impact at 5.68% in 2040. The medium-term ranking is as follows: Low Levy (Scenario 32) < Feebate (Scenario 36) < GFI Flex Only (Scenario 24) < High Levy (Scenario 26), indicating that the Low Levy scenario may be considered relatively benign in the medium term.

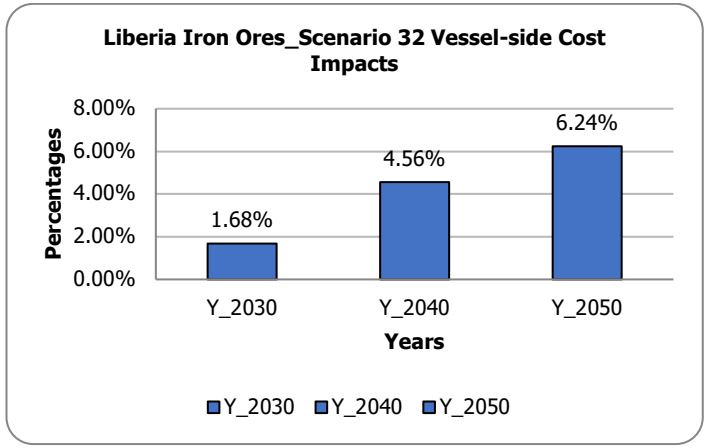
In the long-term (2050), vessel-side cost increases show a narrower range across scenarios, from 6.24% to 6.56%. The ranking is Low Levy (Scenario 32) = High Levy (Scenario 26) < GFI Flex Only (Scenario 24) < Feebate (Scenario 36). Notably, the levy-based scenarios (Scenarios 32 and 26) remain the least impacted in the long term, while the Feebate scenario (Scenario 36) incurs the highest long-term vessel-side cost, in contrast to the High Levy scenario, which had the most significant impact in the short- and medium-term periods.

Overall, a comparison of all four scenarios across short-, medium-, and long-term horizons indicates that the Low Levy scenario (Scenario 32) produces the smallest impacts in the medium term but converges with the High Levy scenario (Scenario 26) by the long term. Given that both levy-based scenarios (Scenarios 32 and 26) exhibit the least long-term vessel-side cost impacts, policymakers may consider adopting one of these approaches. It is important to note, however, that the High Levy scenario may impose higher costs in the short and medium terms before delivering long-term benefits. A comparable trend was observed for the vessel operation costs of crude oil exports from Nigeria and manganese exports from Ghana, suggesting that these patterns may be broadly applicable across key mineral and energy commodities in the region.

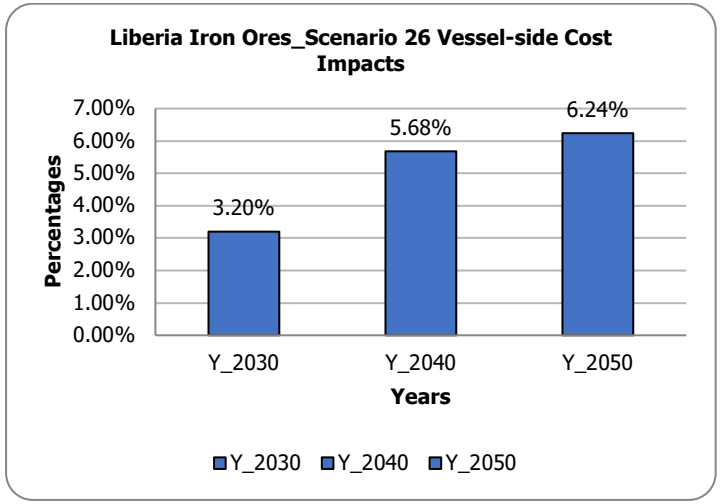
A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)



D. Feebate (Scenario 36)

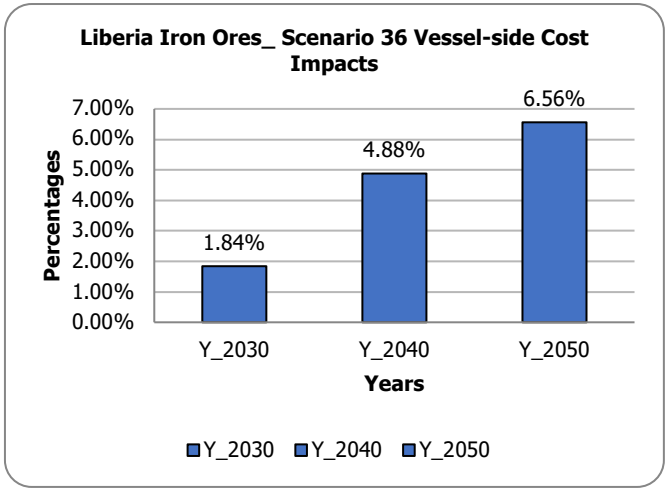


Figure 2: Vessel-side Cost Impact on Exports of Iron Ores to France – by Policy Scenario

3.1.3 Combined Cargo- and Vessel-side Cost Impact on Exports of Iron Ores and Concentrates

By synthesizing the above outlined cargo-side and vessel-side costs analyses, this section evaluates the combined economic impacts of mid-term measures and vessel speed reductions on Liberia's Iron Ores and Concentrates exports.

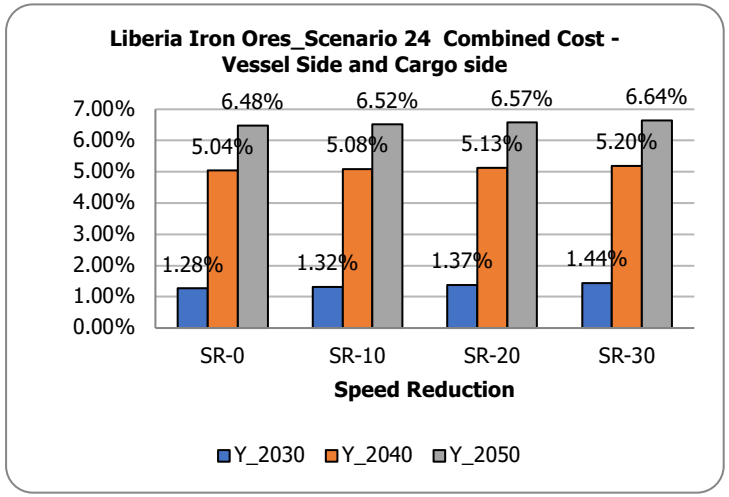
Figures 3 (A–D) present the cumulative impacts of the four policy scenarios (Scenarios 24, 32, 26, and 36) and vessel speed reductions on both cargo-side and vessel-side costs for the export of Iron Ores and Concentrates from Liberia to France. The highest overall cost impacts were observed under the long-term Feebate scenario (Scenario 36), ranging from 6.56% to 6.72%, while the lowest impacts occurred under the short-term GFI Flex Only scenario (Scenario 24), ranging from 1.28% to 1.44%. The maximum combined cost impact of 6.72% was projected for the Feebate scenario in 2050, assuming a 30% vessel speed reduction.

A substantial increase in total costs was observed between the short-term (2030) and medium-term (2040) horizons. Across most scenarios, medium-term cost increases more than doubled those of the short-term, with the exception of the High Levy scenario (Scenario 26), which experienced a smaller relative increase due to its elevated vessel-side cost impact in the medium term. These results suggest that the period between 2030 and 2040 may represent the most challenging years for policy implementation, requiring careful operational adjustments and innovative cost-reduction strategies.

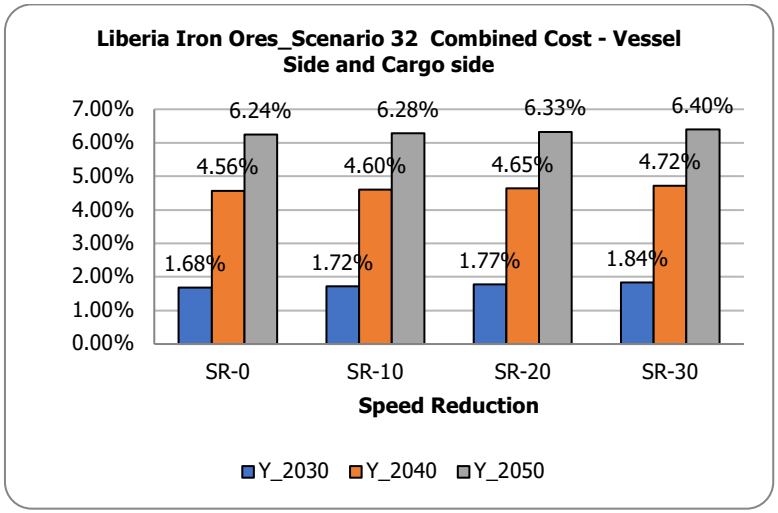
Comparative analysis of the scenarios indicates that the GFI Flex Only scenario (Scenario 24) is the least disruptive in the short term, offering a more business-friendly approach, but its impacts become more pronounced in the medium and long term. The Low Levy scenario (Scenario 32) consistently produces the smallest total cost increases in the medium (2040) and long term (2050), making it an attractive option for adoption. Observed trends of increasing total cost impacts across scenarios were as follows: short-term as 24 < 32 < 36 < 26; medium-term as 32 < 36 < 24 < 26; and long-term as 32 = 26 < 24 < 36, indicating that the levy-based scenarios reach cost equilibrium by 2050.

Although the Low Levy scenario exhibits a slightly higher short-term cost impact (0.40%) compared with GFI Flex Only, its lower medium- and long-term impacts make it the recommended option. The potential adoption of the High Levy scenario (Scenario 26) may depend on policy decisions regarding the allocation of levy-generated revenues to fund innovations aimed at improving vessel efficiency and reducing operational costs.

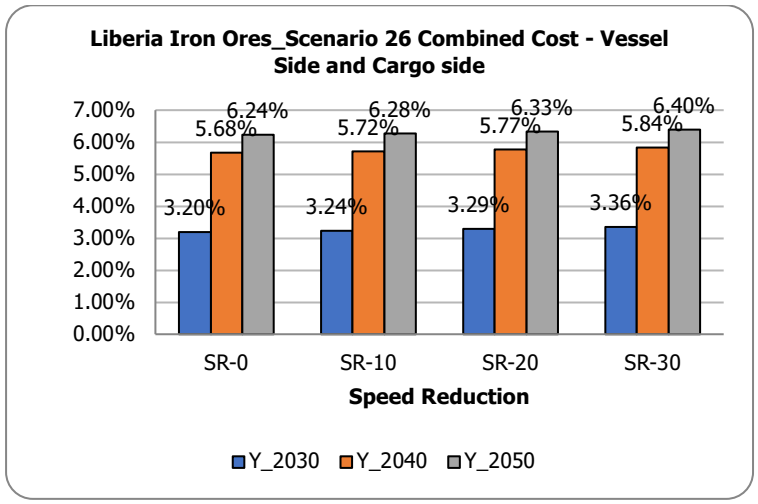
A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)



D. Feebate (Scenario 36)

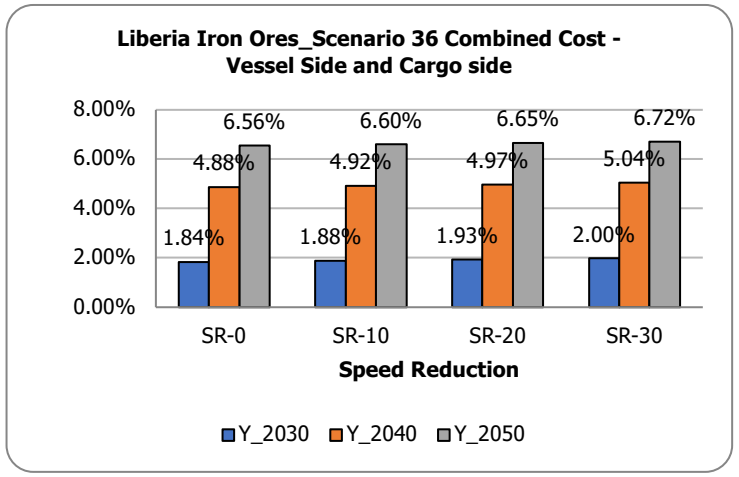


Figure 3: Combined cost impact of the vessel-side and cargo-side on Iron Trades - Four Scenarios Combined

Cargo- and Vessel-side Cost Impact on Exports of Iron Ores and Concentrates to France – by Policy Scenario

3.2 Imports of Petroleum Products from Cote d'Ivoire

3.2.1 Cargo-side Cost Impact on Imports of Petroleum Products

Figure 4 (A–D)'s illustrates the cargo-side economic impacts of vessel speed reductions on Liberia imports of Petroleum Products from Côte d'Ivoire, as part of the assessment of IMO mid-term measures on key import.

Over a distance of 470 nautical miles, a representative tanker operating at 15.5 knots was assumed to facilitate the trade. Under speed reduction scenarios of 10%, 20%, and 30%, vessel speeds decreased to 14.0, 12.4, and 10.9 knots, resulting in leg time increases of 2.2, 4.8, and 8.3 hours, respectively. Incorporating assumed rates of interest (5%), depreciation (10%), and insurance (2%), the corresponding cargo-side cost impacts, when calculated independently of the policy scenario, were 0.007%, 0.015%, and 0.025% of cargo value for the respective speed reductions.

Although these percentage increases are minimal relative to other economic indicators, petroleum products serve as a critical energy source with significant downstream effects on multiple sectors of the economy. Consequently, even small increases in transport costs could have broader implications for energy pricing, production costs, and overall economic activity, highlighting the need to interpret these results within the wider economic context.

3.2.2 Vessel-side Cost Impact on Imports of Petroleum Products

Complementing the cargo-side assessment, this section presents the evaluation of vessel-side costs for Liberia's petroleum imports, which capture the operational financial impacts of mid-term measures on shipping activities.

Figures 5 (A–D) present the vessel-side cost impacts of the proposed policy interventions on imports of Petroleum Products from Côte d'Ivoire into Liberia. The results demonstrate that vessel-side cost increases vary across the four policy scenarios. This pattern is consistent with the trends observed for Liberia's Iron Ores exports discussed in Section 3.1.2. In the short-term (2030), the highest cost impact is projected under the High Levy scenario (Scenario 26), with an estimated increase of 3.84%, substantially higher than the alternative scenarios, which range between 1.54% and 2.21%. The lowest short-term impact is observed under the GFI Flex Only scenario (Scenario 24).

Overall, the Low Levy scenario (Scenario 32) emerges as the preferred option for medium- and long-term planning, as it produces the lowest projected increases in 2040 and 2050. Notably, the High Levy scenario reaches long-term cost equilibrium with the Low Levy scenario (both at 7.49%

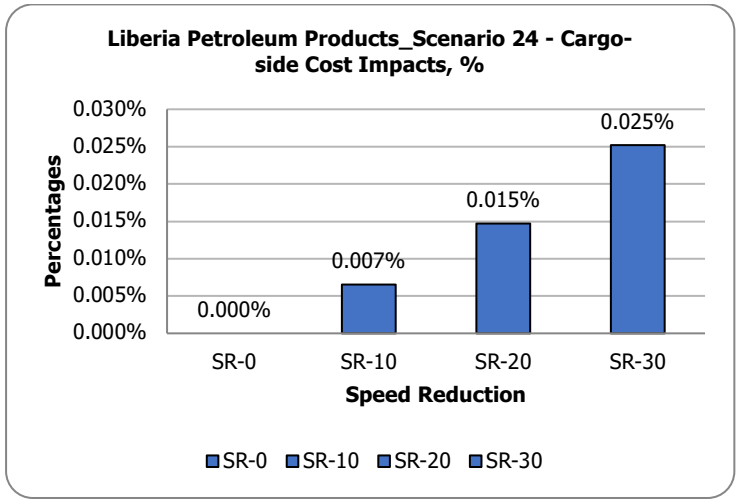
increase), suggesting that it could also be considered viable, provided that revenues generated in the short- and medium-term are strategically applied to incentivize innovative operational improvements and efficiency gains in vessel operations.

3.2.3 Combined Cargo- and Vessel-side Cost Impact on Imports of Petroleum Products

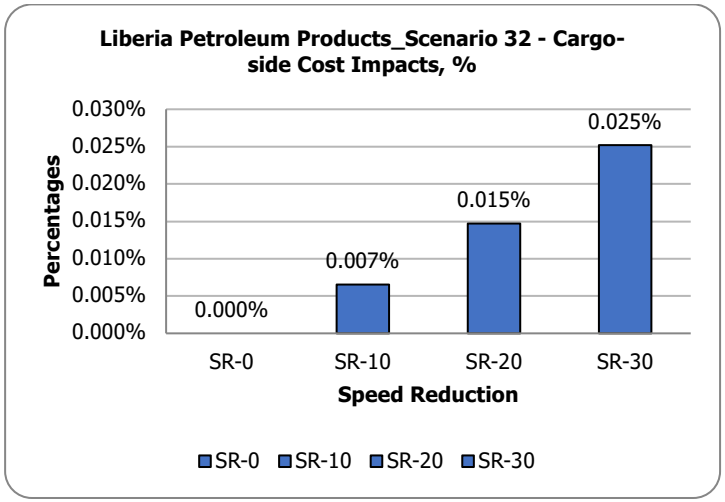
Figures 6 (A–D) illustrate the cumulative impacts of vessel- and cargo-side costs on Liberia's imports of Petroleum Products under the four modelled policy scenarios (Scenarios 24, 32, 26, and 36). The highest combined cost impact, 7.90%, was observed under the Feebate scenario (Scenario 36) in 2050, assuming a 30% vessel speed reduction, indicating that this scenario produces the greatest long-term financial burden.

Comparatively, the Feebate scenario (Scenario 36), followed by the GFI Flex Only scenario (Scenario 24), consistently shows the largest increases across all long-term projections. In contrast, the levy-based scenarios (Scenarios 26 and 32) yield the smallest long-term cost increases. This suggests that, despite potential short- and medium-term cost burdens, the Low and High Levy scenarios may represent the most business-friendly options over the long term, as they minimize cumulative financial impacts. These patterns closely mirror the results observed for Liberia's Iron Ores and concentrates exports, indicating that the proposed interventions are likely to influence both the energy and mineral sectors in similar ways, with implications for operational planning and policy prioritization.

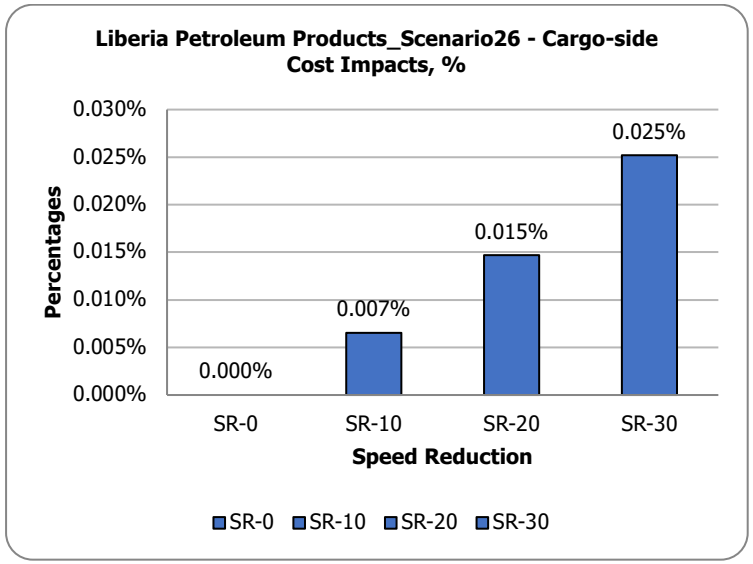
A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)



D. Feebate (Scenario 36)

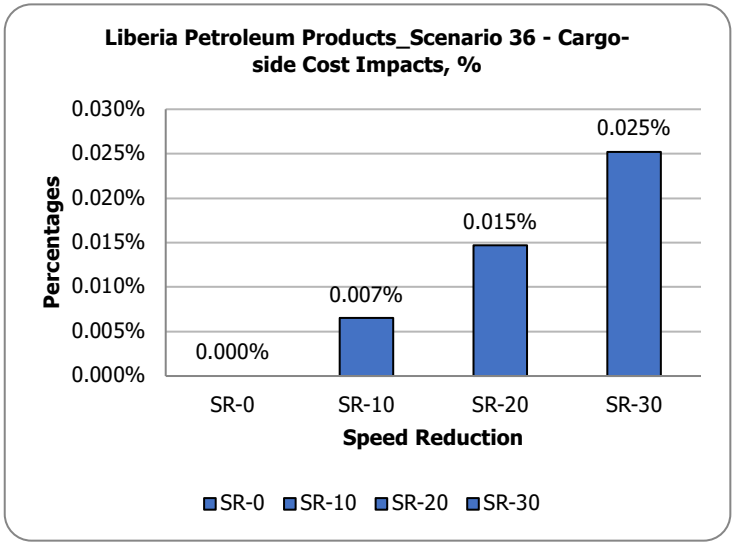
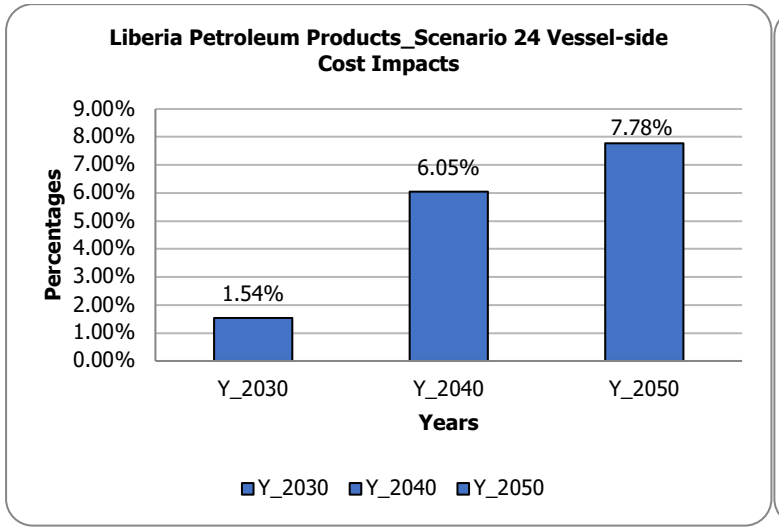
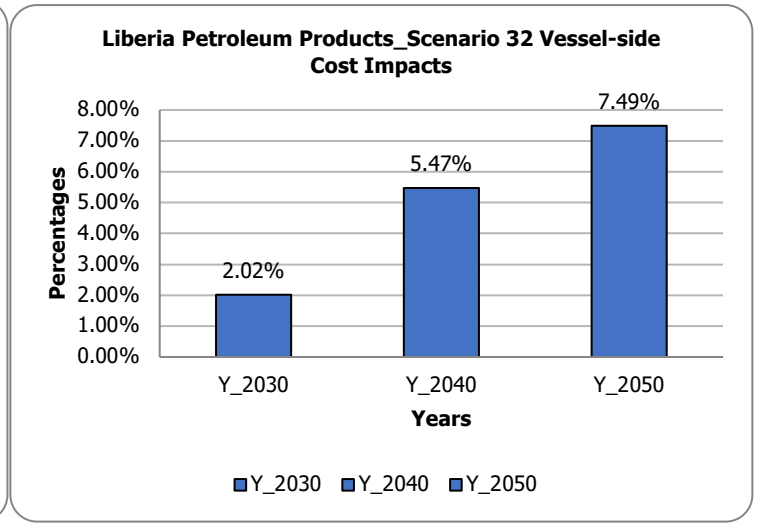


Figure 4: Cargo-side Cost Impact on Imports of Petroleum Products from Cote d'Ivoire – by Policy Scenario

A. GFI Flex Only (Scenario 24)

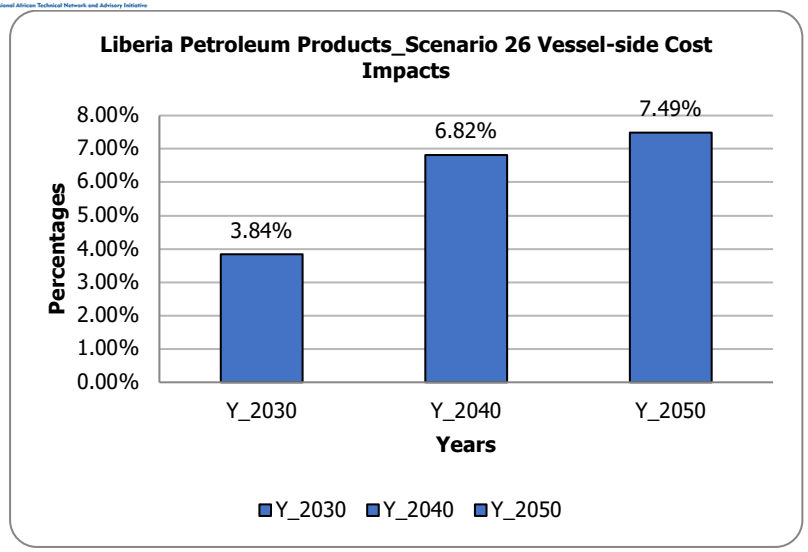


B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)

D. Feebate (Scenario 36)



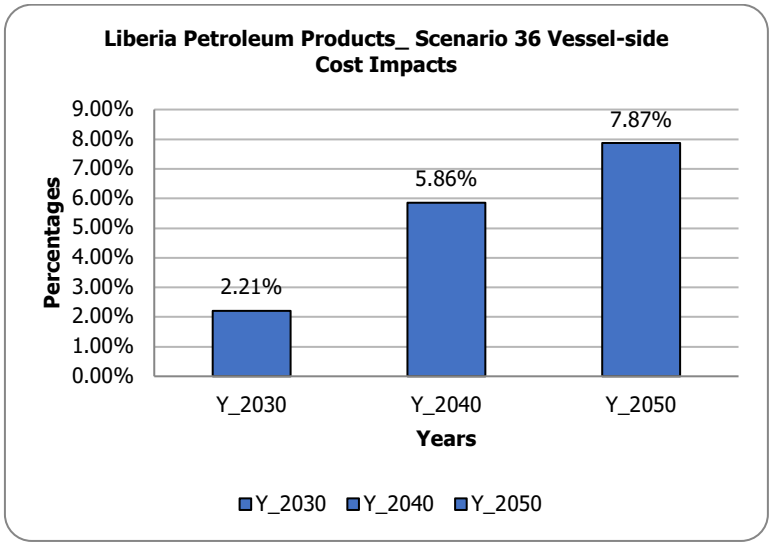
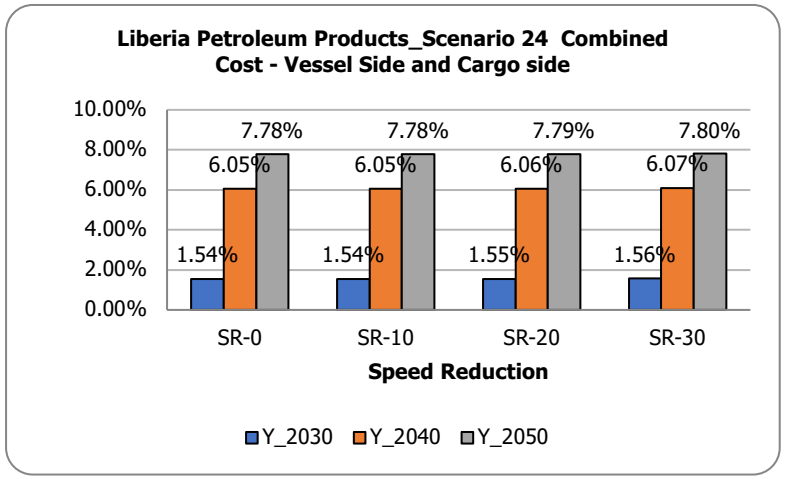
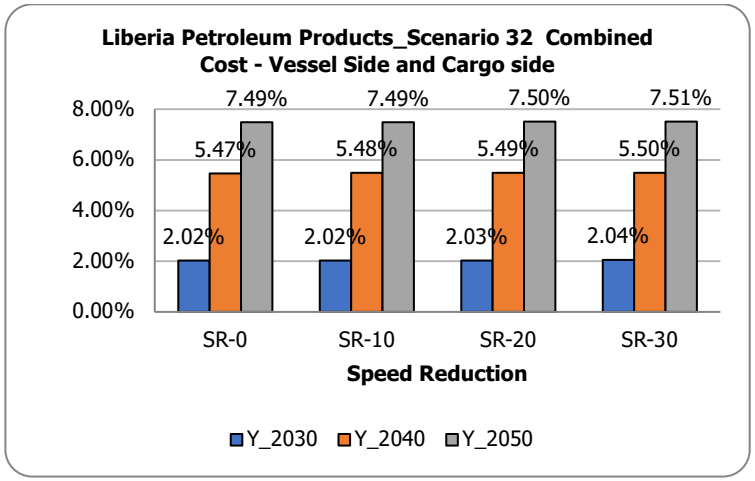


Figure 5: Vessel-side Cost Impact on Imports of Petroleum Products from Cote d'Ivoire – by Policy Scenario

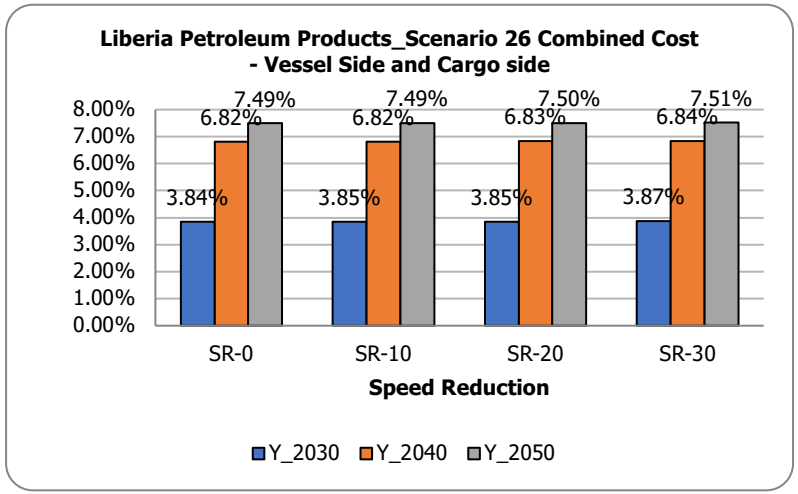
A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)



D. Feebate (Scenario 36)

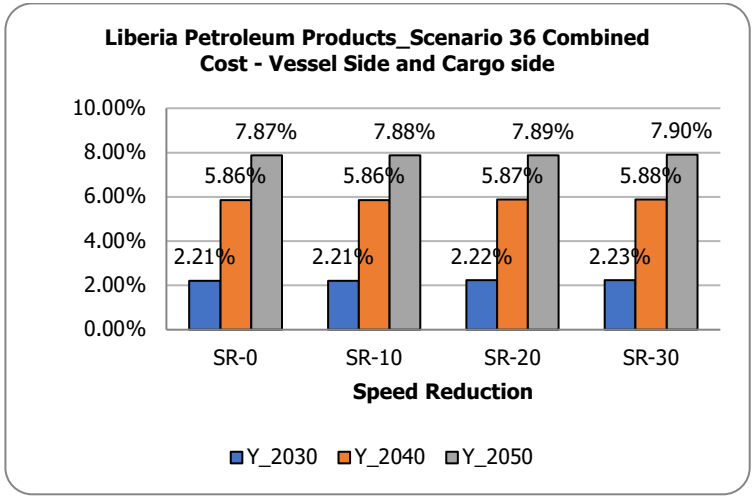


Figure 6: Combined Cargo- and Vessel-side Cost Impact on Imports of Petroleum Products from Cote d'Ivoire – by Policy Scenario

3.3 Exports of Timber to the Netherlands

Having examined Liberia's critical mineral exports and energy-related imports, the analysis now shifts to other key sectors of the Liberian economy, including agricultural exports and food imports, to capture the broader economic implications of the proposed policy interventions. The first two analyses presented in Sections 3.1 and 3.2 focused on critical minerals and raw material exports essential for infrastructure and manufacturing, as well as energy-related imports, selected to represent the highest-volume trade flows in Liberia's economy. Sections 3.3 and 3.4 expand the scope to additional strategically important commodities. Section 3.3 examines the export of Timber from Liberia to the Netherlands, highlighting its role as an agricultural-based raw material contributing to manufacturing, infrastructure, and housing development. Section 3.4 focuses on food and agricultural imports, specifically Food Products and Vegetable Oils from the United States, which are critical to national food security and broader economic stability.

3.3.1 Cargo-side Cost Impact on Exports of Timber

Figure 7 (A–D) illustrates the economic impact of the proposed interventions on the cargo-side costs of Timber exports from Liberia to the Netherlands. The trade covers a distance of 3,292 nautical miles, with a representative general cargo vessel operating at 15.5 knots. Vessel speed reductions of 10%, 20%, and 30% were applied, consistent with the scenarios used for other commodities in this study. Timber depreciation was assumed to be 20%, reflecting its intermediate shelf-life relative to more perishable agricultural goods. Under these assumptions, cargo-side cost impacts were estimated at 0.07%, 0.16%, and 0.28% for the respective speed reduction scenarios, independent of the policy scenario applied.

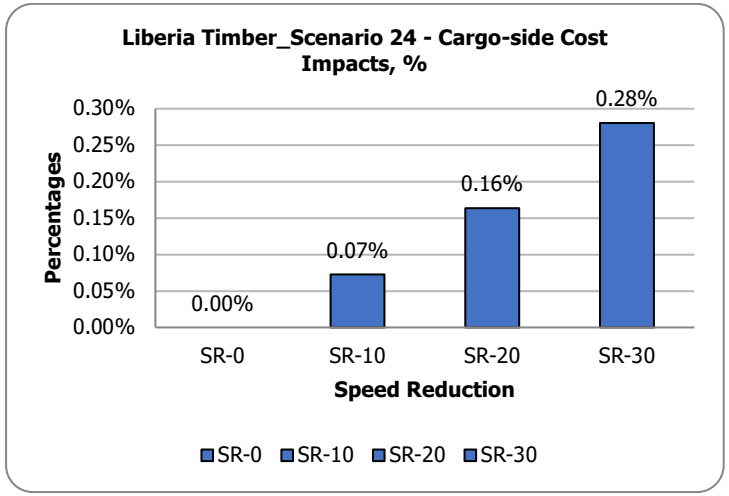
The results indicate that cargo-side costs could increase to 0.28% under the maximum 30% speed reduction scenario. This increase is comparable to the cargo-side cost impact of crude oil exports from Nigeria, which rose between 0.07% and 0.26%, despite Timber's higher depreciation rate. Notably, the Timber cargo cost increases are substantially higher than those for petroleum product imports (0.007%–0.025%), highlighting the potential for higher export costs to influence trade balances. Elevated speed reduction rates may also pose value retention risks for Timber, similar to other agricultural commodities, although the deterioration rate for Timber is slower than for perishable food products. These findings underscore the need for careful operational planning and risk management to mitigate potential negative trade effects arising from increased cargo-side costs.

3.3.2 Vessel-side Cost Impact on Exports of Timber

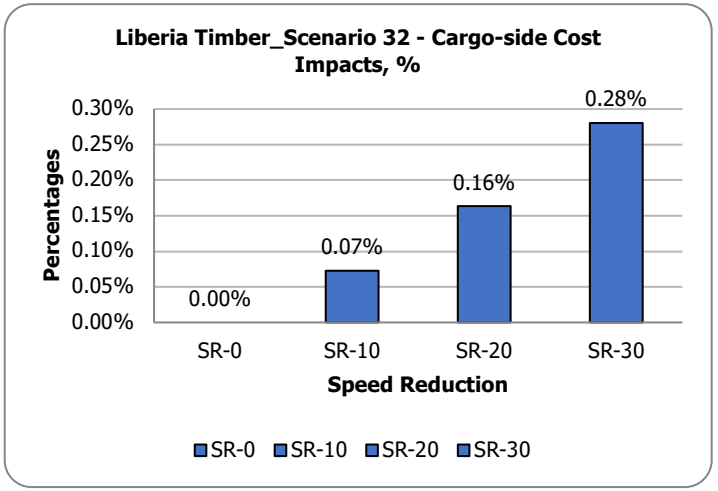
Figures 8 (A–D) present the vessel-side cost impacts of the four possible policy scenarios for Timber exports from Liberia to the Netherlands. Total vessel-side cost increases for 2030, 2040, and 2050 are projected to range from 2.13% to 10.91%. The lowest increase, 2.13%, occurs under the GFI Flex Only scenario (Scenario 24) in the short term, while the highest increase, 10.91%, is associated with the Feebate scenario (Scenario 36) in the long term. In general, cost increases were more pronounced between the short-term and medium-term periods than between medium-term and long-term horizons, a trend consistent with other commodities modelled in this study.

Notably, the percentage impacts for the levy scenarios (Scenarios 26 and 32) converge in the long term (2050), reflecting cost equilibrium over extended planning horizons. Overall, these vessel-side trends mirror those observed for other Liberian exports and imports, suggesting that the Low and High Levy scenarios may be more favorable over the long term, whereas the GFI Flex Only scenario remains the least disruptive in the short term. These findings provide critical insight for policymakers when considering operational cost implications and the strategic adoption of IMO mid-term measures for agricultural exports.

A. GFI Flex Only (Scenario 24)

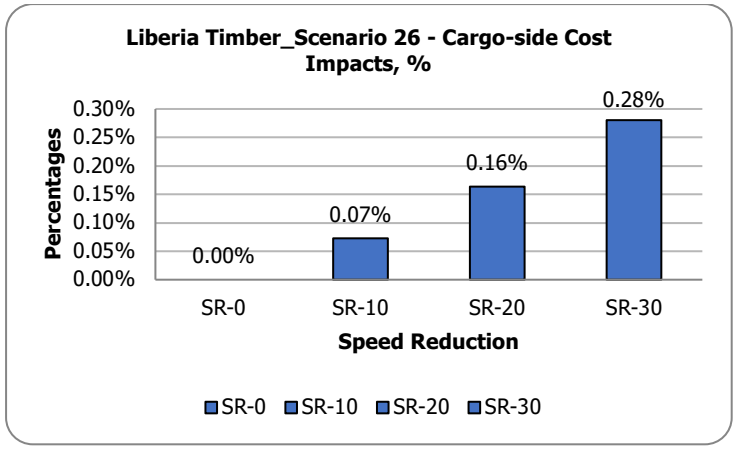


B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)

D. Feebate (Scenario 36)



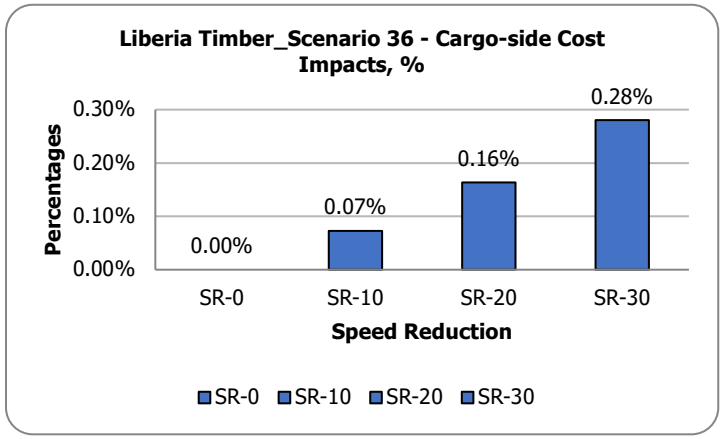
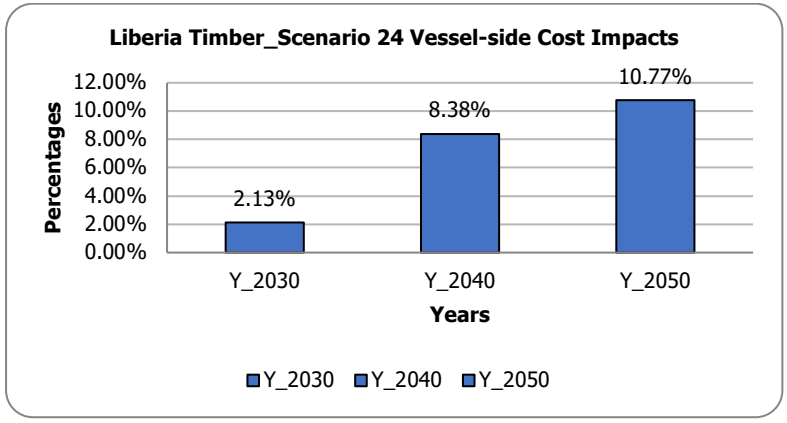
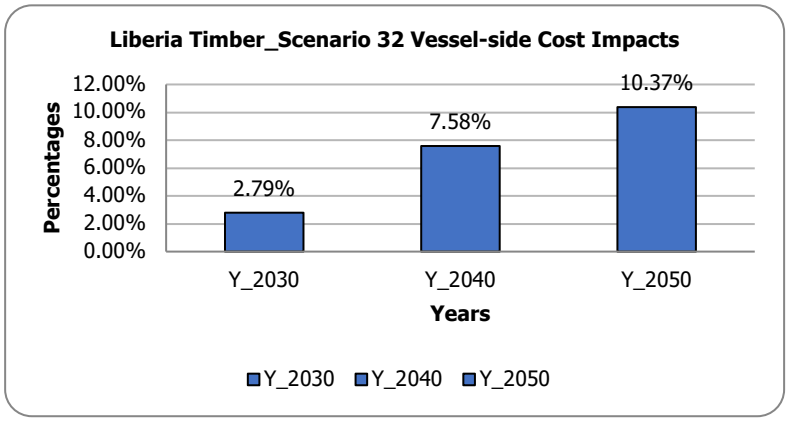


Figure 7: Cargo-side Cost Impact on Exports of Timber to the Netherlands – by Policy Scenario

A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)

D. Feebate (Scenario 36)

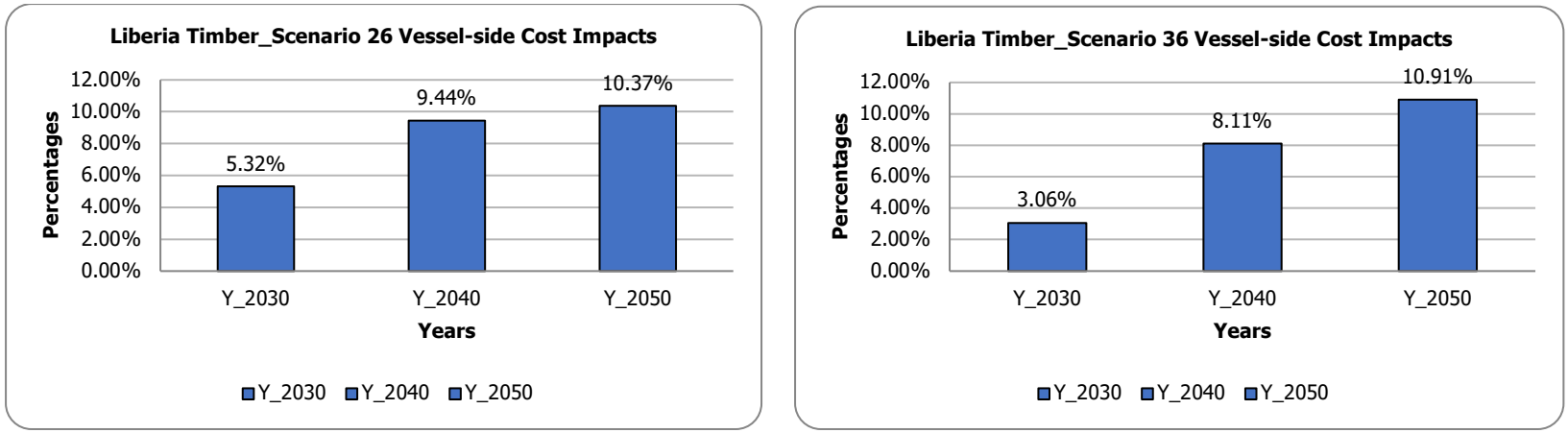


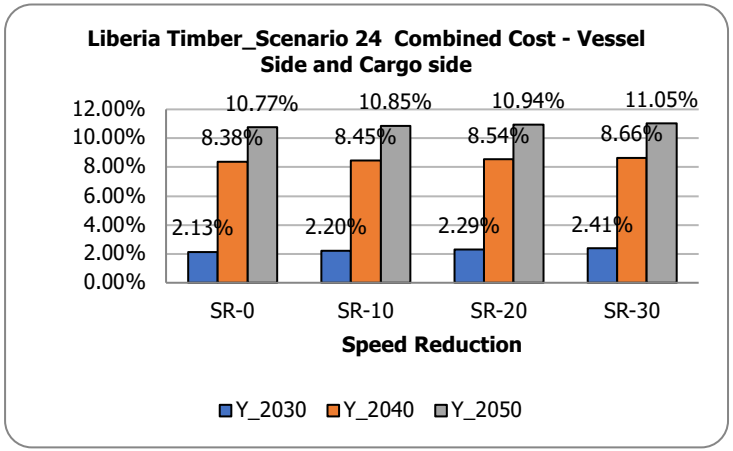
Figure 8: Vessel-side Cost Impact on Exports of Timber to the Netherlands – by Policy Scenario

3.3.3 Combined Cargo- and Vessel-side Cost Impact on Exports of Timber

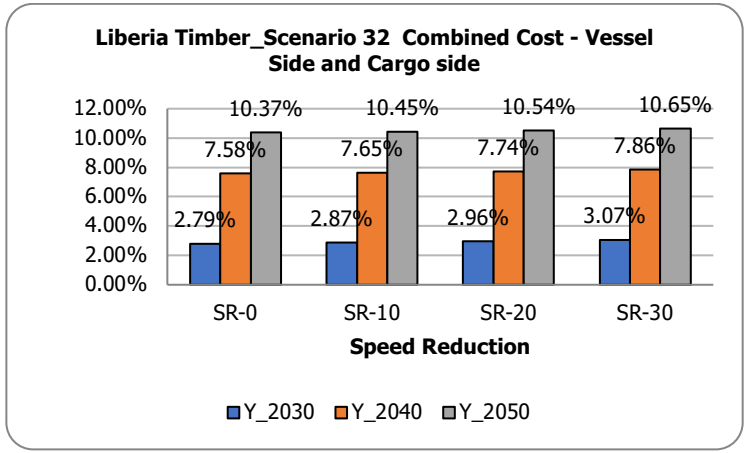
The combined vessel- and cargo-side costs impact model results from the exports of Timber from Liberia to the Netherlands is presented in Figures 9(A-D). Overall, total impacts are expected to range from 2.13% to 11.19%. The least cost increase in the short term (2030) was observed in GFI Flex Only scenario (Scenario 24, 2.13%). The highest long-term impact was associated with the Feebate scenario (Scenario 36; 11.19%). The contribution of cargo-side cost impact was found to be minimal across all these four scenarios. This was noticed across all 4 scenarios and it may be attributed to the independence of the cargo-side cost projections, as previously mentioned and may imply that cost cutting innovations that focus on cost effective vessels' operation may be the needed interventions that research and development investment must be made on.

The High Levy scenario (Scenario 26) is expected to lead to the most impact in the short and medium-terms (5.32 – 5.60% and 9.44 – 9.72% respectively). The two levy scenarios High Levy (Scenario 26) and Low Levy scenario (Scenarios 32) were projected to have the same long term (2050) cost increases (10.32 – 10.65%) which are lower than the other two: the GFI Flex Only (Scenario 24) and the Feebate scenarios (Scenarios 36). Since Timbers are not in high demand, daily needed existential products like food and petroleum products, it may be considered that any of the levy options be adopted. Though comparatively, the Low Levy (Scenario 32) remains the most cost-friendly option in the medium- and long-term, as observed with alternative commodity results. Considering the benefits of the longer term equilibrium of high levy, and the minimal sacrifices of timber not being a recurrently daily demanded commodity with the higher short and medium-term impacts, the High Levy (Scenario 26) may be recommended. The consideration of adopting different scenarios for different classes of commodities based on the combination of their daily demands and how essential they are for immediate human existence is proposed.

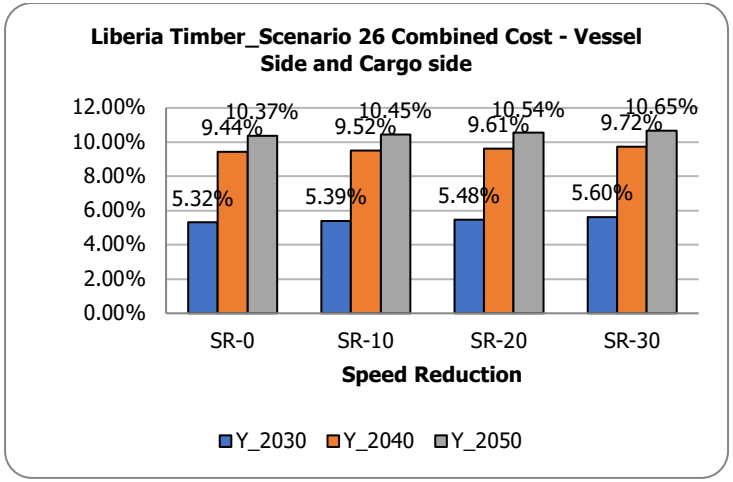
A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)



D. Feebate (Scenario 36)

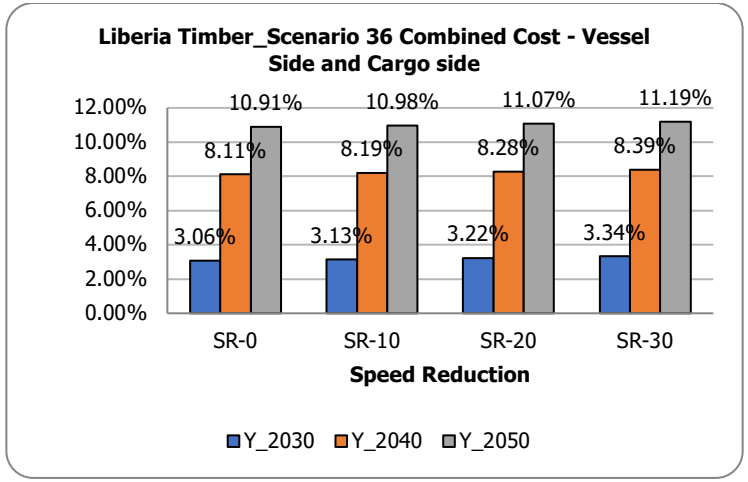


Figure 9: Combined Cargo- and Vessel-side Cost Impact on Exports of Timber to the Netherlands – by Policy Scenario

3.4 Imports of Food Products & Vegetable Oil from Cote d'Ivoire

The choice of Food Products & Vegetable Oil in this section of the case study is both to model the impact of various scenarios of mid-term measures on the import of manufactured goods and also to look at the potential impact on Food Security, since Food Products & Vegetable Oil play remarkable role in the survival of people and are high volume daily demanded commodities.

3.4.1 Cargo-side Cost Impact on Imports of Food Products & Vegetable Oil

Figure 10 (A - D) illustrates the economic effects of vessel speed reduction on imports of Food Products & Vegetable Oil from USA to Liberia. Across a distance of 4784 nm, a representative bulk carrier 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 1.5, 3.4 and 5.9 hours, respectively. Combined with assumptions of 5%, 30% and 2% for the rates of interest, depreciation and insurance costs respectively. The final cargo-side cost impacts associated with each of these three speed reduction scenarios (and independent of the policy scenario) were evaluated to be 0.14%, 0.33% and 0.56%, respectively.

The results of the cargo-side cost modelling, assumed to be independent of the policy scenario considered, indicate that the cargo-side cost increases associated with imports of Food Products & Vegetable Oil from USA are the highest and the most impacted across the four commodities modelled. This is attributable to higher depreciation rates, and long-distance trade partnerships. High impact of the intervention on food raises concern of the impact of the mid-term measure on food security and prices, which may be considered an existential concern. The transition will only be just and equitable when measures are made to address these concerns of food security and other related matters.

3.4.2 Vessel-side Cost Impact on Imports of Food Products & Vegetable Oil

The vessel-side modelling results associated with imports of Food Products & Vegetable Oil are presented in Figures 11(A-D). The results follow a similar trend with the other commodities in this study. The results revealed Food Products & Vegetable Oil's vessel cost for importation will increase with an overall range of 1.09 – 5.58% depending on the scenarios. The vessel side cost increase of Food Products & Vegetable Oil trade comparable to trends across different scenarios are the same as for the other commodities reported above. The high vessel-side cost increase may be a disincentive to the adoption of these interventions, despite the minimal cargo-side cost increase. Increase in the cost of food and energy may have profound impact because these are recurring daily need products and a major need for human existence when compared to other commodities. Therefore, the Low Levy scenario (Scenario 32) which has the least medium and long-term vessel-

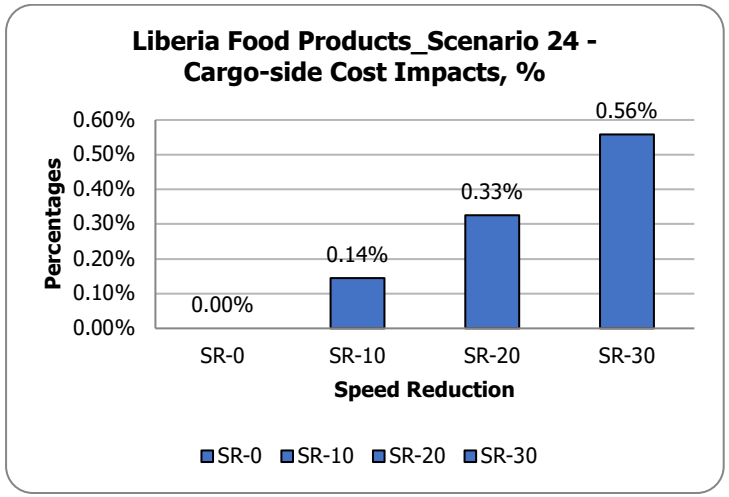
side cost impacts is most preferred, suggesting it offers the most cost sympathetic scenario. This impact study is also pointing out the need to consider policy adoption that is not a "one policy-size fit all" but use different scenarios for class of commodities based on the HS 10 coding system to reduce the effect of the midterm measures on food and energy.

3.4.3 Combined Cargo- and Vessel-side Cost Impact on Imports of Food Products & Vegetable Oil

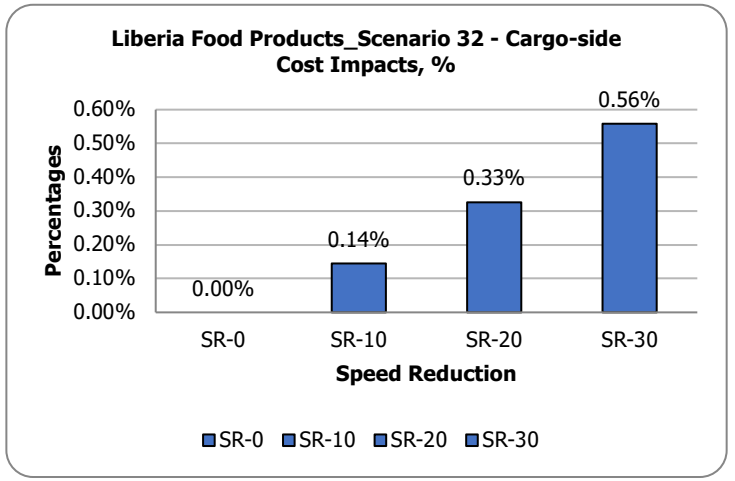
The results presented in Figures labelled 12(A-D) represent the combination of cargo- and vessel-side costs associated with the importation of Food Products & Vegetable Oil from USA to Liberia. The variations across the three speed reductions are negligible because the total increases are more dependent on the vessel-side increase than the cargo-side increase. The observations presented in Section 3.4.2 are therefore valid with respect to the total cost increase. The High Levy (Scenario 26), with the highest short- and medium-term impacts, will not be economically friendly to adopt or may promote hunger. The Feebate scenario (Scenario 36) will also be unsuitable due to its long-term impact being the greatest across all scenarios considered. The choice is therefore between the GFI Flex Only scenario (Scenario 24) and the Low Levy scenario (Scenario 32).

Though the cargo-side cost impact on Food Products & Vegetable Oil obtained in this model's result is moderate and may be considered acceptable, the increase from the vessel-side cost will be translated to the total cost of the commodities and suggests that substantial economic impacts can be expected for imports of Food Products & Vegetable Oil from USA. Furthermore, a resulting social implication connects to these economic impacts due to the food-related nature of the commodities. Increased Food Products & Vegetable Oil costs may negatively impact on quality of life, health of the people, therefore subsidisation for expected increases to Food Products & Vegetable Oil import costs is recommended. This may provide an incentive for policymakers to adopt/vote for the GFI Flex Only or Low Levy scenarios whilst simultaneously making in-country stakeholders better placed to embrace such measures.

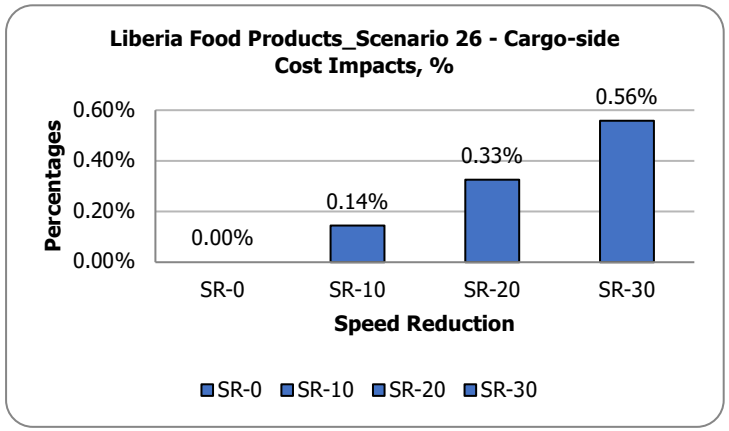
A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)



D. Feebate (Scenario 36)

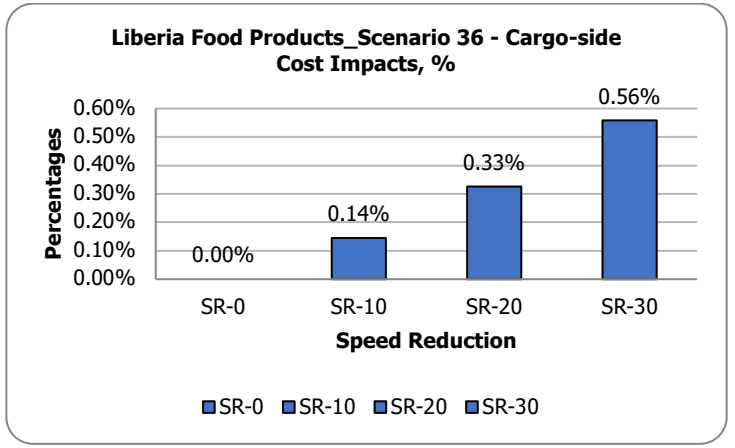
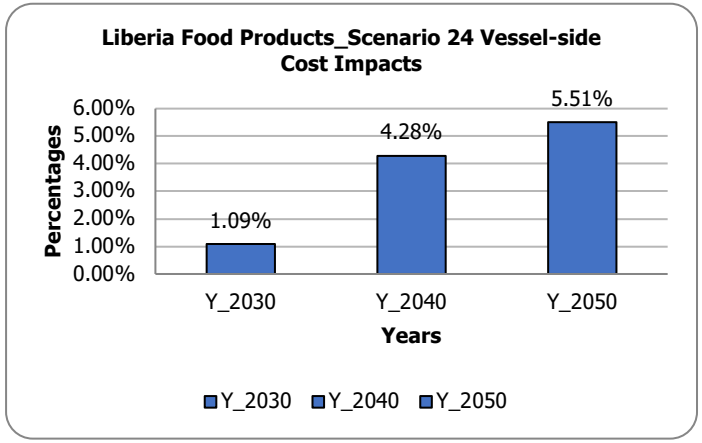
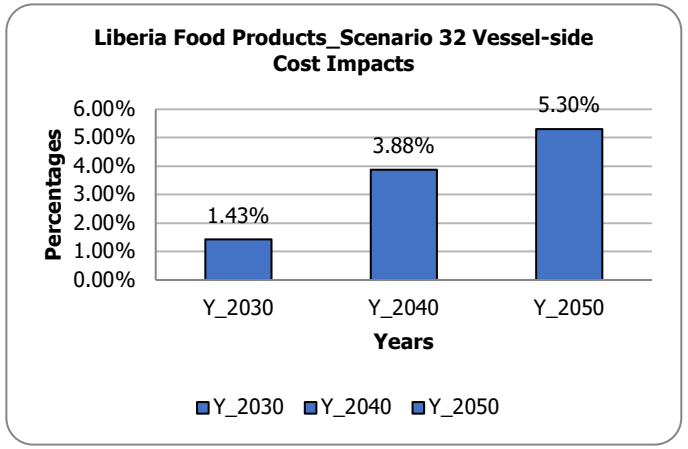


Figure 10: Cargo-side Cost Impact on Imports of Food Products & Vegetable Oil from Cote d'Ivoire – by Policy Scenario

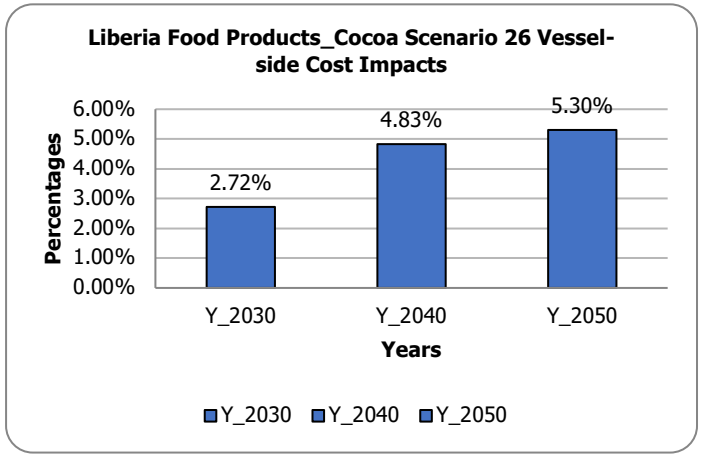
A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)



D. Feebate (Scenario 36)

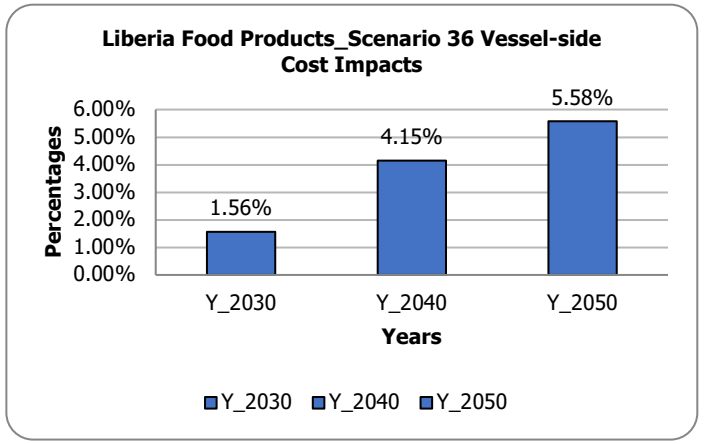
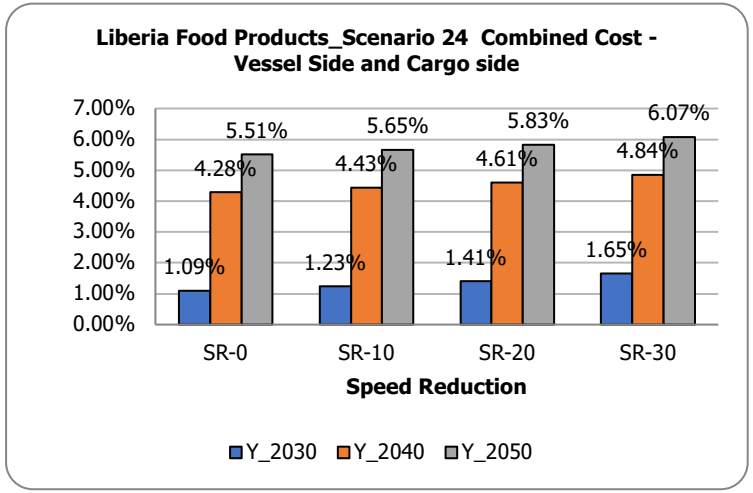
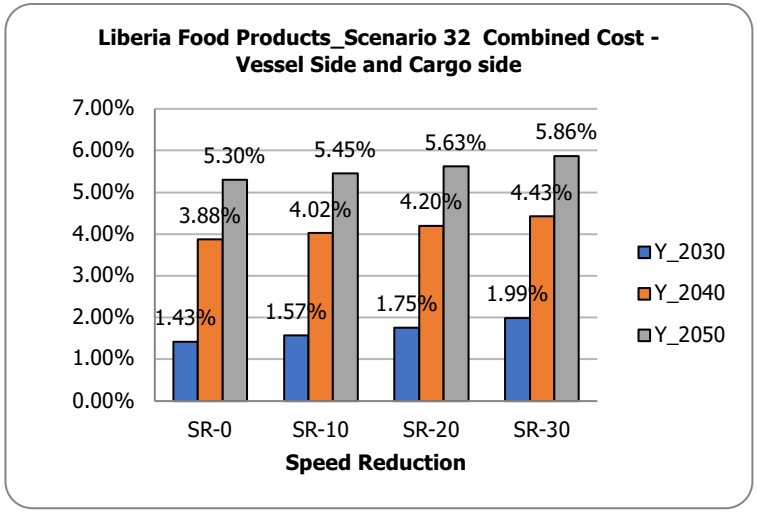


Figure 11: Vessel-side Cost Impact on Imports of Food Products & Vegetable Oil from Cote d'Ivoire – by Policy Scenario

A. GFI Flex Only (Scenario 24)



B. Low Levy (Scenario 32)



C. High Levy (Scenario 26)

D. Feebate (Scenario 36)

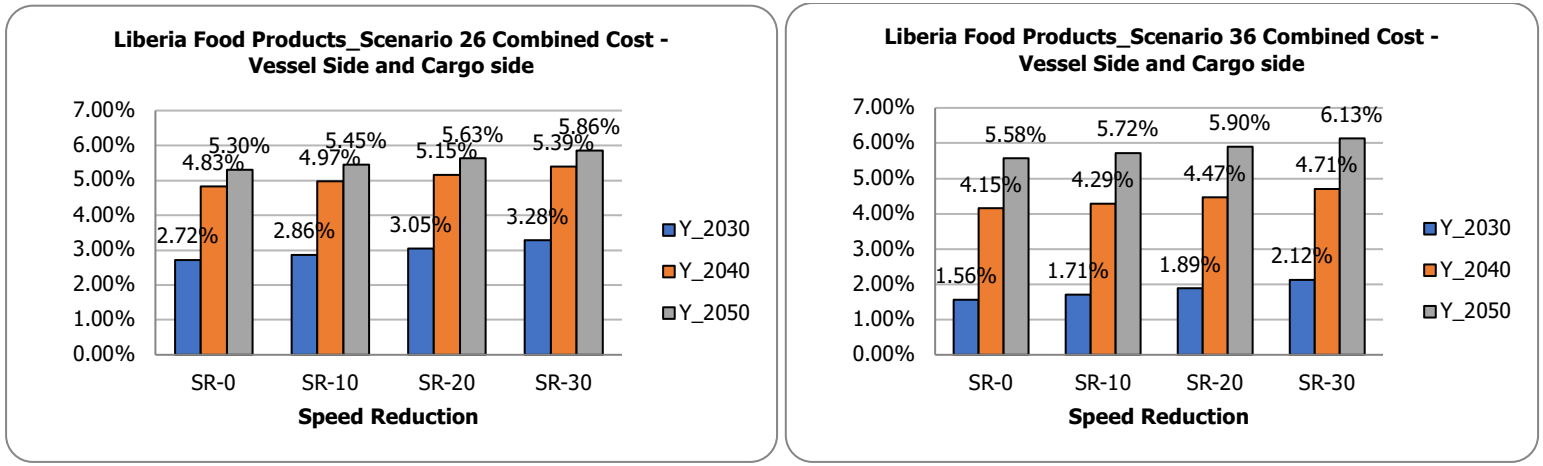


Figure 12: Combined Cargo- and Vessel-side Cost Impact on Imports of Food Products & Vegetable Oil from Cote d'Ivoire – by Policy Scenario

4.0 Potential Implications for Liberia's Trade

Liberia's trade system is highly exposed to variations in shipping costs arising from the IMO's mid-term GHG reduction measures. Analysis of the four policy scenarios: GFI Flex Only (Scenario 24), High Levy (Scenario 26), Low Levy (Scenario 32), and Feebate (Scenario 36), reveals that while cargo-side cost increases remain relatively modest (well below 0.05% in the short term and under 1% in the long term), vessel-side costs impose significant upward pressure on both imports and exports over extended time horizons. These dynamics create systemic vulnerabilities with tangible implications for trade competitiveness, energy affordability, food pricing, and overall macroeconomic and socio-economic stability, underscoring the importance of carefully designed policy interventions and complementary operational strategies.

Exports

The export sector exhibits steadily rising cost pressures over time. For Iron Ore, shipping costs increase from 1.28% in the short term to 6.72% in the long term, depending on the policy scenario. While these increases are manageable initially, they have the potential to weaken Liberia's competitiveness, particularly given the scale of its iron ore trade and the highly competitive nature of global markets. Over the long term, higher-cost scenarios, such as Scenario 24 (6.64%) and Scenario 36 (6.40%), may erode Liberia's position relative to lower-cost producers.

Timber exports are even more sensitive to these dynamics. Cargo- and vessel-side costs rise from 2.41% under Scenario 24 in the short term to as high as 11.19% under Scenario 36 in the long term. Even under the comparatively favourable Low Levy scenario (Scenario 32), vessel-side costs reach 7.86% in the medium term and 10.65% in the long term. Persistent cost increases of this magnitude threaten the competitiveness of Liberian timber in global markets, particularly as importing regions implement stricter environmental standards. Unless exporters can absorb these additional costs, access targeted state support, or leverage operational efficiencies and green certification schemes (Fang Wang et al., 2018), the risk of market share erosion is significant. This vulnerability is further amplified by emerging carbon-related trade measures, such as the European Union's Carbon Border Adjustment Mechanism (CBAM), which is especially relevant for Liberia's timber exports to the Netherlands. The combined effects of elevated shipping costs and carbon-related trade barriers could substantially constrain Liberia's long-term participation in international timber markets.

Imports

Liberia's reliance on imported petroleum constitutes a significant structural vulnerability. Petroleum imports are projected to experience cost increases of 1.56% in the short term, rising to nearly 7.9% in the long term under the modeled scenarios. Given petroleum's central role in Liberia's energy mix, industrial processes, and transport sector, these increases are likely to transmit throughout the economy, driving higher consumer prices, rising transport costs, and sustained inflationary pressures. Imports from Côte d'Ivoire are less exposed to long-haul shipping cost escalations due to the coastal nature of this trade, but they remain sensitive to broader shifts in shipping costs and global fuel price dynamics, particularly given that petroleum products accounted for approximately 17.3% of Liberia's imports in 2023 (OEC, n.d.). The absence of domestic refining capacity or large-scale alternative energy sources further amplifies Liberia's exposure to external cost shocks, especially for long-haul imports from markets such as China.

Food products and vegetable oil imports similarly exhibit significant cost pressures, with shipping costs rising from 1.65% in the short term to 6.13% in the long term. These increases carry acute social risks, as over 81% of Liberia's population experiences moderate or severe food insecurity, and 93% cannot afford a healthy diet (FAO, 2022). Reliance on imported staples means that even modest increases in shipping costs may trigger inflationary shocks, with disproportionately adverse effects on vulnerable populations.

Overall, Liberia's trade profile highlights heightened exposure to combined cargo- and vessel-side cost increases, with timber exports and petroleum imports emerging as the most at-risk sectors. Trade distance, particularly for agricultural commodities such as food products, vegetable oil, and timber, is a key determinant of exposure, irrespective of policy scenario options. While short-term cost impacts may remain manageable, medium- and long-term projections reveal deeper structural challenges for trade competitiveness and macroeconomic stability. Of particular concern is the escalation of food import costs, which could exacerbate existing food insecurity. Without compensatory measures, whether through targeted international support, domestic policy interventions, or operational efficiency gains, the IMO's decarbonisation measures risk amplifying Liberia's socio-economic vulnerabilities. As a trade-dependent developing economy and a prominent maritime flag state, Liberia is uniquely positioned to leverage its role in international negotiations to secure equitable support and ensure that global decarbonisation efforts do not disproportionately undermine national development objectives

5.0 Conclusion

The Liberia LEAP Task 4 case study demonstrates that the IMO's mid-term GHG reduction measures are likely to progressively drive up trade costs across Liberia's key commodities, with the magnitude and timing of impacts varying according to the specific policy scenario implemented.

These cost pressures manifest along distinct short-, medium-, and long-term trajectories, with significant implications for Liberia's trade competitiveness, macroeconomic stability, and socio-economic resilience. The findings underscore the importance of carefully calibrating policy adoption, incorporating complementary mitigation strategies, and leveraging Liberia's position in international negotiations to ensure that decarbonisation objectives are achieved without disproportionately undermining national development goals.

Short-term Implications

Scenario 24 (GFI Flex Only) produces the lowest short-term cost increases across Liberia's major traded commodities: iron ore (1.44%), timber (2.41%), petroleum products (1.56%), and food products (1.65%). The absence of levy-induced costs or redistributive mechanisms under this scenario allows exporters and importers to maintain relatively competitive pricing in the near term, absorbing much of the financial pressure through internal adjustments or minor price shifts. However, the scenario lacks structural provisions to mitigate long-term exposure, as no revenues are recycled into the economy. As a result, the initial short-term reprieve may be offset by growing vulnerabilities and the need for tighter measures in later periods. By contrast, Scenario 26 (High Levy) imposes the highest immediate cost burdens, with only partial mitigation from redistributive mechanisms, leaving Liberia relatively disadvantaged in the short term under this policy pathway.

Medium-term Implications

In the medium term, Scenario 32 (Low Levy) emerges as the most favourable pathway for Liberia, as levy revenues provide opportunities for targeted reinvestment. Under this scenario, cost increases are comparatively modest: iron ore (4.72%), timber (7.86%), petroleum (5.50%), and food products (4.43%). These redistributive flows could be strategically deployed to alleviate food insecurity, buffer inflationary pressures from petroleum and food imports, and finance improvements in port efficiency, bunkering infrastructure, and vessel retrofits. Liberia's status as one of the world's largest flag registries further enhances the potential for reinvestment in maritime capacity building, fostering new sources of competitiveness in shipping services. In contrast, Scenario 26 (High Levy) continues to impose the highest costs during this period, maintaining the trajectory of short-term financial pressure observed under this policy pathway.

Long-term Implications

By the long term, structural cost pressures become increasingly pronounced across Liberia's key commodities. Timber exports are the most affected, with cumulative cost increases reaching 10.65% under Scenarios 24 (GFI Flex Only) and 32 (Low Levy), and 11.19% under Scenario 36 (Feebate). Petroleum imports similarly rise, ranging from 7.51% under Scenarios 24 and 32 to

7.9% under Scenario 36. Levy-based frameworks (Scenarios 26 and 32) ultimately impose the lowest long-term cost burdens, as revenues can be strategically reinvested in net-zero enabling activities. Over time, such reinvestments may offset a portion of the initial cost shocks and contribute to stabilizing the economy. In contrast, Scenario 36 (Feebate) generates the highest long-term cost increases without redistributive mechanisms, rendering it the least advantageous pathway. The absence of compensatory measures under this scenario risks suppressing GDP growth in export-dependent sectors, particularly timber, while rising costs for food and petroleum imports could exert downward pressure on household incomes and overall welfare.

Synthesis and Conclusion

Taken together, the analysis indicates that Liberia's short-term relief under Scenario 24 (GFI Flex Only) is outweighed by heightened medium- and long-term vulnerabilities, particularly in timber exports and petroleum imports. Levy-based pathways with revenue redistribution, such as in Scenario 32 (Low Levy) and, to a lesser extent, Scenario 26 (High Levy), offer a more sustainable trajectory, as reinvested revenues can mitigate structural risks. For Liberia, such revenues could be deployed to strengthen food security, upgrade maritime infrastructure, expand access to cleaner fuels, and enhance technical capacity, leveraging the country's global standing as a major flag state.

In the absence of redistributive mechanisms, Liberia risks being locked into a trajectory of declining trade competitiveness, widening trade deficits, rising inflation, and deteriorating socio-economic indicators. Export revenues, especially from timber, could fall due to reduced global demand or displacement by lower-cost competitors, while import-dependent sectors would face increasing cost pressures, exacerbating food insecurity and energy affordability challenges. These dynamics could dampen GDP growth, worsen terms of trade, and intensify poverty.

Overall, the economic impact of the IMO's mid-term measures on Liberia will be determined by the interaction of three key factors: (i) the design of the policy scenario, (ii) the presence or absence of redistributive mechanisms, and (iii) Liberia's capacity to implement domestic strategies that reduce reliance on high-cost imports while enhancing trade resilience. While the GFI Flex Only pathway (Scenario 24) minimizes short-term costs, long-term stability and resilience are best achieved under levy-based frameworks (Scenarios 32 and 26), where revenues can be strategically reinvested. Effective management of these risks will require coordinated engagement between government authorities, industry stakeholders, and international partners to ensure equitable access to redistributed revenues, align with regional trade frameworks, and advance a national agenda for sustainable and competitive trade.

References

- FAO (2022) *Agriculture and Food Security in Liberia*. Food and Agriculture Organization of the United Nations. Available at: https://www.fao.org/liberia/our-office/liberia-agriculture-food-security/en (Accessed: [15 September 2025]).
- OEC (n.d.) *Liberia – Exports, Imports, and Trade Partners*. The Observatory of Economic Complexity. Available at: https://oec.world/en/profile/country/lbr?selector343id=Import (Accessed: [16 September 2025])
- Wang, D-F., Dong, Q.-L., Peng, Z.-M., Khan, S. Abdul Rehman & Tarasov, A. (2018) 'The Green Logistics Impact on International Trade: Evidence from Developed and Developing Countries', *Sustainability*, 10(7), p. 2235. doi:10.3390/su10072235.

APPENDIX 1

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. 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.

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. Delay 10|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]

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]

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.

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 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) 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 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 Times$_{GSA-X}$ = Distance # / Speed$_{GSA-X}$). 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) (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 1 – Explanation of cargo-side calculation methodology provided in (APEC, 2019).

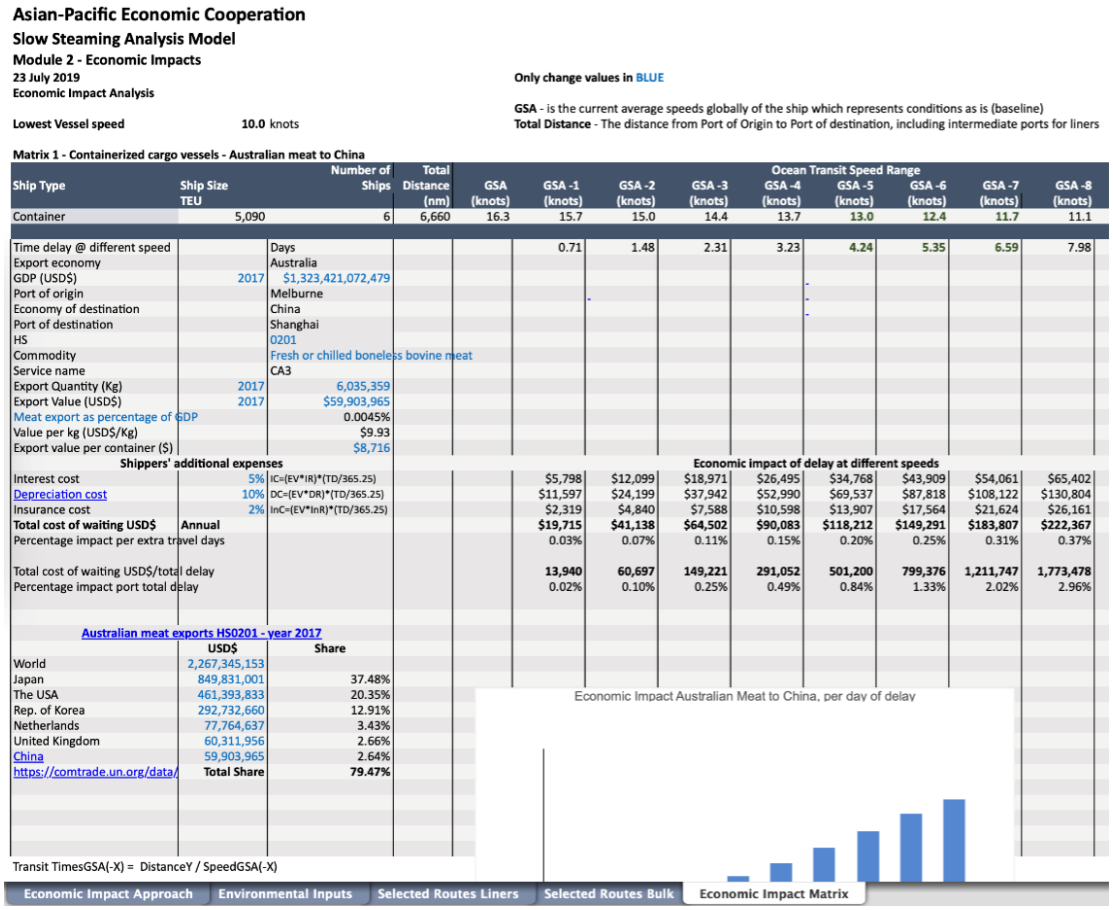
The official Task 4 method considers the costs of interest, depreciation and insurance, assuming that each results in a percentage loss of cargo per day of delay. (APEC, 2019) states that "the interest, depreciation and insurance cost estimates were developed by multiplying the rates for each of the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

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

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

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

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)	GSA (knots)	Ocean Transit Speed Range 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 2 – Screenshot of the Economic Impact Matrix model for Australian Meat to France 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)	Ocean Transit Speed Range 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	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	$1,323,421,072,479										
Port of origin		Melburne										
Economy of destination		China										
Port of destination		Shanghai										
HS		0201										
Commodity		Fresh or chilled boneless bovine meat										
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Export Quantity (Kg)	2017	6,035,359										
Export Value (USD$)	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%										
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https://comtrade.un.org/data/	**Total Share**	**79.47%**										

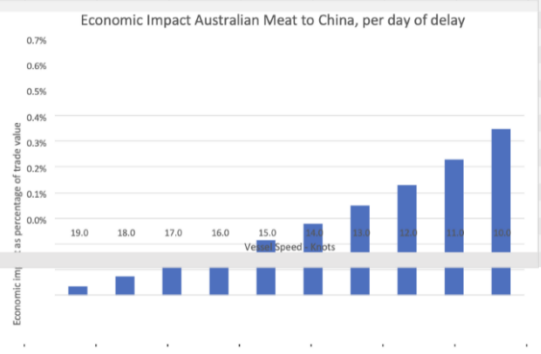


Figure 3 – Alternative screenshot of the Economic Impact Matrix model for Australian Meat to France presented unreferenced as the penultimate page of Appendix B in (APEC, 2019).

Finally, included as an unreferenced figure in the penultimate page of (APEC, 2019) is the screenshot presented in Figure 3. The screenshot shows a similar spreadsheet model as Figure 2 in projecting impacts for Australian meat exports to France. However, final cost impacts are observed to be calculated via the 'non-linear' approach as described qualitatively in (APEC, 2019) and presented in Figure 1. It's believed that the differences between Figures 2 and 3 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 1 and model presented in Figure 3, 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.